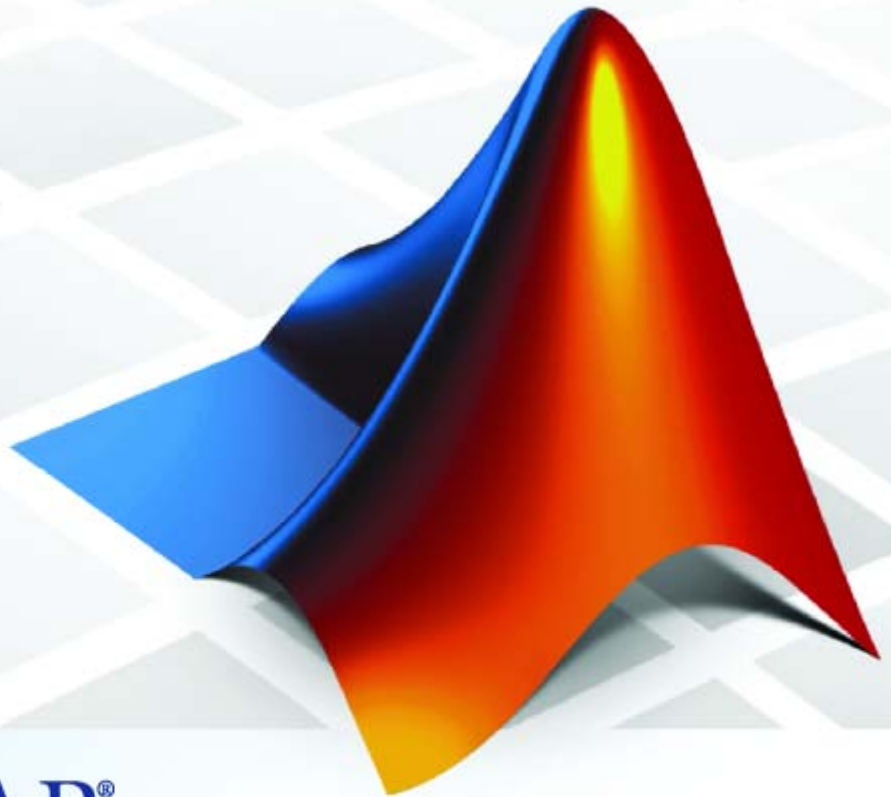


**MATLAB® 7**

Function Reference: Volume 3 (P-Z)



**MATLAB®**

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| September 2007 | Online only     | Revised for 7.5 (Release 2007b)       |





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# Functions — By Category

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Desktop Tools and Development Environment (p. 1-3)

Startup, Command Window, help, editing and debugging, tuning, other general functions

Mathematics (p. 1-13)

Arrays and matrices, linear algebra, other areas of mathematics

Data Analysis (p. 1-41)

Basic data operations, descriptive statistics, covariance and correlation, filtering and convolution, numerical derivatives and integrals, Fourier transforms, time series analysis

Programming and Data Types (p. 1-49)

Function/expression evaluation, program control, function handles, object oriented programming, error handling, operators, data types, dates and times, timers

File I/O (p. 1-76)

General and low-level file I/O, plus specific file formats, like audio, spreadsheet, HDF, images

Graphics (p. 1-86)

Line plots, annotating graphs, specialized plots, images, printing, Handle Graphics

3-D Visualization (p. 1-97)

Surface and mesh plots, view control, lighting and transparency, volume visualization

Creating Graphical User Interfaces  
(p. 1-104)

GUIDE, programming graphical  
user interfaces

External Interfaces (p. 1-109)

Interfaces to DLLs, Java, COM and  
ActiveX, Web services, and serial  
port devices, and C and Fortran  
routines

## Desktop Tools and Development Environment

|  |  |
|--|--|
| Startup and Shutdown (p. 1-3)                        | Startup and shutdown options, preferences                                    |
| Command Window and History (p. 1-4)                  | Control Command Window and History, enter statements and run functions       |
| Help for Using MATLAB (p. 1-5)                       | Command line help, online documentation in the Help browser, demos           |
| Workspace, Search Path, and File Operations (p. 1-6) | Work with files, MATLAB search path, manage variables                        |
| Programming Tools (p. 1-8)                           | Edit and debug M-files, improve performance, source control, publish results |
| System (p. 1-11)                                     | Identify current computer, license, product version, and more                |

### Startup and Shutdown

|                  |  |
|------------------|--|
| exit             | Terminate MATLAB (same as quit)  |
| finish           | MATLAB termination M-file  |
| matlab (UNIX)    | Start MATLAB (UNIX systems)  |
| matlab (Windows) | Start MATLAB (Windows systems)   |
| matlabrc         | MATLAB startup M-file for single-user systems or system administrators |
| prefdir          | Directory containing preferences, history, and layout files            |
| preferences      | Open Preferences dialog box for MATLAB and related products            |

|         |  |
|---------|--|
| quit    | Terminate MATLAB                               |
| startup | MATLAB startup M-file for user-defined options |

## **Command Window and History**

|                       |  |
|-----------------------|--|
| clc                   | Clear Command Window   |
| commandhistory        | Open Command History window, or select it if already open      |
| commandwindow         | Open Command Window, or select it if already open              |
| diary                 | Save session to file   |
| dos                   | Execute DOS command and return result                          |
| format                | Set display format for output                                  |
| home                  | Move cursor to upper-left corner of Command Window             |
| matlabcolon (matlab:) | Run specified function via hyperlink                           |
| more                  | Control paged output for Command Window                        |
| perl                  | Call Perl script using appropriate operating system executable |
| system                | Execute operating system command and return result             |
| unix                  | Execute UNIX command and return result                         |



## Help for Using MATLAB

|                  |  |
|------------------|--|
| builddocsearchdb | Build searchable documentation database                            |
| demo             | Access product demos via Help browser                              |
| doc              | Reference page in Help browser                                     |
| docopt           | Web browser for UNIX platforms                                     |
| docsearch        | Open Help browser <b>Search</b> pane and search for specified term |
| echodemo         | Run M-file demo step-by-step in Command Window                     |
| help             | Help for MATLAB functions in Command Window                        |
| helpbrowser      | Open Help browser to access all online documentation and demos     |
| helpwin          | Provide access to M-file help for all functions                    |
| info             | Information about contacting The MathWorks                         |
| lookfor          | Search for keyword in all help entries                             |
| playshow         | Run M-file demo (deprecated; use echodemo instead)                 |
| support          | Open MathWorks Technical Support Web page                          |
| web              | Open Web site or file in Web browser or Help browser               |
| whatsnew         | Release Notes for MathWorks products                               |

## **Workspace, Search Path, and File Operations**

Workspace (p. 1-6)

Manage variables

Search Path (p. 1-6)

View and change MATLAB search path

File Operations (p. 1-7)

View and change files and directories

### **Workspace**

assignin

Assign value to variable in specified workspace

clear

Remove items from workspace, freeing up system memory

evalin

Execute MATLAB expression in specified workspace

exist

Check existence of variable, function, directory, or Java class

openvar

Open workspace variable in Array Editor or other tool for graphical editing

pack

Consolidate workspace memory

uiimport

Open Import Wizard to import data

which

Locate functions and files

workspace

Open Workspace browser to manage workspace

### **Search Path**

addpath

Add directories to MATLAB search path

genpath

Generate path string

partialpath

Partial pathname description

|                                 |  |
|---------------------------------|--|
| <code>path</code>               | View or change MATLAB directory search path                    |
| <code>path2rc</code>            | Save current MATLAB search path to <code>pathdef.m</code> file |
| <code>pathdef</code>            | Directories in MATLAB search path                              |
| <code>pathsep</code>            | Path separator for current platform                            |
| <code>pathtool</code>           | Open Set Path dialog box to view and change MATLAB path        |
| <code>restoredefaultpath</code> | Restore default MATLAB search path                             |
| <code>rmpath</code>             | Remove directories from MATLAB search path                     |
| <code>savepath</code>           | Save current MATLAB search path to <code>pathdef.m</code> file |

## File Operations

See also “File I/O” on page 1-76 functions.

|                          |   |
|--------------------------|---|
| <code>cd</code>          | Change working directory  |
| <code>copyfile</code>    | Copy file or directory  |
| <code>delete</code>      | Remove files or graphics objects                                |
| <code>dir</code>         | Directory listing   |
| <code>exist</code>       | Check existence of variable, function, directory, or Java class |
| <code>fileattrib</code>  | Set or get attributes of file or directory                      |
| <code>filebrowser</code> | Current Directory browser                                       |
| <code>isdir</code>       | Determine whether input is a directory                          |
| <code>lookfor</code>     | Search for keyword in all help entries                          |

|            |  |
|------------|--|
| ls         | Directory contents on UNIX system                    |
| matlabroot | Root directory of MATLAB installation                |
| mkdir      | Make new directory                                   |
| movefile   | Move file or directory                               |
| pwd        | Identify current directory                           |
| recycle    | Set option to move deleted files to recycle folder   |
| rehash     | Refresh function and file system path caches         |
| rmdir      | Remove directory                                     |
| toolboxdir | Root directory for specified toolbox                 |
| type       | Display contents of file                             |
| web        | Open Web site or file in Web browser or Help browser |
| what       | List MATLAB files in current directory               |
| which      | Locate functions and files                           |

## **Programming Tools**

|   |  |
|---|--|
| Edit and Debug M-Files (p. 1-9)               | Edit and debug M-files                                     |
| Improve Performance and Tune M-Files (p. 1-9) | Improve performance and find potential problems in M-files |
| Source Control (p. 1-10)                      | Interface MATLAB with source control system                |
| Publishing (p. 1-10)                          | Publish M-file code and results                            |

## Edit and Debug M-Files

|             |   |
|-------------|---|
| clipboard   | Copy and paste strings to and from system clipboard |
| datatipinfo | Produce short description of input variable         |
| dbclear     | Clear breakpoints                                   |
| dbcont      | Resume execution                                    |
| dbdown      | Change local workspace context when in debug mode   |
| dbquit      | Quit debug mode                                     |
| dbstack     | Function call stack                                 |
| dbstatus    | List all breakpoints                                |
| dbstep      | Execute one or more lines from current breakpoint   |
| dbstop      | Set breakpoints                                     |
| dbtype      | List M-file with line numbers                       |
| dbup        | Change local workspace context                      |
| debug       | List M-file debugging functions                     |
| edit        | Edit or create M-file                               |
| keyboard    | Input from keyboard                                 |

## Improve Performance and Tune M-Files

|          |  |
|----------|--|
| memory   | Help for memory limitations  |
| mlint    | Check M-files for possible problems  |
| mlintrpt | Run <code>mlint</code> for file or directory, reporting results in browser |
| pack     | Consolidate workspace memory   |
| profile  | Profile execution time for function  |

|          |  |
|----------|--|
| profsave | Save profile report in HTML format           |
| rehash   | Refresh function and file system path caches |
| sparse   | Create sparse matrix                         |
| zeros    | Create array of all zeros                    |

### **Source Control**

|               |  |
|---------------|--|
| checkin       | Check files into source control system (UNIX)            |
| checkout      | Check files out of source control system (UNIX)          |
| cmopts        | Name of source control system                            |
| customverctrl | Allow custom source control system (UNIX)                |
| undocheckout  | Undo previous checkout from source control system (UNIX) |
| verctrl       | Source control actions (Windows)                         |

### **Publishing**

|          |  |
|----------|--|
| grabcode | MATLAB code from M-files published to HTML                               |
| notebook | Open M-book in Microsoft Word (Windows)                                  |
| publish  | Publish M-file containing cells, saving output to file of specified type |

## System

|                                      |  |
|--------------------------------------|--|
| Operating System Interface (p. 1-11) | Exchange operating system information and commands with MATLAB |
| MATLAB Version and License (p. 1-12) | Information about MATLAB version and license                   |

## Operating System Interface

|                   |  |
|-------------------|--|
| clipboard         | Copy and paste strings to and from system clipboard            |
| computer          | Information about computer on which MATLAB is running          |
| dos               | Execute DOS command and return result                          |
| getenv            | Environment variable   |
| hostid            | MATLAB server host identification number                       |
| maxNumCompThreads | Controls maximum number of computational threads               |
| perl              | Call Perl script using appropriate operating system executable |
| setenv            | Set environment variable                                       |
| system            | Execute operating system command and return result             |
| unix              | Execute UNIX command and return result                         |
| winqueryreg       | Item from Microsoft Windows registry                           |

## **MATLAB Version and License**

|                          |   |
|--------------------------|---|
| <code>ismac</code>       | Determine whether running Macintosh OS X versions of MATLAB |
| <code>ispc</code>        | Determine whether PC (Windows) version of MATLAB            |
| <code>isstudent</code>   | Determine whether Student Version of MATLAB                 |
| <code>isunix</code>      | Determine whether UNIX version of MATLAB                    |
| <code>javachk</code>     | Generate error message based on Java feature support        |
| <code>license</code>     | Return license number or perform licensing task             |
| <code>prefdir</code>     | Directory containing preferences, history, and layout files |
| <code>usejava</code>     | Determine whether Java feature is supported in MATLAB       |
| <code>ver</code>         | Version information for MathWorks products                  |
| <code>verLessThan</code> | Compare toolbox version to specified version string         |
| <code>version</code>     | Version number for MATLAB                                   |



# Mathematics

|  |  |
|--|--|
| Arrays and Matrices (p. 1-14)                      | Basic array operators and operations, creation of elementary and specialized arrays and matrices                                     |
| Linear Algebra (p. 1-19)                           | Matrix analysis, linear equations, eigenvalues, singular values, logarithms, exponentials, factorization                             |
| Elementary Math (p. 1-23)                          | Trigonometry, exponentials and logarithms, complex values, rounding, remainders, discrete math                                       |
| Polynomials (p. 1-28)                              | Multiplication, division, evaluation, roots, derivatives, integration, eigenvalue problem, curve fitting, partial fraction expansion |
| Interpolation and Computational Geometry (p. 1-28) | Interpolation, Delaunay triangulation and tessellation, convex hulls, Voronoi diagrams, domain generation                            |
| Cartesian Coordinate System Conversion (p. 1-31)   | Conversions between Cartesian and polar or spherical coordinates   |
| Nonlinear Numerical Methods (p. 1-31)              | Differential equations, optimization, integration  |
| Specialized Math (p. 1-35)                         | Airy, Bessel, Jacobi, Legendre, beta, elliptic, error, exponential integral, gamma functions   |
| Sparse Matrices (p. 1-36)                          | Elementary sparse matrices, operations, reordering algorithms, linear algebra, iterative methods, tree operations                    |
| Math Constants (p. 1-39)                           | Pi, imaginary unit, infinity, Not-a-Number, largest and smallest positive floating point numbers, floating point relative accuracy   |

## Arrays and Matrices

Basic Information (p. 1-14)

Display array contents, get array information, determine array type

Operators (p. 1-15)

Arithmetic operators

Elementary Matrices and Arrays (p. 1-16)

Create elementary arrays of different types, generate arrays for plotting, array indexing, etc.

Array Operations (p. 1-17)

Operate on array content, apply function to each array element, find cumulative product or sum, etc.

Array Manipulation (p. 1-17)

Create, sort, rotate, permute, reshape, and shift array contents

Specialized Matrices (p. 1-18)

Create Hadamard, Companion, Hankel, Vandermonde, Pascal matrices, etc.

## Basic Information

disp

Display text or array

display

Display text or array (overloaded method)

isempty

Determine whether array is empty

isequal

Test arrays for equality

isequalwithequalnans

Test arrays for equality, treating NaNs as equal

isfinite

Array elements that are finite

isfloat

Determine whether input is floating-point array

isinf

Array elements that are infinite

isinteger

Determine whether input is integer array

|           |   |
|-----------|---|
| islogical | Determine whether input is logical array                    |
| isnan     | Array elements that are NaN                                 |
| isnumeric | Determine whether input is numeric array                    |
| isscalar  | Determine whether input is scalar                           |
| issparse  | Determine whether input is sparse                           |
| isvector  | Determine whether input is vector                           |
| length    | Length of vector  |
| max       | Largest elements in array                                   |
| min       | Smallest elements in array                                  |
| ndims     | Number of array dimensions                                  |
| numel     | Number of elements in array or subscripted array expression |
| size      | Array dimensions  |

## Operators

|    |                                     |
|----|-------------------------------------|
| +  | Addition                            |
| +  | Unary plus                          |
| -  | Subtraction                         |
| -  | Unary minus                         |
| *  | Matrix multiplication               |
| ^  | Matrix power                        |
| \  | Backslash or left matrix divide     |
| /  | Slash or right matrix divide        |
| '  | Transpose                           |
| .' | Nonconjugated transpose             |
| .* | Array multiplication (element-wise) |

|                 |                                   |
|-----------------|-----------------------------------|
| <code>.^</code> | Array power (element-wise)        |
| <code>.\</code> | Left array divide (element-wise)  |
| <code>/</code>  | Right array divide (element-wise) |

## **Elementary Matrices and Arrays**

|                        |  |
|------------------------|--|
| <code>blkdiag</code>   | Construct block diagonal matrix from input arguments |
| <code>diag</code>      | Diagonal matrices and diagonals of matrix            |
| <code>eye</code>       | Identity matrix                                      |
| <code>freqspace</code> | Frequency spacing for frequency response             |
| <code>ind2sub</code>   | Subscripts from linear index                         |
| <code>linspace</code>  | Generate linearly spaced vectors                     |
| <code>logspace</code>  | Generate logarithmically spaced vectors              |
| <code>meshgrid</code>  | Generate X and Y arrays for 3-D plots                |
| <code>ndgrid</code>    | Generate arrays for N-D functions and interpolation  |
| <code>ones</code>      | Create array of all ones                             |
| <code>rand</code>      | Uniformly distributed pseudorandom numbers           |
| <code>randn</code>     | Normally distributed random numbers                  |
| <code>sub2ind</code>   | Single index from subscripts                         |
| <code>zeros</code>     | Create array of all zeros                            |

## Array Operations

See “Linear Algebra” on page 1-19 and “Elementary Math” on page 1-23 for other array operations.

|            |  |
|------------|--|
| accumarray | Construct array with accumulation  |
| arrayfun   | Apply function to each element of array  |
| bsxfun     | Apply element-by-element binary operation to two arrays with singleton expansion enabled |
| cast       | Cast variable to different data type   |
| cross      | Vector cross product   |
| cumprod    | Cumulative product   |
| cumsum     | Cumulative sum   |
| dot        | Vector dot product   |
| idivide    | Integer division with rounding option  |
| kron       | Kronecker tensor product   |
| prod       | Product of array elements  |
| sum        | Sum of array elements  |
| tril       | Lower triangular part of matrix  |
| triu       | Upper triangular part of matrix  |

## Array Manipulation

|           |  |
|-----------|--|
| blkdiag   | Construct block diagonal matrix from input arguments |
| cat       | Concatenate arrays along specified dimension         |
| circshift | Shift array circularly                               |

|           |   |
|-----------|---|
| diag      | Diagonal matrices and diagonals of matrix             |
| end       | Terminate block of code, or indicate last array index |
| flipdim   | Flip array along specified dimension                  |
| fliplr    | Flip matrix left to right                             |
| flipud    | Flip matrix up to down                                |
| horzcat   | Concatenate arrays horizontally                       |
| inline    | Construct inline object                               |
| ipermute  | Inverse permute dimensions of N-D array               |
| permute   | Rearrange dimensions of N-D array                     |
| repmat    | Replicate and tile array                              |
| reshape   | Reshape array   |
| rot90     | Rotate matrix 90 degrees                              |
| shiftdim  | Shift dimensions                                      |
| sort      | Sort array elements in ascending or descending order  |
| sortrows  | Sort rows in ascending order                          |
| squeeze   | Remove singleton dimensions                           |
| vectorize | Vectorize expression                                  |
| vertcat   | Concatenate arrays vertically                         |

### **Specialized Matrices**

|          |                  |
|----------|------------------|
| compan   | Companion matrix |
| gallery  | Test matrices    |
| hadamard | Hadamard matrix  |
| hankel   | Hankel matrix    |

|           |   |
|-----------|---|
| hilb      | Hilbert matrix                            |
| invhilb   | Inverse of Hilbert matrix                 |
| magic     | Magic square                              |
| pascal    | Pascal matrix                             |
| rosser    | Classic symmetric eigenvalue test problem |
| toeplitz  | Toeplitz matrix                           |
| vander    | Vandermonde matrix                        |
| wilkinson | Wilkinson's eigenvalue test matrix        |

## Linear Algebra

|  |   |
|--|---|
| Matrix Analysis (p. 1-19)                    | Compute norm, rank, determinant, condition number, etc.                             |
| Linear Equations (p. 1-20)                   | Solve linear systems, least squares, LU factorization, Cholesky factorization, etc. |
| Eigenvalues and Singular Values (p. 1-21)    | Eigenvalues, eigenvectors, Schur decomposition, Hessenburg matrices, etc.           |
| Matrix Logarithms and Exponentials (p. 1-22) | Matrix logarithms, exponentials, square root  |
| Factorization (p. 1-22)                      | Cholesky, LU, and QR factorizations, diagonal forms, singular value decomposition   |

## Matrix Analysis

|         |  |
|---------|--|
| cond    | Condition number with respect to inversion   |
| condeig | Condition number with respect to eigenvalues |

|          |   |
|----------|---|
| det      | Matrix determinant                          |
| norm     | Vector and matrix norms                     |
| normest  | 2-norm estimate                             |
| null     | Null space                                  |
| orth     | Range space of matrix                       |
| rank     | Rank of matrix                              |
| rcond    | Matrix reciprocal condition number estimate |
| rref     | Reduced row echelon form                    |
| subspace | Angle between two subspaces                 |
| trace    | Sum of diagonal elements                    |

### **Linear Equations**

|           |   |
|-----------|---|
| chol      | Cholesky factorization  |
| cholinc   | Sparse incomplete Cholesky and Cholesky-Infinity factorizations |
| cond      | Condition number with respect to inversion                      |
| condest   | 1-norm condition number estimate                                |
| funm      | Evaluate general matrix function                                |
| ilu       | Sparse incomplete LU factorization                              |
| inv       | Matrix inverse  |
| linsolve  | Solve linear system of equations                                |
| lsconv    | Least-squares solution in presence of known covariance          |
| lsqnonneg | Solve nonnegative least-squares constraints problem             |
| lu        | LU matrix factorization   |



---

|       |   |
|-------|---|
| luinc | Sparse incomplete LU factorization          |
| pinv  | Moore-Penrose pseudoinverse of matrix       |
| qr    | Orthogonal-triangular decomposition         |
| rcond | Matrix reciprocal condition number estimate |

### **Eigenvalues and Singular Values**

|          |  |
|----------|--|
| balance  | Diagonal scaling to improve eigenvalue accuracy            |
| cdf2rdf  | Convert complex diagonal form to real block diagonal form  |
| condeig  | Condition number with respect to eigenvalues               |
| eig      | Find eigenvalues and eigenvectors                          |
| eigs     | Find largest eigenvalues and eigenvectors of sparse matrix |
| gsvd     | Generalized singular value decomposition                   |
| hess     | Hessenberg form of matrix                                  |
| ordeig   | Eigenvalues of quasitriangular matrices                    |
| ordqz    | Reorder eigenvalues in QZ factorization                    |
| ordschur | Reorder eigenvalues in Schur factorization                 |
| poly     | Polynomial with specified roots                            |
| polyeig  | Polynomial eigenvalue problem                              |

|         |   |
|---------|---|
| rsf2csf | Convert real Schur form to complex Schur form                   |
| schur   | Schur decomposition   |
| sqrtn   | Matrix square root  |
| ss2tf   | Convert state-space filter parameters to transfer function form |
| svd     | Singular value decomposition                                    |
| svds    | Find singular values and vectors                                |

### **Matrix Logarithms and Exponentials**

|       |                    |
|-------|--------------------|
| expm  | Matrix exponential |
| logm  | Matrix logarithm   |
| sqrtn | Matrix square root |

### **Factorization**

|            |   |
|------------|---|
| balance    | Diagonal scaling to improve eigenvalue accuracy                 |
| cdf2rdf    | Convert complex diagonal form to real block diagonal form       |
| chol       | Cholesky factorization  |
| cholinc    | Sparse incomplete Cholesky and Cholesky-Infinity factorizations |
| cholupdate | Rank 1 update to Cholesky factorization                         |
| gsvd       | Generalized singular value decomposition                        |
| ilu        | Sparse incomplete LU factorization                              |
| lu         | LU matrix factorization   |

|          |   |
|----------|---|
| luinc    | Sparse incomplete LU factorization            |
| planerot | Givens plane rotation                         |
| qr       | Orthogonal-triangular decomposition           |
| qrdelete | Remove column or row from QR factorization    |
| qrinsert | Insert column or row into QR factorization    |
| qrupdate |   |
| qz       | QZ factorization for generalized eigenvalues  |
| rsf2csf  | Convert real Schur form to complex Schur form |
| svd      | Singular value decomposition                  |

## Elementary Math

|   |   |
|---|---|
| Trigonometric (p. 1-24)                       | Trigonometric functions with results in radians or degrees  |
| Exponential (p. 1-25)                         | Exponential, logarithm, power, and root functions   |
| Complex (p. 1-26)                             | Numbers with real and imaginary components, phase angles  |
| Rounding and Remainder (p. 1-27)              | Rounding, modulus, and remainder  |
| Discrete Math (e.g., Prime Factors) (p. 1-27) | Prime factors, factorials, permutations, rational fractions, least common multiple, greatest common divisor |

**Trigonometric**

|       |                                      |
|-------|--------------------------------------|
| acos  | Inverse cosine; result in radians    |
| acosd | Inverse cosine; result in degrees    |
| acosh | Inverse hyperbolic cosine            |
| acot  | Inverse cotangent; result in radians |
| acotd | Inverse cotangent; result in degrees |
| acoth | Inverse hyperbolic cotangent         |
| acsc  | Inverse cosecant; result in radians  |
| acscd | Inverse cosecant; result in degrees  |
| acsch | Inverse hyperbolic cosecant          |
| asec  | Inverse secant; result in radians    |
| asecd | Inverse secant; result in degrees    |
| asech | Inverse hyperbolic secant            |
| asin  | Inverse sine; result in radians      |
| asind | Inverse sine; result in degrees      |
| asinh | Inverse hyperbolic sine              |
| atan  | Inverse tangent; result in radians   |
| atan2 | Four-quadrant inverse tangent        |
| atand | Inverse tangent; result in degrees   |
| atanh | Inverse hyperbolic tangent           |
| cos   | Cosine of argument in radians        |
| cosd  | Cosine of argument in degrees        |
| cosh  | Hyperbolic cosine                    |
| cot   | Cotangent of argument in radians     |
| cotd  | Cotangent of argument in degrees     |
| coth  | Hyperbolic cotangent                 |
| csc   | Cosecant of argument in radians      |

|       |  |
|-------|--|
| cscd  | Cosecant of argument in degrees        |
| csch  | Hyperbolic cosecant                    |
| hypot | Square root of sum of squares          |
| sec   | Secant of argument in radians          |
| secd  | Secant of argument in degrees          |
| sech  | Hyperbolic secant                      |
| sin   | Sine of argument in radians            |
| sind  | Sine of argument in degrees            |
| sinh  | Hyperbolic sine of argument in radians |
| tan   | Tangent of argument in radians         |
| tand  | Tangent of argument in degrees         |
| tanh  | Hyperbolic tangent                     |

## Exponential

|          |  |
|----------|--|
| exp      | Exponential  |
| expm1    | Compute $\exp(x) - 1$ accurately for small values of $x$                       |
| log      | Natural logarithm  |
| log10    | Common (base 10) logarithm   |
| log1p    | Compute $\log(1+x)$ accurately for small values of $x$                         |
| log2     | Base 2 logarithm and dissect floating-point numbers into exponent and mantissa |
| nextpow2 | Next higher power of 2   |
| nthroot  | Real $n$ th root of real numbers   |
| pow2     | Base 2 power and scale floating-point numbers                                  |

|          |   |
|----------|---|
| reallog  | Natural logarithm for nonnegative real arrays |
| realpow  | Array power for real-only output              |
| realsqrt | Square root for nonnegative real arrays       |
| sqrt     | Square root                                   |

## **Complex**

|          |   |
|----------|---|
| abs      | Absolute value and complex magnitude                      |
| angle    | Phase angle   |
| complex  | Construct complex data from real and imaginary components |
| conj     | Complex conjugate   |
| cplxpair | Sort complex numbers into complex conjugate pairs         |
| i        | Imaginary unit  |
| imag     | Imaginary part of complex number                          |
| isreal   | Determine whether input is real array                     |
| j        | Imaginary unit  |
| real     | Real part of complex number                               |
| sign     | Signum function   |
| unwrap   | Correct phase angles to produce smoother phase plots      |

## Rounding and Remainder

|         |                                       |
|---------|---------------------------------------|
| ceil    | Round toward infinity                 |
| fix     | Round toward zero                     |
| floor   | Round toward minus infinity           |
| idivide | Integer division with rounding option |
| mod     | Modulus after division                |
| rem     | Remainder after division              |
| round   | Round to nearest integer              |

## Discrete Math (e.g., Prime Factors)

|           |  |
|-----------|--|
| factor    | Prime factors                            |
| factorial | Factorial function                       |
| gcd       | Greatest common divisor                  |
| isprime   | Array elements that are prime numbers    |
| lcm       | Least common multiple                    |
| nchoosek  | Binomial coefficient or all combinations |
| perms     | All possible permutations                |
| primes    | Generate list of prime numbers           |
| rat, rats | Rational fraction approximation          |

## Polynomials

|          |  |
|----------|--|
| conv     | Convolution and polynomial multiplication                              |
| deconv   | Deconvolution and polynomial division                                  |
| poly     | Polynomial with specified roots  |
| polyder  | Polynomial derivative  |
| polyeig  | Polynomial eigenvalue problem  |
| polyfit  | Polynomial curve fitting   |
| polyint  | Integrate polynomial analytically                                      |
| polyval  | Polynomial evaluation  |
| polyvalm | Matrix polynomial evaluation   |
| residue  | Convert between partial fraction expansion and polynomial coefficients |
| roots    | Polynomial roots   |

## Interpolation and Computational Geometry

|   |  |
|---|--|
| Interpolation (p. 1-29)                           | Data interpolation, data gridding, polynomial evaluation, nearest point search |
| Delaunay Triangulation and Tessellation (p. 1-30) | Delaunay triangulation and tessellation, triangular surface and mesh plots     |
| Convex Hull (p. 1-30)                             | Plot convex hull, plotting functions   |
| Voronoi Diagrams (p. 1-30)                        | Plot Voronoi diagram, patch graphics object, plotting functions                |
| Domain Generation (p. 1-31)                       | Generate arrays for 3-D plots, or for N-D functions and interpolation          |



## Interpolation

|           |  |
|-----------|--|
| dsearch   | Search Delaunay triangulation for nearest point              |
| dsearchn  | N-D nearest point search                                     |
| griddata  | Data gridding  |
| griddata3 | Data gridding and hypersurface fitting for 3-D data          |
| griddatan | Data gridding and hypersurface fitting (dimension $\geq 2$ ) |
| interp1   | 1-D data interpolation (table lookup)                        |
| interp1q  | Quick 1-D linear interpolation                               |
| interp2   | 2-D data interpolation (table lookup)                        |
| interp3   | 3-D data interpolation (table lookup)                        |
| interpft  | 1-D interpolation using FFT method                           |
| interpN   | N-D data interpolation (table lookup)                        |
| meshgrid  | Generate X and Y arrays for 3-D plots                        |
| mkpp      | Make piecewise polynomial                                    |
| ndgrid    | Generate arrays for N-D functions and interpolation          |
| padecoeff | Padé approximation of time delays                            |
| pchip     | Piecewise Cubic Hermite Interpolating Polynomial (PCHIP)     |
| ppval     | Evaluate piecewise polynomial                                |
| spline    | Cubic spline data interpolation                              |
| tsearchn  | N-D closest simplex search                                   |
| unmkpp    | Piecewise polynomial details                                 |

## **Delaunay Triangulation and Tessellation**

|           |   |
|-----------|---|
| delaunay  | Delaunay triangulation                          |
| delaunay3 | 3-D Delaunay tessellation                       |
| delaunayn | N-D Delaunay tessellation                       |
| dsearch   | Search Delaunay triangulation for nearest point |
| dsearchn  | N-D nearest point search                        |
| tetramesh | Tetrahedron mesh plot                           |
| trimesh   | Triangular mesh plot                            |
| triplot   | 2-D triangular plot                             |
| trisurf   | Triangular surface plot                         |
| tsearch   | Search for enclosing Delaunay triangle          |
| tsearchn  | N-D closest simplex search                      |

## **Convex Hull**

|           |                              |
|-----------|------------------------------|
| convhull  | Convex hull                  |
| convhulln | N-D convex hull              |
| patch     | Create patch graphics object |
| plot      | 2-D line plot                |
| trisurf   | Triangular surface plot      |

## **Voronoi Diagrams**

|         |   |
|---------|---|
| dsearch | Search Delaunay triangulation for nearest point |
| patch   | Create patch graphics object                    |
| plot    | 2-D line plot                                   |

|          |                     |
|----------|---------------------|
| voronoi  | Voronoi diagram     |
| voronoin | N-D Voronoi diagram |

## Domain Generation

|          |   |
|----------|---|
| meshgrid | Generate X and Y arrays for 3-D plots               |
| ndgrid   | Generate arrays for N-D functions and interpolation |

## Cartesian Coordinate System Conversion

|          |   |
|----------|---|
| cart2pol | Transform Cartesian coordinates to polar or cylindrical |
| cart2sph | Transform Cartesian coordinates to spherical            |
| pol2cart | Transform polar or cylindrical coordinates to Cartesian |
| sph2cart | Transform spherical coordinates to Cartesian            |

## Nonlinear Numerical Methods

|   |  |
|---|--|
| Ordinary Differential Equations (IVP) (p. 1-32) | Solve stiff and nonstiff differential equations, define the problem, set solver options, evaluate solution |
| Delay Differential Equations (p. 1-33)          | Solve delay differential equations with constant and general delays, set solver options, evaluate solution |
| Boundary Value Problems (p. 1-33)               | Solve boundary value problems for ordinary differential equations, set solver options, evaluate solution   |

|   |  |
|---|--|
| Partial Differential Equations<br>(p. 1-34)     | Solve initial-boundary value problems for parabolic-elliptic PDEs, evaluate solution                   |
| Optimization (p. 1-34)                          | Find minimum of single and multivariable functions, solve nonnegative least-squares constraint problem |
| Numerical Integration (Quadrature)<br>(p. 1-34) | Evaluate Simpson, Lobatto, and vectorized quadratures, evaluate double and triple integrals            |

### **Ordinary Differential Equations (IVP)**

|  |   |
|--|---|
| decic  | Compute consistent initial conditions for <code>ode15i</code>                   |
| deval  | Evaluate solution of differential equation problem                              |
| ode15i   | Solve fully implicit differential equations, variable order method              |
| ode23, ode45, ode113, ode15s,<br>ode23s, ode23t, ode23tb | Solve initial value problems for ordinary differential equations                |
| odefile  | Define differential equation problem for ordinary differential equation solvers |
| odeget   | Ordinary differential equation options parameters                               |
| odeset   | Create or alter options structure for ordinary differential equation solvers    |
| odextend   | Extend solution of initial value problem for ordinary differential equation     |

## Delay Differential Equations

|        |  |
|--------|--|
| dde23  | Solve delay differential equations (DDEs) with constant delays         |
| ddeget | Extract properties from delay differential equations options structure |
| ddesd  | Solve delay differential equations (DDEs) with general delays          |
| ddeset | Create or alter delay differential equations options structure         |
| deval  | Evaluate solution of differential equation problem                     |

## Boundary Value Problems

|          |   |
|----------|---|
| bvp4c    | Solve boundary value problems for ordinary differential equations |
| bvp5c    | Solve boundary value problems for ordinary differential equations |
| bvpget   | Extract properties from options structure created with bvpset     |
| bvpinit  | Form initial guess for bvp4c                                      |
| bvpset   | Create or alter options structure of boundary value problem       |
| bvpxtend | Form guess structure for extending boundary value solutions       |
| deval    | Evaluate solution of differential equation problem                |

## Partial Differential Equations

|        |  |
|--------|--|
| pdepe  | Solve initial-boundary value problems for parabolic-elliptic PDEs in 1-D |
| pdeval | Evaluate numerical solution of PDE using output of pdepe                 |

## Optimization

|            |   |
|------------|---|
| fminbnd    | Find minimum of single-variable function on fixed interval                        |
| fminsearch | Find minimum of unconstrained multivariable function using derivative-free method |
| fzero      | Find root of continuous function of one variable                                  |
| lsqnonneg  | Solve nonnegative least-squares constraints problem                               |
| optimget   | Optimization options values   |
| optimset   | Create or edit optimization options structure                                     |

## Numerical Integration (Quadrature)

|         |  |
|---------|--|
| dblquad | Numerically evaluate double integral                             |
| quad    | Numerically evaluate integral, adaptive Simpson quadrature       |
| quadgk  | Numerically evaluate integral, adaptive Gauss-Kronrod quadrature |
| quadl   | Numerically evaluate integral, adaptive Lobatto quadrature       |

quadv  
triplequad

Vectorized quadrature  
Numerically evaluate triple integral

## Specialized Math

airy  
besselh  
  
besseli  
besselj  
besselk  
  
bessely  
beta  
betainc  
betaln  
ellipj  
ellipke  
  
erf, erfc, erfex, erfinv, erfcinv  
expint  
gamma, gammainc, gammaln  
legendre  
psi

Airy functions  
Bessel function of third kind (Hankel function)  
Modified Bessel function of first kind  
Bessel function of first kind  
Modified Bessel function of second kind  
Bessel function of second kind  
Beta function  
Incomplete beta function  
Logarithm of beta function  
Jacobi elliptic functions  
Complete elliptic integrals of first and second kind  
Error functions  
Exponential integral  
Gamma functions  
Associated Legendre functions  
Psi (polygamma) function

## Sparse Matrices

|  |   |
|--|---|
| Elementary Sparse Matrices (p. 1-36)           | Create random and nonrandom sparse matrices   |
| Full to Sparse Conversion (p. 1-37)            | Convert full matrix to sparse, sparse matrix to full  |
| Working with Sparse Matrices (p. 1-37)         | Test matrix for sparseness, get information on sparse matrix, allocate sparse matrix, apply function to nonzero elements, visualize sparsity pattern. |
| Reordering Algorithms (p. 1-37)                | Random, column, minimum degree, Dulmage-Mendelsohn, and reverse Cuthill-McKee permutations  |
| Linear Algebra (p. 1-38)                       | Compute norms, eigenvalues, factorizations, least squares, structural rank  |
| Linear Equations (Iterative Methods) (p. 1-38) | Methods for conjugate and biconjugate gradients, residuals, lower quartile  |
| Tree Operations (p. 1-39)                      | Elimination trees, tree plotting, factorization analysis  |

## Elementary Sparse Matrices

|           |  |
|-----------|--|
| spdiags   | Extract and create sparse band and diagonal matrices |
| speye     | Sparse identity matrix                               |
| sprand    | Sparse uniformly distributed random matrix           |
| sprandn   | Sparse normally distributed random matrix            |
| sprandsym | Sparse symmetric random matrix                       |



## Full to Sparse Conversion

|                        |  |
|------------------------|--|
| <code>find</code>      | Find indices and values of nonzero elements      |
| <code>full</code>      | Convert sparse matrix to full matrix             |
| <code>sparse</code>    | Create sparse matrix                             |
| <code>spconvert</code> | Import matrix from sparse matrix external format |

## Working with Sparse Matrices

|                       |   |
|-----------------------|---|
| <code>issparse</code> | Determine whether input is sparse                       |
| <code>nnz</code>      | Number of nonzero matrix elements                       |
| <code>nonzeros</code> | Nonzero matrix elements                                 |
| <code>nzmax</code>    | Amount of storage allocated for nonzero matrix elements |
| <code>spalloc</code>  | Allocate space for sparse matrix                        |
| <code>spfun</code>    | Apply function to nonzero sparse matrix elements        |
| <code>spones</code>   | Replace nonzero sparse matrix elements with ones        |
| <code>spparms</code>  | Set parameters for sparse matrix routines               |
| <code>spy</code>      | Visualize sparsity pattern                              |

## Reordering Algorithms

|                     |   |
|---------------------|---|
| <code>amd</code>    | Approximate minimum degree permutation        |
| <code>colamd</code> | Column approximate minimum degree permutation |

|          |  |
|----------|--|
| colperm  | Sparse column permutation based on nonzero count           |
| dmperm   | Dulmage-Mendelsohn decomposition                           |
| ldl      | Block ldl' factorization for Hermitian indefinite matrices |
| randperm | Random permutation   |
| symamd   | Symmetric approximate minimum degree permutation           |
| symrcm   | Sparse reverse Cuthill-McKee ordering                      |

### **Linear Algebra**

|           |   |
|-----------|---|
| cholinc   | Sparse incomplete Cholesky and Cholesky-Infinity factorizations |
| condest   | 1-norm condition number estimate                                |
| eigs      | Find largest eigenvalues and eigenvectors of sparse matrix      |
| ilu       | Sparse incomplete LU factorization                              |
| luinc     | Sparse incomplete LU factorization                              |
| normest   | 2-norm estimate   |
| spaugment | Form least squares augmented system                             |
| sprank    | Structural rank   |
| svds      | Find singular values and vectors                                |

### **Linear Equations (Iterative Methods)**

|          |   |
|----------|---|
| bicg     | Biconjugate gradients method            |
| bicgstab | Biconjugate gradients stabilized method |

|        |   |
|--------|---|
| cgs    | Conjugate gradients squared method                  |
| gmres  | Generalized minimum residual method (with restarts) |
| lsqr   | LSQR method   |
| minres | Minimum residual method                             |
| pcg    | Preconditioned conjugate gradients method           |
| qmr    | Quasi-minimal residual method                       |
| symmlq | Symmetric LQ method                                 |

### Tree Operations

|            |  |
|------------|--|
| etree      | Elimination tree                                   |
| etreeplot  | Plot elimination tree                              |
| gplot      | Plot nodes and links representing adjacency matrix |
| symbfact   | Symbolic factorization analysis                    |
| treelayout | Lay out tree or forest                             |
| treeplot   | Plot picture of tree                               |

### Math Constants

|        |  |
|--------|--|
| eps    | Floating-point relative accuracy         |
| i      | Imaginary unit                           |
| Inf    | Infinity                                 |
| intmax | Largest value of specified integer type  |
| intmin | Smallest value of specified integer type |
| j      | Imaginary unit                           |

NaN

Not-a-Number

pi

Ratio of circle's circumference to its diameter,  $\pi$

realmax

Largest positive floating-point number

realmin

Smallest positive normalized floating-point number

## Data Analysis

|  |                                  |
|--|----------------------------------|
| Basic Operations (p. 1-41)             | Sums, products, sorting          |
| Descriptive Statistics (p. 1-41)       | Statistical summaries of data    |
| Filtering and Convolution (p. 1-42)    | Data preprocessing               |
| Interpolation and Regression (p. 1-42) | Data fitting                     |
| Fourier Transforms (p. 1-43)           | Frequency content of data        |
| Derivatives and Integrals (p. 1-43)    | Data rates and accumulations     |
| Time Series Objects (p. 1-44)          | Methods for timeseries objects   |
| Time Series Collections (p. 1-47)      | Methods for tscollection objects |

### Basic Operations

|          |  |
|----------|--|
| cumprod  | Cumulative product                                   |
| cumsum   | Cumulative sum                                       |
| prod     | Product of array elements                            |
| sort     | Sort array elements in ascending or descending order |
| sortrows | Sort rows in ascending order                         |
| sum      | Sum of array elements                                |

### Descriptive Statistics

|          |                                |
|----------|--------------------------------|
| corrcoef | Correlation coefficients       |
| cov      | Covariance matrix              |
| max      | Largest elements in array      |
| mean     | Average or mean value of array |
| median   | Median value of array          |

|      |                               |
|------|-------------------------------|
| min  | Smallest elements in array    |
| mode | Most frequent values in array |
| std  | Standard deviation            |
| var  | Variance                      |

## Filtering and Convolution

|         |   |
|---------|---|
| conv    | Convolution and polynomial multiplication |
| conv2   | 2-D convolution                           |
| convn   | N-D convolution                           |
| deconv  | Deconvolution and polynomial division     |
| detrend | Remove linear trends                      |
| filter  | 1-D digital filter                        |
| filter2 | 2-D digital filter                        |

## Interpolation and Regression

|                        |                                       |
|------------------------|---------------------------------------|
| interp1                | 1-D data interpolation (table lookup) |
| interp2                | 2-D data interpolation (table lookup) |
| interp3                | 3-D data interpolation (table lookup) |
| interp                 | N-D data interpolation (table lookup) |
| mldivide \, mrdivide / | Left or right matrix division         |
| polyfit                | Polynomial curve fitting              |
| polyval                | Polynomial evaluation                 |

## Fourier Transforms

|           |   |
|-----------|---|
| abs       | Absolute value and complex magnitude                        |
| angle     | Phase angle   |
| cplxpair  | Sort complex numbers into complex conjugate pairs           |
| fft       | Discrete Fourier transform                                  |
| fft2      | 2-D discrete Fourier transform                              |
| fftn      | N-D discrete Fourier transform                              |
| fftshift  | Shift zero-frequency component to center of spectrum        |
| fftw      | Interface to FFTW library run-time algorithm tuning control |
| ifft      | Inverse discrete Fourier transform                          |
| ifft2     | 2-D inverse discrete Fourier transform                      |
| ifftn     | N-D inverse discrete Fourier transform                      |
| ifftshift | Inverse FFT shift   |
| nextpow2  | Next higher power of 2                                      |
| unwrap    | Correct phase angles to produce smoother phase plots        |

## Derivatives and Integrals

|          |  |
|----------|--|
| cumtrapz | Cumulative trapezoidal numerical integration |
| del2     | Discrete Laplacian                           |
| diff     | Differences and approximate derivatives      |

gradient

Numerical gradient

polyder

Polynomial derivative

polyint

Integrate polynomial analytically

trapz

Trapezoidal numerical integration

## Time Series Objects

General Purpose (p. 1-44)

Combine `timeseries` objects, query and set `timeseries` object properties, plot `timeseries` objects

Data Manipulation (p. 1-45)

Add or delete data, manipulate `timeseries` objects

Event Data (p. 1-46)

Add or delete events, create new `timeseries` objects based on event data

Descriptive Statistics (p. 1-46)

Descriptive statistics for `timeseries` objects

## General Purpose

`get` (`timeseries`)

Query `timeseries` object property values

`getdatasamplesize`

Size of data sample in `timeseries` object

`getqualitydesc`

Data quality descriptions

`isempty` (`timeseries`)

Determine whether `timeseries` object is empty

`length` (`timeseries`)

Length of time vector

`plot` (`timeseries`)

Plot time series

`set` (`timeseries`)

Set properties of `timeseries` object

`size` (`timeseries`)

Size of `timeseries` object



---

|                           |   |
|---------------------------|---|
| <code>timeseries</code>   | Create <code>timeseries</code> object                     |
| <code>tsdata.event</code> | Construct event object for <code>timeseries</code> object |
| <code>tsprops</code>      | Help on <code>timeseries</code> object properties         |
| <code>tstool</code>       | Open Time Series Tools GUI                                |

## Data Manipulation

|  |  |
|--|--|
| <code>addsample</code>                       | Add data sample to <code>timeseries</code> object                        |
| <code>ctranspose (timeseries)</code>         | Transpose <code>timeseries</code> object                                 |
| <code>delsample</code>                       | Remove sample from <code>timeseries</code> object                        |
| <code>detrend (timeseries)</code>            | Subtract mean or best-fit line and all NaNs from time series             |
| <code>filter (timeseries)</code>             | Shape frequency content of time series                                   |
| <code>getabstime (timeseries)</code>         | Extract date-string time vector into cell array                          |
| <code>getinterpmethod</code>                 | Interpolation method for <code>timeseries</code> object                  |
| <code>getsampleusingtime (timeseries)</code> | Extract data samples into new <code>timeseries</code> object             |
| <code>idealfilter (timeseries)</code>        | Apply ideal (noncausal) filter to <code>timeseries</code> object         |
| <code>resample (timeseries)</code>           | Select or interpolate <code>timeseries</code> data using new time vector |
| <code>setabstime (timeseries)</code>         | Set times of <code>timeseries</code> object as date strings              |
| <code>setinterpmethod</code>                 | Set default interpolation method for <code>timeseries</code> object      |

|                                     |   |
|-------------------------------------|---|
| <code>synchronize</code>            | Synchronize and resample two <code>timeseries</code> objects using common time vector |
| <code>transpose (timeseries)</code> | Transpose <code>timeseries</code> object  |
| <code>vertcat (timeseries)</code>   | Vertical concatenation of <code>timeseries</code> objects                             |

### Event Data

|                                 |  |
|---------------------------------|--|
| <code>addevent</code>           | Add event to <code>timeseries</code> object                                  |
| <code>delevent</code>           | Remove <code>tsdata.event</code> objects from <code>timeseries</code> object |
| <code>gettsafteratevent</code>  | New <code>timeseries</code> object with samples occurring at or after event  |
| <code>gettsafterevent</code>    | New <code>timeseries</code> object with samples occurring after event        |
| <code>gettsatevent</code>       | New <code>timeseries</code> object with samples occurring at event           |
| <code>gettsbeforeatevent</code> | New <code>timeseries</code> object with samples occurring before or at event |
| <code>gettsbeforeevent</code>   | New <code>timeseries</code> object with samples occurring before event       |
| <code>gettsbetweenevents</code> | New <code>timeseries</code> object with samples occurring between events     |

### Descriptive Statistics

|                                  |   |
|----------------------------------|---|
| <code>iqr (timeseries)</code>    | Interquartile range of <code>timeseries</code> data |
| <code>max (timeseries)</code>    | Maximum value of <code>timeseries</code> data       |
| <code>mean (timeseries)</code>   | Mean value of <code>timeseries</code> data          |
| <code>median (timeseries)</code> | Median value of <code>timeseries</code> data        |

|                               |  |
|-------------------------------|--|
| <code>min (timeseries)</code> | Minimum value of <code>timeseries</code> data      |
| <code>std (timeseries)</code> | Standard deviation of <code>timeseries</code> data |
| <code>sum (timeseries)</code> | Sum of <code>timeseries</code> data                |
| <code>var (timeseries)</code> | Variance of <code>timeseries</code> data           |

## Time Series Collections

|                             |   |
|-----------------------------|---|
| General Purpose (p. 1-47)   | Query and set <code>tscollection</code> object properties, plot <code>tscollection</code> objects |
| Data Manipulation (p. 1-48) | Add or delete data, manipulate <code>tscollection</code> objects                                  |

### General Purpose

|                                     |   |
|-------------------------------------|---|
| <code>get (tscollection)</code>     | Query <code>tscollection</code> object property values      |
| <code>isempty (tscollection)</code> | Determine whether <code>tscollection</code> object is empty |
| <code>length (tscollection)</code>  | Length of time vector                                       |
| <code>plot (timeseries)</code>      | Plot time series  |
| <code>set (tscollection)</code>     | Set properties of <code>tscollection</code> object          |
| <code>size (tscollection)</code>    | Size of <code>tscollection</code> object                    |
| <code>tscollection</code>           | Create <code>tscollection</code> object                     |
| <code>tstool</code>                 | Open Time Series Tools GUI                                  |

## Data Manipulation

|   |  |
|---|--|
| <code>addsampletocollection</code>                | Add sample to <code>tscollection</code> object   |
| <code>addts</code>                                | Add <code>timeseries</code> object to <code>tscollection</code> object                     |
| <code>delsamplefromcollection</code>              | Remove sample from <code>tscollection</code> object  |
| <code>getabstime (tscollection)</code>            | Extract date-string time vector into cell array  |
| <code>getsamplingsusingtime (tscollection)</code> | Extract data samples into new <code>tscollection</code> object                             |
| <code>gettimeseriesnames</code>                   | Cell array of names of <code>timeseries</code> objects in <code>tscollection</code> object |
| <code>horzcat (tscollection)</code>               | Horizontal concatenation for <code>tscollection</code> objects                             |
| <code>removets</code>                             | Remove <code>timeseries</code> objects from <code>tscollection</code> object               |
| <code>resample (tscollection)</code>              | Select or interpolate data in <code>tscollection</code> using new time vector              |
| <code>setabstime (tscollection)</code>            | Set times of <code>tscollection</code> object as date strings                              |
| <code>settimeseriesnames</code>                   | Change name of <code>timeseries</code> object in <code>tscollection</code>                 |
| <code>vertcat (tscollection)</code>               | Vertical concatenation for <code>tscollection</code> objects                               |

## Programming and Data Types

|  |   |
|--|---|
| Data Types (p. 1-49)                       | Numeric, character, structures, cell arrays, and data type conversion   |
| Data Type Conversion (p. 1-58)             | Convert one numeric type to another, numeric to string, string to numeric, structure to cell array, etc.                |
| Operators and Special Characters (p. 1-60) | Arithmetic, relational, and logical operators, and special characters   |
| String Functions (p. 1-63)                 | Create, identify, manipulate, parse, evaluate, and compare strings  |
| Bit-wise Functions (p. 1-66)               | Perform set, shift, and, or, compare, etc. on specific bit fields   |
| Logical Functions (p. 1-66)                | Evaluate conditions, testing for true or false  |
| Relational Functions (p. 1-67)             | Compare values for equality, greater than, less than, etc.  |
| Set Functions (p. 1-67)                    | Find set members, unions, intersections, etc.   |
| Date and Time Functions (p. 1-68)          | Obtain information about dates and times  |
| Programming in MATLAB (p. 1-68)            | M-files, function/expression evaluation, program control, function handles, object oriented programming, error handling |

### Data Types

|                                  |   |
|----------------------------------|---|
| Numeric Types (p. 1-50)          | Integer and floating-point data                                 |
| Characters and Strings (p. 1-51) | Characters and arrays of characters                             |
| Structures (p. 1-52)             | Data of varying types and sizes stored in fields of a structure |

|                                      |  |
|--------------------------------------|--|
| Cell Arrays (p. 1-53)                | Data of varying types and sizes stored in cells of array |
| Function Handles (p. 1-54)           | Invoke a function indirectly via handle                  |
| MATLAB Classes and Objects (p. 1-55) | MATLAB object-oriented class system                      |
| Java Classes and Objects (p. 1-55)   | Access Java classes through MATLAB interface             |
| Data Type Identification (p. 1-57)   | Determine data type of a variable                        |

## **Numeric Types**

|            |  |
|------------|--|
| arrayfun   | Apply function to each element of array          |
| cast       | Cast variable to different data type             |
| cat        | Concatenate arrays along specified dimension     |
| class      | Create object or return class of object          |
| find       | Find indices and values of nonzero elements      |
| intmax     | Largest value of specified integer type          |
| intmin     | Smallest value of specified integer type         |
| intwarning | Control state of integer warnings                |
| ipermute   | Inverse permute dimensions of N-D array          |
| isa        | Determine whether input is object of given class |
| isequal    | Test arrays for equality                         |

|                                   |  |
|-----------------------------------|--|
| <code>isequalwithequalnans</code> | Test arrays for equality, treating NaNs as equal   |
| <code>isfinite</code>             | Array elements that are finite                     |
| <code>isinf</code>                | Array elements that are infinite                   |
| <code>isnan</code>                | Array elements that are NaN                        |
| <code>isnumeric</code>            | Determine whether input is numeric array           |
| <code>isreal</code>               | Determine whether input is real array              |
| <code>isscalar</code>             | Determine whether input is scalar                  |
| <code>isvector</code>             | Determine whether input is vector                  |
| <code>permute</code>              | Rearrange dimensions of N-D array                  |
| <code>realmax</code>              | Largest positive floating-point number             |
| <code>realmin</code>              | Smallest positive normalized floating-point number |
| <code>reshape</code>              | Reshape array                                      |
| <code>squeeze</code>              | Remove singleton dimensions                        |
| <code>zeros</code>                | Create array of all zeros                          |

## Characters and Strings

See “String Functions” on page 1-63 for all string-related functions.

|                      |   |
|----------------------|---|
| <code>cellstr</code> | Create cell array of strings from character array |
| <code>char</code>    | Convert to character array (string)               |
| <code>eval</code>    | Execute string containing MATLAB expression       |
| <code>findstr</code> | Find string within another, longer string         |

|                 |   |
|-----------------|---|
| isstr           | Determine whether input is character array          |
| regexp, regexpi | Match regular expression                            |
| sprintf         | Write formatted data to string                      |
| sscanf          | Read formatted data from string                     |
| strcat          | Concatenate strings horizontally                    |
| strcmp, strcmpi | Compare strings                                     |
| strings         | MATLAB string handling                              |
| strjust         | Justify character array                             |
| strmatch        | Find possible matches for string                    |
| strread         | Read formatted data from string                     |
| strrep          | Find and replace substring                          |
| strtrim         | Remove leading and trailing white space from string |
| strvcat         | Concatenate strings vertically                      |

## **Structures**

|             |  |
|-------------|--|
| arrayfun    | Apply function to each element of array              |
| cell2struct | Convert cell array to structure array                |
| class       | Create object or return class of object              |
| deal        | Distribute inputs to outputs                         |
| fieldnames  | Field names of structure, or public fields of object |
| getfield    | Field of structure array                             |
| isa         | Determine whether input is object of given class     |
| isequal     | Test arrays for equality                             |



|             |  |
|-------------|--|
| isfield     | Determine whether input is structure array field |
| isscalar    | Determine whether input is scalar                |
| isstruct    | Determine whether input is structure array       |
| isvector    | Determine whether input is vector                |
| orderfields | Order fields of structure array                  |
| rmfield     | Remove fields from structure                     |
| setfield    | Set value of structure array field               |
| struct      | Create structure array                           |
| struct2cell | Convert structure to cell array                  |
| structfun   | Apply function to each field of scalar structure |

## Cell Arrays

|             |   |
|-------------|---|
| cell        | Construct cell array                              |
| cell2mat    | Convert cell array of matrices to single matrix   |
| cell2struct | Convert cell array to structure array             |
| celldisp    | Cell array contents                               |
| cellfun     | Apply function to each cell in cell array         |
| cellplot    | Graphically display structure of cell array       |
| cellstr     | Create cell array of strings from character array |
| class       | Create object or return class of object           |
| deal        | Distribute inputs to outputs                      |

|                          |  |
|--------------------------|--|
| <code>isa</code>         | Determine whether input is object of given class |
| <code>iscell</code>      | Determine whether input is cell array            |
| <code>iscellstr</code>   | Determine whether input is cell array of strings |
| <code>isequal</code>     | Test arrays for equality                         |
| <code>isscalar</code>    | Determine whether input is scalar                |
| <code>isvector</code>    | Determine whether input is vector                |
| <code>mat2cell</code>    | Divide matrix into cell array of matrices        |
| <code>num2cell</code>    | Convert numeric array to cell array              |
| <code>struct2cell</code> | Convert structure to cell array                  |

### **Function Handles**

|                                  |   |
|----------------------------------|---|
| <code>class</code>               | Create object or return class of object             |
| <code>feval</code>               | Evaluate function                                   |
| <code>func2str</code>            | Construct function name string from function handle |
| <code>functions</code>           | Information about function handle                   |
| <code>function_handle (@)</code> | Handle used in calling functions indirectly         |
| <code>isa</code>                 | Determine whether input is object of given class    |
| <code>isequal</code>             | Test arrays for equality                            |
| <code>str2func</code>            | Construct function handle from function name string |

## **MATLAB Classes and Objects**

|             |  |
|-------------|--|
| class       | Create object or return class of object                  |
| fieldnames  | Field names of structure, or public fields of object     |
| inferiorto  | Establish inferior class relationship                    |
| isa         | Determine whether input is object of given class         |
| isobject    | Determine whether input is MATLAB OOPs object            |
| loadobj     | User-defined extension of load function for user objects |
| methods     | Information on class methods                             |
| methodsview | Information on class methods in separate window          |
| saveobj     | User-defined extension of save function for user objects |
| subsasgn    | Subscripted assignment for objects                       |
| subsindex   | Subscripted indexing for objects                         |
| subsref     | Subscripted reference for objects                        |
| substruct   | Create structure argument for subsasgn or subsref        |
| superiorto  | Establish superior class relationship                    |

## **Java Classes and Objects**

|        |   |
|--------|---|
| cell   | Construct cell array                                  |
| class  | Create object or return class of object               |
| clear  | Remove items from workspace, freeing up system memory |
| depfun | List dependencies of M-file or P-file                 |

|                            |   |
|----------------------------|---|
| <code>exist</code>         | Check existence of variable, function, directory, or Java class |
| <code>fieldnames</code>    | Field names of structure, or public fields of object            |
| <code>im2java</code>       | Convert image to Java image                                     |
| <code>import</code>        | Add package or class to current Java import list                |
| <code>inmem</code>         | Names of M-files, MEX-files, Java classes in memory             |
| <code>isa</code>           | Determine whether input is object of given class                |
| <code>isjava</code>        | Determine whether input is Java object                          |
| <code>javaaddpath</code>   | Add entries to dynamic Java class path                          |
| <code>javaArray</code>     | Construct Java array  |
| <code>javachk</code>       | Generate error message based on Java feature support            |
| <code>javaclasspath</code> | Set and get dynamic Java class path                             |
| <code>javaMethod</code>    | Invoke Java method  |
| <code>javaObject</code>    | Construct Java object   |
| <code>javarmpath</code>    | Remove entries from dynamic Java class path                     |
| <code>methods</code>       | Information on class methods                                    |
| <code>methodsview</code>   | Information on class methods in separate window                 |
| <code>usejava</code>       | Determine whether Java feature is supported in MATLAB           |
| <code>which</code>         | Locate functions and files                                      |

## Data Type Identification

|           |  |
|-----------|--|
| is*       | Detect state                                     |
| isa       | Determine whether input is object of given class |
| iscell    | Determine whether input is cell array            |
| iscellstr | Determine whether input is cell array of strings |
| ischar    | Determine whether item is character array        |
| isfield   | Determine whether input is structure array field |
| isfloat   | Determine whether input is floating-point array  |
| isinteger | Determine whether input is integer array         |
| isjava    | Determine whether input is Java object           |
| islogical | Determine whether input is logical array         |
| isnumeric | Determine whether input is numeric array         |
| isobject  | Determine whether input is MATLAB OOPs object    |
| isreal    | Determine whether input is real array            |
| isstr     | Determine whether input is character array       |
| isstruct  | Determine whether input is structure array       |

validateattributes

Check validity of array

who, whos

List variables in workspace

## Data Type Conversion

Numeric (p. 1-58)

Convert data of one numeric type to another numeric type

String to Numeric (p. 1-58)

Convert characters to numeric equivalent

Numeric to String (p. 1-59)

Convert numeric to character equivalent

Other Conversions (p. 1-59)

Convert to structure, cell array, function handle, etc.

## Numeric

cast

Cast variable to different data type

double

Convert to double precision

int8, int16, int32, int64

Convert to signed integer

single

Convert to single precision

typecast

Convert data types without changing underlying data

uint8, uint16, uint32, uint64

Convert to unsigned integer

## String to Numeric

base2dec

Convert base N number string to decimal number

bin2dec

Convert binary number string to decimal number

cast

Cast variable to different data type

|                |  |
|----------------|--|
| hex2dec        | Convert hexadecimal number string to decimal number          |
| hex2num        | Convert hexadecimal number string to double-precision number |
| str2double     | Convert string to double-precision value                     |
| str2num        | Convert string to number                                     |
| unicode2native | Convert Unicode characters to numeric bytes                  |

### **Numeric to String**

|                |   |
|----------------|---|
| cast           | Cast variable to different data type            |
| char           | Convert to character array (string)             |
| dec2base       | Convert decimal to base N number in string      |
| dec2bin        | Convert decimal to binary number in string      |
| dec2hex        | Convert decimal to hexadecimal number in string |
| int2str        | Convert integer to string                       |
| mat2str        | Convert matrix to string                        |
| native2unicode | Convert numeric bytes to Unicode characters     |
| num2str        | Convert number to string                        |

### **Other Conversions**

|             |   |
|-------------|---|
| cell2mat    | Convert cell array of matrices to single matrix |
| cell2struct | Convert cell array to structure array           |

|                          |   |
|--------------------------|---|
| <code>datestr</code>     | Convert date and time to string format                  |
| <code>func2str</code>    | Construct function name string from function handle     |
| <code>logical</code>     | Convert numeric values to logical                       |
| <code>mat2cell</code>    | Divide matrix into cell array of matrices               |
| <code>num2cell</code>    | Convert numeric array to cell array                     |
| <code>num2hex</code>     | Convert singles and doubles to IEEE hexadecimal strings |
| <code>str2func</code>    | Construct function handle from function name string     |
| <code>str2mat</code>     | Form blank-padded character matrix from strings         |
| <code>struct2cell</code> | Convert structure to cell array                         |

## **Operators and Special Characters**

|                                |  |
|--------------------------------|--|
| Arithmetic Operators (p. 1-60) | Plus, minus, power, left and right divide, transpose, etc. |
| Relational Operators (p. 1-61) | Equal to, greater than, less than or equal to, etc.        |
| Logical Operators (p. 1-61)    | Element-wise and short circuit and, or, not                |
| Special Characters (p. 1-62)   | Array constructors, line continuation, comments, etc.      |

### **Arithmetic Operators**

|                |       |
|----------------|-------|
| <code>+</code> | Plus  |
| <code>-</code> | Minus |



|    |                                     |
|----|-------------------------------------|
| .  | Decimal point                       |
| =  | Assignment                          |
| *  | Matrix multiplication               |
| /  | Matrix right division               |
| \  | Matrix left division                |
| ^  | Matrix power                        |
| '  | Matrix transpose                    |
| .* | Array multiplication (element-wise) |
| ./ | Array right division (element-wise) |
| .\ | Array left division (element-wise)  |
| .^ | Array power (element-wise)          |
| .' | Array transpose                     |

### Relational Operators

|    |                          |
|----|--------------------------|
| <  | Less than                |
| <= | Less than or equal to    |
| >  | Greater than             |
| >= | Greater than or equal to |
| == | Equal to                 |
| ~= | Not equal to             |

### Logical Operators

See also “Logical Functions” on page 1-66 for functions like xor, all, any, etc.

|    |                        |
|----|------------------------|
| && | Logical AND            |
|    | Logical OR             |
| &  | Logical AND for arrays |

| Logical OR for arrays  
~ Logical NOT

### **Special Characters**

: Create vectors, subscript arrays, specify for-loop iterations  
( ) Pass function arguments, prioritize operators  
[ ] Construct array, concatenate elements, specify multiple outputs from function  
{ } Construct cell array, index into cell array  
. Insert decimal point, define structure field, reference methods of object  
.() Reference dynamic field of structure  
.. Reference parent directory  
... Continue statement to next line  
, Separate rows of array, separate function input/output arguments, separate commands  
; Separate columns of array, suppress output from current command  
% Insert comment line into code  
  
%{ %} Insert block of comments into code  
! Issue command to operating system  
' ' Construct character array  
@ Construct function handle, reference class directory

## String Functions

|  |  |
|--|--|
| Description of Strings in MATLAB (p. 1-63) | Basics of string handling in MATLAB                                  |
| String Creation (p. 1-63)                  | Create strings, cell arrays of strings, concatenate strings together |
| String Identification (p. 1-64)            | Identify characteristics of strings                                  |
| String Manipulation (p. 1-64)              | Convert case, strip blanks, replace characters                       |
| String Parsing (p. 1-65)                   | Formatted read, regular expressions, locate substrings               |
| String Evaluation (p. 1-65)                | Evaluate stated expression in string                                 |
| String Comparison (p. 1-65)                | Compare contents of strings  |

## Description of Strings in MATLAB

|         |                        |
|---------|------------------------|
| strings | MATLAB string handling |
|---------|------------------------|

## String Creation

|         |   |
|---------|---|
| blanks  | Create string of blank characters                 |
| cellstr | Create cell array of strings from character array |
| char    | Convert to character array (string)               |
| sprintf | Write formatted data to string                    |
| strcat  | Concatenate strings horizontally                  |
| strvcat | Concatenate strings vertically                    |

## String Identification

|                             |   |
|-----------------------------|---|
| <code>class</code>          | Create object or return class of object           |
| <code>isa</code>            | Determine whether input is object of given class  |
| <code>iscellstr</code>      | Determine whether input is cell array of strings  |
| <code>ischar</code>         | Determine whether item is character array         |
| <code>isletter</code>       | Array elements that are alphabetic letters        |
| <code>isscalar</code>       | Determine whether input is scalar                 |
| <code>isspace</code>        | Array elements that are space characters          |
| <code>isstrprop</code>      | Determine whether string is of specified category |
| <code>isvector</code>       | Determine whether input is vector                 |
| <code>validatestring</code> | Check validity of text string                     |

## String Manipulation

|                      |   |
|----------------------|---|
| <code>deblank</code> | Strip trailing blanks from end of string            |
| <code>lower</code>   | Convert string to lowercase                         |
| <code>strjust</code> | Justify character array                             |
| <code>strrep</code>  | Find and replace substring                          |
| <code>strtrim</code> | Remove leading and trailing white space from string |
| <code>upper</code>   | Convert string to uppercase                         |

## String Parsing

|   |   |
|---|---|
| <code>findstr</code>                      | Find string within another, longer string |
| <code>regexp</code> , <code>regexp</code> | Match regular expression                  |
| <code>regexprep</code>                    | Replace string using regular expression   |
| <code>regextranslate</code>               | Translate string into regular expression  |
| <code>sscanf</code>                       | Read formatted data from string           |
| <code>strfind</code>                      | Find one string within another            |
| <code>strread</code>                      | Read formatted data from string           |
| <code>strtok</code>                       | Selected parts of string                  |

## String Evaluation

|                     |  |
|---------------------|--|
| <code>eval</code>   | Execute string containing MATLAB expression      |
| <code>evalc</code>  | Evaluate MATLAB expression with capture          |
| <code>evalin</code> | Execute MATLAB expression in specified workspace |

## String Comparison

|  |                                       |
|--|---------------------------------------|
| <code>strcmp</code> , <code>strcmpi</code>   | Compare strings                       |
| <code>strmatch</code>                        | Find possible matches for string      |
| <code>strncmp</code> , <code>strncmpi</code> | Compare first n characters of strings |

## Bit-wise Functions

|           |   |
|-----------|---|
| bitand    | Bitwise AND                                     |
| bitemp    | Bitwise complement                              |
| bitget    | Bit at specified position                       |
| bitmax    | Maximum double-precision floating-point integer |
| bitor     | Bitwise OR                                      |
| bitset    | Set bit at specified position                   |
| bitshift  | Shift bits specified number of places           |
| bitxor    | Bitwise XOR                                     |
| swapbytes | Swap byte ordering                              |

## Logical Functions

|           |  |
|-----------|--|
| all       | Determine whether all array elements are nonzero |
| and       | Find logical AND of array or scalar inputs       |
| any       | Determine whether any array elements are nonzero |
| false     | Logical 0 (false)                                |
| find      | Find indices and values of nonzero elements      |
| isa       | Determine whether input is object of given class |
| iskeyword | Determine whether input is MATLAB keyword        |
| isvarname | Determine whether input is valid variable name   |
| logical   | Convert numeric values to logical                |

|      |   |
|------|---|
| not  | Find logical NOT of array or scalar input |
| or   | Find logical OR of array or scalar inputs |
| true | Logical 1 (true)                          |
| xor  | Logical exclusive-OR                      |

See “Operators and Special Characters” on page 1-60 for logical operators.

## Relational Functions

|    |                                   |
|----|-----------------------------------|
| eq | Test for equality                 |
| ge | Test for greater than or equal to |
| gt | Test for greater than             |
| le | Test for less than or equal to    |
| lt | Test for less than                |
| ne | Test for inequality               |

See “Operators and Special Characters” on page 1-60 for relational operators.

## Set Functions

|           |  |
|-----------|--|
| intersect | Find set intersection of two vectors               |
| ismember  | Array elements that are members of set             |
| issorted  | Determine whether set elements are in sorted order |
| setdiff   | Find set difference of two vectors                 |
| setxor    | Find set exclusive OR of two vectors               |
| union     | Find set union of two vectors                      |
| unique    | Find unique elements of vector                     |

## Date and Time Functions

|           |   |
|-----------|---|
| addtodate | Modify date number by field                   |
| calendar  | Calendar for specified month                  |
| clock     | Current time as date vector                   |
| cputime   | Elapsed CPU time                              |
| date      | Current date string                           |
| datenum   | Convert date and time to serial date number   |
| datestr   | Convert date and time to string format        |
| datevec   | Convert date and time to vector of components |
| eomday    | Last day of month                             |
| etime     | Time elapsed between date vectors             |
| now       | Current date and time                         |
| weekday   | Day of week                                   |

## Programming in MATLAB

|  |   |
|--|---|
| M-File Functions and Scripts<br>(p. 1-69)            | Declare functions, handle arguments, identify dependencies, etc.  |
| Evaluation of Expressions and Functions<br>(p. 1-70) | Evaluate expression in string, apply function to array, run script file, etc.                             |
| Timer Functions (p. 1-71)                            | Schedule execution of MATLAB commands   |
| Variables and Functions in Memory<br>(p. 1-72)       | List files in memory, clear M-files in memory, assign to variable in nondefault workspace, refresh caches |



|                           |   |
|---------------------------|---|
| Control Flow (p. 1-73)    | if-then-else, for loops, switch-case, try-catch   |
| Error Handling (p. 1-74)  | Generate warnings and errors, test for and catch errors, retrieve most recent error message |
| MEX Programming (p. 1-75) | Compile MEX function from C or Fortran code, list MEX-files in memory, debug MEX-files      |

## **M-File Functions and Scripts**

|  |   |
|--|---|
| <code>addOptional (inputParser)</code>   | Add optional argument to <code>inputParser</code> schema        |
| <code>addParamValue (inputParser)</code> | Add parameter-value argument to <code>inputParser</code> schema |
| <code>addRequired (inputParser)</code>   | Add required argument to <code>inputParser</code> schema        |
| <code>createCopy (inputParser)</code>    | Create copy of <code>inputParser</code> object                  |
| <code>depsdir</code>                     | List dependent directories of M-file or P-file                  |
| <code>depsfun</code>                     | List dependencies of M-file or P-file                           |
| <code>echo</code>                        | Echo M-files during execution                                   |
| <code>end</code>                         | Terminate block of code, or indicate last array index           |
| <code>function</code>                    | Declare M-file function   |
| <code>input</code>                       | Request user input  |
| <code>inputname</code>                   | Variable name of function input                                 |
| <code>inputParser</code>                 | Construct input parser object                                   |
| <code>mfilename</code>                   | Name of currently running M-file                                |
| <code>namelengthmax</code>               | Maximum identifier length                                       |
| <code>nargchk</code>                     | Validate number of input arguments                              |

|                     |  |
|---------------------|--|
| nargin, nargsout    | Number of function arguments             |
| nargoutchk          | Validate number of output arguments      |
| parse (inputParser) | Parse and validate named inputs          |
| pcode               | Create prepared pseudocode file (P-file) |
| script              | Script M-file description                |
| syntax              | Two ways to call MATLAB functions        |
| varargin            | Variable length input argument list      |
| varargout           | Variable length output argument list     |

### **Evaluation of Expressions and Functions**

|          |  |
|----------|--|
| ans      | Most recent answer                               |
| arrayfun | Apply function to each element of array          |
| assert   | Generate error when condition is violated        |
| builtin  | Execute built-in function from overloaded method |
| cellfun  | Apply function to each cell in cell array        |
| echo     | Echo M-files during execution                    |
| eval     | Execute string containing MATLAB expression      |
| evalc    | Evaluate MATLAB expression with capture          |
| evalin   | Execute MATLAB expression in specified workspace |
| feval    | Evaluate function                                |

|           |  |
|-----------|--|
| iskeyword | Determine whether input is MATLAB keyword        |
| isvarname | Determine whether input is valid variable name   |
| pause     | Halt execution temporarily                       |
| run       | Run script that is not on current path           |
| script    | Script M-file description                        |
| structfun | Apply function to each field of scalar structure |
| symvar    | Determine symbolic variables in expression       |
| tic, toc  | Measure performance using stopwatch timer        |

### Timer Functions

|                 |  |
|-----------------|--|
| delete (timer)  | Remove timer object from memory              |
| disp (timer)    | Information about timer object               |
| get (timer)     | Timer object properties                      |
| isvalid (timer) | Determine whether timer object is valid      |
| set (timer)     | Configure or display timer object properties |
| start           | Start timer(s) running                       |
| startat         | Start timer(s) running at specified time     |
| stop            | Stop timer(s)                                |
| timer           | Construct timer object                       |
| timerfind       | Find timer objects                           |

|              |   |
|--------------|---|
| timerfindall | Find timer objects, including invisible objects |
| wait         | Wait until timer stops running                  |

## **Variables and Functions in Memory**

|               |  |
|---------------|--|
| ans           | Most recent answer   |
| assignin      | Assign value to variable in specified workspace                    |
| datatipinfo   | Produce short description of input variable                        |
| genvarname    | Construct valid variable name from string                          |
| global        | Declare global variables   |
| inmem         | Names of M-files, MEX-files, Java classes in memory                |
| isglobal      | Determine whether input is global variable                         |
| mislocked     | Determine whether M-file or MEX-file cannot be cleared from memory |
| mlock         | Prevent clearing M-file or MEX-file from memory                    |
| munlock       | Allow clearing M-file or MEX-file from memory                      |
| namelengthmax | Maximum identifier length  |
| pack          | Consolidate workspace memory                                       |
| persistent    | Define persistent variable   |
| rehash        | Refresh function and file system path caches                       |

## Control Flow

|           |   |
|-----------|---|
| break     | Terminate execution of for or while loop              |
| case      | Execute block of code if condition is true            |
| catch     | Specify how to respond to error in try statement      |
| continue  | Pass control to next iteration of for or while loop   |
| else      | Execute statements if condition is false              |
| elseif    | Execute statements if additional condition is true    |
| end       | Terminate block of code, or indicate last array index |
| error     | Display message and abort function                    |
| for       | Execute block of code specified number of times       |
| if        | Execute statements if condition is true               |
| otherwise | Default part of switch statement                      |
| return    | Return to invoking function                           |
| switch    | Switch among several cases, based on expression       |
| try       | Attempt to execute block of code, and catch errors    |
| while     | Repeatedly execute statements while condition is true |

## Error Handling

|                                     |   |
|-------------------------------------|---|
| <code>addCause (MException)</code>  | Append MException objects                         |
| <code>assert</code>                 | Generate error when condition is violated         |
| <code>catch</code>                  | Specify how to respond to error in try statement  |
| <code>disp (MException)</code>      | Display MException object                         |
| <code>eq (MException)</code>        | Compare MException objects for equality           |
| <code>error</code>                  | Display message and abort function                |
| <code>ferror</code>                 | Query MATLAB about errors in file input or output |
| <code>getReport (MException)</code> | Get error message for exception                   |
| <code>intwarning</code>             | Control state of integer warnings                 |
| <code>isequal (MException)</code>   | Compare MException objects for equality           |
| <code>last (MException)</code>      | Last uncaught exception                           |
| <code>lasterr</code>                | Last error message                                |
| <code>lasterror</code>              | Last error message and related information        |
| <code>lastwarn</code>               | Last warning message                              |
| <code>MException</code>             | Construct MException object                       |
| <code>ne (MException)</code>        | Compare MException objects for inequality         |
| <code>rethrow</code>                | Reissue error                                     |
| <code>rethrow (MException)</code>   | Reissue existing exception                        |
| <code>throw (MException)</code>     | Terminate function and issue exception            |

|         |  |
|---------|--|
| try     | Attempt to execute block of code, and catch errors |
| warning | Warning message                                    |

### **MEX Programming**

|        |  |
|--------|--|
| dbmex  | Enable MEX-file debugging                                |
| inmem  | Names of M-files, MEX-files, Java classes in memory      |
| mex    | Compile MEX-function from C, C++, or Fortran source code |
| mexext | MEX-filename extension                                   |

## File I/O

|  |  |
|--|--|
| File Name Construction (p. 1-76)         | Get path, directory, filename information; construct filenames |
| Opening, Loading, Saving Files (p. 1-77) | Open files; transfer data between files and MATLAB workspace   |
| Memory Mapping (p. 1-77)                 | Access file data via memory map using MATLAB array indexing    |
| Low-Level File I/O (p. 1-77)             | Low-level operations that use a file identifier                |
| Text Files (p. 1-78)                     | Delimited or formatted I/O to text files                       |
| XML Documents (p. 1-79)                  | Documents written in Extensible Markup Language                |
| Spreadsheets (p. 1-79)                   | Excel and Lotus 1-2-3 files                                    |
| Scientific Data (p. 1-80)                | CDF, FITS, HDF formats   |
| Audio and Audio/Video (p. 1-81)          | General audio functions; SparcStation, WAVE, AVI files         |
| Images (p. 1-83)                         | Graphics files   |
| Internet Exchange (p. 1-84)              | URL, FTP, zip, tar, and e-mail                                 |

To see a listing of file formats that are readable from MATLAB, go to file formats.

### File Name Construction

|            |  |
|------------|--|
| filemarker | Character to separate file name and internal function name |
| fileparts  | Parts of file name and path                                |
| filesep    | Directory separator for current platform                   |
| fullfile   | Build full filename from parts                             |



|          |                                      |
|----------|--------------------------------------|
| tempdir  | Name of system's temporary directory |
| tempname | Unique name for temporary file       |

## Opening, Loading, Saving Files

|            |  |
|------------|--|
| daqread    | Read Data Acquisition Toolbox (.daq) file      |
| filehandle | Construct file handle object                   |
| importdata | Load data from disk file                       |
| load       | Load workspace variables from disk             |
| open       | Open files based on extension                  |
| save       | Save workspace variables to disk               |
| uiimport   | Open Import Wizard to import data              |
| winopen    | Open file in appropriate application (Windows) |

## Memory Mapping

|                   |                                     |
|-------------------|-------------------------------------|
| disp (memmapfile) | Information about memmapfile object |
| get (memmapfile)  | Memmapfile object properties        |
| memmapfile        | Construct memmapfile object         |

## Low-Level File I/O

|        |   |
|--------|---|
| fclose | Close one or more open files                      |
| feof   | Test for end-of-file                              |
| ferror | Query MATLAB about errors in file input or output |

|                      |  |
|----------------------|--|
| <code>fgetl</code>   | Read line from file, discarding newline character      |
| <code>fgets</code>   | Read line from file, keeping newline character         |
| <code>fopen</code>   | Open file, or obtain information about open files      |
| <code>fprintf</code> | Write formatted data to file                           |
| <code>fread</code>   | Read binary data from file                             |
| <code>frewind</code> | Move file position indicator to beginning of open file |
| <code>fscanf</code>  | Read formatted data from file                          |
| <code>fseek</code>   | Set file position indicator                            |
| <code>ftell</code>   | File position indicator                                |
| <code>fwrite</code>  | Write binary data to file                              |

## **Text Files**

|                       |   |
|-----------------------|---|
| <code>csvread</code>  | Read comma-separated value file                       |
| <code>csvwrite</code> | Write comma-separated value file                      |
| <code>dlmread</code>  | Read ASCII-delimited file of numeric data into matrix |
| <code>dlmwrite</code> | Write matrix to ASCII-delimited file                  |
| <code>textread</code> | Read data from text file; write to multiple outputs   |
| <code>textscan</code> | Read formatted data from text file or string          |

## XML Documents

|          |  |
|----------|--|
| xmlread  | Parse XML document and return Document Object Model node |
| xmlwrite | Serialize XML Document Object Model node                 |
| xslt     | Transform XML document using XSLT engine                 |

## Spreadsheets

|                                     |  |
|-------------------------------------|--|
| Microsoft Excel Functions (p. 1-79) | Read and write Microsoft Excel spreadsheet |
| Lotus 1-2-3 Functions (p. 1-79)     | Read and write Lotus WK1 spreadsheet       |

## Microsoft Excel Functions

|          |  |
|----------|--|
| xlsinfo  | Determine whether file contains Microsoft Excel (.xls) spreadsheet |
| xlsread  | Read Microsoft Excel spreadsheet file (.xls)                       |
| xlswrite | Write Microsoft Excel spreadsheet file (.xls)                      |

## Lotus 1-2-3 Functions

|          |   |
|----------|---|
| wk1info  | Determine whether file contains 1-2-3 WK1 worksheet |
| wk1read  | Read Lotus 1-2-3 WK1 spreadsheet file into matrix   |
| wk1write | Write matrix to Lotus 1-2-3 WK1 spreadsheet file    |

## Scientific Data

|  |                                  |
|--|----------------------------------|
| Common Data Format (CDF)<br>(p. 1-80)        | Work with CDF files              |
| Flexible Image Transport System<br>(p. 1-80) | Work with FITS files             |
| Hierarchical Data Format (HDF)<br>(p. 1-81)  | Work with HDF files              |
| Band-Interleaved Data (p. 1-81)              | Work with band-interleaved files |

## Common Data Format (CDF)

|           |  |
|-----------|--|
| cdfepoch  | Construct cdfepoch object for<br>Common Data Format (CDF) export |
| cdfinfo   | Information about Common Data<br>Format (CDF) file               |
| cdfread   | Read data from Common Data<br>Format (CDF) file                  |
| cdfwrite  | Write data to Common Data Format<br>(CDF) file                   |
| todatenum | Convert CDF epoch object to<br>MATLAB datenum                    |

## Flexible Image Transport System

|          |                             |
|----------|-----------------------------|
| fitsinfo | Information about FITS file |
| fitsread | Read data from FITS file    |

## Hierarchical Data Format (HDF)

|           |   |
|-----------|---|
| hdf       | Summary of MATLAB HDF4 capabilities               |
| hdf5      | Summary of MATLAB HDF5 capabilities               |
| hdf5info  | Information about HDF5 file                       |
| hdf5read  | Read HDF5 file                                    |
| hdf5write | Write data to file in HDF5 format                 |
| hdffinfo  | Information about HDF4 or HDF-EOS file            |
| hdfread   | Read data from HDF4 or HDF-EOS file               |
| hdftool   | Browse and import data from HDF4 or HDF-EOS files |

## Band-Interleaved Data

|                |   |
|----------------|---|
| multibandread  | Read band-interleaved data from binary file |
| multibandwrite | Write band-interleaved data to file         |

## Audio and Audio/Video

|   |   |
|---|---|
| General (p. 1-82)                               | Create audio player object, obtain information about multimedia files, convert to/from audio signal |
| SPARCstation-Specific Sound Functions (p. 1-82) | Access NeXT/SUN (.au) sound files   |

Microsoft WAVE Sound Functions  
(p. 1-83)

Access Microsoft WAVE (.wav) sound  
files

Audio/Video Interleaved (AVI)  
Functions (p. 1-83)

Access Audio/Video interleaved  
(.avi) sound files

## **General**

audioplayer

Create audio player object

audiorecorder

Create audio recorder object

beep

Produce beep sound

lin2mu

Convert linear audio signal to  
mu-law

mmfileinfo

Information about multimedia file

mmreader

Create multimedia reader object for  
reading video files

mu2lin

Convert mu-law audio signal to  
linear

read

Read video frame data from  
multimedia reader object

sound

Convert vector into sound

soundsc

Scale data and play as sound

## **SPARCstation-Specific Sound Functions**

aufinfo

Information about NeXT/SUN (.au)  
sound file

auread

Read NeXT/SUN (.au) sound file

auwrite

Write NeXT/SUN (.au) sound file

## Microsoft WAVE Sound Functions

|           |   |
|-----------|---|
| wavinfo   | Information about Microsoft WAVE (.wav) sound file  |
| wavplay   | Play recorded sound on PC-based audio output device |
| wavread   | Read Microsoft WAVE (.wav) sound file               |
| wavrecord | Record sound using PC-based audio input device      |
| wavwrite  | Write Microsoft WAVE (.wav) sound file              |

## Audio/Video Interleaved (AVI) Functions

|                 |  |
|-----------------|--|
| addframe        | Add frame to Audio/Video Interleaved (AVI) file              |
| avifile         | Create new Audio/Video Interleaved (AVI) file                |
| aviinfo         | Information about Audio/Video Interleaved (AVI) file         |
| aviread         | Read Audio/Video Interleaved (AVI) file                      |
| close (avifile) | Close Audio/Video Interleaved (AVI) file                     |
| movie2avi       | Create Audio/Video Interleaved (AVI) movie from MATLAB movie |

## Images

|          |  |
|----------|--|
| exifread | Read EXIF information from JPEG and TIFF image files |
| im2java  | Convert image to Java image                          |

|         |                                 |
|---------|---------------------------------|
| imfinfo | Information about graphics file |
| imread  | Read image from graphics file   |
| imwrite | Write image to graphics file    |

## **Internet Exchange**

|                                 |   |
|---------------------------------|---|
| URL, Zip, Tar, E-Mail (p. 1-84) | Send e-mail, read from given URL, extract from tar or zip file, compress and decompress files |
| FTP Functions (p. 1-84)         | Connect to FTP server, download from server, manage FTP files, close server connection        |

## **URL, Zip, Tar, E-Mail**

|          |                                     |
|----------|-------------------------------------|
| gunzip   | Uncompress GNU zip files            |
| gzip     | Compress files into GNU zip files   |
| sendmail | Send e-mail message to address list |
| tar      | Compress files into tar file        |
| untar    | Extract contents of tar file        |
| unzip    | Extract contents of zip file        |
| urlread  | Read content at URL                 |
| urlwrite | Save contents of URL to file        |
| zip      | Compress files into zip file        |

## **FTP Functions**

|        |                                 |
|--------|---------------------------------|
| ascii  | Set FTP transfer type to ASCII  |
| binary | Set FTP transfer type to binary |



---

|                           |  |
|---------------------------|--|
| <code>cd (ftp)</code>     | Change current directory on FTP server     |
| <code>close (ftp)</code>  | Close connection to FTP server             |
| <code>delete (ftp)</code> | Remove file on FTP server                  |
| <code>dir (ftp)</code>    | Directory contents on FTP server           |
| <code>ftp</code>          | Connect to FTP server, creating FTP object |
| <code>mget</code>         | Download file from FTP server              |
| <code>mkdir (ftp)</code>  | Create new directory on FTP server         |
| <code>mput</code>         | Upload file or directory to FTP server     |
| <code>rename</code>       | Rename file on FTP server                  |
| <code>rmdir (ftp)</code>  | Remove directory on FTP server             |

## Graphics

|                                  |  |
|----------------------------------|--|
| Basic Plots and Graphs (p. 1-86) | Linear line plots, log and semilog plots   |
| Plotting Tools (p. 1-87)         | GUIs for interacting with plots  |
| Annotating Plots (p. 1-87)       | Functions for and properties of titles, axes labels, legends, mathematical symbols |
| Specialized Plotting (p. 1-88)   | Bar graphs, histograms, pie charts, contour plots, function plotters               |
| Bit-Mapped Images (p. 1-92)      | Display image object, read and write graphics file, convert to movie frames        |
| Printing (p. 1-92)               | Printing and exporting figures to standard formats                                 |
| Handle Graphics (p. 1-93)        | Creating graphics objects, setting properties, finding handles                     |

### Basic Plots and Graphs

|           |  |
|-----------|--|
| box       | Axes border  |
| errorbar  | Plot error bars along curve                            |
| hold      | Retain current graph in figure                         |
| LineStyle | Line specification string syntax                       |
| loglog    | Log-log scale plot                                     |
| plot      | 2-D line plot  |
| plot3     | 3-D line plot  |
| plotyy    | 2-D line plots with y-axes on both left and right side |
| polar     | Polar coordinate plot                                  |

semilogx, semilogy  
subplot

Semilogarithmic plots  
Create axes in tiled positions

## Plotting Tools

figurepalette  
pan  
plotbrowser  
plotedit  
plottools  
propertyeditor  
rotate3d  
showplottool  
zoom

Show or hide figure palette  
Pan view of graph interactively  
Show or hide figure plot browser  
Interactively edit and annotate plots  
Show or hide plot tools  
Show or hide property editor  
Rotate 3-D view using mouse  
Show or hide figure plot tool  
Turn zooming on or off or magnify  
by factor

## Annotating Plots

annotation  
clabel  
datacursormode  
  
datetick  
gtext  
legend  
line  
rectangle  
texlabel

Create annotation objects  
Contour plot elevation labels  
Enable or disable interactive data  
cursor mode  
Date formatted tick labels  
Mouse placement of text in 2-D view  
Graph legend for lines and patches  
Create line object  
Create 2-D rectangle object  
Produce TeX format from character  
string

|                        |                                   |
|------------------------|-----------------------------------|
| title                  | Add title to current axes         |
| xlabel, ylabel, zlabel | Label $x$ -, $y$ -, and $z$ -axis |

## Specialized Plotting

|  |  |
|--|--|
| Area, Bar, and Pie Plots (p. 1-88)     | 1-D, 2-D, and 3-D graphs and charts                                      |
| Contour Plots (p. 1-89)                | Unfilled and filled contours in 2-D and 3-D                              |
| Direction and Velocity Plots (p. 1-89) | Comet, compass, feather and quiver plots                                 |
| Discrete Data Plots (p. 1-89)          | Stair, step, and stem plots  |
| Function Plots (p. 1-89)               | Easy-to-use plotting utilities for graphing functions                    |
| Histograms (p. 1-90)                   | Plots for showing distributions of data                                  |
| Polygons and Surfaces (p. 1-90)        | Functions to generate and plot surface patches in two or more dimensions |
| Scatter/Bubble Plots (p. 1-91)         | Plots of point distributions   |
| Animation (p. 1-91)                    | Functions to create and play movies of plots                             |

## Area, Bar, and Pie Plots

|             |  |
|-------------|--|
| area        | Filled area 2-D plot                     |
| bar, barh   | Plot bar graph (vertical and horizontal) |
| bar3, bar3h | Plot 3-D bar chart                       |
| pareto      | Pareto chart                             |
| pie         | Pie chart                                |
| pie3        | 3-D pie chart                            |

## Contour Plots

|                         |                                    |
|-------------------------|------------------------------------|
| <code>contour</code>    | Contour plot of matrix             |
| <code>contour3</code>   | 3-D contour plot                   |
| <code>contourc</code>   | Low-level contour plot computation |
| <code>contourf</code>   | Filled 2-D contour plot            |
| <code>ezcontour</code>  | Easy-to-use contour plotter        |
| <code>ezcontourf</code> | Easy-to-use filled contour plotter |

## Direction and Velocity Plots

|                      |                                   |
|----------------------|-----------------------------------|
| <code>comet</code>   | 2-D comet plot                    |
| <code>comet3</code>  | 3-D comet plot                    |
| <code>compass</code> | Plot arrows emanating from origin |
| <code>feather</code> | Plot velocity vectors             |
| <code>quiver</code>  | Quiver or velocity plot           |
| <code>quiver3</code> | 3-D quiver or velocity plot       |

## Discrete Data Plots

|                     |                                 |
|---------------------|---------------------------------|
| <code>stairs</code> | Stairstep graph                 |
| <code>stem</code>   | Plot discrete sequence data     |
| <code>stem3</code>  | Plot 3-D discrete sequence data |

## Function Plots

|                         |                                    |
|-------------------------|------------------------------------|
| <code>ezcontour</code>  | Easy-to-use contour plotter        |
| <code>ezcontourf</code> | Easy-to-use filled contour plotter |
| <code>ezmesh</code>     | Easy-to-use 3-D mesh plotter       |

|         |   |
|---------|---|
| ezmeshc | Easy-to-use combination mesh/contour plotter    |
| ezplot  | Easy-to-use function plotter                    |
| ezplot3 | Easy-to-use 3-D parametric curve plotter        |
| ezpolar | Easy-to-use polar coordinate plotter            |
| ezsurf  | Easy-to-use 3-D colored surface plotter         |
| ezsurfz | Easy-to-use combination surface/contour plotter |
| fplot   | Plot function between specified limits          |

## **Histograms**

|       |                      |
|-------|----------------------|
| hist  | Histogram plot       |
| histc | Histogram count      |
| rose  | Angle histogram plot |

## **Polygons and Surfaces**

|           |   |
|-----------|---|
| convhull  | Convex hull                                     |
| cylinder  | Generate cylinder                               |
| delaunay  | Delaunay triangulation                          |
| delaunay3 | 3-D Delaunay tessellation                       |
| delaunayn | N-D Delaunay tessellation                       |
| dsearch   | Search Delaunay triangulation for nearest point |
| dsearchn  | N-D nearest point search                        |
| ellipsoid | Generate ellipsoid                              |

|           |  |
|-----------|--|
| fill      | Filled 2-D polygons                    |
| fill3     | Filled 3-D polygons                    |
| inpolygon | Points inside polygonal region         |
| pcolor    | Pseudocolor (checkerboard) plot        |
| polyarea  | Area of polygon                        |
| rectint   | Rectangle intersection area            |
| ribbon    | Ribbon plot                            |
| slice     | Volumetric slice plot                  |
| sphere    | Generate sphere                        |
| tsearch   | Search for enclosing Delaunay triangle |
| tsearchn  | N-D closest simplex search             |
| voronoi   | Voronoi diagram                        |
| waterfall | Waterfall plot                         |

### **Scatter/Bubble Plots**

|            |                     |
|------------|---------------------|
| plotmatrix | Scatter plot matrix |
| scatter    | Scatter plot        |
| scatter3   | 3-D scatter plot    |

### **Animation**

|          |                                      |
|----------|--------------------------------------|
| frame2im | Convert movie frame to indexed image |
| getframe | Capture movie frame                  |
| im2frame | Convert image to movie frame         |

|           |   |
|-----------|---|
| movie     | Play recorded movie frames                |
| noanimate | Change EraseMode of all objects to normal |

## **Bit-Mapped Images**

|           |                                      |
|-----------|--------------------------------------|
| frame2im  | Convert movie frame to indexed image |
| im2frame  | Convert image to movie frame         |
| im2java   | Convert image to Java image          |
| image     | Display image object                 |
| imagesc   | Scale data and display image object  |
| iminfo    | Information about graphics file      |
| imformats | Manage image file format registry    |
| imread    | Read image from graphics file        |
| imwrite   | Write image to graphics file         |
| ind2rgb   | Convert indexed image to RGB image   |

## **Printing**

|                 |   |
|-----------------|---|
| frameedit       | Edit print frames for Simulink and Stateflow block diagrams |
| hgexport        | Export figure   |
| orient          | Hardcopy paper orientation                                  |
| print, printopt | Print figure or save to file and configure printer defaults |
| printdlg        | Print dialog box  |



|              |  |
|--------------|--|
| printpreview | Preview figure to print                                      |
| savesas      | Save figure or Simulink block diagram using specified format |

## Handle Graphics

|  |  |
|--|--|
| Finding and Identifying Graphics Objects (p. 1-93) | Find and manipulate graphics objects via their handles |
| Object Creation Functions (p. 1-94)                | Constructors for core graphics objects                 |
| Plot Objects (p. 1-94)                             | Property descriptions for plot objects                 |
| Figure Windows (p. 1-95)                           | Control and save figures                               |
| Axes Operations (p. 1-96)                          | Operate on axes objects                                |
| Operating on Object Properties (p. 1-96)           | Query, set, and link object properties                 |

## Finding and Identifying Graphics Objects

|          |  |
|----------|--|
| allchild | Find all children of specified objects                         |
| ancestor | Ancestor of graphics object                                    |
| copyobj  | Copy graphics objects and their descendants                    |
| delete   | Remove files or graphics objects                               |
| findall  | Find all graphics objects                                      |
| findfigs | Find visible offscreen figures                                 |
| findobj  | Locate graphics objects with specific properties               |
| gca      | Current axes handle  |
| gcbf     | Handle of figure containing object whose callback is executing |

|          |  |
|----------|--|
| gcho     | Handle of object whose callback is executing |
| gco      | Handle of current object                     |
| get      | Query object properties                      |
| ishandle | Is object handle valid                       |
| propedit | Open Property Editor                         |
| set      | Set object properties                        |

### **Object Creation Functions**

|               |                                    |
|---------------|------------------------------------|
| axes          | Create axes graphics object        |
| figure        | Create figure graphics object      |
| hggroup       | Create hggroup object              |
| hgtransform   | Create hgtransform graphics object |
| image         | Display image object               |
| light         | Create light object                |
| line          | Create line object                 |
| patch         | Create patch graphics object       |
| rectangle     | Create 2-D rectangle object        |
| root object   | Root object properties             |
| surface       | Create surface object              |
| text          | Create text object in current axes |
| uicontextmenu | Create context menu                |

### **Plot Objects**

|                                   |  |
|-----------------------------------|--|
| Annotation Arrow Properties       | Define annotation arrow properties       |
| Annotation Doublearrow Properties | Define annotation doublearrow properties |

|                                 |  |
|---------------------------------|--|
| Annotation Ellipse Properties   | Define annotation ellipse properties   |
| Annotation Line Properties      | Define annotation line properties      |
| Annotation Rectangle Properties | Define annotation rectangle properties |
| Annotation Textarrow Properties | Define annotation textarrow properties |
| Annotation Textbox Properties   | Define annotation textbox properties   |
| Areaseries Properties           | Define areaseries properties           |
| Barseries Properties            | Define barseries properties            |
| Contourgroup Properties         | Define contourgroup properties         |
| Errorbarseries Properties       | Define errorbarseries properties       |
| Image Properties                | Define image properties                |
| Lineseries Properties           | Define lineseries properties           |
| Quivergroup Properties          | Define quivergroup properties          |
| Scattergroup Properties         | Define scattergroup properties         |
| Stairseries Properties          | Define stairseries properties          |
| Stemseries Properties           | Define stemseries properties           |
| Surfaceplot Properties          | Define surfaceplot properties          |

## Figure Windows

|          |   |
|----------|---|
| clf      | Clear current figure window                     |
| close    | Remove specified figure                         |
| closereq | Default figure close request function           |
| drawnow  | Flushes event queue and updates figure window   |
| gcf      | Current figure handle                           |
| hgload   | Load Handle Graphics object hierarchy from file |

|         |  |
|---------|--|
| hgsave  | Save Handle Graphics object hierarchy to file                |
| newplot | Determine where to draw graphics objects                     |
| opengl  | Control OpenGL rendering                                     |
| refresh | Redraw current figure  |
| saveas  | Save figure or Simulink block diagram using specified format |

### **Axes Operations**

|             |                                  |
|-------------|----------------------------------|
| axis        | Axis scaling and appearance      |
| box         | Axes border                      |
| cla         | Clear current axes               |
| gca         | Current axes handle              |
| grid        | Grid lines for 2-D and 3-D plots |
| ishold      | Current hold state               |
| makehgtform | Create 4-by-4 transform matrix   |

### **Operating on Object Properties**

|             |   |
|-------------|---|
| get         | Query object properties                             |
| linkaxes    | Synchronize limits of specified 2-D axes            |
| linkprop    | Keep same value for corresponding properties        |
| refreshdata | Refresh data in graph when data source is specified |
| set         | Set object properties                               |

## 3-D Visualization

|                                  |  |
|----------------------------------|--|
| Surface and Mesh Plots (p. 1-97) | Plot matrices, visualize functions of two variables, specify colormap          |
| View Control (p. 1-99)           | Control the camera viewpoint, zooming, rotation, aspect ratio, set axis limits |
| Lighting (p. 1-101)              | Add and control scene lighting   |
| Transparency (p. 1-101)          | Specify and control object transparency  |
| Volume Visualization (p. 1-102)  | Visualize gridded volume data  |

### Surface and Mesh Plots

|  |  |
|--|--|
| Creating Surfaces and Meshes (p. 1-97) | Visualizing gridded and triangulated data as lines and surfaces                              |
| Domain Generation (p. 1-98)            | Gridding data and creating arrays  |
| Color Operations (p. 1-98)             | Specifying, converting, and manipulating color spaces, colormaps, colorbars, and backgrounds |
| Colormaps (p. 1-99)                    | Built-in colormaps you can use   |

### Creating Surfaces and Meshes

|                    |   |
|--------------------|---|
| hidden             | Remove hidden lines from mesh plot        |
| mesh, meshc, meshz | Mesh plots                                |
| peaks              | Example function of two variables         |
| surf, surfc        | 3-D shaded surface plot                   |
| surface            | Create surface object                     |
| surf1              | Surface plot with colormap-based lighting |

|           |                         |
|-----------|-------------------------|
| tetramesh | Tetrahedron mesh plot   |
| trimesh   | Triangular mesh plot    |
| triplot   | 2-D triangular plot     |
| trisurf   | Triangular surface plot |

### Domain Generation

|          |                                       |
|----------|---------------------------------------|
| griddata | Data gridding                         |
| meshgrid | Generate X and Y arrays for 3-D plots |

### Color Operations

|                |  |
|----------------|--|
| brighten       | Brighten or darken colormap                                    |
| caxis          | Color axis scaling   |
| colorbar       | Colorbar showing color scale                                   |
| colordef       | Set default property values to display different color schemes |
| colormap       | Set and get current colormap                                   |
| colormapeditor | Start colormap editor  |
| ColorSpec      | Color specification  |
| graymon        | Set default figure properties for grayscale monitors           |
| hsv2rgb        | Convert HSV colormap to RGB colormap                           |
| rgb2hsv        | Convert RGB colormap to HSV colormap                           |
| rgbplot        | Plot colormap  |
| shading        | Set color shading properties                                   |
| spinmap        | Spin colormap  |

|          |   |
|----------|---|
| surfnorm | Compute and display 3-D surface normals |
| whitebg  | Change axes background color            |

## Colormaps

|          |   |
|----------|---|
| contrast | Grayscale colormap for contrast enhancement |
|----------|---|

## View Control

|   |  |
|---|--|
| Controlling the Camera Viewpoint (p. 1-99)          | Orbiting, dollying, pointing, rotating camera positions and setting fields of view |
| Setting the Aspect Ratio and Axis Limits (p. 1-100) | Specifying what portions of axes to view and how to scale them                     |
| Object Manipulation (p. 1-100)                      | Panning, rotating, and zooming views   |
| Selecting Region of Interest (p. 1-101)             | Interactively identifying rectangular regions                                      |

## Controlling the Camera Viewpoint

|               |  |
|---------------|--|
| camdolly      | Move camera position and target                    |
| cameratoolbar | Control camera toolbar programmatically            |
| camlookat     | Position camera to view object or group of objects |
| camorbit      | Rotate camera position around camera target        |
| campan        | Rotate camera target around camera position        |

|             |  |
|-------------|--|
| campos      | Set or query camera position           |
| camproj     | Set or query projection type           |
| camroll     | Rotate camera about view axis          |
| camtarget   | Set or query location of camera target |
| camup       | Set or query camera up vector          |
| camva       | Set or query camera view angle         |
| camzoom     | Zoom in and out on scene               |
| makehgtform | Create 4-by-4 transform matrix         |
| view        | Viewpoint specification                |
| viewmtx     | View transformation matrices           |

### **Setting the Aspect Ratio and Axis Limits**

|                  |                                     |
|------------------|-------------------------------------|
| daspect          | Set or query axes data aspect ratio |
| pbaspect         | Set or query plot box aspect ratio  |
| xlim, ylim, zlim | Set or query axis limits            |

### **Object Manipulation**

|                  |   |
|------------------|---|
| pan              | Pan view of graph interactively                                   |
| reset            | Reset graphics object properties to their defaults                |
| rotate           | Rotate object in specified direction                              |
| rotate3d         | Rotate 3-D view using mouse                                       |
| selectmoveresize | Select, move, resize, or copy axes and uicontrol graphics objects |
| zoom             | Turn zooming on or off or magnify by factor                       |



## Selecting Region of Interest

|          |  |
|----------|--|
| dragrect | Drag rectangles with mouse               |
| rbbox    | Create rubberband box for area selection |

## Lighting

|            |  |
|------------|--|
| camlight   | Create or move light object in camera coordinates        |
| diffuse    | Calculate diffuse reflectance                            |
| light      | Create light object                                      |
| lightangle | Create or position light object in spherical coordinates |
| lighting   | Specify lighting algorithm                               |
| material   | Control reflectance properties of surfaces and patches   |
| specular   | Calculate specular reflectance                           |

## Transparency

|          |   |
|----------|---|
| alim     | Set or query axes alpha limits                          |
| alpha    | Set transparency properties for objects in current axes |
| alphamap | Specify figure alphamap (transparency)                  |

## Volume Visualization

|                   |  |
|-------------------|--|
| coneplot          | Plot velocity vectors as cones in 3-D vector field |
| contourslice      | Draw contours in volume slice planes               |
| curl              | Compute curl and angular velocity of vector field  |
| divergence        | Compute divergence of vector field                 |
| flow              | Simple function of three variables                 |
| interpstreamspeed | Interpolate stream-line vertices from flow speed   |
| isocaps           | Compute isosurface end-cap geometry                |
| isocolors         | Calculate isosurface and patch colors              |
| isonormals        | Compute normals of isosurface vertices             |
| isosurface        | Extract isosurface data from volume data           |
| reducepatch       | Reduce number of patch faces                       |
| reducevolume      | Reduce number of elements in volume data set       |
| shrinkfaces       | Reduce size of patch faces                         |
| slice             | Volumetric slice plot                              |
| smooth3           | Smooth 3-D data                                    |
| stream2           | Compute 2-D streamline data                        |
| stream3           | Compute 3-D streamline data                        |
| streamline        | Plot streamlines from 2-D or 3-D vector data       |
| streamparticles   | Plot stream particles                              |
| streamribbon      | 3-D stream ribbon plot from vector volume data     |

streamslice

Plot streamlines in slice planes

streamtube

Create 3-D stream tube plot

subvolume

Extract subset of volume data set

surf2patch

Convert surface data to patch data

volumebounds

Coordinate and color limits for  
volume data

## Creating Graphical User Interfaces

|   |  |
|---|--|
| Predefined Dialog Boxes (p. 1-104)        | Dialog boxes for error, user input, waiting, etc.    |
| Deploying User Interfaces (p. 1-105)      | Launch GUIs, create the handles structure            |
| Developing User Interfaces (p. 1-105)     | Start GUIDE, manage application data, get user input |
| User Interface Objects (p. 1-106)         | Create GUI components                                |
| Finding Objects from Callbacks (p. 1-107) | Find object handles from within callbacks functions  |
| GUI Utility Functions (p. 1-107)          | Move objects, wrap text                              |
| Controlling Program Execution (p. 1-108)  | Wait and resume based on user input                  |

### Predefined Dialog Boxes

|                           |  |
|---------------------------|--|
| <code>dialog</code>       | Create and display dialog box                      |
| <code>errordlg</code>     | Create and open error dialog box                   |
| <code>export2wsdlg</code> | Export variables to workspace                      |
| <code>helpdlg</code>      | Create and open help dialog box                    |
| <code>inputdlg</code>     | Create and open input dialog box                   |
| <code>listdlg</code>      | Create and open list-selection dialog box          |
| <code>msgbox</code>       | Create and open message box                        |
| <code>printdlg</code>     | Print dialog box                                   |
| <code>printpreview</code> | Preview figure to print                            |
| <code>questdlg</code>     | Create and open question dialog box                |
| <code>uigetdir</code>     | Open standard dialog box for selecting a directory |

|                         |  |
|-------------------------|--|
| <code>uigetfile</code>  | Open standard dialog box for retrieving files                        |
| <code>uigetpref</code>  | Open dialog box for retrieving preferences                           |
| <code>uiopen</code>     | Open file selection dialog box with appropriate file filters         |
| <code>uiputfile</code>  | Open standard dialog box for saving files                            |
| <code>uisave</code>     | Open standard dialog box for saving workspace variables              |
| <code>uisetcolor</code> | Open standard dialog box for setting object's <code>ColorSpec</code> |
| <code>uisetfont</code>  | Open standard dialog box for setting object's font characteristics   |
| <code>waitbar</code>    | Open waitbar   |
| <code>warndlg</code>    | Open warning dialog box  |

## Deploying User Interfaces

|                         |  |
|-------------------------|--|
| <code>guidata</code>    | Store or retrieve GUI data                           |
| <code>guihandles</code> | Create structure of handles                          |
| <code>movegui</code>    | Move GUI figure to specified location on screen      |
| <code>openfig</code>    | Open new copy or raise existing copy of saved figure |

## Developing User Interfaces

|                         |                                   |
|-------------------------|-----------------------------------|
| <code>addpref</code>    | Add preference                    |
| <code>getappdata</code> | Value of application-defined data |
| <code>getpref</code>    | Preference                        |

|                                 |   |
|---------------------------------|---|
| <code>ginput</code>             | Graphical input from mouse or cursor              |
| <code>guidata</code>            | Store or retrieve GUI data                        |
| <code>guide</code>              | Open GUI Layout Editor                            |
| <code>inspect</code>            | Open Property Inspector                           |
| <code>isappdata</code>          | True if application-defined data exists           |
| <code>ispref</code>             | Test for existence of preference                  |
| <code>rmappdata</code>          | Remove application-defined data                   |
| <code>rmpref</code>             | Remove preference                                 |
| <code>setappdata</code>         | Specify application-defined data                  |
| <code>setpref</code>            | Set preference                                    |
| <code>uigetpref</code>          | Open dialog box for retrieving preferences        |
| <code>uisetpref</code>          | Manage preferences used in <code>uigetpref</code> |
| <code>waitfor</code>            | Wait for condition before resuming execution      |
| <code>waitforbuttonpress</code> | Wait for key press or mouse-button click          |

## **User Interface Objects**

|                            |  |
|----------------------------|--|
| <code>menu</code>          | Generate menu of choices for user input  |
| <code>uibuttongroup</code> | Create container object to exclusively manage radio buttons and toggle buttons |
| <code>uicontextmenu</code> | Create context menu  |
| <code>uicontrol</code>     | Create user interface control object   |

|                           |                                 |
|---------------------------|---------------------------------|
| <code>uimenu</code>       | Create menus on figure windows  |
| <code>uipanel</code>      | Create panel container object   |
| <code>uipushtool</code>   | Create push button on toolbar   |
| <code>uitoggletool</code> | Create toggle button on toolbar |
| <code>uitoolbar</code>    | Create toolbar on figure        |

## Finding Objects from Callbacks

|                       |  |
|-----------------------|--|
| <code>findall</code>  | Find all graphics objects                                      |
| <code>findfigs</code> | Find visible offscreen figures                                 |
| <code>findobj</code>  | Locate graphics objects with specific properties               |
| <code>gcbf</code>     | Handle of figure containing object whose callback is executing |
| <code>gcbo</code>     | Handle of object whose callback is executing                   |

## GUI Utility Functions

|                               |   |
|-------------------------------|---|
| <code>align</code>            | Align user interface controls (uicontrols) and axes               |
| <code>getpixelposition</code> | Get component position in pixels                                  |
| <code>listfonts</code>        | List available system fonts                                       |
| <code>selectmoveresize</code> | Select, move, resize, or copy axes and uicontrol graphics objects |
| <code>setpixelposition</code> | Set component position in pixels                                  |
| <code>textwrap</code>         | Wrapped string matrix for given uicontrol                         |
| <code>uistack</code>          | Reorder visual stacking order of objects                          |

## **Controlling Program Execution**

uiresume, uiwait

Control program execution



## External Interfaces

|   |  |
|---|--|
| Dynamic Link Libraries (p. 1-109)             | Access functions stored in external shared library (.dll) files            |
| Java (p. 1-110)                               | Work with objects constructed from Java API and third-party class packages |
| Component Object Model and ActiveX (p. 1-111) | Integrate COM components into your application                             |
| Web Services (p. 1-113)                       | Communicate between applications over a network using SOAP and WSDL        |
| Serial Port Devices (p. 1-113)                | Read and write to devices connected to your computer's serial port         |

See also MATLAB C and Fortran API Reference for functions you can use in external routines that interact with MATLAB programs and the data in MATLAB workspaces.

## Dynamic Link Libraries

|                  |   |
|------------------|---|
| calllib          | Call function in external library                                     |
| libfunctions     | Information on functions in external library                          |
| libfunctionsview | Create window displaying information on functions in external library |
| libisloaded      | Determine whether external library is loaded                          |
| libpointer       | Create pointer object for use with external libraries                 |
| libstruct        | Construct structure as defined in external library                    |

|               |                                     |
|---------------|-------------------------------------|
| loadlibrary   | Load external library into MATLAB   |
| unloadlibrary | Unload external library from memory |

## **Java**

|               |  |
|---------------|--|
| class         | Create object or return class of object              |
| fieldnames    | Field names of structure, or public fields of object |
| import        | Add package or class to current Java import list     |
| inspect       | Open Property Inspector                              |
| isa           | Determine whether input is object of given class     |
| isjava        | Determine whether input is Java object               |
| ismethod      | Determine whether input is object method             |
| isprop        | Determine whether input is object property           |
| javaaddpath   | Add entries to dynamic Java class path               |
| javaArray     | Construct Java array                                 |
| javachk       | Generate error message based on Java feature support |
| javaclasspath | Set and get dynamic Java class path                  |
| javaMethod    | Invoke Java method                                   |
| javaObject    | Construct Java object                                |
| javarmpath    | Remove entries from dynamic Java class path          |
| methods       | Information on class methods                         |

|             |   |
|-------------|---|
| methodsview | Information on class methods in separate window       |
| usejava     | Determine whether Java feature is supported in MATLAB |

## Component Object Model and ActiveX

|                      |  |
|----------------------|--|
| actxcontrol          | Create ActiveX control in figure window                  |
| actxcontrollist      | List all currently installed ActiveX controls            |
| actxcontrolselect    | Open GUI to create ActiveX control                       |
| actxGetRunningServer | Get handle to running instance of Automation server      |
| actxserver           | Create COM server  |
| addproperty          | Add custom property to object                            |
| class                | Create object or return class of object                  |
| delete (COM)         | Remove COM control or server                             |
| deleteproperty       | Remove custom property from object                       |
| enableservice        | Enable, disable, or report status of Automation server   |
| eventlisteners       | List of events attached to listeners                     |
| events               | List of events control can trigger                       |
| Execute              | Execute MATLAB command in server                         |
| Feval (COM)          | Evaluate MATLAB function in server                       |
| fieldnames           | Field names of structure, or public fields of object     |
| get (COM)            | Get property value from interface, or display properties |

|                       |  |
|-----------------------|--|
| GetCharArray          | Get character array from server                          |
| GetFullMatrix         | Get matrix from server                                   |
| GetVariable           | Get data from variable in server workspace               |
| GetWorkspaceData      | Get data from server workspace                           |
| inspect               | Open Property Inspector                                  |
| interfaces            | List custom interfaces to COM server                     |
| invoke                | Invoke method on object or interface, or display methods |
| isa                   | Determine whether input is object of given class         |
| iscom                 | Is input COM object                                      |
| isevent               | Is input event   |
| isinterface           | Is input COM interface                                   |
| ismethod              | Determine whether input is object method                 |
| isprop                | Determine whether input is object property               |
| load (COM)            | Initialize control object from file                      |
| MaximizeCommandWindow | Open server window on Windows desktop                    |
| methods               | Information on class methods                             |
| methodsview           | Information on class methods in separate window          |
| MinimizeCommandWindow | Minimize size of server window                           |
| move                  | Move or resize control in parent window                  |
| propedit (COM)        | Open built-in property page for control                  |
| PutCharArray          | Store character array in server                          |

|                     |   |
|---------------------|---|
| PutFullMatrix       | Store matrix in server                              |
| PutWorkspaceData    | Store data in server workspace                      |
| Quit (COM)          | Terminate MATLAB server                             |
| registerevent       | Register event handler with control's event         |
| release             | Release interface                                   |
| save (COM)          | Serialize control object to file                    |
| set (COM)           | Set object or interface property to specified value |
| unregisterallevents | Unregister all events for control                   |
| unregisterevent     | Unregister event handler with control's event       |

## Web Services

|                     |   |
|---------------------|---|
| callSoapService     | Send SOAP message off to endpoint                               |
| createClassFromWsdL | Create MATLAB object based on WSDL file                         |
| createSoapMessage   | Create SOAP message to send to server                           |
| parseSoapResponse   | Convert response string from SOAP server into MATLAB data types |

## Serial Port Devices

|                 |   |
|-----------------|---|
| clear (serial)  | Remove serial port object from MATLAB workspace |
| delete (serial) | Remove serial port object from memory           |
| disp (serial)   | Serial port object summary information          |

|                               |  |
|-------------------------------|--|
| <code>fclose (serial)</code>  | Disconnect serial port object from device                    |
| <code>fgetl (serial)</code>   | Read line of text from device and discard terminator         |
| <code>fgets (serial)</code>   | Read line of text from device and include terminator         |
| <code>fopen (serial)</code>   | Connect serial port object to device                         |
| <code>fprintf (serial)</code> | Write text to device   |
| <code>fread (serial)</code>   | Read binary data from device                                 |
| <code>fscanf (serial)</code>  | Read data from device, and format as text                    |
| <code>fwrite (serial)</code>  | Write binary data to device                                  |
| <code>get (serial)</code>     | Serial port object properties                                |
| <code>instrcallback</code>    | Event information when event occurs                          |
| <code>instrfind</code>        | Read serial port objects from memory to MATLAB workspace     |
| <code>instrfindall</code>     | Find visible and hidden serial port objects                  |
| <code>isvalid (serial)</code> | Determine whether serial port objects are valid              |
| <code>length (serial)</code>  | Length of serial port object array                           |
| <code>load (serial)</code>    | Load serial port objects and variables into MATLAB workspace |
| <code>readasync</code>        | Read data asynchronously from device                         |
| <code>record</code>           | Record data and event information to file                    |
| <code>save (serial)</code>    | Save serial port objects and variables to MAT-file           |
| <code>serial</code>           | Create serial port object                                    |

---

|                            |  |
|----------------------------|--|
| <code>serialbreak</code>   | Send break to device connected to serial port      |
| <code>set (serial)</code>  | Configure or display serial port object properties |
| <code>size (serial)</code> | Size of serial port object array                   |
| <code>stopasync</code>     | Stop asynchronous read and write operations        |





# Functions — Alphabetical List

---

Arithmetic Operators + - \* / \ ^ '   
Relational Operators < > <= >= == ~=   
Logical Operators: Elementwise & | ~   
Logical Operators: Short-circuit && ||   
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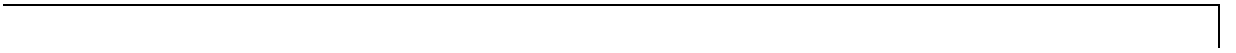
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# pack

---

**Purpose** Consolidate workspace memory

**Syntax**

```
pack
pack filename
pack('filename')
```

**Description** `pack` frees up needed space by reorganizing information so that it only uses the minimum memory required. All variables from your base and global workspaces are preserved. Any persistent variables that are defined at the time are set to their default value (the empty matrix, []).

MATLAB temporarily stores your workspace data in a file called `tp#####.mat` (where ##### is a numeric value) that is located in your temporary directory. (You can use the command `dir(tempdir)` to see the files in this directory).

`pack filename` frees space in memory, temporarily storing workspace data in a file specified by `filename`. This file resides in your current working directory and, unless specified otherwise, has a `.mat` file extension.

`pack('filename')` is the function form of `pack`.

**Remarks** You can only run `pack` from the MATLAB command line.

If you specify a `filename` argument, that file must reside in a directory for which you have write permission.

The `pack` function does not affect the amount of memory allocated to the MATLAB process. You must quit MATLAB to free up this memory.

Since MATLAB uses a heap method of memory management, extended MATLAB sessions may cause memory to become fragmented. When memory is fragmented, there may be plenty of free space, but not enough contiguous memory to store a new large variable.

If you get the `Out of memory` message from MATLAB, the `pack` function may find you some free memory without forcing you to delete variables.

The `pack` function frees space by

- Saving all variables in the base and global workspaces to a temporary file.
- Clearing all variables and functions from memory.
- Reloading the base and global workspace variables back from the temporary file and then deleting the file.

If you use `pack` and there is still not enough free memory to proceed, you must clear some variables. If you run out of memory often, you can allocate larger matrices earlier in the MATLAB session and use these system-specific tips:

- UNIX: Ask your system manager to increase your swap space.
- Windows: Increase virtual memory using the Windows Control Panel.

To maintain persistent variables when you run `pack`, use `mlock` in the function.

## Examples

Change the current directory to one that is writable, run `pack`, and return to the previous directory.

```
cwd = pwd;  
cd(tempdir);  
pack  
cd(cwd)
```

## See Also

`clear`, `memory`

# padecoeff

---

**Purpose** Padé approximation of time delays

**Syntax** [num,den] = padecoeff(T,N)

**Description** [num,den] = padecoeff(T,N) returns the Nth-order Padé approximation of the continuous-time delay  $T$  in transfer function form. The row vectors num and den contain the numerator and denominator coefficients in descending powers of  $T$ . Both are Nth-order polynomials.

Class support for input  $T$ :

float: double, single

**Class Support** Input  $T$  support floating-point values of type single or double.

**References** [1] Golub, G. H. and C. F. Van Loan *Matrix Computations* Johns Hopkins University Press, Baltimore: 1989, pp. 557-558.

**See Also** pade



**Purpose** Page setup dialog box

**Syntax** `dlg = pagesetupdlg(fig)`

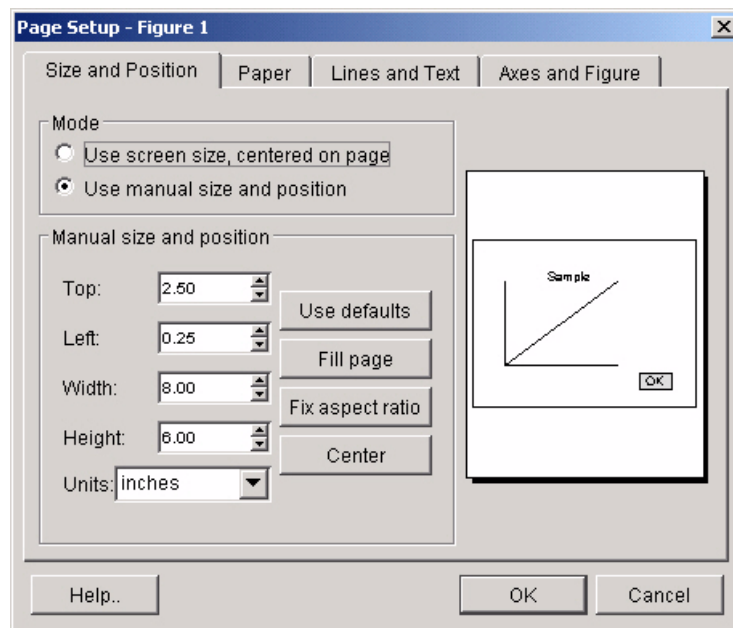
---

**Note** This function is obsolete. Use `printpreview` instead.

---

**Description** `dlg = pagesetupdlg(fig)` creates a dialog box from which a set of pagelayout properties for the figure window, `fig`, can be set. `pagesetupdlg` implements the "Page Setup..." option in the **Figure File Menu**.

`pagesetupdlg` supports setting the layout for a single figure. `fig` must be a single figure handle, not a vector of figures or a simulink diagram.



# pagesetupdlg

---


## **See Also**

printdlg, printpreview, printopt

**Purpose**

Pan view of graph interactively

**GUI Alternatives**

Use the **Pan** tool  on the figure toolbar to enable and disable pan mode on a plot, or select **Pan** from the figure's **Tools** menu. For details, see “Panning — Shifting Your View of the Graph” in the MATLAB Graphics documentation.

**Syntax**

```
pan on
pan xon
pan yon
pan off
pan
pan(figure_handle,...)
h = pan(figure_handle)
```

**Description**

`pan on` turns on mouse-based panning in the current figure.

`pan xon` turns on panning only in the *x* direction in the current figure.

`pan yon` turns on panning only in the *y* direction in the current figure.

`pan off` turns panning off in the current figure.

`pan` toggles the pan state in the current figure on or off.

`pan(figure_handle,...)` sets the pan state in the specified figure.

`h = pan(figure_handle)` returns the figure's pan *mode object* for the figure *figure\_handle* for you to customize the mode's behavior.

**Using Pan Mode Objects**

Access the following properties of pan mode objects via `get` and modify some of them using `set`:

*Enable* 'on' | 'off'

Specifies whether this figure mode is currently enabled on the figure.

*Motion* 'horizontal' | 'vertical' | 'both'

The type of panning enabled for the figure.

FigureHandle <handle>

The associated figure handle. This read-only property cannot be set.

ButtonDownFilter <function\_handle>

The application can inhibit the panning operation under circumstances the programmer defines, depending on what the callback returns. The input function handle should reference a function with two implicit arguments (similar to handle callbacks):

```
function [res] = myfunction(obj,event_obj)
% obj          handle to the object that has been clicked on.
% event_obj    handle to event object (empty in this release).
% res          a logical flag to determine whether the pan
%              operation should take place or the 'ButtonDownFcn'
%              property of the object should take precedence.
```

ActionPreCallback <function\_handle>

Set this callback to listen to when a pan operation will start. The input function handle should reference a function with two implicit arguments (similar to handle callbacks):

```
function myfunction(obj,event_obj)
% obj          handle to the figure that has been clicked on.
% event_obj    handle to event object.
```

The event object has the following read-only property:

|      |   |
|------|---|
| Axes | The handle of the axes that is being panned |
|------|---|

ActionPostCallback <function\_handle>

Set this callback to listen to when a pan operation has finished. The input function handle should reference a function with two implicit arguments (similar to handle callbacks):

```
function myfunction(obj,event_obj)
```

```
% obj          handle to the figure that has been clicked on.  
% event_obj    handle to event object. The object has the same  
%              properties as the event_obj of the  
%              'ActionPreCallback' callback.
```

```
flags = isAllowAxesPan(h,axes)
```

Calling the function `isAllowAxesPan` on the pan object, `h`, with a vector of axes handles, `axes`, as input returns a logical array of the same dimension as the axes handle vector, which indicates whether a pan operation is permitted on the axes objects.

```
setAllowAxesPan(h,axes,flag)
```

Calling the function `setAllowAxesPan` on the pan object, `h`, with a vector of axes handles, `axes`, and a logical scalar, `flag`, either allows or disallows a pan operation on the axes objects.

```
info = getAxesPanMotion(h,axes)
```

Calling the function `getAxesPanMotion` on the pan object, `h`, with a vector of axes handles, `axes`, as input will return a character cell array of the same dimension as the axes handle vector, which indicates the type of pan operation for each axes. Possible values for the type of operation are 'horizontal', 'vertical' or 'both'.

```
setAxesPanMotion(h,axes,style)
```

Calling the function `setAxesPanMotion` on the pan object, `h`, with a vector of axes handles, `axes`, and a character array, `style`, sets the style of panning on each axes.

## Examples

### Example 1 – Entering Pan Mode

Plot a graph and turn on Pan mode:

```
plot(magic(10));  
pan on  
% pan on the plot
```

## Example 2 – Constrained Pan

Constrain pan to  $x$ -axis using set:

```
plot(magic(10));
h = pan;
set(h,'Motion','horizontal','Enable','on');
% pan on the plot in the horizontal direction.
```

## Example 3 – Constrained Pan in Subplots

Create four axes as subplots and give each one a different panning behavior:

```
ax1 = subplot(2,2,1);
plot(1:10);
h = pan;
ax2 = subplot(2,2,2);
plot(rand(3));
setAllowAxesPan(h,ax2,false);
ax3 = subplot(2,2,3);
plot(peaks);
setAxesPanMotion(h,ax3,'horizontal');
ax4 = subplot(2,2,4);
contour(peaks);
setAxesPanMotion(h,ax4,'vertical');
% pan on the plots.
```

## Example 4 – Coding a ButtonDown Callback

Create a `buttonDown` callback for pan mode objects to trigger. Copy the following code to a new M-file, execute it, and observe panning behavior:

```
function demo
% Allow a line to have its own 'ButtonDownFcn' callback.
hLine = plot(rand(1,10));
set(hLine,'ButtonDownFcn','disp(''This executes'')');
set(hLine,'Tag','DoNotIgnore');
```

```
h = pan;
set(h,'ButtonDownFilter',@mycallback);
set(h,'Enable','on');
% mouse click on the line
%
function [flag] = mycallback(obj,event_obj)
% If the tag of the object is 'DoNotIgnore', then return true.
objTag = get(obj,'Tag');
if strcmpi(objTag,'DoNotIgnore')
    flag = true;
else
    flag = false;
end
```

### Example 5 – Coding Pre- and Post-Callback Behavior

Create callbacks for pre- and post-ButtonDown events for pan mode objects to trigger. Copy the following code to a new M-file, execute it, and observe panning behavior:

```
function demo
% Listen to pan events
plot(1:10);
h = pan;
set(h,'ActionPreCallback',@myprecallback);
set(h,'ActionPostCallback',@mypostcallback);
set(h,'Enable','on');
%
function myprecallback(obj,evd)
disp('A pan is about to occur.');
```

```
%
function mypostcallback(obj,evd)
newLim = get(evd.Axes,'XLim');
msgbox(sprintf('The new X-Limits are [%f %f].',newLim));
```

## Example 6 – Creating a Context Menu for Pan Mode

Coding a context menu that lets the user to switch to Zoom mode by right-clicking:

```
figure; plot(magic(10));
hCM = uicontextmenu;
hMenu = uimenu('Parent',hCM,'Label','Switch to zoom',...
    'Callback','zoom(gcf,'on')');
hPan = pan(gcf);
set(hPan,'UIContextMenu',hCM);
pan('on')
```

You cannot add items to the built-in pan context menu, but you can replace it with your own.

### Remarks

You can create a pan mode object once and use it to customize the behavior of different axes, as Example 3 illustrates. You can also change its callback functions on the fly.

When you assign different pan behaviors to different subplot axes via a mode object and then link them using the `linkaxes` function, the behavior of the axes you manipulate with the mouse carries over to the linked axes, regardless of the behavior you previously set for the other axes.

### See Also

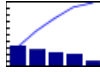
`zoom`, `linkaxes`, `rotate3d`


“Object Manipulation” on page 1-100 for related functions



**Purpose**

Pareto chart

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
pareto(Y)
pareto(Y, names)
pareto(Y, X)
H = pareto(...)
```

**Description**

Pareto charts display the values in the vector  $Y$  as bars drawn in descending order. Values in  $Y$  must be nonnegative and not include NaNs. Only the first 95% of the cumulative distribution is displayed.

`pareto(Y)` labels each bar with its element index in  $Y$  and also plots a line displaying the cumulative sum of  $Y$ .

`pareto(Y, names)` labels each bar with the associated name in the string matrix or cell array `names`.

`pareto(Y, X)` labels each bar with the associated value from  $X$ .

`pareto(ax, ...)` plots a Pareto chart in existing axes `ax` rather than GCA.

`H = pareto(...)` returns a combination of patch and line object handles.

**Examples**

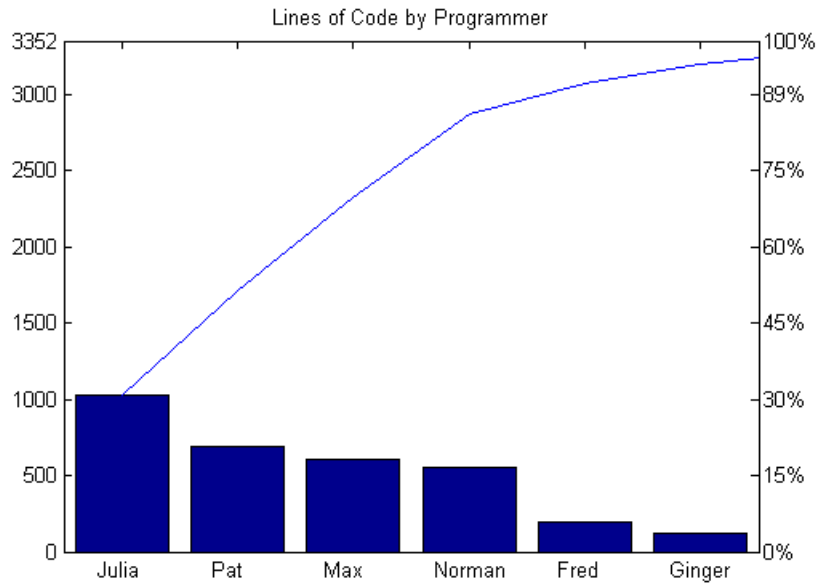
Example 1:

Examine the cumulative productivity of a group of programmers to see how normal its distribution is:

# pareto

---

```
codelines = [200 120 555 608 1024 101 57 687];
coders =
{'Fred', 'Ginger', 'Norman', 'Max', 'Julia', 'Wally', 'Heidi', 'Pat'};
pareto(codelines, coders)
title('Lines of Code by Programmer')
```



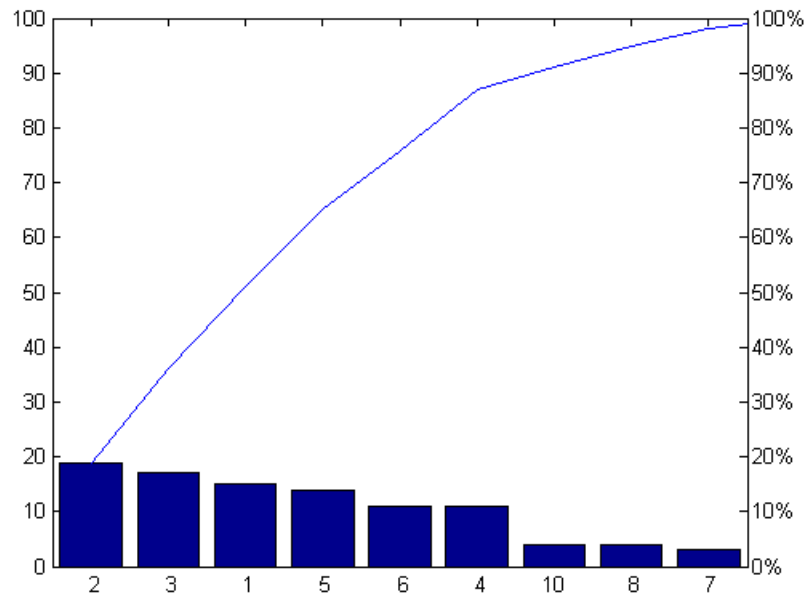
Example 2:

Generate a vector,  $X$ , representing diagnostic codes with values from 1 to 10 indicating various faults on devices emerging from a production line:

```
X = min(round(abs(randn(100,1)*4))+1,10);
```

Plot a Pareto chart showing the frequency of failure for each diagnostic code from the most to the least common:

```
pareto(hist(X))
```

**Remarks**

You can use `pareto` to display the output of `hist`, even for vectors that include negative numbers. Because only the first 95 percent of values are displayed, one or more of the smallest bars may not appear. If you extend the `Xlim` of your chart, you can display all the values, but the new bars will not be labeled.

**See Also**

`hist`, `bar`

# parse (inputParser)

---

**Purpose** Parse and validate named inputs

**Syntax** `p.parse(arglist)`  
`parse(p, arglist)`

**Description** `p.parse(arglist)` parses and validates the inputs named in `arglist`. `parse(p, arglist)` is functionally the same as the syntax above.

---

**Note** For more information on the `inputParser` class, see [Parsing Inputs with inputParser](#) in the MATLAB Programming documentation.

---

## Examples

Write an M-file function called `publish_ip`, based on the MATLAB `publish` function, to illustrate the use of the `inputParser` class. Construct an instance of `inputParser` and assign it to variable `p`:

```
function publish_ip(script, varargin)
    p = inputParser; % Create an instance of the inputParser class.
```

Add arguments to the schema. See the reference pages for the `addRequired`, `addOptional`, and `addParamValue` methods for help with this:

```
p.addRequired('script', @ischar);
p.addOptional('format', 'html', ...
    @(x)any(strcmpi(x,{'html','ppt','xml','latex'})));
p.addParamValue('outputDir', pwd, @ischar);
p.addParamValue('maxHeight', [], @(x)x>0 && mod(x,1)==0);
p.addParamValue('maxWidth', [], @(x)x>0 && mod(x,1)==0);
```

Call the `parse` method of the object to read and validate each argument in the schema:

```
p.parse(script, varargin{:});
```

Execution of the `parse` method validates each argument and also builds a structure from the input arguments. The name of the structure is `Results`, which is accessible as a property of the object. To get the value of any input argument, type

```
p.Results.argname
```

Continuing with the `publish_ip` exercise, add the following lines to your M-file:

```
% Parse and validate all input arguments.
p.parse(script, varargin{:});

% Display the value for maxHeight.
disp(sprintf('\nThe maximum height is %d.\n', p.Results.maxHeight))

% Display all arguments.
disp 'List of all arguments:'
disp(p.Results)
```

When you call the program, MATLAB assigns those values you pass in the argument list to the appropriate fields of the `Results` structure. Save the M-file and execute it at the MATLAB command prompt with this command:

```
publish_ip('ipscript.m', 'ppt', 'outputDir', 'C:/matlab/test', ...
          'maxWidth', 500, 'maxHeight', 300);
```

```
The maximum height is 300.
```

```
List of all arguments:
    format: 'ppt'
maxHeight: 300
maxWidth: 500
outputDir: 'C:/matlab/test'
    script: 'ipscript.m'
```

## parse (inputParser)

---

### See Also

`inputParser`, `addRequired(inputParser)`,  
`addOptional(inputParser)`, `addParamValue(inputParser)`,  
`createCopy(inputParser)`

- Purpose** Convert response string from SOAP server into MATLAB data types
- Syntax** `parseSoapResponse(response)`
- Description** `parseSoapResponse(response)` converts `response`, a string returned by a SOAP server, into a cell array of appropriate MATLAB data types.
- Example**
- ```
message = createSoapMessage(...  
    'urn:xmethods-delayed-quotes', 'getQuote', {'G00G'}, {'symbol'}, ...  
    {'{http://www.w3.org/2001/XMLSchema}string'}, 'rpc')  
response = callSoapService('http://64.124.140.30:9090/soap', ...  
    'urn:xmethods-delayed-quotes#getQuote', message)  
price = parseSoapResponse(response)
```
- See Also** `callSoapService`, `createClassFromWsd1`, `createSoapMessage`

# partialpath

---

## Purpose

Partial pathname description

## Description

A partial pathname is a pathname relative to the MATLAB path, `matlabpath`. It is used to locate private and method files, which are usually hidden, or to restrict the search for files when more than one file with the given name exists.

A partial pathname contains the last component, or last several components, of the full pathname separated by `/`. For example, `matfun/trace`, `private/children`, and `demos/clown.mat` are valid partial pathnames. Specifying the `@` in method directory names is optional.

Partial pathnames make it easy to find a toolbox or MATLAB relative files on your path, independent of the location where MATLAB is installed.

Many commands accept partial pathnames instead of a full pathname. Some of these commands are

```
help, type, load, exist, what, which, edit, dbtype,  
dbstop, dbclear, fopen
```

## Examples

The following example uses a partial pathname:

```
what graph2d/@figobj
```

```
M-files in directory
```

```
matlabroot\toolbox\matlab\graph2d\@figobj
```

```
deselectall    enddrag        middrag        subsref  
doclick        figobj          set  
doresize       get             subsasgn
```

```
P-files in directory
```

```
matlabroot\toolbox\matlab\graph2d\@figobj
```

```
deselectall    enddrag        middrag        subsref
```



|          |        |          |
|----------|--------|----------|
| doclick  | figobj | set      |
| doresize | get    | subsasgn |

The @ in the class directory name @figobj is not necessary. You get the same response from the following command:

```
what graph2d/figobj
```

## See Also

fileparts, matlabroot, path

# pascal

---

**Purpose** Pascal matrix

**Syntax**  
A = pascal(n)  
A = pascal(n,1)  
A = pascal(n,2)

**Description** A = pascal(n) returns the Pascal matrix of order n: a symmetric positive definite matrix with integer entries taken from Pascal's triangle. The inverse of A has integer entries.

A = pascal(n,1) returns the lower triangular Cholesky factor (up to the signs of the columns) of the Pascal matrix. It is *involutary*, that is, it is its own inverse.

A = pascal(n,2) returns a transposed and permuted version of pascal(n,1). A is a cube root of the identity matrix.

**Examples** pascal(4) returns

|   |   |    |    |
|---|---|----|----|
| 1 | 1 | 1  | 1  |
| 1 | 2 | 3  | 4  |
| 1 | 3 | 6  | 10 |
| 1 | 4 | 10 | 20 |

A = pascal(3,2) produces

A =

|    |    |   |
|----|----|---|
| 1  | 1  | 1 |
| -2 | -1 | 0 |
| 1  | 0  | 0 |

**See Also** chol

**Purpose** Create patch graphics object

**Syntax**

```
patch(X,Y,C)
patch(X,Y,Z,C)
patch(FV)
patch(... 'PropertyName',propertyvalue...)
patch('PropertyName',propertyvalue,...)
handle = patch(...)
```

**Description** `patch` is the low-level graphics function for creating patch graphics objects. A patch object is one or more polygons defined by the coordinates of its vertices. You can specify the coloring and lighting of the patch. See “Creating 3-D Models with Patches” for more information on using patch objects.

`patch(X,Y,C)` adds the filled two-dimensional patch to the current axes. The elements of `X` and `Y` specify the vertices of a polygon. If `X` and `Y` are matrices, MATLAB draws one polygon per column. `C` determines the color of the patch. It can be a single `ColorSpec`, one color per face, or one color per vertex (see “Remarks” on page 2-2396). If `C` is a 1-by-3 vector, it is assumed to be an RGB triplet, specifying a color directly.

`patch(X,Y,Z,C)` creates a patch in three-dimensional coordinates.

`patch(FV)` creates a patch using structure `FV`, which contains the fields `vertices`, `faces`, and optionally `facevertexcdata`. These fields correspond to the `Vertices`, `Faces`, and `FaceVertexCData` patch properties.

`patch(... 'PropertyName',propertyvalue...)` follows the `X`, `Y`, (`Z`), and `C` arguments with property name/property value pairs to specify additional patch properties.

`patch('PropertyName',propertyvalue,...)` specifies all properties using property name/property value pairs. This form enables you to omit the color specification because MATLAB uses the default face color and edge color unless you explicitly assign a value to the `FaceColor` and `EdgeColor` properties. This form also allows you to specify the patch using the `Faces` and `Vertices` properties instead of `x`-, `y`-, and

$z$ -coordinates. See the “Examples” on page 2-2399 section for more information.

`handle = patch(...)` returns the handle of the patch object it creates.

## Remarks

Unlike high-level area creation functions, such as `fill` or `area`, `patch` does not check the settings of the figure and axes `NextPlot` properties. It simply adds the patch object to the current axes.

If the coordinate data does not define closed polygons, `patch` closes the polygons. The data can define concave or intersecting polygons. However, if the edges of an individual patch face intersect themselves, the resulting face may or may not be completely filled. In that case, it is better to break up the face into smaller polygons.

## Specifying Patch Properties

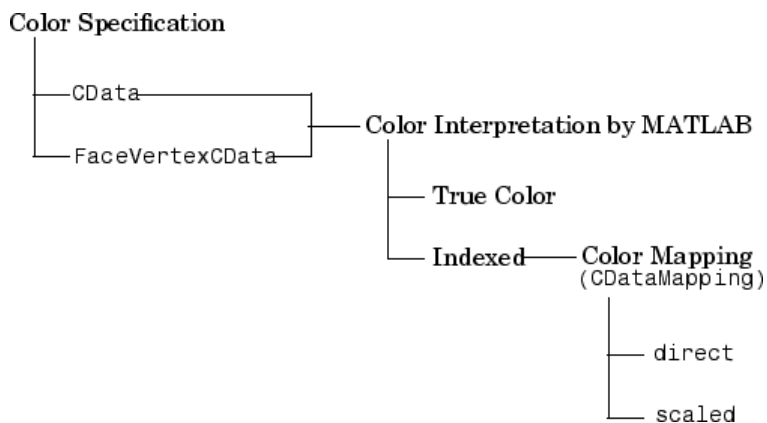
You can specify properties as property name/property value pairs, structure arrays, and cell arrays (see the `set` and `get` reference pages for examples of how to specify these data types).

There are two patch properties that specify color:

- `CData` — Use when specifying  $x$ -,  $y$ -, and  $z$ -coordinates (`XData`, `YData`, `ZData`).
- `FaceVertexCData` — Use when specifying vertices and connection matrix (`Vertices` and `Faces`).

The `CData` and `FaceVertexCData` properties accept color data as indexed or true color (RGB) values. See the `CData` and `FaceVertexCData` property descriptions for information on how to specify color.

Indexed color data can represent either direct indices into the colormap or scaled values that map the data linearly to the entire colormap (see the `caxis` function for more information on this scaling). The `CDataMapping` property determines how MATLAB interprets indexed color data.



## Color Data Interpretation

You can specify patch colors as

- A single color for all faces
- One color for each face, enabling flat coloring
- One color for each vertex, enabling interpolated coloring

The following tables summarize how MATLAB interprets color data defined by the CData and FaceVertexCData properties.

# patch

## Interpretation of the CData Property

| [X,Y,Z]Data | CData Required for |             | Results Obtained                                                                                                            |
|-------------|--------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------|
| Dimensions  | Indexed            | True Color  |                                                                                                                             |
| m-by-n      | scalar             | 1-by-1-by-3 | Use the single color specified for all patch faces. Edges can be only a single color.                                       |
| m-by-n      | 1-by-n<br>(n >= 4) | 1-by-n-by-3 | Use one color for each patch face. Edges can be only a single color.                                                        |
| m-by-n      | m-by-n             | m-by-n-3    | Assign a color to each vertex. Patch faces can be flat (a single color) or interpolated. Edges can be flat or interpolated. |

## Interpretation of the FaceVertexCData Property

| Vertices   | Faces      | FaceVertexCData Required for |            | Results Obtained                                                                                                            |
|------------|------------|------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------|
| Dimensions | Dimensions | Indexed                      | True Color |                                                                                                                             |
| m-by-n     | k-by-3     | scalar                       | 1-by-3     | Use the single color specified for all patch faces. Edges can be only a single color.                                       |
| m-by-n     | k-by-3     | k-by-1                       | k-by-3     | Use one color for each patch face. Edges can be only a single color.                                                        |
| m-by-n     | k-by-3     | m-by-1                       | m-by-3     | Assign a color to each vertex. Patch faces can be flat (a single color) or interpolated. Edges can be flat or interpolated. |

## Examples

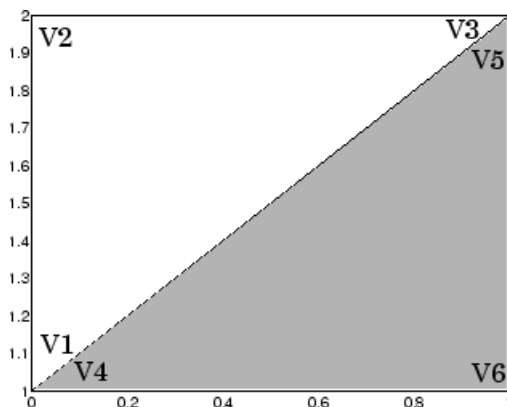
This example creates a patch object using two different methods:

- Specifying  $x$ -,  $y$ -, and  $z$ -coordinates and color data (XData, YData, ZData, and CData properties)
- Specifying vertices, the connection matrix, and color data (Vertices, Faces, FaceVertexCData, and FaceColor properties)

### Specifying X, Y, and Z Coordinates

The first approach specifies the coordinates of each vertex. In this example, the coordinate data defines two triangular faces, each having three vertices. Using true color, the top face is set to white and the bottom face to gray.

```
x = [0 0;0 1;1 1];  
y = [1 1;2 2;2 1];  
z = [1 1;1 1;1 1];  
tcolor(1,1,1:3) = [1 1 1];  
tcolor(1,2,1:3) = [.7 .7 .7];  
patch(x,y,z,tcolor)
```



Notice that each face shares two vertices with the other face ( $V_1$ - $V_4$  and  $V_3$ - $V_5$ ).

## Specifying Vertices and Faces

The Vertices property contains the coordinates of each *unique* vertex defining the patch. The Faces property specifies how to connect these vertices to form each face of the patch. For this example, two vertices share the same location so you need to specify only four of the six vertices. Each row contains the  $x$ -,  $y$ -, and  $z$ -coordinates of each vertex.

```
vert = [0 1 1;0 2 1;1 2 1;1 1 1];
```

There are only two faces, defined by connecting the vertices in the order indicated.

```
fac = [1 2 3;1 3 4];
```

To specify the face colors, define a 2-by-3 matrix containing two RGB color definitions.

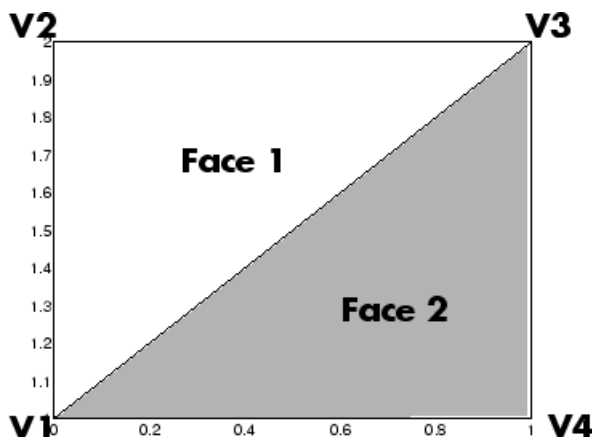
```
tcolor = [1 1 1;.7 .7 .7];
```

With two faces and two colors, MATLAB can color each face with flat shading. This means you must set the FaceColor property to flat, since the faces/vertices technique is available only as a low-level function call (i.e., only by specifying property name/property value pairs).

Create the patch by specifying the Faces, Vertices, and FaceVertexCData properties as well as the FaceColor property.

```
patch('Faces',fac,'Vertices',vert,'FaceVertexCData',tcolor,...  
      'FaceColor','flat')
```

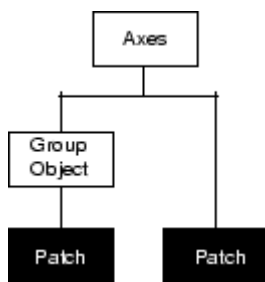




Specifying only unique vertices and their connection matrix can reduce the size of the data for patches having many faces. See the descriptions of the Faces, Vertices, and FaceVertexCData properties for information on how to define them.

MATLAB does not require each face to have the same number of vertices. In cases where they do not, pad the Faces matrix with NaNs. To define a patch with faces that do not close, add one or more NaNs to the row in the Vertices matrix that defines the vertex you do not want connected.

## Object Hierarchy



## Setting Default Properties

You can set default patch properties on the axes, figure, and root levels:

# patch

---

```
set(0, 'DefaultPatchPropertyName', PropertyValue...)  
set(gcf, 'DefaultPatchPropertyName', PropertyValue...)  
set(gca, 'DefaultPatchPropertyName', PropertyValue...)
```

*PropertyName* is the name of the patch property and *PropertyValue* is the value you are specifying. Use `set` and `get` to access patch properties.

## See Also

`area`, `caxis`, `fill`, `fill3`, `isosurface`, `surface`

“Object Creation Functions” on page 1-94 for related functions

Patch Properties for property descriptions

“Creating 3-D Models with Patches” for examples that use patches

## Purpose

Patch properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- “The Property Editor” is an interactive tool that enables you to see and change object property values.
- The set and get commands enable you to set and query the values of properties.

To change the default values of properties, see “Setting Default Property Values”.

See “Core Graphics Objects” for general information about this type of object.

## Patch Property Descriptions

This section lists property names along with the type of values each accepts. Curly braces { } enclose default values.

AlphaDataMapping  
none | {scaled} | direct

*Transparency mapping method.* This property determines how MATLAB interprets indexed alpha data. This property can be any of the following:

- none — The transparency values of FaceVertexAlphaData are between 0 and 1 or are clamped to this range.
- scaled — Transform the FaceVertexAlphaData to span the portion of the alphamap indicated by the axes ALim property, linearly mapping data values to alpha values. (scaled is the default)
- direct — Use the FaceVertexAlphaData as indices directly into the alphamap. When not scaled, the data are usually integer values ranging from 1 to length(alphamap). MATLAB maps values less than 1 to the first alpha value in the alphamap, and values greater than length(alphamap) to the

# Patch Properties

---

last alpha value in the alphamap. Values with a decimal portion are fixed to the nearest lower integer. If `FaceVertexAlphaData` is an array of `uint8` integers, then the indexing begins at 0 (i.e., MATLAB maps a value of 0 to the first alpha value in the alphamap).

`AmbientStrength`  
scalar  $\geq 0$  and  $\leq 1$

*Strength of ambient light.* This property sets the strength of the ambient light, which is a nondirectional light source that illuminates the entire scene. You must have at least one visible light object in the axes for the ambient light to be visible. The axes `AmbientColor` property sets the color of the ambient light, which is therefore the same on all objects in the axes.

You can also set the strength of the diffuse and specular contribution of light objects. See the `DiffuseStrength` and `SpecularStrength` properties.

`Annotation`  
hg.Annotation object Read Only

*Control the display of patch objects in legends.* The `Annotation` property enables you to specify whether this patch object is represented in a figure legend.

Querying the `Annotation` property returns the handle of an `hg.Annotation` object. The `hg.Annotation` object has a property called `LegendInformation`, which contains an `hg.LegendEntry` object.

Once you have obtained the `hg.LegendEntry` object, you can set its `IconDisplayStyle` property to control whether the patch object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                               |
|------------------------|-------------------------------------------------------|
| on                     | Represent this patch object in a legend (default)     |
| off                    | Do not include this patch object in a legend          |
| children               | Same as on because patch objects do not have children |

## Setting the IconDisplayStyle property

These commands set the IconDisplayStyle of a graphics object with handle `hobj` to off:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'off')
```

## Using the IconDisplayStyle property

See “Controlling Legends” for more information and examples.

## Selecting which objects to display in legend

Some graphics functions create multiple objects. For example, `contour3` uses patch objects to create a 3D contour graph. You can use the Annotation property set select a subset of the objects for display in the legend.

```
[X,Y] = meshgrid(-2:.1:2);  
[Cm hC] = contour3(X.*exp(-X.^2-Y.^2));  
hA = get(hC, 'Annotation');  
hLL = get([hA{:}], 'LegendInformation');  
% Set the IconDisplayStyle property to display  
% the first, fifth, and ninth patch in the legend  
set([hLL{:}], {'IconDisplayStyle'}, ...  
    {'on', 'off', 'off', 'off', 'on', 'off', 'off', 'off', 'on'})
```

# Patch Properties

---

```
% Assign DisplayNames for the three patch  
that are displayed in the legend  
set(hC([1,5,9]),{'DisplayName'},{'bottom','middle','top'})  
legend show
```

BackFaceLighting  
unlit | lit | {reverselit}

*Face lighting control.* This property determines how faces are lit when their vertex normals point away from the camera:

- unlit — Face is not lit.
- lit — Face is lit in normal way.
- reverselit — Face is lit as if the vertex pointed towards the camera.

This property is useful for discriminating between the internal and external surfaces of an object. See the Using MATLAB Graphics manual for an example.

BeingDeleted  
on | {off} Read Only

*This object is being deleted.* The BeingDeleted property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the BeingDeleted property to on when the object's delete function callback is called (see the DeleteFcn property) It remains set to on while the delete function executes, after which the object no longer exists.

For example, an object's delete function might call other functions that act on a number of different objects. These functions may not need to perform actions on objects that are going to be deleted, and therefore, can check the object's BeingDeleted property before acting.

BusyAction  
cancel | {queue}

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callback routines. If there is a callback routine executing, callback routines invoked subsequently always attempt to interrupt it. If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

## `ButtonDownFcn`

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Button press callback routine.* A callback routine that executes whenever you press a mouse button while the pointer is over the patch object.

See the figure's `SelectionType` property to determine if modifier keys were also pressed.

Set this property to a function handle that references the callback. You can also use a string that is a valid MATLAB expression or the name of an M-file. The expressions execute in the MATLAB workspace.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

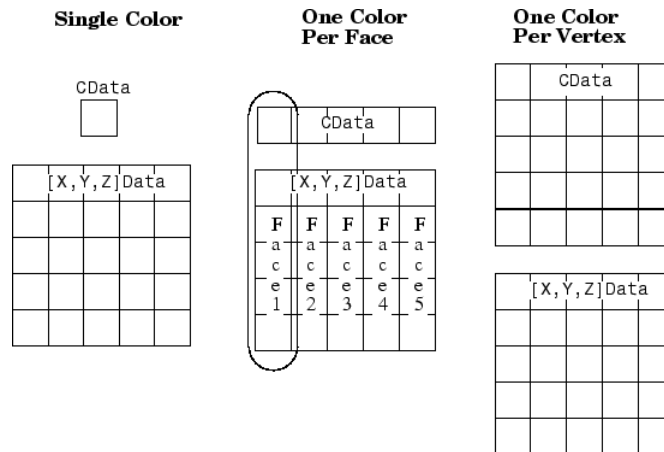
## `CData`

scalar, vector, or matrix

# Patch Properties

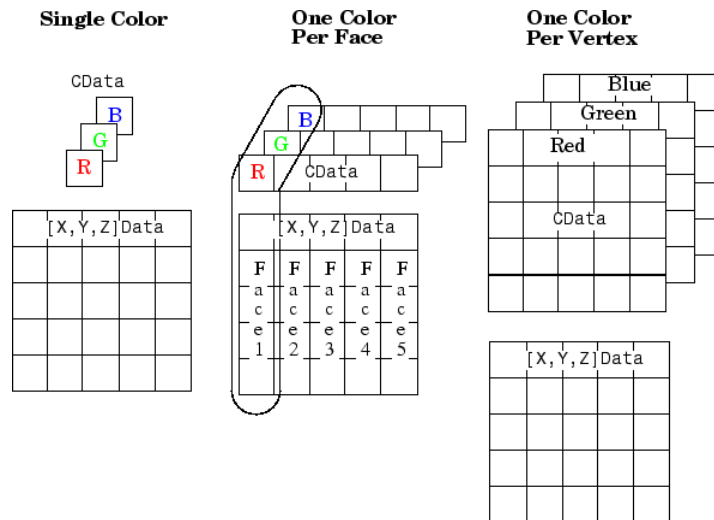
*Patch colors.* This property specifies the color of the patch. You can specify color for each vertex, each face, or a single color for the entire patch. The way MATLAB interprets CData depends on the type of data supplied. The data can be numeric values that are scaled to map linearly into the current colormap, integer values that are used directly as indices into the current colormap, or arrays of RGB values. RGB values are not mapped into the current colormap, but interpreted as the colors defined. On true color systems, MATLAB uses the actual colors defined by the RGB triples.

The following two diagrams illustrate the dimensions of CData with respect to the coordinate data arrays, XData, YData, and ZData. The first diagram illustrates the use of indexed color.



The second diagram illustrates the use of true color. True color requires  $m$ -by- $n$ -by-3 arrays to define red, green, and blue components for each color.





Note that if CData contains NaNs, MATLAB does not color the faces.

See also the Faces, Vertices, and FaceVertexCData properties for an alternative method of patch definition.

CDataMapping  
 {scaled} | direct

*Direct or scaled color mapping.* This property determines how MATLAB interprets indexed color data used to color the patch. (If you use true color specification for CData or FaceVertexCData, this property has no effect.)

- **scaled** — Transform the color data to span the portion of the colormap indicated by the axes CLim property, linearly mapping data values to colors. See the caxis command for more information on this mapping.
- **direct** — Use the color data as indices directly into the colormap. When not scaled, the data are usually integer values

# Patch Properties

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ranging from 1 to `length(colormap)`. MATLAB maps values less than 1 to the first color in the colormap, and values greater than `length(colormap)` to the last color in the colormap. Values with a decimal portion are fixed to the nearest lower integer.

**Children**  
matrix of handles

Always the empty matrix; patch objects have no children.

**Clipping**  
{on} | off

*Clipping to axes rectangle.* When Clipping is on, MATLAB does not display any portion of the patch outside the axes rectangle.

**CreateFcn**  
string or function handle

*Callback routine executed during object creation.* This property defines a callback routine that executes when MATLAB creates a patch object. You must define this property as a default value for patches or in a call to the patch function that creates a new object.

For example, the following statement creates a patch (assuming `x`, `y`, `z`, and `c` are defined), and executes the function referenced by the function handle `@myCreateFcn`.

```
patch(x,y,z,c,'CreateFcn',@myCreateFcn)
```

MATLAB executes the create function after setting all properties for the patch created. Setting this property on an existing patch object has no effect.

The handle of the object whose `CreateFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

DeleteFcn  
string or function handle

*Delete patch callback routine.* A callback routine that executes when you delete the patch object (e.g., when you issue a delete command or clear the axes (cla) or figure (clf) containing the patch). MATLAB executes the routine before deleting the object’s properties so these values are available to the callback routine.

The handle of the object whose DeleteFcn is being executed is accessible only through the root CallbackObject property, which you can query using gcbo.

See Function Handle Callbacks for information on how to use function handles to define the callback function.

DiffuseStrength  
scalar  $\geq 0$  and  $\leq 1$

*Intensity of diffuse light.* This property sets the intensity of the diffuse component of the light falling on the patch. Diffuse light comes from light objects in the axes.

You can also set the intensity of the ambient and specular components of the light on the patch object. See the AmbientStrength and SpecularStrength properties.

DisplayName  
string (default is empty string)

*String used by legend for this patch object.* The legend function uses the string defined by the DisplayName property to label this patch object in the legend.

# Patch Properties

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- If you specify string arguments with the `legend` function, `DisplayName` is set to this patch object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where  $n$  is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call `legend` with the `toggle` or `show` option.

See “Controlling Legends” for more examples.

## EdgeAlpha

`{scalar = 1} | flat | interp`

*Transparency of the edges of patch faces.* This property can be any of the following:

- `scalar` — A single non-`NaN` scalar value between 0 and 1 that controls the transparency of all the edges of the object. 1 (the default) means fully opaque and 0 means completely transparent.
- `flat` — The alpha data (`FaceVertexAlphaData`) of each vertex controls the transparency of the edge that follows it.
- `interp` — Linear interpolation of the alpha data (`FaceVertexAlphaData`) at each vertex determines the transparency of the edge.

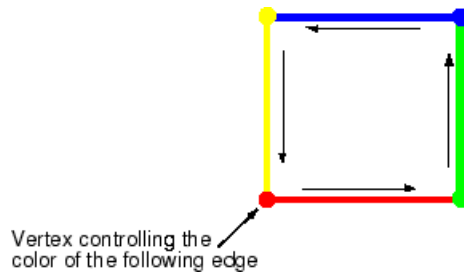
Note that you cannot specify `flat` or `interp` `EdgeAlpha` without first setting `FaceVertexAlphaData` to a matrix containing one alpha value per face (`flat`) or one alpha value per vertex (`interp`).

## EdgeColor

`{ColorSpec} | none | flat | interp`

*Color of the patch edge.* This property determines how MATLAB colors the edges of the individual faces that make up the patch.

- `ColorSpec` — A three-element RGB vector or one of the MATLAB predefined names, specifying a single color for edges. The default edge color is black. See `ColorSpec` for more information on specifying color.
- `none` — Edges are not drawn.
- `flat` — The color of each vertex controls the color of the edge that follows it. This means `flat` edge coloring is dependent on the order in which you specify the vertices:



- `interp` — Linear interpolation of the `CData` or `FaceVertexCData` values at the vertices determines the edge color.

## EdgeLighting

`{none} | flat | gouraud | phong`

*Algorithm used for lighting calculations.* This property selects the algorithm used to calculate the effect of light objects on patch edges. Choices are

# Patch Properties

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- none — Lights do not affect the edges of this object.
- flat — The effect of light objects is uniform across each edge of the patch.
- gouraud — The effect of light objects is calculated at the vertices and then linearly interpolated across the edge lines.
- phong — The effect of light objects is determined by interpolating the vertex normals across each edge line and calculating the reflectance at each pixel. Phong lighting generally produces better results than Gouraud lighting, but takes longer to render.

## EraseMode

{normal} | none | xor | background

*Erase mode.* This property controls the technique MATLAB uses to draw and erase patch objects. Alternative erase modes are useful in creating animated sequences, where control of the way individual objects redraw is necessary to improve performance and obtain the desired effect.

- normal — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- none — Do not erase the patch when it is moved or destroyed. While the object is still visible on the screen after erasing with EraseMode none, you cannot print it because MATLAB stores no information about its former location.
- xor — Draw and erase the patch by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the patch does not damage the color of the objects behind it. However, patch color depends on the color of the screen behind it and is correctly colored only when over the axes background

Color, or the figure background Color if the axes Color is set to none.

- **background** — Erase the patch by drawing it in the axes background Color, or the figure background Color if the axes Color is set to none. This damages objects that are behind the erased patch, but the patch is always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the EraseMode of all objects is normal. This means graphics objects created with EraseMode set to none, xor, or background can look different on screen than on paper. On screen, MATLAB may mathematically combine layers of colors (e.g., perform an XOR of a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

You can use the MATLAB `getframe` command or other screen capture application to create an image of a figure containing nonnormal mode objects.

## FaceAlpha

{scalar = 1} | flat | interp

*Transparency of the patch face.* This property can be any of the following:

- **A scalar** — A single non-NaN value between 0 and 1 that controls the transparency of all the faces of the object. 1 (the default) means fully opaque and 0 means completely transparent (invisible).
- **flat** — The values of the alpha data (`FaceVertexAlphaData`) determine the transparency for each face. The alpha data at the first vertex determines the transparency of the entire face.
- **interp** — Bilinear interpolation of the alpha data (`FaceVertexAlphaData`) at each vertex determines the transparency of each face.

# Patch Properties

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Note that you cannot specify `flat` or `interp` `FaceAlpha` without first setting `FaceVertexAlphaData` to a matrix containing one alpha value per face (`flat`) or one alpha value per vertex (`interp`).

## FaceColor

{ColorSpec} | none | flat | interp

*Color of the patch face.* This property can be any of the following:

- `ColorSpec` — A three-element RGB vector or one of the MATLAB predefined names, specifying a single color for faces. See `ColorSpec` for more information on specifying color.
- `none` — Do not draw faces. Note that edges are drawn independently of faces.
- `flat` — The `CData` or `FaceVertexCData` property must contain one value per face and determines the color for each face in the patch. The color data at the first vertex determines the color of the entire face.
- `interp` — Bilinear interpolation of the color at each vertex determines the coloring of each face. The `CData` or `FaceVertexCData` property must contain one value per vertex.

## FaceLighting

{none} | flat | gouraud | phong

*Algorithm used for lighting calculations.* This property selects the algorithm used to calculate the effect of light objects on patch faces. Choices are

- `none` — Lights do not affect the faces of this object.
- `flat` — The effect of light objects is uniform across the faces of the patch. Select this choice to view faceted objects.
- `gouraud` — The effect of light objects is calculated at the vertices and then linearly interpolated across the faces. Select this choice to view curved surfaces.



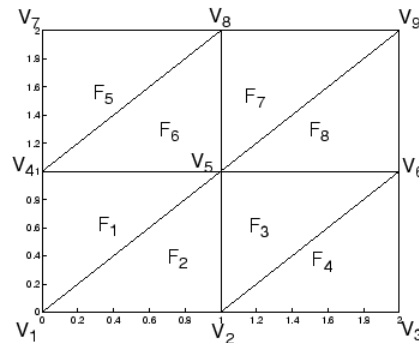
- phong — The effect of light objects is determined by interpolating the vertex normals across each face and calculating the reflectance at each pixel. Select this choice to view curved surfaces. Phong lighting generally produces better results than Gouraud lighting, but takes longer to render.

## Faces

m-by-n matrix

*Vertex connection defining each face.* This property is the connection matrix specifying which vertices in the Vertices property are connected. The Faces matrix defines  $m$  faces with up to  $n$  vertices each. Each row designates the connections for a single face, and the number of elements in that row that are not NaN defines the number of vertices for that face.

The Faces and Vertices properties provide an alternative way to specify a patch that can be more efficient than using  $x$ ,  $y$ , and  $z$  coordinates in most cases. For example, consider the following patch. It is composed of eight triangular faces defined by nine vertices.



Faces property Vertices property

|                |                |                |                |                |                |                |                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| F <sub>1</sub> | V <sub>1</sub> | V <sub>4</sub> | V <sub>5</sub> | V <sub>1</sub> | X <sub>1</sub> | Y <sub>1</sub> | Z <sub>1</sub> |
| F <sub>2</sub> | V <sub>1</sub> | V <sub>5</sub> | V <sub>2</sub> | V <sub>2</sub> | X <sub>2</sub> | Y <sub>2</sub> | Z <sub>2</sub> |
| F <sub>3</sub> | V <sub>2</sub> | V <sub>5</sub> | V <sub>6</sub> | V <sub>3</sub> | X <sub>3</sub> | Y <sub>3</sub> | Z <sub>3</sub> |
| F <sub>4</sub> | V <sub>2</sub> | V <sub>6</sub> | V <sub>3</sub> | V <sub>4</sub> | X <sub>4</sub> | Y <sub>4</sub> | Z <sub>4</sub> |
| F <sub>5</sub> | V <sub>4</sub> | V <sub>7</sub> | V <sub>8</sub> | V <sub>5</sub> | X <sub>5</sub> | Y <sub>5</sub> | Z <sub>5</sub> |
| F <sub>6</sub> | V <sub>4</sub> | V <sub>8</sub> | V <sub>5</sub> | V <sub>6</sub> | X <sub>6</sub> | Y <sub>6</sub> | Z <sub>6</sub> |
| F <sub>7</sub> | V <sub>5</sub> | V <sub>8</sub> | V <sub>9</sub> | V <sub>7</sub> | X <sub>7</sub> | Y <sub>7</sub> | Z <sub>7</sub> |
| F <sub>8</sub> | V <sub>5</sub> | V <sub>9</sub> | V <sub>6</sub> | V <sub>8</sub> | X <sub>8</sub> | Y <sub>8</sub> | Z <sub>8</sub> |
|                |                |                |                | V <sub>9</sub> | X <sub>9</sub> | Y <sub>9</sub> | Z <sub>9</sub> |

The corresponding Faces and Vertices properties are shown to the right of the patch. Note how some faces share vertices with

# Patch Properties

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other faces. For example, the fifth vertex (V5) is used six times, once each by faces one, two, and three and six, seven, and eight. Without sharing vertices, this same patch requires 24 vertex definitions.

FaceVertexAlphaData  
m-by-1 matrix

*Face and vertex transparency data.* The FaceVertexAlphaData property specifies the transparency of patches that have been defined by the Faces and Vertices properties. The interpretation of the values specified for FaceVertexAlphaData depends on the dimensions of the data.

FaceVertexAlphaData can be one of the following:

- A single value, which applies the same transparency to the entire patch. The FaceAlpha property must be set to flat.
- An m-by-1 matrix (where m is the number of rows in the Faces property), which specifies one transparency value per face. The FaceAlpha property must be set to flat.
- An m-by-1 matrix (where m is the number of rows in the Vertices property), which specifies one transparency value per vertex. The FaceAlpha property must be set to interp.

The AlphaDataMapping property determines how MATLAB interprets the FaceVertexAlphaData property values.

FaceVertexCData  
matrix

*Face and vertex colors.* The FaceVertexCData property specifies the color of patches defined by the Faces and Vertices properties. You must also set the values of the FaceColor, EdgeColor, MarkerFaceColor, or MarkerEdgeColor appropriately. The interpretation of the values specified for FaceVertexCData depends on the dimensions of the data.

For indexed colors, `FaceVertexCData` can be

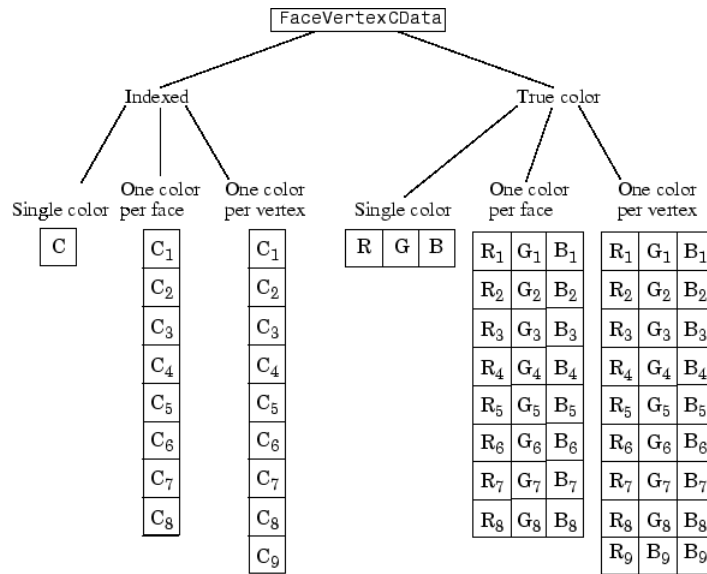
- A single value, which applies a single color to the entire patch
- An  $n$ -by-1 matrix, where  $n$  is the number of rows in the `Faces` property, which specifies one color per face
- An  $n$ -by-1 matrix, where  $n$  is the number of rows in the `Vertices` property, which specifies one color per vertex

For true colors, `FaceVertexCData` can be

- A 1-by-3 matrix, which applies a single color to the entire patch
- An  $n$ -by-3 matrix, where  $n$  is the number of rows in the `Faces` property, which specifies one color per face
- An  $n$ -by-3 matrix, where  $n$  is the number of rows in the `Vertices` property, which specifies one color per vertex

The following diagram illustrates the various forms of the `FaceVertexCData` property for a patch having eight faces and nine vertices. The `CDataMapping` property determines how MATLAB interprets the `FaceVertexCData` property when you specify indexed colors.

# Patch Properties



HandleVisibility  
{on} | callback | off

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. HandleVisibility is useful for preventing command-line users from accidentally drawing into or deleting a figure that contains only user interface devices (such as a dialog box).

Handles are always visible when HandleVisibility is on.

Setting HandleVisibility to callback causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.

Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties).

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

`HitTest`  
{on} | off

*Selectable by mouse click.* `HitTest` determines if the patch can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the patch. If `HitTest` is `off`, clicking the patch selects the object below it (which may be the axes containing it).

`Interruptible`  
{on} | off

# Patch Properties

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*Callback routine interruption mode.* The `Interruptible` property controls whether a patch callback routine can be interrupted by subsequently invoked callback routines. Only callback routines defined for the `ButtonDownFcn` are affected by the `Interruptible` property. MATLAB checks for events that can interrupt a callback routine only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.

`LineStyle`

{-} | -- | : | -. | none

*Edge linestyle.* This property specifies the line style of the patch edges. The following table lists the available line styles.

| Symbol | Line Style           |
|--------|----------------------|
| -      | Solid line (default) |
| --     | Dashed line          |
| :      | Dotted line          |
| -.     | Dash-dot line        |
| none   | No line              |

You can use `LineStyle` `none` when you want to place a marker at each point but do not want the points connected with a line (see the `Marker` property).

`LineWidth`

scalar

*Edge line width.* The width, in points, of the patch edges (1 point =  $\frac{1}{72}$  inch). The default `LineWidth` is 0.5 points.

`Marker`

character (see table)

*Marker symbol.* The Marker property specifies marks that locate vertices. You can set values for the Marker property independently from the LineStyle property. The following tables lists the available markers.

| Marker Specifier | Description                   |
|------------------|-------------------------------|
| +                | Plus sign                     |
| o                | Circle                        |
| *                | Asterisk                      |
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

## MarkerEdgeColor

ColorSpec | none | {auto} | flat

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles).

- ColorSpec — Defines the color to use.
- none — Specifies no color, which makes nonfilled markers invisible.

# Patch Properties

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- auto — Sets MarkerEdgeColor to the same color as the EdgeColor property.

MarkerFaceColor

ColorSpec | {none} | auto | flat

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles).

- ColorSpec — Defines the color to use.
- none — Makes the interior of the marker transparent, allowing the background to show through.
- auto — Sets the fill color to the axes color, or the figure color, if the axes Color property is set to none.

MarkerSize

size in points

*Marker size.* A scalar specifying the size of the marker, in points. The default value for MarkerSize is 6 points (1 point =  $\frac{1}{72}$  inch). Note that MATLAB draws the point marker at  $\frac{1}{3}$  of the specified size.

NormalMode

{auto} | manual

*MATLAB generated or user-specified normal vectors.* When this property is auto, MATLAB calculates vertex normals based on the coordinate data. If you specify your own vertex normals, MATLAB sets this property to manual and does not generate its own data. See also the VertexNormals property.

Parent

handle of axes, hgroup, or hgtransform



*Parent of patch object.* This property contains the handle of the patch object's parent. The parent of a patch object is the axes, hgroup, or hgtransform object that contains it.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

Selected  
on | {off}

*Is object selected?* When this property is on, MATLAB displays selection handles or a dashed box (depending on the number of faces) if the SelectionHighlight property is also on. You can, for example, define the ButtonDownFcn to set this property, allowing users to select the object with the mouse.

SelectionHighlight  
{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by

- Drawing handles at each vertex for a single-faced patch
- Drawing a dashed bounding box for a multifaced patch

When SelectionHighlight is off, MATLAB does not draw the handles.

SpecularColorReflectance  
scalar in the range 0 to 1

*Color of specularly reflected light.* When this property is 0, the color of the specularly reflected light depends on both the color of the object from which it reflects and the color of the light source. When set to 1, the color of the specularly reflected light depends only on the color of the light source (i.e., the light object Color property). The proportions vary linearly for values in between.

# Patch Properties

---

SpecularExponent  
scalar  $\geq 1$

*Harshness of specular reflection.* This property controls the size of the specular spot. Most materials have exponents in the range of 5 to 20.

SpecularStrength  
scalar  $\geq 0$  and  $\leq 1$

*Intensity of specular light.* This property sets the intensity of the specular component of the light falling on the patch. Specular light comes from light objects in the axes.

You can also set the intensity of the ambient and diffuse components of the light on the patch object. See the AmbientStrength and DiffuseStrength properties.

Tag  
string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callback routines.

For example, suppose you use patch objects to create borders for a group of uicontrol objects and want to change the color of the borders in a uicontrol's callback routine. You can specify a Tag with the patch definition

```
patch(X,Y,'k','Tag','PatchBorder')
```

Then use findobj in the uicontrol's callback routine to obtain the handle of the patch and set its FaceColor property.

```
set(findobj('Tag','PatchBorder'),'FaceColor','w')
```

## Type

string (read only)

*Class of the graphics object.* For patch objects, Type is always the string 'patch'.

## UIContextMenu

handle of a uicontextmenu object

*Associate a context menu with the patch.* Assign this property the handle of a uicontextmenu object created in the same figure as the patch. Use the uicontextmenu function to create the context menu. MATLAB displays the context menu whenever you right-click over the patch.

## UserData

matrix

*User-specified data.* Any matrix you want to associate with the patch object. MATLAB does not use this data, but you can access it using set and get.

## VertexNormals

matrix

*Surface normal vectors.* This property contains the vertex normals for the patch. MATLAB generates this data to perform lighting calculations. You can supply your own vertex normal data, even if it does not match the coordinate data. This can be useful to produce interesting lighting effects.

## Vertices

matrix

*Vertex coordinates.* A matrix containing the  $x$ -,  $y$ -,  $z$ -coordinates for each vertex. See the Faces property for more information.

## Visible

{on} | off

# Patch Properties

---

*Patch object visibility.* By default, all patches are visible. When set to off, the patch is not visible, but still exists, and you can query and set its properties.

XData

vector or matrix

*X-coordinates.* The  $x$ -coordinates of the patch vertices. If XData is a matrix, each column represents the  $x$ -coordinates of a single face of the patch. In this case, XData, YData, and ZData must have the same dimensions.

YData

vector or matrix

*Y-coordinates.* The  $y$ -coordinates of the patch vertices. If YData is a matrix, each column represents the  $y$ -coordinates of a single face of the patch. In this case, XData, YData, and ZData must have the same dimensions.

ZData

vector or matrix

*Z-coordinates.* The  $z$ -coordinates of the patch vertices. If ZData is a matrix, each column represents the  $z$ -coordinates of a single face of the patch. In this case, XData, YData, and ZData must have the same dimensions.

## See Also

patch

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | View or change MATLAB directory search path                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>GUI Alternatives</b> | As an alternative to the path function, select <b>File &gt; Set Path</b> to use the Set Path dialog box.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>           | <pre>path path('newpath') path(path,'newpath') path('newpath',path) p = path(...)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Description</b>      | <p>path displays the current MATLAB search path. The initial search path list is defined by toolbox/local/pathdef.m.</p> <p>path('newpath') changes the search path to newpath, where newpath is a string array of directories.</p> <p>path(path,'newpath') adds the newpath directory to the bottom of the current search path. If newpath is already on the path, then path(path,'newpath') moves newpath to the end of the path.</p> <p>path('newpath',path) adds the newpath directory to the top of the current search path. If newpath is already on the path, then path('newpath', path) moves newpath to the beginning of the path.</p> <p>p = path(...) returns the specified path in string variable p.</p> |

---

**Note** Save any M-files you create and any MathWorks supplied M-files that you edit in a directory that is not in the *matlabroot/toolbox* directory tree. If you keep your files in *matlabroot/toolbox* directories, they can be overwritten when you install a new version of MATLAB. Also note that locations of files in the *matlabroot/toolbox* directory tree are loaded and cached in memory at the beginning of each MATLAB session to improve performance. If you save files to *matlabroot/toolbox* directories using an external editor or add or remove files from these directories using file system operations, run `rehash toolbox` before you use the files in the current session. If you make changes to existing files in *matlabroot/toolbox* directories using an external editor, run `clear functionname` before you use the files in the current session. For more information, see the `rehash` reference page or the Toolbox Path Caching topic in the MATLAB Desktop Tools and Development Environment documentation.

---

## Examples

Add a new directory to the search path on Windows.

```
path(path, 'c:/tools/goodstuff')
```

Add a new directory to the search path on UNIX.

```
path(path, '/home/tools/goodstuff')
```

## See Also

`addpath`, `cd`, `dir`, `genpath`, `matlabroot`, `partialpath`, `pathdef`, `pathsep`, `pathtool`, `rehash`, `restoredefaultpath`, `rmpath`, `savepath`, `startup`, `what`

Search Path in the MATLAB Desktop Tools and Development Environment documentation

**Purpose** Save current MATLAB search path to pathdef.m file

**Syntax** path2rc

**Description** path2rc runs savepath. The savepath function is replacing path2rc. Use savepath instead of path2rc and replace instances of path2rc with savepath.

# pathdef

---

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Directories in MATLAB search path                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>GUI Alternatives</b> | As an alternative to the pathdef function, select <b>File &gt; Set Path</b> to use the Set Path dialog box.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Syntax</b>           | pathdef                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Description</b>      | <p>pathdef returns a string listing of the directories in the MATLAB search path. Use path to view each directory in pathdef.m on a separate line.</p> <p>When you start a new session, MATLAB creates the search path defined in the pathdef.m file located in the MATLAB startup directory. If that directory does not contain a pathdef.m file, MATLAB uses the search path defined in <i>matlabroot/toolbox/local/pathdef.m</i>. It modifies the search path using any path statements contained in the startup.m file.</p> <p>Make changes to the path using the <b>Set Path</b> dialog box and addpath and rmpath. While you can edit pathdef.m directly, use caution so you do not accidentally make MATLAB supplied directories unusable. Use savepath to save pathdef.m, and to use that path in future sessions, specify the MATLAB startup directory as its location.</p> |
| <b>See Also</b>         | <p>addpath, cd, dir, genpath, matlabroot, partialpath, path, pathsep, pathtool, rehash, restoredefaultpath, rmpath, savepath, startup, what</p> <p>MATLAB Desktop Tools and Development Environment documentation topics</p> <ul style="list-style-type: none"><li>• How MATLAB Finds the Search Path, pathdef.m</li><li>• Saving Settings to the Path</li><li>• Using the Path in Future Sessions</li><li>• Recovering from Problems with the Search Path</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                 |



|                    |                                                                                                                                                                                                                 |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Path separator for current platform                                                                                                                                                                             |
| <b>Syntax</b>      | <code>c = pathsep</code>                                                                                                                                                                                        |
| <b>Description</b> | <code>c = pathsep</code> returns the path separator character for this platform. The path separator is the character that separates directories in the string returned by the <code>matlabpath</code> function. |
| <b>Examples</b>    | Extract each individual path from the string returned by <code>matlabpath</code> . Use <code>pathsep</code> to define the path separator:                                                                       |

```
s = matlabpath;
p = 1;

while true
    t = strtok(s(p:end), pathsep);
    disp(sprintf('%s', t))
    p = p + length(t) + 1;
    if isempty(strfind(s(p:end),';')) break, end;
end

disp(sprintf('%s', s(p:end)))
```

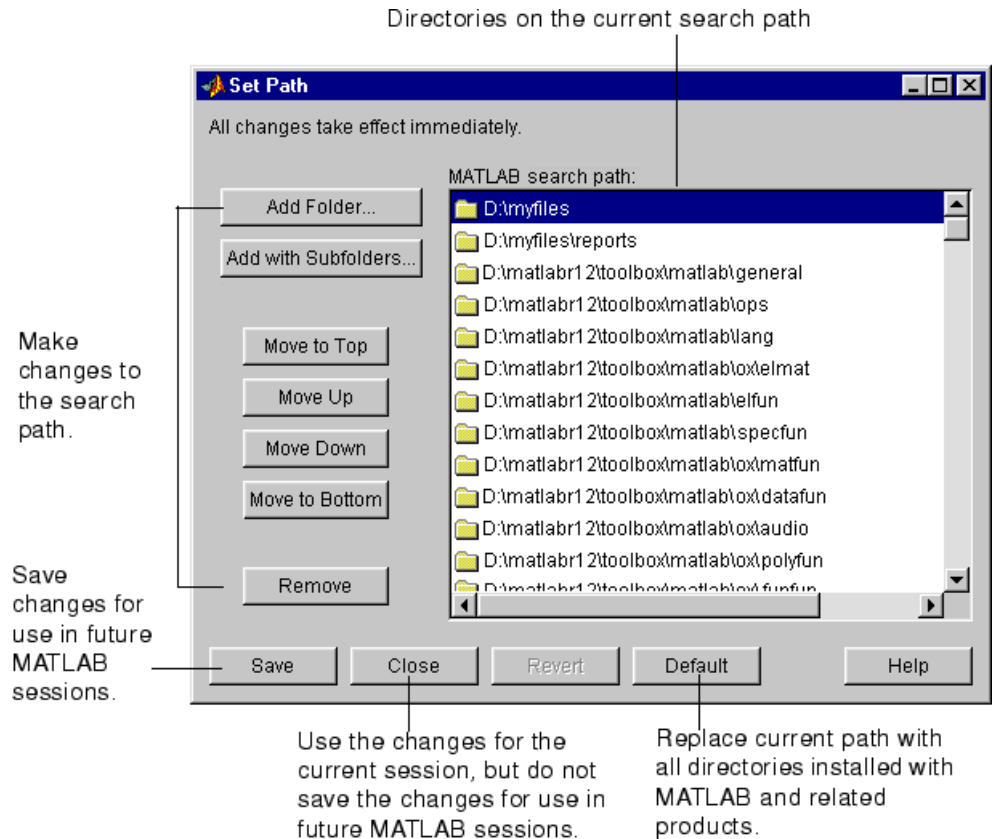
Here is the output:

```
D:\Applications\matlabR14beta2\toolbox\matlab\general
D:\Applications\matlabR14beta2\toolbox\matlab\ops
D:\Applications\matlabR14beta2\toolbox\matlab\lang
D:\Applications\matlabR14beta2\toolbox\matlab\elmat
D:\Applications\matlabR14beta2\toolbox\matlab\elfun
.
.
.
```

|                 |                                                                       |
|-----------------|-----------------------------------------------------------------------|
| <b>See Also</b> | <code>filesep</code> , <code>fullfile</code> , <code>fileparts</code> |
|-----------------|-----------------------------------------------------------------------|

# pathtool

- Purpose** Open Set Path dialog box to view and change MATLAB path
- GUI Alternatives** As an alternative to the `pathtool` function, select **File > Set Path** in the MATLAB desktop.
- Syntax** `pathtool`
- Description** `pathtool` opens the **Set Path** dialog box, a graphical user interface you use to view and modify the MATLAB search path.



## **See Also**

addpath, cd, dir, genpath, matlabroot, partialpath, path, pathdef, pathsep, rehash, restoredefaultpath, rmpath, savepath, startup, what

Search Path topics, including Setting the Search Path, in the MATLAB Desktop Tools and Development Environment documentation

# pause

---

**Purpose** Halt execution temporarily

**Syntax** `pause`  
`pause(n)`  
`pause on`  
`pause off`

**Description** `pause`, by itself, causes M-files to stop and wait for you to press any key before continuing.

`pause(n)` pauses execution for `n` seconds before continuing, where `n` can be any nonnegative real number. The resolution of the clock is platform specific. A fractional pause of 0.01 seconds should be supported on most platforms.

Typing `pause(inf)` puts you into an infinite loop. To return to the MATLAB prompt, type **Ctrl+C**.

`pause on` allows subsequent `pause` commands to pause execution.

`pause off` ensures that any subsequent `pause` or `pause(n)` statements do not pause execution. This allows normally interactive scripts to run unattended.

**Remarks** While MATLAB is paused, the following continue to execute:

- Repainting of figure windows, block diagrams, and Java windows
- HG callbacks from figure windows
- Event handling from Java windows

**See Also** `drawnow`

**Purpose** Set or query plot box aspect ratio

**Syntax**

```
pbaspect
pbaspect([aspect_ratio])
pbaspect('mode')
pbaspect('auto')
pbaspect('manual')
pbaspect(axes_handle,...)
```

**Description** The plot box aspect ratio determines the relative size of the  $x$ -,  $y$ -, and  $z$ -axes.

`pbaspect` with no arguments returns the plot box aspect ratio of the current axes.

`pbaspect([aspect_ratio])` sets the plot box aspect ratio in the current axes to the specified value. Specify the aspect ratio as three relative values representing the ratio of the  $x$ -,  $y$ -, and  $z$ -axes size. For example, a value of `[1 1 1]` (the default) means the plot box is a cube (although with stretch-to-fill enabled, it may not appear as a cube). See Remarks.

`pbaspect('mode')` returns the current value of the plot box aspect ratio mode, which can be either `auto` (the default) or `manual`. See Remarks.

`pbaspect('auto')` sets the plot box aspect ratio mode to `auto`.

`pbaspect('manual')` sets the plot box aspect ratio mode to `manual`.

`pbaspect(axes_handle,...)` performs the set or query on the axes identified by the first argument, `axes_handle`. If you do not specify an axes handle, `pbaspect` operates on the current axes.

**Remarks** `pbaspect` sets or queries values of the axes object `PlotBoxAspectRatio` and `PlotBoxAspectRatioMode` properties.

When the plot box aspect ratio mode is `auto`, MATLAB sets the ratio to `[1 1 1]`, but may change it to accommodate manual settings of the data aspect ratio, camera view angle, or axis limits. See the axes `DataAspectRatio` property for a table listing the interactions between various properties.

Setting a value for the plot box aspect ratio or setting the plot box aspect ratio mode to manual disables the MATLAB stretch-to-fill feature (stretching of the axes to fit the window). This means setting the plot box aspect ratio to its current value,

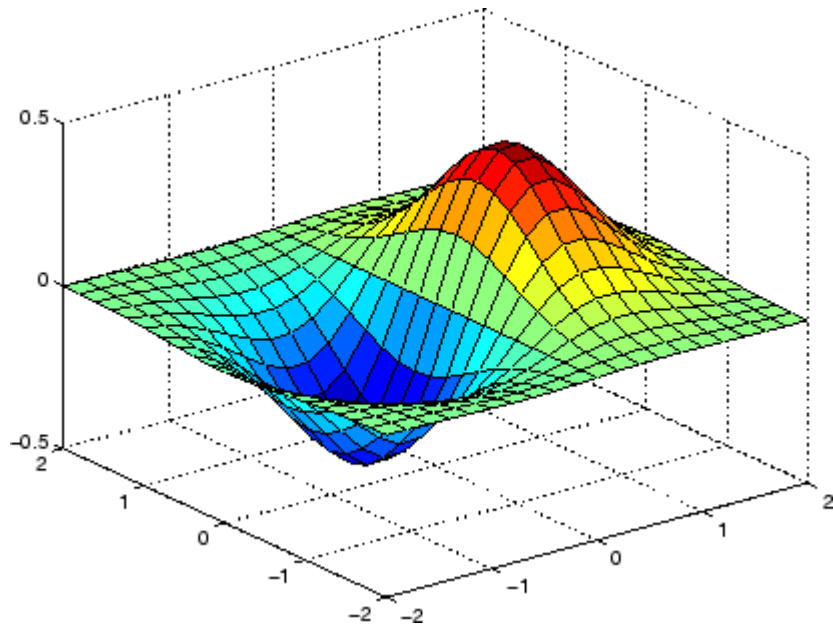
```
pbaspect(pbaspect)
```

can cause a change in the way the graphs look. See the Remarks section of the axes reference description, “Axes Aspect Ratio Properties” in the 3-D Visualization manual, and “Setting Aspect Ratio” in the MATLAB Graphics manual for a discussion of stretch-to-fill.

## Examples

The following surface plot of the function  $z = xe^{-x^2 - y^2}$  is useful to illustrate the plot box aspect ratio. First plot the function over the range  $-2 \leq x \leq 2$ ,  $-2 \leq y \leq 2$ ,

```
[x,y] = meshgrid([-2:.2:2]);  
z = x.*exp(-x.^2 - y.^2);  
surf(x,y,z)
```



Querying the plot box aspect ratio shows that the plot box is square.

```
pbaspect
ans =
    1    1    1
```

It is also interesting to look at the data aspect ratio selected by MATLAB.

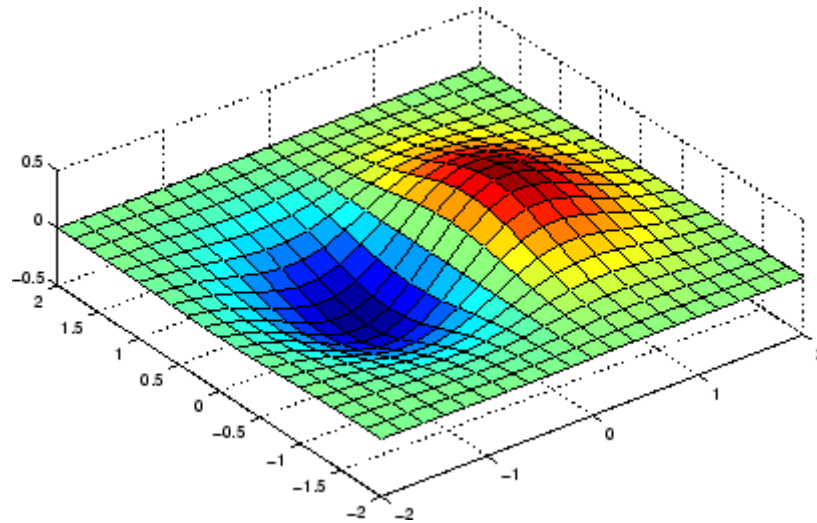
```
daspect
ans =
    4    4    1
```

To illustrate the interaction between the plot box and data aspect ratios, set the data aspect ratio to [1 1 1] and again query the plot box aspect ratio.

```
daspect([1 1 1])
```

# pbaspect

---

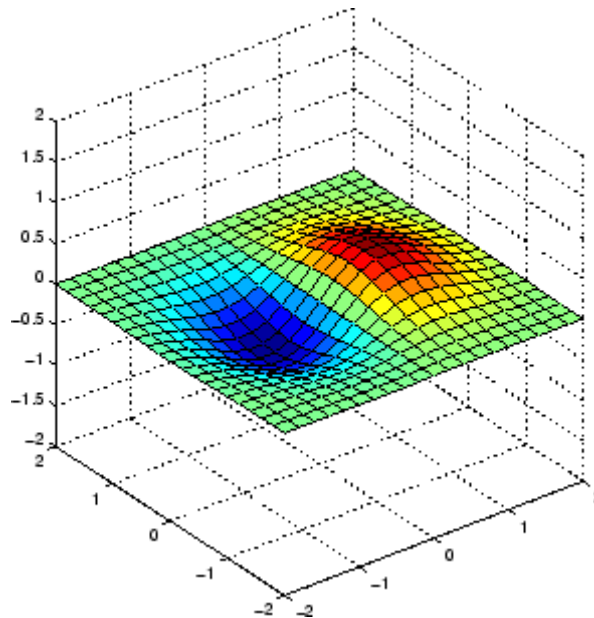


```
pbaspect
ans =
    4    4    1
```

The plot box aspect ratio has changed to accommodate the specified data aspect ratio. Now suppose you want the plot box aspect ratio to be [1 1 1] as well.

```
pbaspect([1 1 1])
```

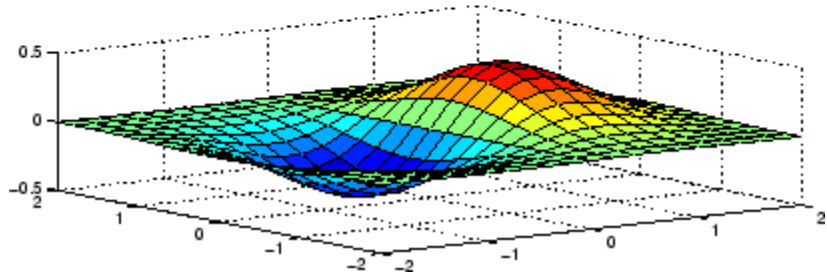
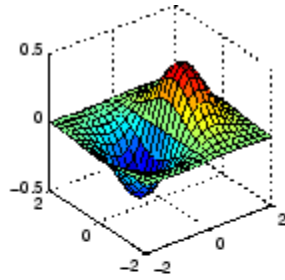




Notice how MATLAB changed the axes limits because of the constraints introduced by specifying both the plot box and data aspect ratios.

You can also use `pbaspect` to disable stretch-to-fill. For example, displaying two subplots in one figure can give surface plots a squashed appearance. Disabling stretch-to-fill,

```
upper_plot = subplot(211);
surf(x,y,z)
lower_plot = subplot(212);
surf(x,y,z)
pbaspect(upper_plot, 'manual')
```



## See Also

`axis`, `daspect`, `xlim`, `ylim`, `zlim`

The axes properties `DataAspectRatio`, `PlotBoxAspectRatio`, `XLim`, `YLim`, `ZLim`

Setting Aspect Ratio in the MATLAB Graphics manual

Axes Aspect Ratio Properties in the 3-D Visualization manual

**Purpose**

Preconditioned conjugate gradients method

**Syntax**

```
x = pcg(A,b)
pcg(A,b,tol)
pcg(A,b,tol,maxit)
pcg(A,b,tol,maxit,M)
pcg(A,b,tol,maxit,M1,M2)
pcg(A,b,tol,maxit,M1,M2,x0)
[x,flag] = pcg(A,b,...)
[x,flag,relres] = pcg(A,b,...)
[x,flag,relres,iter] = pcg(A,b,...)
[x,flag,relres,iter,resvec] = pcg(A,b,...)
```

**Description**

`x = pcg(A,b)` attempts to solve the system of linear equations  $A*x=b$  for  $x$ . The  $n$ -by- $n$  coefficient matrix  $A$  must be symmetric and positive definite, and should also be large and sparse. The column vector  $b$  must have length  $n$ .  $A$  can be a function handle `afun` such that `afun(x)` returns  $A*x$ . See [Function Handles in the MATLAB Programming documentation](#) for more information.

“Parameterizing Functions Called by Function Functions”, in the [MATLAB Mathematics documentation](#), explains how to provide additional parameters to the function `afun`, as well as the preconditioner function `mfun` described below, if necessary.

If `pcg` converges, a message to that effect is displayed. If `pcg` fails to converge after the maximum number of iterations or halts for any reason, a warning message is printed displaying the relative residual  $\text{norm}(b-A*x)/\text{norm}(b)$  and the iteration number at which the method stopped or failed.

`pcg(A,b,tol)` specifies the tolerance of the method. If `tol` is `[]`, then `pcg` uses the default,  $1e-6$ .

`pcg(A,b,tol,maxit)` specifies the maximum number of iterations. If `maxit` is `[]`, then `pcg` uses the default,  $\min(n,20)$ .

`pcg(A,b,tol,maxit,M)` and `pcg(A,b,tol,maxit,M1,M2)` use symmetric positive definite preconditioner  $M$  or  $M = M1*M2$  and

effectively solve the system  $\text{inv}(M) * A * x = \text{inv}(M) * b$  for  $x$ . If  $M$  is `[]` then `pcg` applies no preconditioner.  $M$  can be a function handle `mfun` such that `mfun(x)` returns  $M \backslash x$ .

`pcg(A,b,tol,maxit,M1,M2,x0)` specifies the initial guess. If `x0` is `[]`, then `pcg` uses the default, an all-zero vector.

`[x,flag] = pcg(A,b,...)` also returns a convergence flag.

| Flag | Convergence                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------------------|
| 0    | <code>pcg</code> converged to the desired tolerance <code>tol</code> within <code>maxit</code> iterations.           |
| 1    | <code>pcg</code> iterated <code>maxit</code> times but did not converge.                                             |
| 2    | Preconditioner $M$ was ill-conditioned.                                                                              |
| 3    | <code>pcg</code> stagnated. (Two consecutive iterates were the same.)                                                |
| 4    | One of the scalar quantities calculated during <code>pcg</code> became too small or too large to continue computing. |

Whenever `flag` is not 0, the solution  $x$  returned is that with minimal norm residual computed over all the iterations. No messages are displayed if the `flag` output is specified.

`[x,flag,relres] = pcg(A,b,...)` also returns the relative residual  $\text{norm}(b-A*x)/\text{norm}(b)$ . If `flag` is 0, `relres`  $\leq$  `tol`.

`[x,flag,relres,iter] = pcg(A,b,...)` also returns the iteration number at which  $x$  was computed, where  $0 \leq \text{iter} \leq \text{maxit}$ .

`[x,flag,relres,iter,resvec] = pcg(A,b,...)` also returns a vector of the residual norms at each iteration including  $\text{norm}(b-A*x0)$ .

## Examples

### Example 1

```
n1 = 21;
A = gallery('moler',n1);
b1 = A*ones(n1,1);
tol = 1e-6;
```

```

maxit = 15;
M = diag([10:-1:1 1 1:10]);
[x1,flag1,rr1,iter1,rv1] = pcg(A,b1,tol,maxit,M);

```

Alternatively, you can use the following parameterized matrix-vector product function `afun` in place of the matrix `A`:

```

afun = @(x,n)gallery('moler',n)*x;
n2 = 21;
b2 = afun(ones(n2,1),n2);
[x2,flag2,rr2,iter2,rv2] = pcg(@(x)afun(x,n2),b2,tol,maxit,M);

```

## Example 2

```

A = delsq(numgrid('C',25));
b = ones(length(A),1);
[x,flag] = pcg(A,b)

```

`flag` is 1 because `pcg` does not converge to the default tolerance of  $1e-6$  within the default 20 iterations.

```

R = cholinc(A,1e-3);
[x2,flag2,relres2,iter2,resvec2] = pcg(A,b,1e-8,10,R',R)

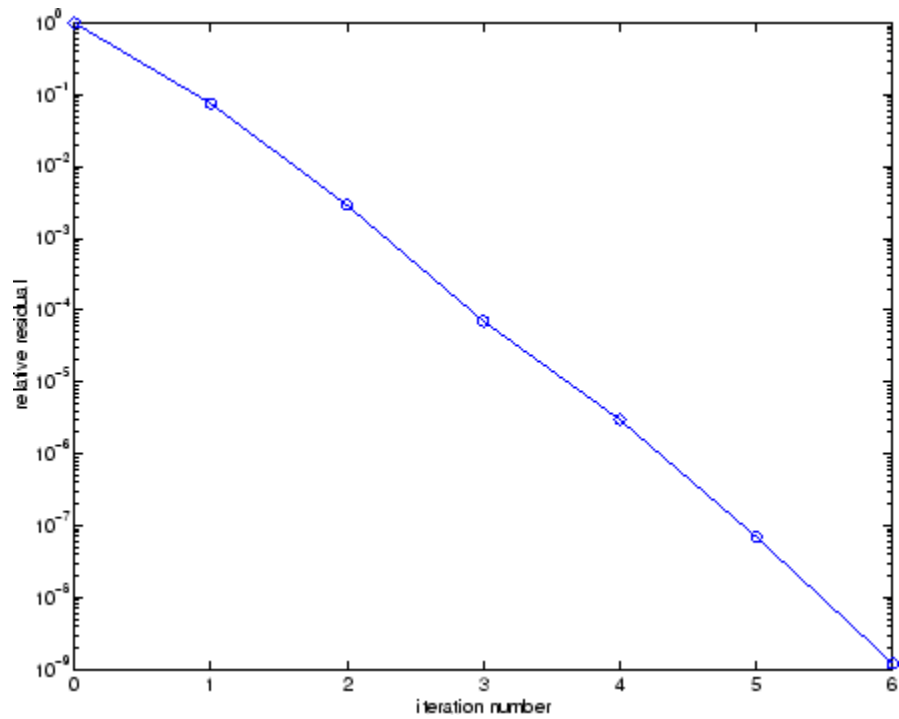
```

`flag2` is 0 because `pcg` converges to the tolerance of  $1.2e-9$  (the value of `relres2`) at the sixth iteration (the value of `iter2`) when preconditioned by the incomplete Cholesky factorization with a drop tolerance of  $1e-3$ . `resvec2(1) = norm(b)` and `resvec2(7) = norm(b-A*x2)`. You can follow the progress of `pcg` by plotting the relative residuals at each iteration starting from the initial estimate (iterate number 0).

```

semilogy(0:iter2,resvec2/norm(b),'-o')
xlabel('iteration number')
ylabel('relative residual')

```



### See Also

bicg, bicgstab, cgs, cholinc, gmres, lsqr, minres, qmr, symmlq  
function\_handle (@), mldivide (\)

### References

[1] Barrett, R., M. Berry, T. F. Chan, et al., *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*, SIAM, Philadelphia, 1994.

**Purpose**

Piecewise Cubic Hermite Interpolating Polynomial (PCHIP)

**Syntax**

```
yi = pchip(x,y,xi)
pp = pchip(x,y)
```

**Description**

`yi = pchip(x,y,xi)` returns vector `yi` containing elements corresponding to the elements of `xi` and determined by piecewise cubic interpolation within vectors `x` and `y`. The vector `x` specifies the points at which the data `y` is given. If `y` is a matrix, then the interpolation is performed for each column of `y` and `yi` is `length(xi)-by-size(y,2)`.

`pp = pchip(x,y)` returns a piecewise polynomial structure for use by `ppval`. `x` can be a row or column vector. `y` is a row or column vector of the same length as `x`, or a matrix with `length(x)` columns.

`pchip` finds values of an underlying interpolating function  $P(x)$  at intermediate points, such that:

- On each subinterval  $x_k \leq x \leq x_{k+1}$ ,  $P(x)$  is the cubic Hermite interpolant to the given values and certain slopes at the two endpoints.
- $P(x)$  interpolates  $y$ , i.e.,  $P(x_j) = y_j$ , and the first derivative  $P'(x)$  is continuous.  $P''(x)$  is probably not continuous; there may be jumps at the  $x_j$ .
- The slopes at the  $x_j$  are chosen in such a way that  $P(x)$  preserves the shape of the data and respects monotonicity. This means that, on intervals where the data are monotonic, so is  $P(x)$ ; at points where the data has a local extremum, so does  $P(x)$ .

---

**Note** If  $y$  is a matrix,  $P(x)$  satisfies the above for each column of  $y$ .

---

## Remarks

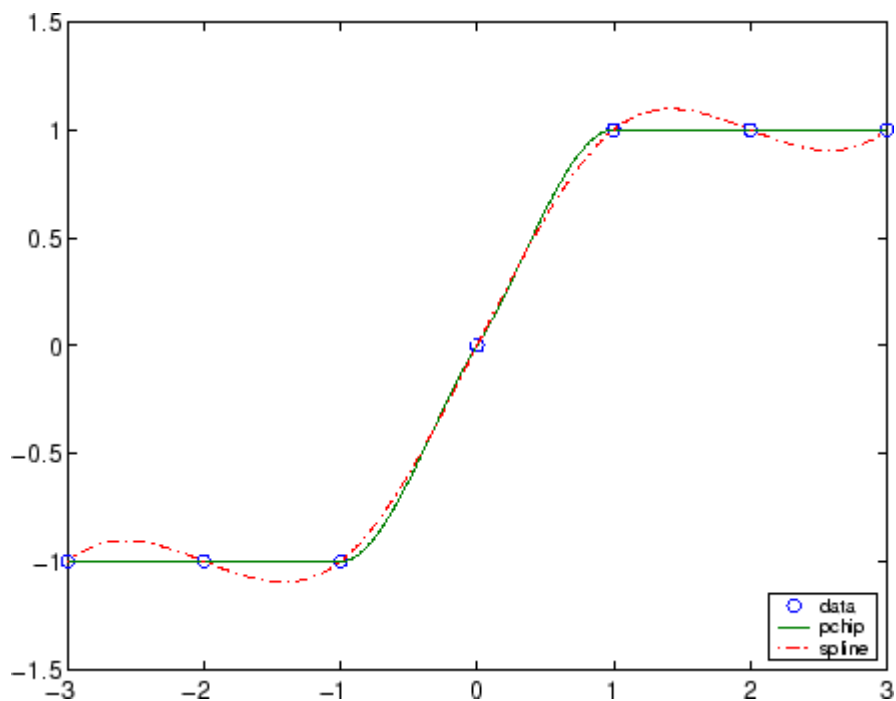
spline constructs  $S(x)$  in almost the same way pchip constructs  $P(x)$ . However, spline chooses the slopes at the  $x_j$  differently, namely to make even  $S''(x)$  continuous. This has the following effects:

- spline produces a smoother result, i.e.  $S''(x)$  is continuous.
- spline produces a more accurate result if the data consists of values of a smooth function.
- pchip has no overshoots and less oscillation if the data are not smooth.
- pchip is less expensive to set up.
- The two are equally expensive to evaluate.

## Examples

```
x = -3:3;
y = [-1 -1 -1 0 1 1 1];
t = -3:.01:3;
p = pchip(x,y,t);
s = spline(x,y,t);
plot(x,y,'o',t,p,'-',t,s,'-.-')
legend('data','pchip','spline',4)
```





## See Also

interp1, spline, ppval

## References

- [1] Fritsch, F. N. and R. E. Carlson, "Monotone Piecewise Cubic Interpolation," *SIAM J. Numerical Analysis*, Vol. 17, 1980, pp.238-246.
- [2] Kahaner, David, Cleve Moler, Stephen Nash, *Numerical Methods and Software*, Prentice Hall, 1988.

# pcode

---

**Purpose** Create prepared pseudocode file (P-file)

**Syntax**

```
pcode fun  
pcode *.m  
pcode fun1 fun2 ...  
pcode... -inplace
```

**Description** `pcode fun` parses the M-file `fun.m` into the P-file `fun.p` and puts it into the current directory. The original M-file can be anywhere on the search path.

`pcode *.m` creates P-files for all the M-files in the current directory.


`pcode fun1 fun2 ...` creates P-files for the listed functions.

`pcode... -inplace` creates P-files in the same directory as the M-files. An error occurs if the files can't be created.

**Purpose** Pseudocolor (checkerboard) plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
pcolor(C)
pcolor(X,Y,C)
pcolor(axes_handles,...)
h = pcolor(...)
```

## Description

A pseudocolor plot is a rectangular array of cells with colors determined by  $C$ . MATLAB creates a pseudocolor plot using each set of four adjacent points in  $C$  to define a surface rectangle (i.e., cell).

The default shading is faceted, which colors each cell with a single color. The last row and column of  $C$  are not used in this case. With shading `interp`, each cell is colored by bilinear interpolation of the colors at its four vertices, using all elements of  $C$ .

The minimum and maximum elements of  $C$  are assigned the first and last colors in the colormap. Colors for the remaining elements in  $C$  are determined by a linear mapping from value to colormap element.

`pcolor(C)` draws a pseudocolor plot. The elements of  $C$  are linearly mapped to an index into the current colormap. The mapping from  $C$  to the current colormap is defined by `colormap` and `caxis`.

`pcolor(X,Y,C)` draws a pseudocolor plot of the elements of  $C$  at the locations specified by  $X$  and  $Y$ . The plot is a logically rectangular, two-dimensional grid with vertices at the points  $[X(i,j), Y(i,j)]$ .  $X$  and  $Y$  are vectors or matrices that specify the spacing of the grid lines. If

X and Y are vectors, X corresponds to the columns of C and Y corresponds to the rows. If X and Y are matrices, they must be the same size as C.

`pcolor(axes_handles,...)` plots into the axes with handle `axes_handle` instead of the current axes (`gca`).

`h = pcolor(...)` returns a handle to a surface graphics object.

## Remarks

A pseudocolor plot is a flat surface plot viewed from above. `pcolor(X,Y,C)` is the same as viewing `surf(X,Y,zeros(size(X)),C)` using `view([0 90])`.

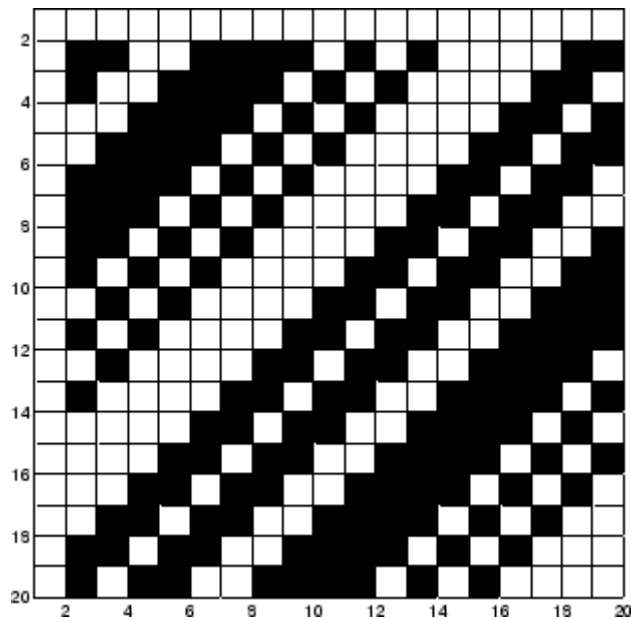
When you use shading `faceted` or shading `flat`, the constant color of each cell is the color associated with the corner having the smallest *x-y* coordinates. Therefore, `C(i,j)` determines the color of the cell in the *i*th row and *j*th column. The last row and column of C are not used.

When you use shading `interp`, each cell's color results from a bilinear interpolation of the colors at its four vertices, and all elements of C are used.

## Examples

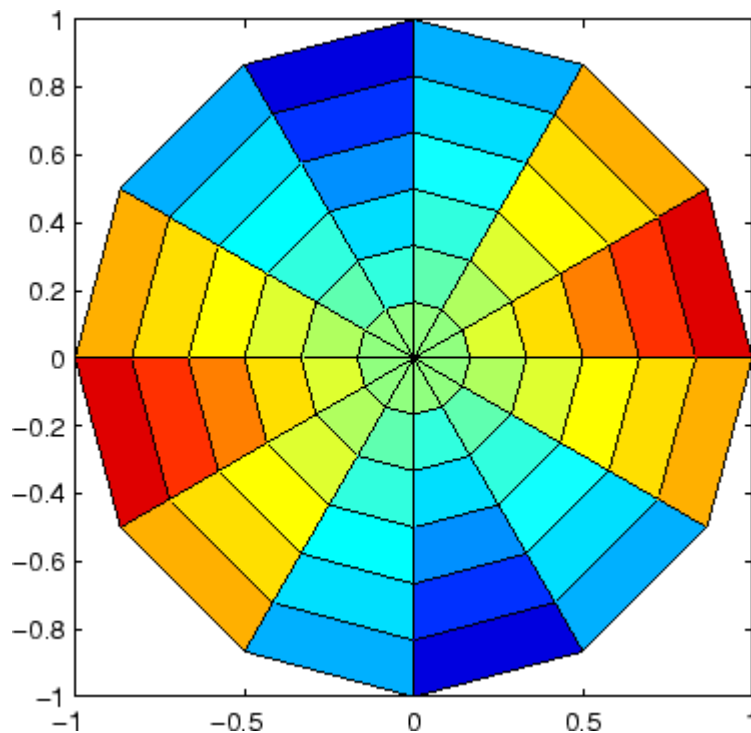
A Hadamard matrix has elements that are +1 and -1. A colormap with only two entries is appropriate when displaying a pseudocolor plot of this matrix.

```
pcolor(hadamard(20))
colormap(gray(2))
axis ij
axis square
```



A simple color wheel illustrates a polar coordinate system.

```
n = 6;  
r = (0:n)'/n;  
theta = pi*(-n:n)/n;  
X = r*cos(theta);  
Y = r*sin(theta);  
C = r*cos(2*theta);  
pcolor(X,Y,C)  
axis equal tight
```



## Algorithm

The number of vertex colors for `pcolor(C)` is the same as the number of cells for `image(C)`. `pcolor` differs from `image` in that `pcolor(C)` specifies the colors of vertices, which are scaled to fit the colormap; changing the axes `clim` property changes this color mapping. `image(C)` specifies the colors of cells and directly indexes into the colormap without scaling. Additionally, `pcolor(X,Y,C)` can produce parametric grids, which is not possible with `image`.

## See Also

`caxis`, `image`, `mesh`, `shading`, `surf`, `view`

**Purpose** Solve initial-boundary value problems for parabolic-elliptic PDEs in 1-D

**Syntax**

```
sol = pdepe(m,pdefun,icfun,bcfun,xmesh,tspan)
sol = pdepe(m,pdefun,icfun,bcfun,xmesh,tspan,options)
```

## Arguments

|         |                                                                                                                                                                                                                                                                                                                                                                           |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| m       | A parameter corresponding to the symmetry of the problem. <i>m</i> can be slab = 0, cylindrical = 1, or spherical = 2.                                                                                                                                                                                                                                                    |
| pdefun  | A handle to a function that defines the components of the PDE.                                                                                                                                                                                                                                                                                                            |
| icfun   | A handle to a function that defines the initial conditions.                                                                                                                                                                                                                                                                                                               |
| bcfun   | A handle to a function that defines the boundary conditions.                                                                                                                                                                                                                                                                                                              |
| xmesh   | A vector [ <i>x</i> <sub>0</sub> , <i>x</i> <sub>1</sub> , ..., <i>x</i> <sub><i>n</i></sub> ] specifying the points at which a numerical solution is requested for every value in <i>tspan</i> . The elements of <i>xmesh</i> must satisfy <i>x</i> <sub>0</sub> < <i>x</i> <sub>1</sub> < ... < <i>x</i> <sub><i>n</i></sub> . The length of <i>xmesh</i> must be >= 3. |
| tspan   | A vector [ <i>t</i> <sub>0</sub> , <i>t</i> <sub>1</sub> , ..., <i>t</i> <sub><i>f</i></sub> ] specifying the points at which a solution is requested for every value in <i>xmesh</i> . The elements of <i>tspan</i> must satisfy <i>t</i> <sub>0</sub> < <i>t</i> <sub>1</sub> < ... < <i>t</i> <sub><i>f</i></sub> . The length of <i>tspan</i> must be >= 3.           |
| options | Some options of the underlying ODE solver are available in pdepe: RelTol, AbsTol, NormControl, InitialStep, and MaxStep. In most cases, default values for these options provide satisfactory solutions. See odeset for details.                                                                                                                                          |

## Description

`sol = pdepe(m,pdefun,icfun,bcfun,xmesh,tspan)` solves initial-boundary value problems for systems of parabolic and elliptic PDEs in the one space variable *x* and time *t*. `pdefun`, `icfun`, and

bcfun are function handles. See “Function Handles” in the MATLAB Programming documentation for more information. The ordinary differential equations (ODEs) resulting from discretization in space are integrated to obtain approximate solutions at times specified in tspan. The pdepe function returns values of the solution on a mesh provided in xmesh.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the functions pdefun, icfun, or bcfun, if necessary.

pdepe solves PDEs of the form:

$$c\left(x, t, u, \frac{\partial u}{\partial x}\right) \frac{\partial u}{\partial t} = x^{-m} \frac{\partial}{\partial x} \left( x^m f\left(x, t, u, \frac{\partial u}{\partial x}\right) \right) + s\left(x, t, u, \frac{\partial u}{\partial x}\right)$$

The PDEs hold for  $t_0 \leq t \leq t_f$  and  $a \leq x \leq b$ . The interval  $[a, b]$  must be finite.  $m$  can be 0, 1, or 2, corresponding to slab, cylindrical, or spherical symmetry, respectively. If  $m > 0$ , then  $a$  must be  $>= 0$ .

In Equation 2-2,  $f(x, t, u, \partial u/\partial x)$  is a flux term and  $s(x, t, u, \partial u/\partial x)$  is a source term. The coupling of the partial derivatives with respect to time is restricted to multiplication by a diagonal matrix  $c(x, t, u, \partial u/\partial x)$ . The diagonal elements of this matrix are either identically zero or positive. An element that is identically zero corresponds to an elliptic equation and otherwise to a parabolic equation. There must be at least one parabolic equation. An element of  $c$  that corresponds to a parabolic equation can vanish at isolated values of  $x$  if those values of  $x$  are mesh points. Discontinuities in  $c$  and/or  $s$  due to material interfaces are permitted provided that a mesh point is placed at each interface.

For  $t = t_0$  and all  $x$ , the solution components satisfy initial conditions of the form

$$u(x, t_0) = u_0(x)$$



(2-3)

For all  $t$  and either  $x = a$  or  $x = b$ , the solution components satisfy a boundary condition of the form

$$p(x, t, u) + q(x, t) f\left(x, t, u, \frac{\partial u}{\partial x}\right) = 0 \quad (2-4)$$

Elements of  $q$  are either identically zero or never zero. Note that the boundary conditions are expressed in terms of the flux  $f$  rather than  $\partial u / \partial x$ . Also, of the two coefficients, only  $p$  can depend on  $u$ .

In the call `sol = pdepe(m, pdefun, icfun, bcfun, xmesh, tspan)`:

- `m` corresponds to  $m$ .
- `xmesh(1)` and `xmesh(end)` correspond to  $a$  and  $b$ .
- `tspan(1)` and `tspan(end)` correspond to  $t_0$  and  $t_f$ .
- `pdefun` computes the terms  $c$ ,  $f$ , and  $s$  (Equation 2-2). It has the form

$$[c, f, s] = pdefun(x, t, u, dudx)$$

The input arguments are scalars  $x$  and  $t$  and vectors  $u$  and  $dudx$  that approximate the solution  $u$  and its partial derivative with respect to  $x$ , respectively.  $c$ ,  $f$ , and  $s$  are column vectors.  $c$  stores the diagonal elements of the matrix  $c$  (Equation 2-2).

- `icfun` evaluates the initial conditions. It has the form

$$u = icfun(x)$$

When called with an argument  $x$ , `icfun` evaluates and returns the initial values of the solution components at  $x$  in the column vector  $u$ .

- `bcfun` evaluates the terms  $p$  and  $q$  of the boundary conditions (Equation 2-4). It has the form

$$[p1, q1, pr, qr] = bcfun(x1, u1, xr, ur, t)$$

$u_l$  is the approximate solution at the left boundary  $x_l = a$  and  $u_r$  is the approximate solution at the right boundary  $x_r = b$ .  $p_l$  and  $q_l$  are column vectors corresponding to  $P$  and  $Q$  evaluated at  $x_l$ , similarly  $p_r$  and  $q_r$  correspond to  $x_r$ . When  $m > 0$  and  $a = 0$ , boundedness of the solution near  $x = 0$  requires that the flux  $f$  vanish at  $a = 0$ . `pdepe` imposes this boundary condition automatically and it ignores values returned in  $p_l$  and  $q_l$ .

`pdepe` returns the solution as a multidimensional array `sol`.  $u_i = u_i = \text{sol}(:, :, i)$  is an approximation to the  $i$ th component of the solution vector  $u$ . The element  $u_i(j, k) = \text{sol}(j, k, i)$  approximates  $u_i$  at  $(t, x) = (\text{tspan}(j), \text{xmesh}(k))$ .

$u_i = \text{sol}(j, :, i)$  approximates component  $i$  of the solution at time  $\text{tspan}(j)$  and mesh points  $\text{xmesh}(:)$ . Use `pdeval` to compute the approximation and its partial derivative  $\partial u_i / \partial x$  at points not included in  $\text{xmesh}$ . See `pdeval` for details.

`sol = pdepe(m, pdefun, icfun, bcfun, xmesh, tspan, options)` solves as above with default integration parameters replaced by values in `options`, an argument created with the `odeset` function. Only some of the options of the underlying ODE solver are available in `pdepe`: `RelTol`, `AbsTol`, `NormControl`, `InitialStep`, and `MaxStep`. The defaults obtained by leaving off the input argument `options` will generally be satisfactory. See `odeset` for details.

## Remarks

- The arrays `xmesh` and `tspan` play different roles in `pdepe`.
  - tspan** – The `pdepe` function performs the time integration with an ODE solver that selects both the time step and formula dynamically. The elements of `tspan` merely specify where you want answers and the cost depends weakly on the length of `tspan`.
  - xmesh** – Second order approximations to the solution are made on the mesh specified in `xmesh`. Generally, it is best to use closely spaced mesh points where the solution changes rapidly. `pdepe` does *not* select the mesh in  $x$  automatically. You must provide an appropriate fixed mesh in `xmesh`. The cost depends strongly on the length of

xmesh. When  $m > 0$ , it is not necessary to use a fine mesh near  $x = 0$  to account for the coordinate singularity.

- The time integration is done with ode15s. pdepe exploits the capabilities of ode15s for solving the differential-algebraic equations that arise when Equation 2-2 contains elliptic equations, and for handling Jacobians with a specified sparsity pattern.
- After discretization, elliptic equations give rise to algebraic equations. If the elements of the initial conditions vector that correspond to elliptic equations are not "consistent" with the discretization, pdepe tries to adjust them before beginning the time integration. For this reason, the solution returned for the initial time may have a discretization error comparable to that at any other time. If the mesh is sufficiently fine, pdepe can find consistent initial conditions close to the given ones. If pdepe displays a message that it has difficulty finding consistent initial conditions, try refining the mesh.

No adjustment is necessary for elements of the initial conditions vector that correspond to parabolic equations.

## Examples

**Example 1.** This example illustrates the straightforward formulation, computation, and plotting of the solution of a single PDE.

$$\pi^2 \frac{\partial u}{\partial t} = \frac{\partial}{\partial x} \left( \frac{\partial u}{\partial x} \right)$$

This equation holds on an interval  $0 \leq x \leq 1$  for times  $t \geq 0$ .

The PDE satisfies the initial condition

$$u(x, 0) = \sin \pi x$$

and boundary conditions

$$u(0, t) \equiv 0$$

$$\pi e^{-t} + \frac{\partial u}{\partial x}(1, t) = 0$$

It is convenient to use subfunctions to place all the functions required by pdepe in a single M-file.

```
function pdex1

m = 0;
x = linspace(0,1,20);
t = linspace(0,2,5);

sol = pdepe(m,@pdex1pde,@pdex1ic,@pdex1bc,x,t);
% Extract the first solution component as u.
u = sol(:,:,1);

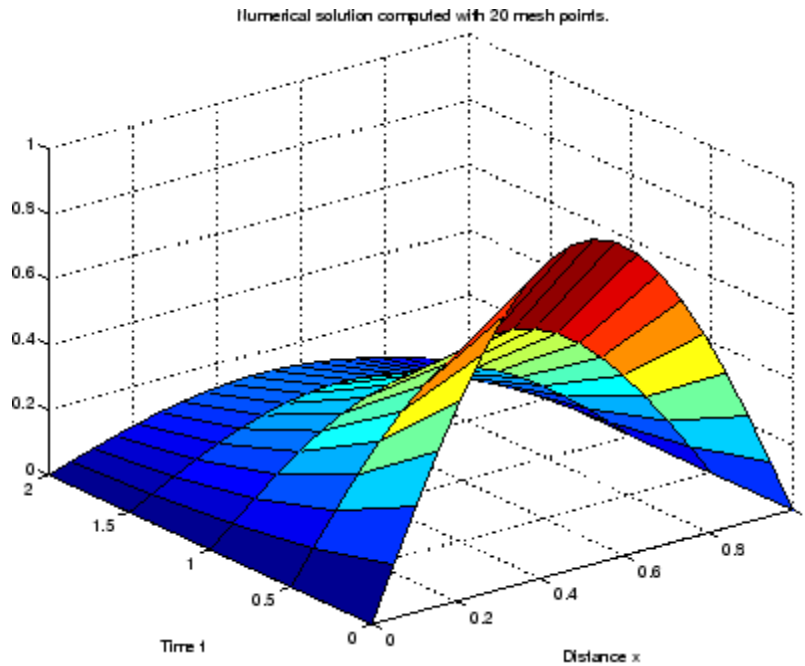
% A surface plot is often a good way to study a solution.
surf(x,t,u)
title('Numerical solution computed with 20 mesh points.')
xlabel('Distance x')
ylabel('Time t')

% A solution profile can also be illuminating.
figure
plot(x,u(end,:))
title('Solution at t = 2')
xlabel('Distance x')
ylabel('u(x,2)')
% -----
function [c,f,s] = pdex1pde(x,t,u,DuDx)
c = pi^2;
f = DuDx;
s = 0;
% -----
function u0 = pdex1ic(x)
u0 = sin(pi*x);
% -----
function [pl,ql,pr,qr] = pdex1bc(xl,ul,xr,ur,t)
pl = ul;
ql = 0;
```

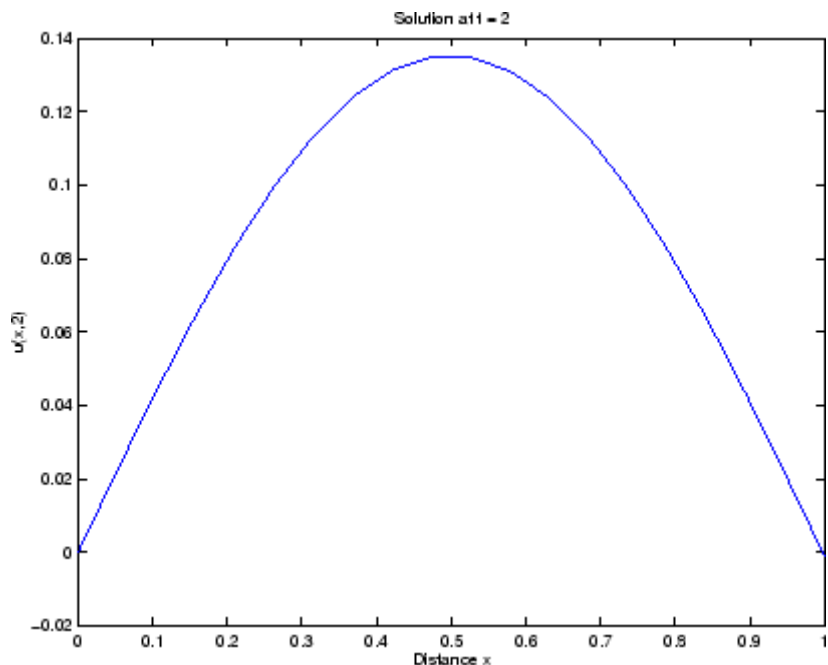
```
pr = pi * exp(-t);  
qr = 1;
```

In this example, the PDE, initial condition, and boundary conditions are coded in subfunctions `pdex1pde`, `pdex1ic`, and `pdex1bc`.

The surface plot shows the behavior of the solution.



The following plot shows the solution profile at the final value of  $t$  (i.e.,  $t = 2$ ).



**Example 2.** This example illustrates the solution of a system of PDEs. The problem has boundary layers at both ends of the interval. The solution changes rapidly for small  $t$ .

The PDEs are

$$\frac{\partial u_1}{\partial t} = 0.024 \frac{\partial^2 u_1}{\partial x^2} - F(u_1 - u_2)$$

$$\frac{\partial u_2}{\partial t} = 0.170 \frac{\partial^2 u_2}{\partial x^2} + F(u_1 - u_2)$$

where  $F(y) = \exp(5.73y) - \exp(-11.46y)$ .

This equation holds on an interval  $0 \leq x \leq 1$  for times  $t \geq 0$ .

The PDE satisfies the initial conditions

$$u_1(x, 0) \equiv 1$$

$$u_2(x, 0) \equiv 0$$

and boundary conditions

$$\frac{\partial u_1}{\partial x}(0, t) \equiv 0$$

$$u_2(0, t) \equiv 0$$

$$u_1(1, t) \equiv 1$$

$$\frac{\partial u_2}{\partial x}(1, t) \equiv 0$$

In the form expected by pdepe, the equations are

$$\begin{bmatrix} 1 \\ 1 \end{bmatrix} \cdot \frac{\partial}{\partial t} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \frac{\partial}{\partial x} \begin{bmatrix} 0.024(\partial u_1 / \partial x) \\ 0.170(\partial u_2 / \partial x) \end{bmatrix} + \begin{bmatrix} -F(u_1 - u_2) \\ F(u_1 - u_2) \end{bmatrix}$$

The boundary conditions on the partial derivatives of  $\mathbf{u}$  have to be written in terms of the flux. In the form expected by pdepe, the left boundary condition is

$$\begin{bmatrix} 0 \\ u_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} \cdot \begin{bmatrix} 0.024(\partial u_1 / \partial x) \\ 0.170(\partial u_2 / \partial x) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

and the right boundary condition is

$$\begin{bmatrix} u_1 - 1 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} .* \begin{bmatrix} 0.024(\partial u_1 / \partial x) \\ 0.170(\partial u_2 / \partial x) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

The solution changes rapidly for small  $t$ . The program selects the step size in time to resolve this sharp change, but to see this behavior in the plots, the example must select the output times accordingly. There are boundary layers in the solution at both ends of [0,1], so the example places mesh points near 0 and 1 to resolve these sharp changes. Often some experimentation is needed to select a mesh that reveals the behavior of the solution.

```
function pdex4
m = 0;
x = [0 0.005 0.01 0.05 0.1 0.2 0.5 0.7 0.9 0.95 0.99 0.995 1];
t = [0 0.005 0.01 0.05 0.1 0.5 1 1.5 2];

sol = pdepe(m,@pdex4pde,@pdex4ic,@pdex4bc,x,t);
u1 = sol(:,:,1);
u2 = sol(:,:,2);

figure
surf(x,t,u1)
title('u1(x,t)')
xlabel('Distance x')
ylabel('Time t')

figure
surf(x,t,u2)
title('u2(x,t)')
xlabel('Distance x')
ylabel('Time t')
% -----
function [c,f,s] = pdex4pde(x,t,u,DuDx)
c = [1; 1];
f = [0.024; 0.17] .* DuDx;
y = u(1) - u(2);
```



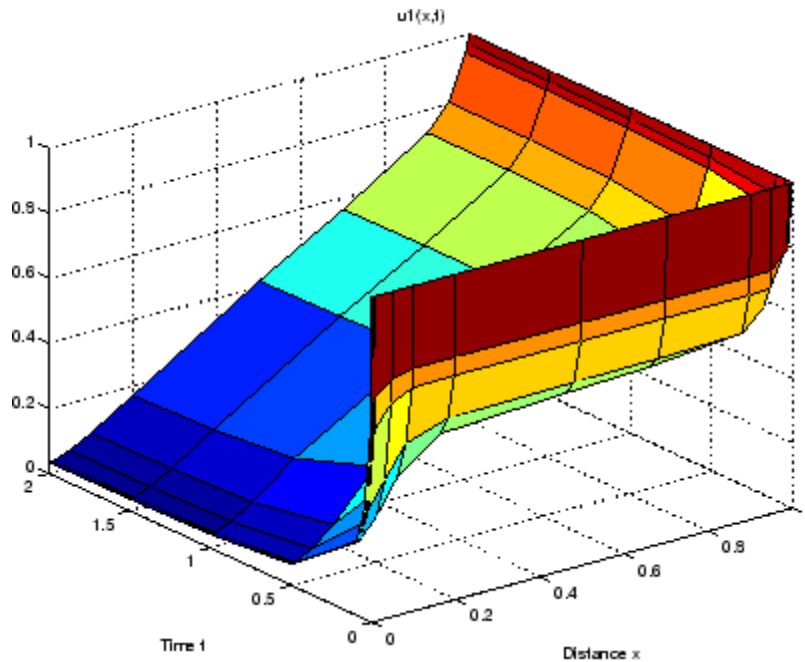
```

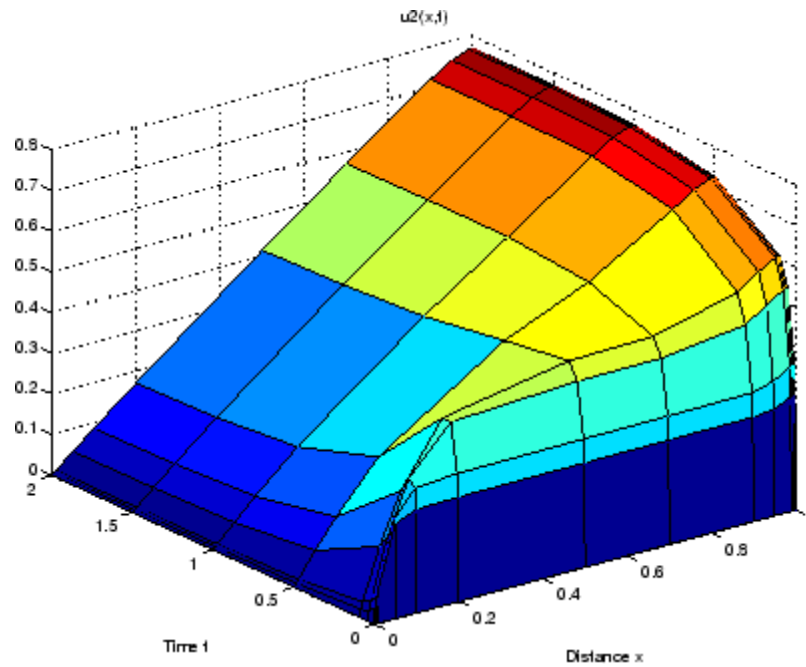
F = exp(5.73*y)-exp(-11.47*y);
s = [-F; F];
% -----
function u0 = pdex4ic(x);
u0 = [1; 0];
% -----
function [pl,q1,pr,qr] = pdex4bc(xl,u1,xr,ur,t)
pl = [0; u1(2)];
q1 = [1; 0];
pr = [ur(1)-1; 0];
qr = [0; 1];

```

In this example, the PDEs, initial conditions, and boundary conditions are coded in subfunctions `pdex4pde`, `pdex4ic`, and `pdex4bc`.

The surface plots show the behavior of the solution components.





## See Also

`function_handle` (@), `pdeval`, `ode15s`, `odeset`, `odeget`

## References

[1] Skeel, R. D. and M. Berzins, "A Method for the Spatial Discretization of Parabolic Equations in One Space Variable," *SIAM Journal on Scientific and Statistical Computing*, Vol. 11, 1990, pp.1-32.

**Purpose** Evaluate numerical solution of PDE using output of pdepe

**Syntax** [uout,duoutdx] = pdeval(m,x,ui,xout)

### Arguments

|       |                                                                                                                                                     |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| m     | Symmetry of the problem: slab = 0, cylindrical = 1, spherical = 2. This is the first input argument used in the call to pdepe.                      |
| xmesh | A vector [x0, x1, ..., xn] specifying the points at which the elements of ui were computed. This is the same vector with which pdepe was called.    |
| ui    | A vector sol(j,:,i) that approximates component i of the solution at time $t_f$ and mesh points xmesh, where sol is the solution returned by pdepe. |
| xout  | A vector of points from the interval [x0,xn] at which the interpolated solution is requested.                                                       |

### Description

[uout,duoutdx] = pdeval(m,x,ui,xout) approximates the solution  $u_i$  and its partial derivative  $\frac{\partial u_i}{\partial x}$  at points from the interval [x0,xn]. The pdeval function returns the computed values in uout and duoutdx, respectively.

---

**Note** pdeval evaluates the partial derivative  $\frac{\partial u_i}{\partial x}$  rather than the flux  $f$ . Although the flux is continuous, the partial derivative may have a jump at a material interface.

---

### See Also

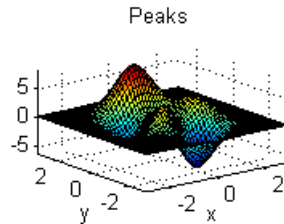
pdepe

# peaks

---

## Purpose

Example function of two variables



## Syntax

```
Z = peaks;  
Z = peaks(n);  
Z = peaks(V);  
Z = peaks(X,Y);
```

```
peaks;  
peaks(N);  
peaks(V);  
peaks(X,Y);
```

```
X,Y,Z] = peaks;  
[X,Y,Z] = peaks(n);  
[X,Y,Z] = peaks(V);
```

## Description

`peaks` is a function of two variables, obtained by translating and scaling Gaussian distributions, which is useful for demonstrating `mesh`, `surf`, `pcolor`, `contour`, and so on.

`Z = peaks;` returns a 49-by-49 matrix.

`Z = peaks(n);` returns an n-by-n matrix.

`Z = peaks(V);` returns an n-by-n matrix, where `n = length(V)`.

`Z = peaks(X,Y);` evaluates `peaks` at the given `X` and `Y` (which must be the same size) and returns a matrix the same size.

`peaks(...)` (with no output argument) plots the peaks function with `surf`.

`[X,Y,Z] = peaks(...)`; returns two additional matrices, `X` and `Y`, for parametric plots, for example, `surf(X,Y,Z,delta(Z))`. If not given as input, the underlying matrices `X` and `Y` are

```
[X,Y] = meshgrid(V,V)
```

where `V` is a given vector, or `V` is a vector of length `n` with elements equally spaced from `-3` to `3`. If no input argument is given, the default `n` is `49`.

**See Also**

`meshgrid`, `surf`

# perl

---

**Purpose** Call Perl script using appropriate operating system executable

**Syntax**

```
perl('perlfile')
perl('perlfile',arg1,arg2,...)
result = perl(...)
```

**Description** `perl('perlfile')` calls the Perl script `perlfile`, using the appropriate operating system Perl executable. Perl is included with MATLAB on Windows systems, and thus MATLAB users can run M-files containing the `perl` function. On Unix systems, MATLAB just calls the Perl interpreter that's available with the OS

`perl('perlfile',arg1,arg2,...)` calls the Perl script `perlfile`, using the appropriate operating system Perl executable, and passes the arguments `arg1`, `arg2`, and so on, to `perlfile`.

`result = perl(...)` returns the results of attempted Perl call to `result`.

**Examples** Given the Perl script, `hello.pl`

```
$input = $ARGV[0];
print "Hello $input.";
```

run the following statement in MATLAB

```
perl('hello.pl','World')
```

MATLAB returns

```
ans =
Hello World.
```

It is sometimes beneficial to use Perl scripts instead of MATLAB code. The `perl` function allows you to run those scripts from within MATLAB. Specific examples where you might choose to use a Perl script include

- Perl script already exists

- Perl script preprocesses data quickly, formatting it in a way more easily read by MATLAB
- Perl has features not supported by MATLAB

**See Also**

! (exclamation point), dos, regexp, system, unix

# perms

---

**Purpose** All possible permutations

**Syntax** `P = perms(v)`

**Description** `P = perms(v)`, where `v` is a row vector of length `n`, creates a matrix whose rows consist of all possible permutations of the `n` elements of `v`. Matrix `P` contains `n!` rows and `n` columns.

**Examples** The command `perms(2:2:6)` returns *all* the permutations of the numbers 2, 4, and 6:

```
6     4     2
6     2     4
4     6     2
4     2     6
2     4     6
2     6     4
```

**Limitations** This function is only practical for situations where `n` is less than about 15.

**See Also** `nchoosek`, `permute`, `randperm`



**Purpose** Rearrange dimensions of N-D array

**Syntax** `B = permute(A,order)`

**Description** `B = permute(A,order)` rearranges the dimensions of `A` so that they are in the order specified by the vector `order`. `B` has the same values of `A` but the order of the subscripts needed to access any particular element is rearranged as specified by `order`. All the elements of `order` must be unique.

**Remarks** `permute` and `ipermute` are a generalization of transpose (`.`' ) for multidimensional arrays.

**Examples** Given any matrix `A`, the statement

```
permute(A,[2 1])
```

is the same as `A'`.

For example:

```
A = [1 2; 3 4]; permute(A,[2 1])
ans =
     1     3
     2     4
```

The following code permutes a three-dimensional array:

```
X = rand(12,13,14);
Y = permute(X,[2 3 1]);
size(Y)
ans =
    13    14    12
```

**See Also** `ipermute`, `circshift`

# persistent

---

**Purpose** Define persistent variable

**Syntax** `persistent X Y Z`

**Description** `persistent X Y Z` defines X, Y, and Z as variables that are local to the function in which they are declared; yet their values are retained in memory between calls to the function. Persistent variables are similar to global variables because MATLAB creates permanent storage for both. They differ from global variables in that persistent variables are known only to the function in which they are declared. This prevents persistent variables from being changed by other functions or from the MATLAB command line.

Persistent variables are cleared when the M-file is cleared from memory or when the M-file is changed. To keep an M-file in memory until MATLAB quits, use `mlock`.

If the persistent variable does not exist the first time you issue the persistent statement, it is initialized to the empty matrix.

It is an error to declare a variable persistent if a variable with the same name exists in the current workspace. MATLAB also errors if you declare any of a function's input or output arguments as persistent within that same function. For example, the following persistent declaration is invalid:

```
function myfun(argA, argB, argC)
persistent argB
```

**Remarks** There is no function form of the persistent command (i.e., you cannot use parentheses and quote the variable names).

**Example** This function prompts a user to enter a directory name to use in locating one or more files. If the user has already entered this information, and it requires no modification, they do not need to enter it again. This is because the function stores it in a persistent variable (`lastDir`), and offers it as the default selection. Here is the function definition:

```
function find_file(file)
persistent lastDir

if isempty(lastDir)
    prompt = 'Enter directory:  ';
else
    prompt = ['Enter directory[' lastDir ']:  '];
end
response = input(prompt, 's');

if ~isempty(response)
    dirName = response;
else
    dirName = lastDir;
end

dir(strcat(dirName, file))
lastDir = dirName;
```

Execute the function twice. The first time, it prompts you to enter the information and does not offer a default:

```
cd(matlabroot)

find_file('is*.m')
Enter directory:  toolbox/matlab/strfun/

iscellstr.m  ischar.m  isletter.m  isspace.m  isstr.m
isstrprop.m
```

The second time, it does offer a default taken from the persistent variable dirName:

```
find_file('is*.m')
Enter directory[toolbox/matlab/strfun/]:
toolbox/matlab/elmat/
```

## **persistent**

---

|                                     |                         |                         |
|-------------------------------------|-------------------------|-------------------------|
| <code>isempty.m</code>              | <code>isfinite.m</code> | <code>isscalar.m</code> |
| <code>isequal.m</code>              | <code>isinf.m</code>    | <code>isvector.m</code> |
| <code>isequalwithequalnans.m</code> | <code>isnan.m</code>    |                         |

### **See Also**

`global`, `clear`, `mislocked`, `mlock`, `munlock`, `isempty`

---

|                    |                                                                                                                                                                 |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Ratio of circle's circumference to its diameter, $\pi$                                                                                                          |
| <b>Syntax</b>      | pi                                                                                                                                                              |
| <b>Description</b> | pi returns the floating-point number nearest the value of $\pi$ . The expressions <code>4*atan(1)</code> and <code>imag(log(-1))</code> provide the same value. |
| <b>Examples</b>    | <p>The expression <code>sin(pi)</code> is not exactly zero because pi is not exactly <math>\pi</math>.</p> <pre>sin(pi)  ans =      1.2246e-16</pre>            |
| <b>See Also</b>    | ans, eps, i, Inf, j, NaN                                                                                                                                        |

# pie


---

## Purpose

Pie chart



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
pie(X)
pie(X,explode)
pie(...,labels)
pie(axes_handle,...)
h = pie(...)
```

## Description

`pie(X)` draws a pie chart using the data in `X`. Each element in `X` is represented as a slice in the pie chart.

`pie(X,explode)` offsets a slice from the pie. `explode` is a vector or matrix of zeros and nonzeros that correspond to `X`. A nonzero value offsets the corresponding slice from the center of the pie chart, so that `X(i,j)` is offset from the center if `explode(i,j)` is nonzero. `explode` must be the same size as `X`.

`pie(...,labels)` specifies text labels for the slices. The number of labels must equal the number of elements in `X`. For example,

```
pie(1:3,{'Taxes','Expenses','Profit'})
```

`pie(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes (`gca`).

`h = pie(...)` returns a vector of handles to patch and text graphics objects.

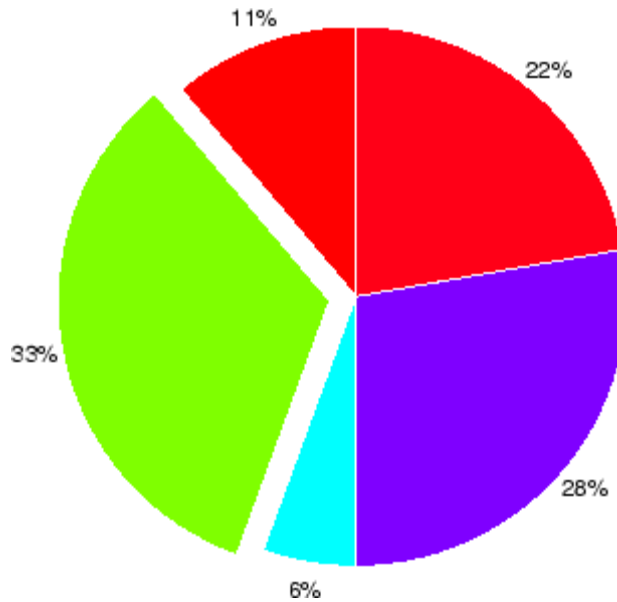
**Remarks**

The values in  $X$  are normalized via  $X/\text{sum}(X)$  to determine the area of each slice of the pie. If  $\text{sum}(X) \leq 1$ , the values in  $X$  directly specify the area of the pie slices. MATLAB draws only a partial pie if  $\text{sum}(X) < 1$ .

**Examples**

Emphasize the second slice in the chart by setting its corresponding explode element to 1.

```
x = [1 3 0.5 2.5 2];  
explode = [0 1 0 0 0];  
pie(x,explode)  
colormap jet
```

**See Also**

pie3


# pie3

---

**Purpose** 3-D pie chart



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
pie3(X)
pie3(X,explode)
pie3(...,labels)
pie3(axes_handle,...)
h = pie3(...)
```

## Description

`pie3(X)` draws a three-dimensional pie chart using the data in `X`. Each element in `X` is represented as a slice in the pie chart.

`pie3(X,explode)` specifies whether to offset a slice from the center of the pie chart. `X(i,j)` is offset from the center of the pie chart if `explode(i,j)` is nonzero. `explode` must be the same size as `X`.

`pie3(...,labels)` specifies text labels for the slices. The number of labels must equal the number of elements in `X`. For example,

```
pie3(1:3,{'Taxes','Expenses','Profit'})
```

`pie3(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes (`gca`).

`h = pie3(...)` returns a vector of handles to patch, surface, and text graphics objects.



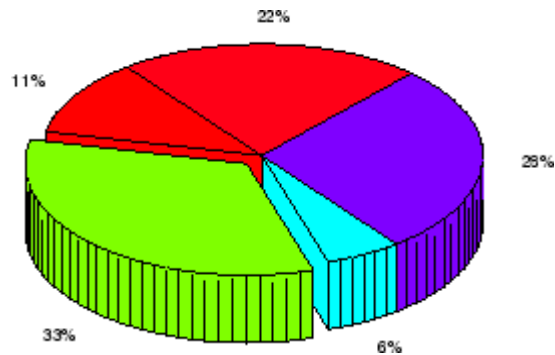
**Remarks**

The values in  $X$  are normalized via  $X/\text{sum}(X)$  to determine the area of each slice of the pie. If  $\text{sum}(X) \leq 1$ , the values in  $X$  directly specify the area of the pie slices. MATLAB draws only a partial pie if  $\text{sum}(X) < 1$ .

**Examples**

Offset a slice in the pie chart by setting the corresponding explode element to 1:

```
x = [1 3 0.5 2.5 2];  
explode = [0 1 0 0 0];  
pie3(x,explode)  
colormap hsv
```

**See Also**

pie

**Purpose** Moore-Penrose pseudoinverse of matrix

**Syntax**  
`B = pinv(A)`  
`B = pinv(A,tol)`

**Definition** The Moore-Penrose pseudoinverse is a matrix  $B$  of the same dimensions as  $A'$  satisfying four conditions:

$A*B*A = A$   
 $B*A*B = B$   
 $A*B$  is Hermitian  
 $B*A$  is Hermitian

The computation is based on `svd(A)` and any singular values less than `tol` are treated as zero.

**Description** `B = pinv(A)` returns the Moore-Penrose pseudoinverse of  $A$ .

`B = pinv(A,tol)` returns the Moore-Penrose pseudoinverse and overrides the default tolerance, `max(size(A))*norm(A)*eps`.

**Examples** If  $A$  is square and not singular, then `pinv(A)` is an expensive way to compute `inv(A)`. If  $A$  is not square, or is square and singular, then `inv(A)` does not exist. In these cases, `pinv(A)` has some of, but not all, the properties of `inv(A)`.

If  $A$  has more rows than columns and is not of full rank, then the overdetermined least squares problem

`minimize norm(A*x-b)`

does not have a unique solution. Two of the infinitely many solutions are

`x = pinv(A)*b`

and

`y = A\b`

These two are distinguished by the facts that  $\text{norm}(x)$  is smaller than the norm of any other solution and that  $y$  has the fewest possible nonzero components.

For example, the matrix generated by

```
A = magic(8); A = A(:,1:6)
```

is an 8-by-6 matrix that happens to have  $\text{rank}(A) = 3$ .

```
A =
    64     2     3    61    60     6
     9    55    54    12    13    51
    17    47    46    20    21    43
    40    26    27    37    36    30
    32    34    35    29    28    38
    41    23    22    44    45    19
    49    15    14    52    53    11
     8    58    59     5     4    62
```

The right-hand side is  $b = 260 \cdot \text{ones}(8, 1)$ ,

```
b =
    260
    260
    260
    260
    260
    260
    260
    260
    260
```

The scale factor 260 is the 8-by-8 magic sum. With all eight columns, one solution to  $A \cdot x = b$  would be a vector of all 1's. With only six columns, the equations are still consistent, so a solution exists, but it is not all 1's. Since the matrix is rank deficient, there are infinitely many solutions. Two of them are

```
x = pinv(A)*b
```

which is

```
x =  
  1.1538  
  1.4615  
  1.3846  
  1.3846  
  1.4615  
  1.1538
```

and

```
y = A\b
```

which produces this result.

```
Warning: Rank deficient, rank = 3  tol =  1.8829e-013.  
y =  
  4.0000  
  5.0000  
   0  
   0  
   0  
 -1.0000
```

Both of these are exact solutions in the sense that  $\text{norm}(A*x-b)$  and  $\text{norm}(A*y-b)$  are on the order of roundoff error. The solution  $x$  is special because

```
norm(x) = 3.2817
```

is smaller than the norm of any other solution, including

```
norm(y) = 6.4807
```

On the other hand, the solution  $y$  is special because it has only three nonzero components.

## See Also

inv, qr, rank, svd

**Purpose** Givens plane rotation

**Syntax** `[G,y] = planerot(x)`

**Description** `[G,y] = planerot(x)` where  $x$  is a 2-component column vector, returns a 2-by-2 orthogonal matrix  $G$  so that  $y = G*x$  has  $y(2) = 0$ .

**Examples**

```
x = [3 4];  
[G,y] = planerot(x')  
  
G =  
    0.6000    0.8000  
   -0.8000    0.6000  
  
y =  
    5  
    0
```

**See Also** `qrdelete`, `qrinsert`

# playshow

---

**Purpose** Run M-file demo (deprecated; use echodemo instead)

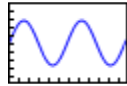
**Syntax** `playshow filename`

**Description** `playshow filename` runs `filename`, which is a demo. Replace `playshow filename` with `echodemo filename`. Note that other arguments supported by `playshow` are not supported by `echodemo`.

**See Also** `demo`, `echodemo`, `helpbrowser`

**Purpose**

2-D line plot

**Contents**

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“See Also” on page 2-2493

**GUI Alternatives**

Use the Plot Selector  to graph selected variables in the Workspace Browser and the Plot Catalog, accessed from the Figure Palette. Directly manipulate graphs in *plot edit* mode, and modify them using the Property Editor. For details, see *Using Plot Edit Mode*, and *The Figure Palette in the MATLAB Graphics documentation*, and also *Creating Graphics from the Workspace Browser in the MATLAB Desktop documentation*.

**Syntax**

```
plot(Y)
plot(X1,Y1,...)
plot(X1,Y1,LineStyle,...)
plot(...,'PropertyName',PropertyValue,...)
plot(axes_handle,...)
h = plot(...)
```

```
hlines = plot('v6',...)
```

## Description

`plot(Y)` plots the columns of  $Y$  versus their index if  $Y$  is a real number. If  $Y$  is complex, `plot(Y)` is equivalent to `plot(real(Y), imag(Y))`. In all other uses of `plot`, the imaginary component is ignored.

`plot(X1, Y1, ...)` plots all lines defined by  $X_n$  versus  $Y_n$  pairs. If only  $X_n$  or  $Y_n$  is a matrix, the vector is plotted versus the rows or columns of the matrix, depending on whether the vector's row or column dimension matches the matrix. If  $X_n$  is a scalar and  $Y_n$  is a vector, disconnected line objects are created and plotted as discrete points vertically at  $X_n$ .

`plot(X1, Y1, LineSpec, ...)` plots all lines defined by the  $X_n, Y_n, \text{LineSpec}$  triples, where `LineSpec` is a line specification that determines line type, marker symbol, and color of the plotted lines. You can mix  $X_n, Y_n, \text{LineSpec}$  triples with  $X_n, Y_n$  pairs:  
`plot(X1, Y1, X2, Y2, LineSpec, X3, Y3)`.

---

**Note** See `LineSpec` for a list of line style, marker, and color specifiers.

---

`plot(..., 'PropertyName', PropertyValue, ...)` sets properties to the specified property values for all lineseries graphics objects created by `plot`. (See the “Examples” on page 2-2490 section for examples.)

`plot(axes_handle, ...)` plots into the axes with the handle `axes_handle` instead of into the current axes (`gca`).

`h = plot(...)` returns a column vector of handles to lineseries graphics objects, one handle per line.

## Backward-Compatible Version

`hlines = plot('v6', ...)` returns the handles to line objects instead of lineseries objects.



---

**Note** The v6 option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See Plot Objects and Backward Compatibility for more information.

## Remarks

### Cycling Through Line Colors and Styles

If you do not specify a color when plotting more than one line, `plot` automatically cycles through the colors in the order specified by the current axes `ColorOrder` property. After cycling through all the colors defined by `ColorOrder`, `plot` then cycles through the line styles defined in the axes `LineStyleOrder` property.

The default `LineStyleOrder` property has a single entry (a solid line with no marker).

By default, MATLAB resets the `ColorOrder` and `LineStyleOrder` properties each time you call `plot`. If you want the changes you make to these properties to persist, you must define these changes as default values. For example,

```
set(0, 'DefaultAxesColorOrder', [0 0 0], ...  
      'DefaultAxesLineStyleOrder', '-|-.|--|:')
```

sets the default `ColorOrder` to use only the color black and sets the `LineStyleOrder` to use solid, dash-dot, dash-dash, and dotted line styles.

### Prevent Resetting of Color and Styles with `hold all`

The `all` option to the `hold` command prevents the `ColorOrder` and `LineStyleOrder` from being reset in subsequent `plot` commands. In the following sequence of commands, MATLAB continues to cycle through the colors defined by the axes `ColorOrder` property (see above).

```
plot(rand(12,2))  
hold all
```

```
plot(randn(12,2))
```

## Additional Information

- See [Creating Line Plots and Annotating Graphs](#) for more information on plotting.
- See [LineStyleSpec](#) for more information on specifying line styles and colors.

## Examples

### Specifying the Color and Size of Markers

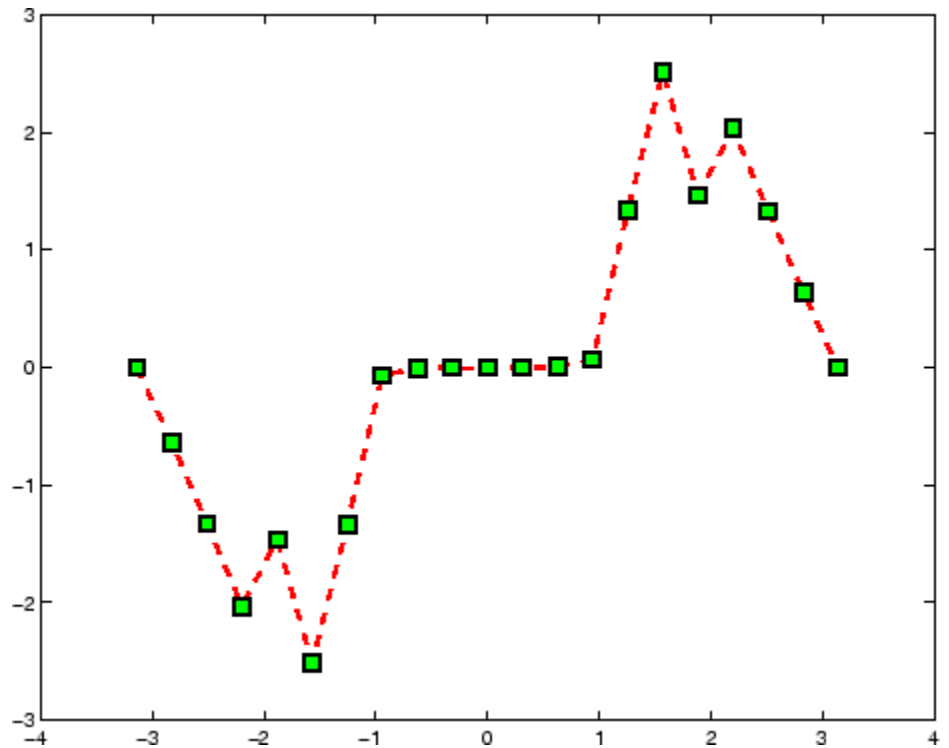
You can also specify other line characteristics using graphics properties (see [line](#) for a description of these properties):

- `LineWidth` — Specifies the width (in points) of the line.
- `MarkerEdgeColor` — Specifies the color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles).
- `MarkerFaceColor` — Specifies the color of the face of filled markers.
- `MarkerSize` — Specifies the size of the marker in units of points.

For example, these statements,

```
x = -pi:pi/10:pi;  
y = tan(sin(x)) - sin(tan(x));  
plot(x,y,'--rs','LineWidth',2,...  
      'MarkerEdgeColor','k',...  
      'MarkerFaceColor','g',...  
      'MarkerSize',10)
```

produce this graph.

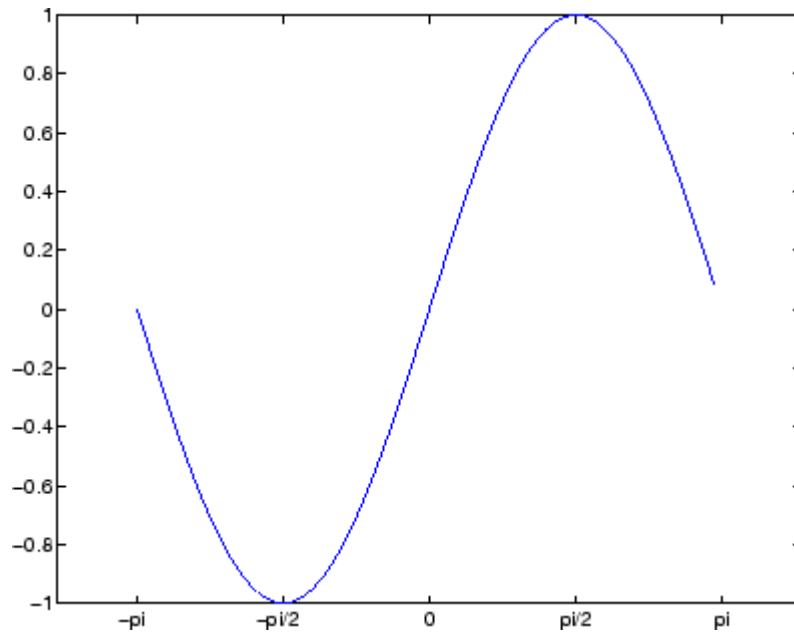


### Specifying Tick-Mark Location and Labeling

You can adjust the axis tick-mark locations and the labels appearing at each tick. For example, this plot of the sine function relabels the  $x$ -axis with more meaningful values:

```
x = -pi:.1:pi;  
y = sin(x);  
plot(x,y)  
set(gca,'XTick',-pi:pi/2:pi)  
set(gca,'XTickLabel',{'-pi','-pi/2','0','pi/2','pi'})
```

Now add axis labels and annotate the point  $-\pi/4, \sin(-\pi/4)$ .



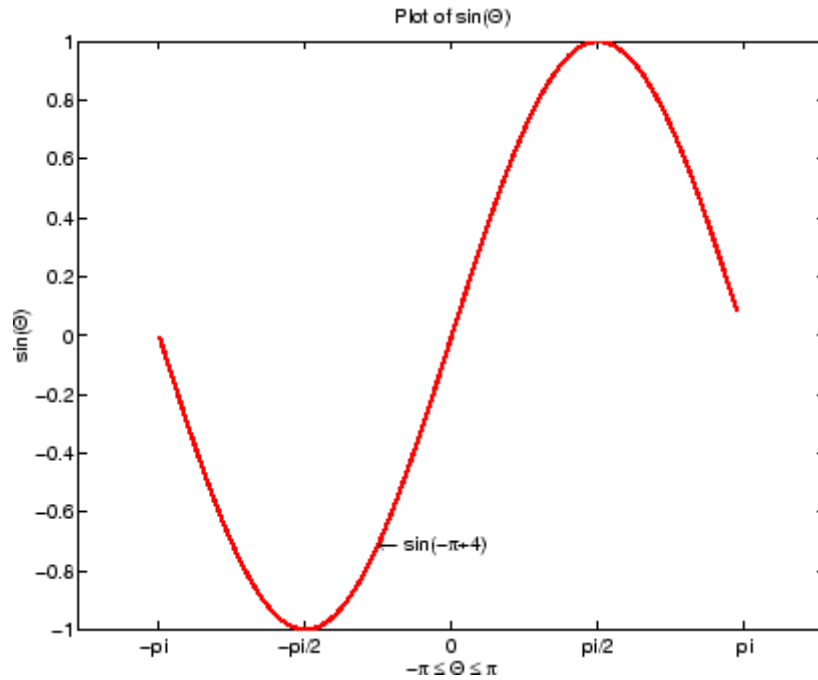
## Adding Titles, Axis Labels, and Annotations

MATLAB enables you to add axis labels and titles. For example, using the graph from the previous example, add an  $x$ - and  $y$ -axis label:

```
xlabel('-\pi \leq \Theta \leq \pi')
ylabel('sin(\Theta)')
title('Plot of sin(\Theta)')
text(-pi/4,sin(-pi/4),'\leftarrow sin(-\pi\div4)',...
     'HorizontalAlignment','left')
```

Now change the line color to red by first finding the handle of the line object created by plot and then setting its `Color` property. In the same statement, set the `LineWidth` property to 2 points.

```
set(findobj(gca,'Type','line','Color',[0 0 1]),...
     'Color','red',...
     'LineWidth',2)
```



## See Also

axis, bar, grid, hold, legend, line, LineSpec, loglog, plot3, plotyy, semilogx, semilogy, subplot, title, xlabel, xlim, ylabel, ylim, zlabel, zlim, stem

See the text String property for a list of symbols and how to display them.

See the Plot Editor for information on plot annotation tools in the figure window toolbar.

See “Basic Plots and Graphs” on page 1-86 for related functions.

# plot (timeseries)

---

## Purpose

Plot time series

## Syntax

```
plot(ts)
plot(tsc.tsname)
plot(function)
```

## Description

`plot(ts)` plots the time-series data against time and interpolates values between samples by using either zero-order-hold ('zoh') or linear interpolation.

`plot(tsc.tsname)` plots the timeseries object `tsname` that is part of the `tscollection tsc`.

`plot(function)` accepts the modifiers used by the MATLAB plotting utility for numerical arrays. These modifiers can be specified as auxiliary inputs for modifying the appearance of the plot. See Examples below.

## Remarks

Time-series events, when defined, are marked in the plot by a red circular marker.

## Examples


`plot(ts, '-r*')` uses a regular line with the color red and marker '\*' to render the plot.

`plot(ts, 'ko', 'MarkerSize', 3)` uses black circular markers of size 3 to render the plot.

**Purpose**

3-D line plot

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
plot3(X1,Y1,Z1,...)
plot3(X1,Y1,Z1,LineStyle,...)
plot3(...,'PropertyName',PropertyValue,...)
h = plot3(...)
```

**Description**

The `plot3` function displays a three-dimensional plot of a set of data points.

`plot3(X1,Y1,Z1,...)`, where  $X1$ ,  $Y1$ ,  $Z1$  are vectors or matrices, plots one or more lines in three-dimensional space through the points whose coordinates are the elements of  $X1$ ,  $Y1$ , and  $Z1$ .

`plot3(X1,Y1,Z1,LineStyle,...)` creates and displays all lines defined by the  $Xn, Yn, Zn, LineSpec$  quads, where `LineStyle` is a line specification that determines line style, marker symbol, and color of the plotted lines.

`plot3(...,'PropertyName',PropertyValue,...)` sets properties to the specified property values for all line graphics objects created by `plot3`.

`h = plot3(...)` returns a column vector of handles to lineseries graphics objects, with one handle per object.

# plot3

---

## Remarks

If one or more of  $X1$ ,  $Y1$ ,  $Z1$  is a vector, the vectors are plotted versus the rows or columns of the matrix, depending whether the vectors' lengths equal the number of rows or the number of columns.

You can mix  $Xn, Yn, Zn$  triples with  $Xn, Yn, Zn, LineSpec$  quads, for example,

```
plot3(X1,Y1,Z1,X2,Y2,Z2,LineSpec,X3,Y3,Z3)
```

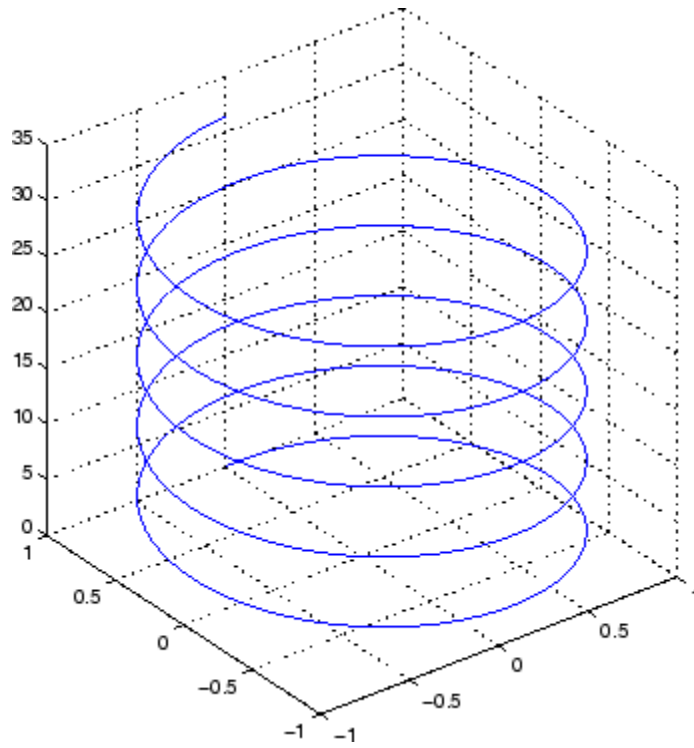
See `LineSpec` and `plot` for information on line types and markers.

## Examples

Plot a three-dimensional helix.

```
t = 0:pi/50:10*pi;  
plot3(sin(t),cos(t),t)  
grid on  
axis square
```





**See Also**

`axis`, `bar3`, `grid`, `line`, `LineStyle`, `loglog`, `plot`, `semilogx`, `semilogy`, `subplot`

**Purpose** Show or hide figure plot browser



## GUI Alternatives

Click the larger **Plotting Tools** icon  on the figure toolbar to collectively enable plotting tools, and the smaller icon  to collectively disable them. Open or close the **Plot Browser** tool from the figure's **View** menu. For details, see “The Plot Browser” in the MATLAB Graphics documentation.

## Syntax

```
plotbrowser('on')  
plotbrowser('off')  
plotbrowser('toggle')  
plotbrowser  
plotbrowser(figure_handle,...)
```

## Description

`plotbrowser('on')` displays the Plot Browser on the current figure.  
`plotbrowser('off')` hides the Plot Browser on the current figure.  
`plotbrowser('toggle')` or `plotbrowser` toggles the visibility of the Plot Browser on the current figure.  
`plotbrowser(figure_handle,...)` shows or hides the Plot Browser on the figure specified by *figure\_handle*.

## See Also

`plottools`, `figurepalette`, `propertyeditor`

**Purpose** Interactively edit and annotate plots

**Syntax**

```

plottedit on
plottedit off
plottedit
plottedit(h)
plottedit('state')
plottedit(h,'state')
```

**Description** `plottedit on` starts plot edit mode for the current figure, allowing you to use a graphical interface to annotate and edit plots easily. In plot edit mode, you can label axes, change line styles, and add text, line, and arrow annotations.

`plottedit off` ends plot mode for the current figure.

`plottedit` toggles the plot edit mode for the current figure.

`plottedit(h)` toggles the plot edit mode for the figure specified by figure handle `h`.

`plottedit('state')` specifies the `plottedit` state for the current figure. Values for `state` can be as shown.

| Value for state | Description                                     |
|-----------------|-------------------------------------------------|
| on              | Starts plot edit mode                           |
| off             | Ends plot edit mode                             |
| showtoolsmenu   | Displays the <b>Tools</b> menu in the menu bar  |
| hidetoolsmenu   | Removes the <b>Tools</b> menu from the menu bar |

**Note** `hidetoolsmenu` is intended for GUI developers who do not want the **Tools** menu to appear in applications that use the figure window.

`plottedit(h, 'state')` specifies the plottedit state for figure handle `h`.

## Remarks

## Plot Editing Mode Graphical Interface Components

To start plot edit mode, click this button.

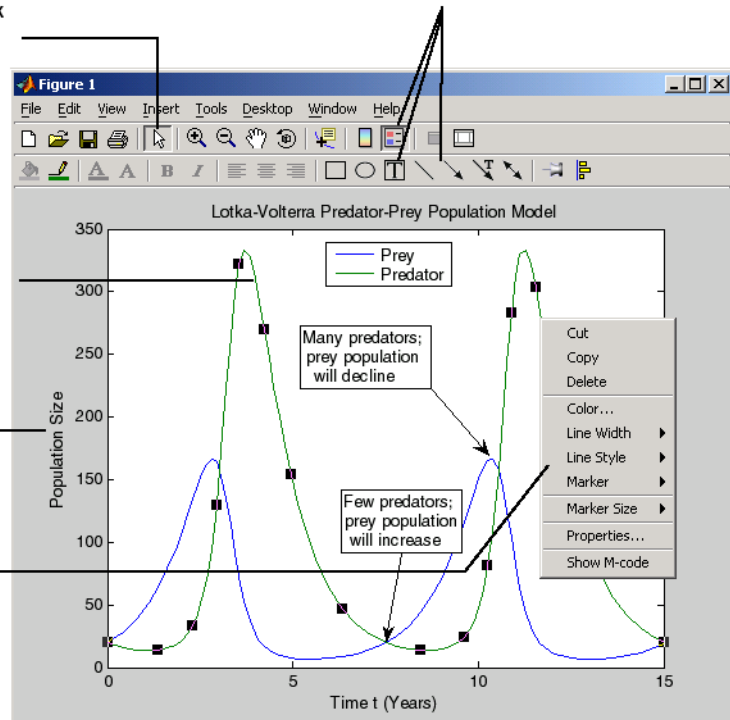
Use the Edit, Insert, and Tools menus to add objects or edit existing objects in a graph.

Double-click on an object to select it.

Position labels, legends, and other objects by clicking and dragging.

Access object-specific plot edit functions through context-sensitive pop-up menus.

Use these toolbar buttons to add a legend, text, and arrows.



## Examples

Start plot edit mode for figure 2.

```
plottedit(2)
```

End plot edit mode for figure 2.

```
plottedit(2, 'off')
```

Hide the **Tools** menu for the current figure:

```
plottedit('hidetoolsmenu')
```

## **See Also**

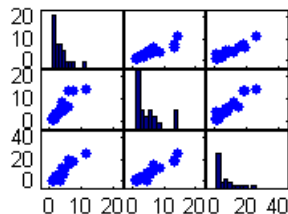
axes, line, open, plot, print, saveas, text, propedit

# plotmatrix

---

## Purpose

Scatter plot matrix



## Syntax

```
plotmatrix(X,Y)
plotmatrix(...,'LineStyle')
[H,AX,BigAx,P] = plotmatrix(...)
```

## Description

`plotmatrix(X,Y)` scatter plots the columns of  $X$  against the columns of  $Y$ . If  $X$  is  $p$ -by- $m$  and  $Y$  is  $p$ -by- $n$ , `plotmatrix` produces an  $n$ -by- $m$  matrix of axes. `plotmatrix(Y)` is the same as `plotmatrix(Y,Y)` except that the diagonal is replaced by `hist(Y(:,i))`.

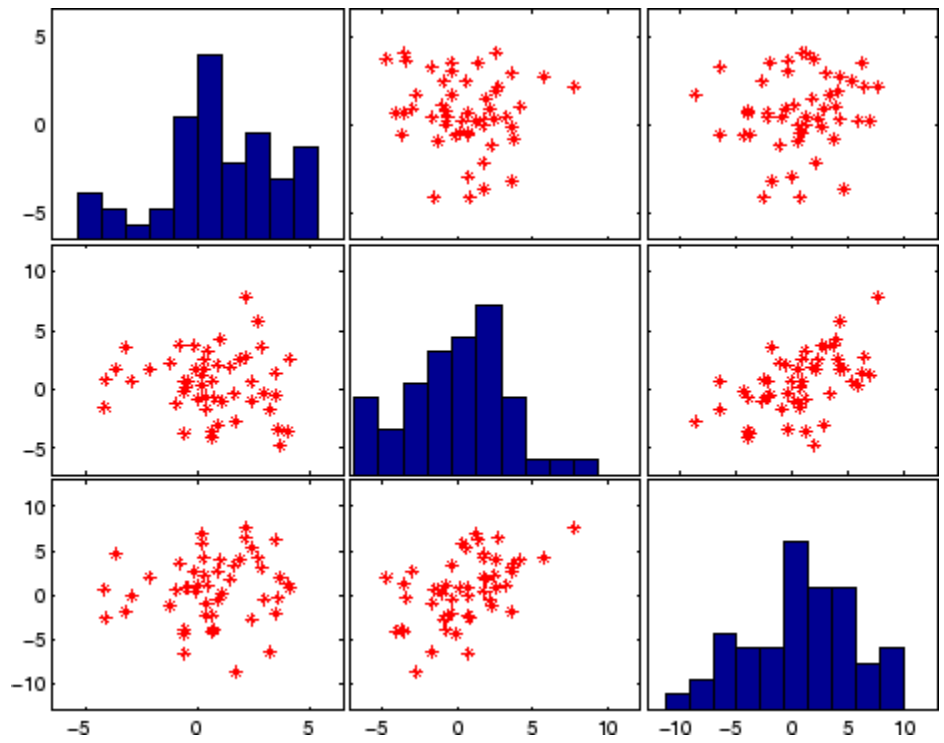
`plotmatrix(...,'LineStyle')` uses a `LineStyle` to create the scatter plot. The default is `'.'`.

`[H,AX,BigAx,P] = plotmatrix(...)` returns a matrix of handles to the objects created in `H`, a matrix of handles to the individual subaxes in `AX`, a handle to a big (invisible) axes that frames the subaxes in `BigAx`, and a matrix of handles for the histogram plots in `P`. `BigAx` is left as the current axes so that a subsequent `title`, `xlabel`, or `ylabel` command is centered with respect to the matrix of axes.

## Examples

Generate plots of random data.

```
x = randn(50,3); y = x*[-1 2 1;2 0 1;1 -2 3]';
plotmatrix(y,'r')
```

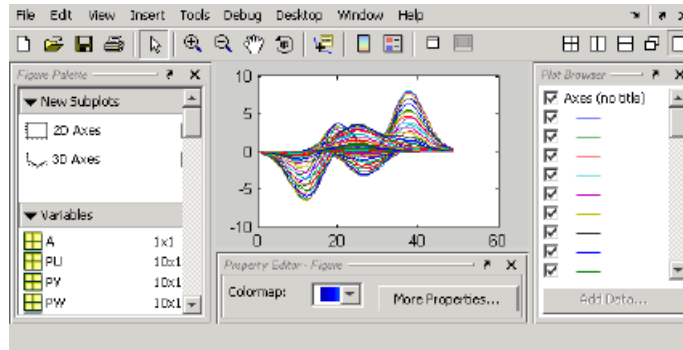


**See Also**



scatter, scatter3

## Purpose

Show or hide plot tools



## GUI Alternatives

Click the larger **Plotting Tools** icon  on the figure toolbar to collectively enable plotting tools, and the smaller icon  to collectively disable them. Individually select the **Figure Palette**, **Plot Browser**, and **Property Editor** tools from the figure's **View** menu. For details, see “Plotting Tools — Interactive Plotting” in the MATLAB Graphics documentation.

## Syntax

```
plottools('on')
plottools('off')
plottools
plottools(figure_handle,...)
plottools(...,'tool')
```

## Description

`plottools('on')` displays the Figure Palette, Plot Browser, and Property Editor on the current figure, configured as you last used them.

`plottools('off')` hides the Figure Palette, Plot Browser, and Property Editor on the current figure.

`plottools` with no arguments, is the same as `plottools('on')`

`plottools(figure_handle,...)` displays or hides the plot tools on the specified figure instead of on the current figure.



`plottools(..., 'tool')` operates on the specified tool only. *tool* can be one of the following strings:

- `figurepalette`
- `plotbrowser`
- `propertyeditor`

---

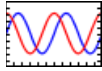
**Note** The first time you open the plotting tools, all three of them appear, grouped around the current figure as shown above. If you close, move, or undock any of the tools, MATLAB remembers the configuration you left them in and restores it when you invoke the tools for subsequent figures, both within and across MATLAB sessions.

---


## See Also

`figurepalette`, `plotbrowser`, `propertyeditor`

**Purpose** 2-D line plots with y-axes on both left and right side



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see “Plotting Tools — Interactive Plotting” in the MATLAB Graphics documentation and “Creating Plots from the Workspace Browser” in the MATLAB Desktop Tools documentation.

## Syntax

```
plotyy(X1,Y1,X2,Y2)
plotyy(X1,Y1,X2,Y2,function)
plotyy(X1,Y1,X2,Y2,'function1','function2')
[AX,H1,H2] = plotyy(...)
```

## Description

`plotyy(X1,Y1,X2,Y2)` plots  $X1$  versus  $Y1$  with  $y$ -axis labeling on the left and plots  $X2$  versus  $Y2$  with  $y$ -axis labeling on the right.

`plotyy(X1,Y1,X2,Y2,function)` uses the specified plotting function to produce the graph.

`function` can be either a function handle or a string specifying `plot`, `semilogx`, `semilogy`, `loglog`, `stem`, or any MATLAB function that accepts the syntax

```
h = function(x,y)
```

For example,

```
plotyy(x1,y1,x2,y2,@loglog) % function handle
plotyy(x1,y1,x2,y2,'loglog') % string
```

Function handles enable you to access user-defined subfunctions and can provide other advantages. See `@` for more information on using function handles.

`plotyy(X1,Y1,X2,Y2,'function1','function2')` uses `function1(X1,Y1)` to plot the data for the left axis and `function2(X2,Y2)` to plot the data for the right axis.

`[AX,H1,H2] = plotyy(...)` returns the handles of the two axes created in `AX` and the handles of the graphics objects from each plot in `H1` and `H2`. `AX(1)` is the left axes and `AX(2)` is the right axes.

## Examples

This example graphs two mathematical functions using `plot` as the plotting function. The two *y*-axes enable you to display both sets of data on one graph even though relative values of the data are quite different.

```
x = 0:0.01:20;
y1 = 200*exp(-0.05*x).*sin(x);
y2 = 0.8*exp(-0.5*x).*sin(10*x);
[AX,H1,H2] = plotyy(x,y1,x,y2,'plot');
```

You can use the handles returned by `plotyy` to label the axes and set the line styles used for plotting. With the axes handles you can specify the `YLabel` properties of the left- and right-side *y*-axis:

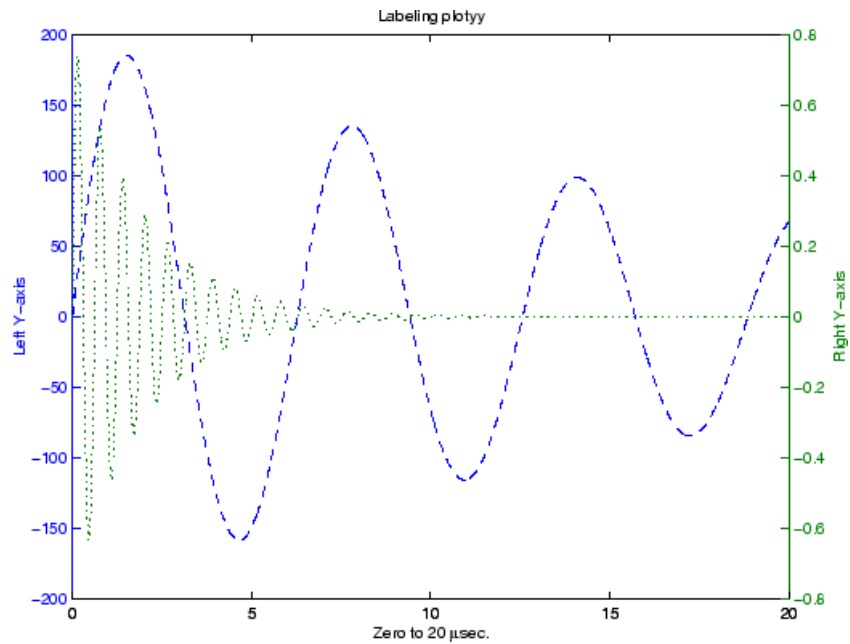
```
set(get(AX(1),'Ylabel'),'String','Slow Decay')
set(get(AX(2),'Ylabel'),'String','Fast Decay')
```

Use the `xlabel` and `title` commands to label the *x*-axis and add a title:

```
xlabel('Time (\musec)')
title('Multiple Decay Rates')
```

Use the line handles to set the `LineStyle` properties of the left- and right-side plots:

```
set(H1,'LineStyle','--')
set(H2,'LineStyle',':')
```



## See Also

plot, loglog, semilogx, semilogy, axes properties XAxisLocation, YAxisLocation

See “Using Multiple X- and Y-Axes” for more information.

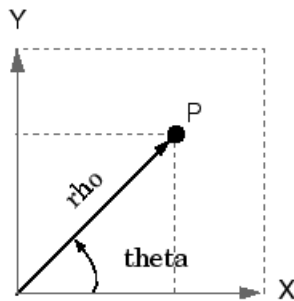
**Purpose** Transform polar or cylindrical coordinates to Cartesian

**Syntax**  
`[X,Y] = pol2cart(THETA,RHO)`  
`[X,Y,Z] = pol2cart(THETA,RHO,Z)`

**Description** `[X,Y] = pol2cart(THETA,RHO)` transforms the polar coordinate data stored in corresponding elements of THETA and RHO to two-dimensional Cartesian, or *xy*, coordinates. The arrays THETA and RHO must be the same size (or either can be scalar). The values in THETA must be in radians.

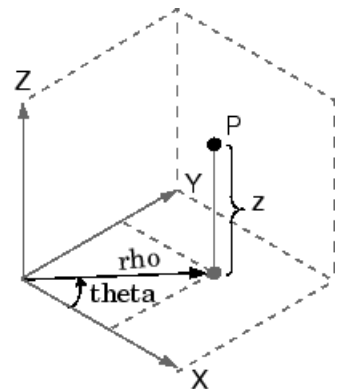
*xyz*, `[X,Y,Z] = pol2cart(THETA,RHO,Z)` transforms the cylindrical coordinate data stored in corresponding elements of THETA, RHO, and Z to three-dimensional Cartesian, or coordinates. The arrays THETA, RHO, and Z must be the same size (or any can be scalar). The values in THETA must be in radians.

**Algorithm** The mapping from polar and cylindrical coordinates to Cartesian coordinates is:



Polar to Cartesian Mapping

$$\begin{aligned} \text{theta} &= \text{atan2}(y,x) \\ \text{rho} &= \text{sqrt}(x.^2 + y.^2) \end{aligned}$$



Cylindrical to Cartesian Mapping

$$\begin{aligned} \text{theta} &= \text{atan2}(y,x) \\ \text{rho} &= \text{sqrt}(x.^2 + y.^2) \\ z &= z \end{aligned}$$

# pol2cart

---


## **See Also**

cart2pol, cart2sph, sph2cart

**Purpose**

Polar coordinate plot

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
polar(theta,rho)
polar(theta,rho,LineStyle)
polar(axes_handle,...)
h = polar(...)
```

**Description**

The `polar` function accepts polar coordinates, plots them in a Cartesian plane, and draws the polar grid on the plane.

`polar(theta,rho)` creates a polar coordinate plot of the angle `theta` versus the radius `rho`. `theta` is the angle from the  $x$ -axis to the radius vector specified in radians; `rho` is the length of the radius vector specified in dataspace units.

`polar(theta,rho,LineStyle)` `LineStyle` specifies the line type, plot symbol, and color for the lines drawn in the polar plot.

`polar(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes (`gca`).

`h = polar(...)` returns the handle of a line object in `h`.

**Remarks**

Negative  $r$  values reflect through the origin, rotating by  $\pi$  (since  $(\theta,r)$  transforms to  $(r\cos(\theta), r\sin(\theta))$ ). If you want different behavior, you can manipulate  $r$  prior to plotting. For example, you can make  $r$  equal to  $\max(0,r)$  or  $\text{abs}(r)$ .

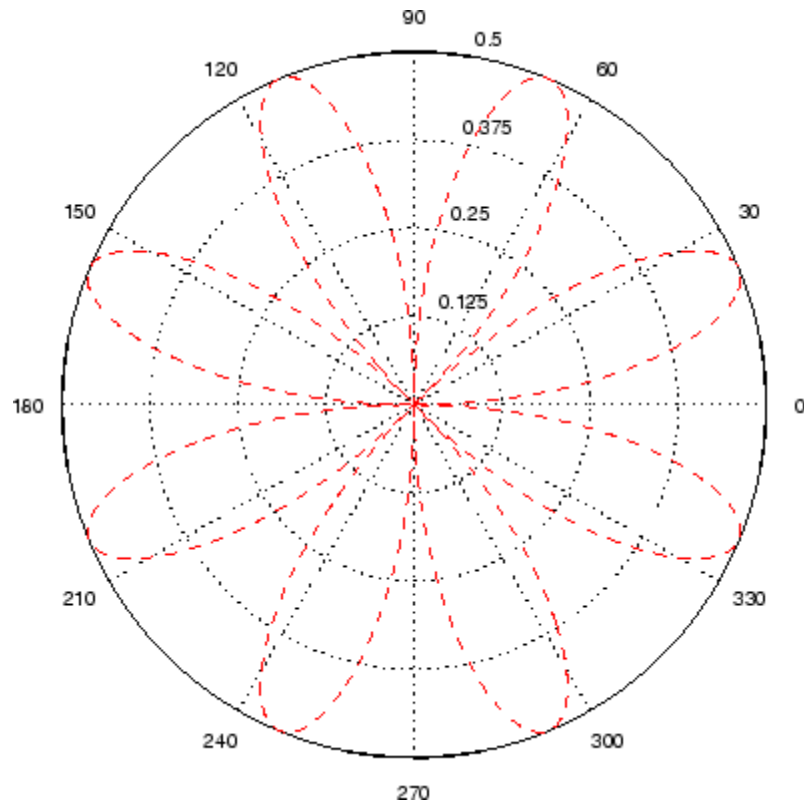
# polar

---

## Examples

Create a simple polar plot using a dashed red line:

```
t = 0:.01:2*pi;  
polar(t,sin(2*t).*cos(2*t),'--r')
```



## See Also

[cart2pol](#), [compass](#), [LineStyle](#), [plot](#), [pol2cart](#), [rose](#)



**Purpose**

Polynomial with specified roots

**Syntax**

`p = poly(A)`  
`p = poly(r)`

**Description**

`p = poly(A)` where  $A$  is an  $n$ -by- $n$  matrix returns an  $n+1$  element row vector whose elements are the coefficients of the characteristic polynomial,  $\det(sl - A)$ . The coefficients are ordered in descending powers: if a vector  $c$  has  $n+1$  components, the polynomial it represents is  $c_1s^n + \dots + c_n s + c_{n+1}$

`p = poly(r)` where  $r$  is a vector returns a row vector whose elements are the coefficients of the polynomial whose roots are the elements of  $r$ .

**Remarks**

Note the relationship of this command to

`r = roots(p)`

which returns a column vector whose elements are the roots of the polynomial specified by the coefficients row vector  $p$ . For vectors, `roots` and `poly` are inverse functions of each other, up to ordering, scaling, and roundoff error.

**Examples**

MATLAB displays polynomials as row vectors containing the coefficients ordered by descending powers. The characteristic equation of the matrix

```
A =
     1     2     3
     4     5     6
     7     8     0
```

is returned in a row vector by `poly`:

```
p = poly(A)
p =
```

```
1 -6 -72 -27
```

The roots of this polynomial (eigenvalues of matrix A) are returned in a column vector by roots:

```
r = roots(p)
```

```
r =
```

```
12.1229  
-5.7345  
-0.3884
```

## Algorithm

The algorithms employed for `poly` and `roots` illustrate an interesting aspect of the modern approach to eigenvalue computation. `poly(A)` generates the characteristic polynomial of A, and `roots(poly(A))` finds the roots of that polynomial, which are the eigenvalues of A. But both `poly` and `roots` use `eig`, which is based on similarity transformations. The classical approach, which characterizes eigenvalues as roots of the characteristic polynomial, is actually reversed.

If A is an n-by-n matrix, `poly(A)` produces the coefficients `c(1)` through `c(n+1)`, with `c(1) = 1`, in

$$\det(\lambda I - A) = c_1 \lambda^n + \dots + c_n \lambda + c_{n+1}$$

The algorithm is

```
z = eig(A);  
c = zeros(n+1,1); c(1) = 1;  
for j = 1:n  
    c(2:j+1) = c(2:j+1) - z(j)*c(1:j);  
end
```

This recursion is easily derived by expanding the product.

$$(\lambda - \lambda_1)(\lambda - \lambda_2) \dots (\lambda - \lambda_n)$$

It is possible to prove that `poly(A)` produces the coefficients in the characteristic polynomial of a matrix within roundoff error of `A`. This is true even if the eigenvalues of `A` are badly conditioned. The traditional algorithms for obtaining the characteristic polynomial, which do not use the eigenvalues, do not have such satisfactory numerical properties.

**See Also**

`conv`, `polyval`, `residue`, `roots`

# polyarea

---

**Purpose** Area of polygon

**Syntax**  
`A = polyarea(X,Y)`  
`A = polyarea(X,Y,dim)`

**Description** `A = polyarea(X,Y)` returns the area of the polygon specified by the vertices in the vectors `X` and `Y`.

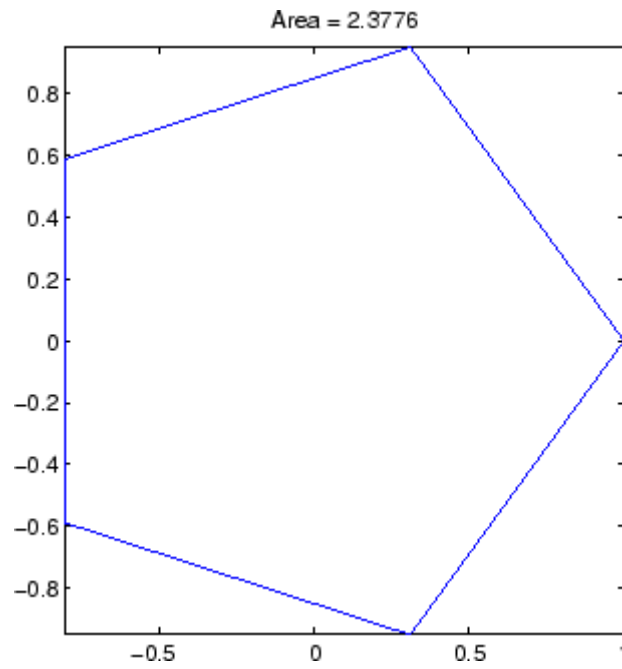
If `X` and `Y` are matrices of the same size, then `polyarea` returns the area of polygons defined by the columns `X` and `Y`.

If `X` and `Y` are multidimensional arrays, `polyarea` returns the area of the polygons in the first nonsingleton dimension of `X` and `Y`.

`A = polyarea(X,Y,dim)` operates along the dimension specified by scalar `dim`.

**Examples**

```
L = linspace(0,2.*pi,6); xv = cos(L)';yv = sin(L)';  
xv = [xv ; xv(1)]; yv = [yv ; yv(1)];  
A = polyarea(xv,yv);  
plot(xv,yv); title(['Area = ' num2str(A)]); axis image
```



**See Also**

convhull, inpolygon, rectint

# polyder

---

**Purpose** Polynomial derivative

**Syntax**  
`k = polyder(p)`  
`k = polyder(a,b)`  
`[q,d] = polyder(b,a)`

**Description** The `polyder` function calculates the derivative of polynomials, polynomial products, and polynomial quotients. The operands `a`, `b`, and `p` are vectors whose elements are the coefficients of a polynomial in descending powers.

`k = polyder(p)` returns the derivative of the polynomial `p`.

`k = polyder(a,b)` returns the derivative of the product of the polynomials `a` and `b`.

`[q,d] = polyder(b,a)` returns the numerator `q` and denominator `d` of the derivative of the polynomial quotient `b/a`.

**Examples** The derivative of the product

$$(3x^2 + 6x + 9)(x^2 + 2x)$$

is obtained with

```
a = [3 6 9];  
b = [1 2 0];  
k = polyder(a,b)  
k =  
    12    36    42    18
```

This result represents the polynomial

$$12x^3 + 36x^2 + 42x + 18$$

**See Also** `conv`, `deconv`

**Purpose**

Polynomial eigenvalue problem

**Syntax**

```
[X,e] = polyeig(A0,A1,...,Ap)
e = polyeig(A0,A1,...,Ap)
[X, e, s] = polyeig(A0,A1,...,AP)
```

**Description**

`[X,e] = polyeig(A0,A1,...,Ap)` solves the polynomial eigenvalue problem of degree  $p$

$$(A_0 + \lambda A_1 + \dots + \lambda^p A_p)x = 0$$

where polynomial degree  $p$  is a non-negative integer, and  $A_0, A_1, \dots, A_p$  are input matrices of order  $n$ . The output consists of a matrix  $X$  of size  $n$ -by- $n \times p$  whose columns are the eigenvectors, and a vector  $e$  of length  $n \times p$  containing the eigenvalues.

If  $\lambda$  is the  $j$ th eigenvalue in  $e$ , and  $x$  is the  $j$ th column of eigenvectors in  $X$ , then  $(A_0 + \lambda A_1 + \dots + \lambda^p A_p)x$  is approximately 0.

`e = polyeig(A0,A1,...,Ap)` is a vector of length  $n \times p$  whose elements are the eigenvalues of the polynomial eigenvalue problem.

`[X, e, s] = polyeig(A0,A1,...,AP)` also returns a vector  $s$  of length  $p \times n$  containing condition numbers for the eigenvalues. At least one of  $A_0$  and  $A_p$  must be nonsingular. Large condition numbers imply that the problem is close to a problem with multiple eigenvalues.

**Remarks**

Based on the values of  $p$  and  $n$ , `polyeig` handles several special cases:

- $p = 0$ , or `polyeig(A)` is the standard eigenvalue problem: `eig(A)`.
- $p = 1$ , or `polyeig(A,B)` is the generalized eigenvalue problem: `eig(A,-B)`.
- $n = 1$ , or `polyeig(a0,a1,...,ap)` for scalars  $a_0, a_1, \dots, a_p$  is the standard polynomial problem: `roots([ap ... a1 a0])`.

If both  $A_0$  and  $A_p$  are singular the problem is potentially ill-posed. Theoretically, the solutions might not exist or might not be unique. Computationally, the computed solutions might be inaccurate. If one, but not both, of  $A_0$  and  $A_p$  is singular, the problem is well posed, but some of the eigenvalues might be zero or infinite.

Note that scaling  $A_0, A_1, \dots, A_p$  to have  $\text{norm}(A_i)$  roughly equal 1 may increase the accuracy of `polyeig`. In general, however, this cannot be achieved. (See Tisseur [3] for more detail.)

## Algorithm

The `polyeig` function uses the QZ factorization to find intermediate results in the computation of generalized eigenvalues. It uses these intermediate results to determine if the eigenvalues are well-determined. See the descriptions of `eig` and `qz` for more on this.

## See Also

`condeig`, `eig`, `qz`

## References

- [1] Dedieu, Jean-Pierre Dedieu and Francoise Tisseur, "Perturbation theory for homogeneous polynomial eigenvalue problems," *Linear Algebra Appl.*, Vol. 358, pp. 71-94, 2003.
- [2] Tisseur, Francoise and Karl Meerbergen, "The quadratic eigenvalue problem," *SIAM Rev.*, Vol. 43, Number 2, pp. 235-286, 2001.
- [3] Francoise Tisseur, "Backward error and condition of polynomial eigenvalue problems" *Linear Algebra Appl.*, Vol. 309, pp. 339-361, 2000.



**Purpose** Polynomial curve fitting

**Syntax**

```
p = polyfit(x,y,n)
[p,S] = polyfit(x,y,n)
[p,S,mu] = polyfit(x,y,n)
```

**Description** `p = polyfit(x,y,n)` finds the coefficients of a polynomial  $p(x)$  of degree  $n$  that fits the data,  $p(x(i))$  to  $y(i)$ , in a least squares sense. The result `p` is a row vector of length  $n+1$  containing the polynomial coefficients in descending powers

$$p(x) = p_1x^n + p_2x^{n-1} + \dots + p_nx + p_{n+1}$$

`[p,S] = polyfit(x,y,n)` returns the polynomial coefficients `p` and a structure `S` for use with `polyval` to obtain error estimates or predictions. Structure `S` contains fields `R`, `df`, and `normr`, for the triangular factor from a QR decomposition of the Vandermonde matrix of `X`, the degrees of freedom, and the norm of the residuals, respectively. If the data `Y` are random, an estimate of the covariance matrix of `P` is  $(R\text{inv}*R\text{inv}')*normr^2/df$ , where `Rinv` is the inverse of `R`. If the errors in the data `y` are independent normal with constant variance, `polyval` produces error bounds that contain at least 50% of the predictions.

`[p,S,mu] = polyfit(x,y,n)` finds the coefficients of a polynomial in

$$\hat{x} = \frac{x - \mu_1}{\mu_2}$$

where  $\mu_1 = \text{mean}(x)$  and  $\mu_2 = \text{std}(x)$ . `mu` is the two-element vector  $[\mu_1, \mu_2]$ . This centering and scaling transformation improves the numerical properties of both the polynomial and the fitting algorithm.

**Examples** This example involves fitting the error function,  $\text{erf}(x)$ , by a polynomial in  $x$ . This is a risky project because  $\text{erf}(x)$  is a bounded function, while polynomials are unbounded, so the fit might not be very good.

First generate a vector of x points, equally spaced in the interval **[0, 2.5]**; then evaluate erf(x) at those points.

```
x = (0: 0.1: 2.5)';  
y = erf(x);
```

The coefficients in the approximating polynomial of degree 6 are

```
p = polyfit(x,y,6)
```

```
p =
```

```
0.0084 -0.0983 0.4217 -0.7435 0.1471 1.1064 0.0004
```

There are seven coefficients and the polynomial is

$$0.0084x^6 - 0.0983x^5 + 0.4217x^4 - 0.7435x^3 + 0.1471x^2 + 1.1064x + 0.0004$$

To see how good the fit is, evaluate the polynomial at the data points with

```
f = polyval(p,x);
```

A table showing the data, fit, and error is

```
table = [x y f y-f]
```

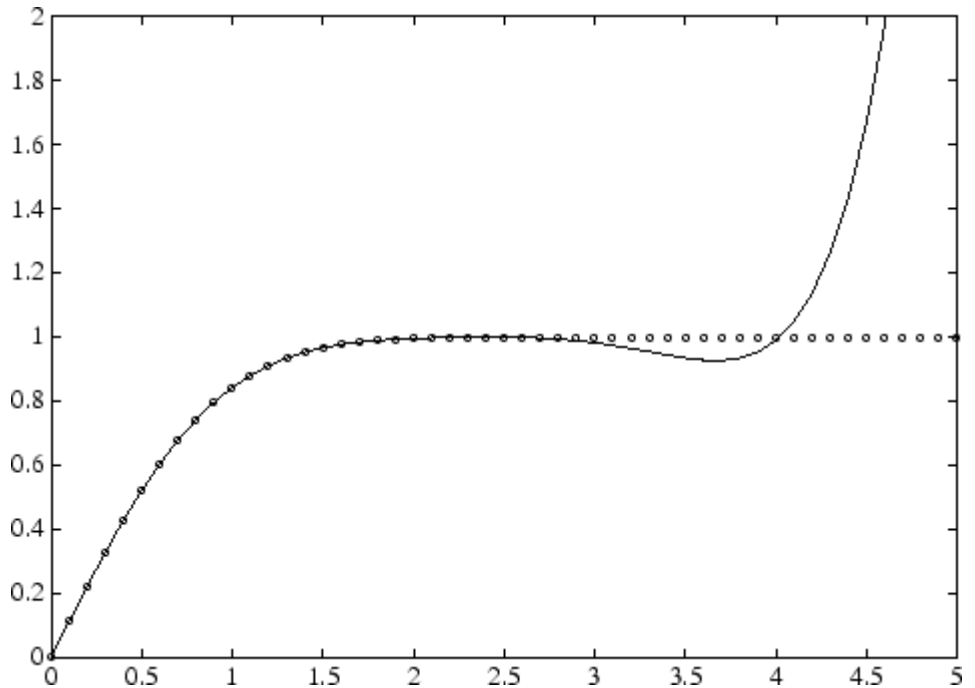
```
table =
```

|        |        |        |         |
|--------|--------|--------|---------|
| 0      | 0      | 0.0004 | -0.0004 |
| 0.1000 | 0.1125 | 0.1119 | 0.0006  |
| 0.2000 | 0.2227 | 0.2223 | 0.0004  |
| 0.3000 | 0.3286 | 0.3287 | -0.0001 |
| 0.4000 | 0.4284 | 0.4288 | -0.0004 |
| ...    |        |        |         |
| 2.1000 | 0.9970 | 0.9969 | 0.0001  |
| 2.2000 | 0.9981 | 0.9982 | -0.0001 |
| 2.3000 | 0.9989 | 0.9991 | -0.0003 |
| 2.4000 | 0.9993 | 0.9995 | -0.0002 |

```
2.5000    0.9996    0.9994    0.0002
```

So, on this interval, the fit is good to between three and four digits. Beyond this interval the graph shows that the polynomial behavior takes over and the approximation quickly deteriorates.

```
x = (0: 0.1: 5)';
y = erf(x);
f = polyval(p,x);
plot(x,y,'o',x,f,'-')
axis([0 5 0 2])
```



## Algorithm

The `polyfit` M-file forms the Vandermonde matrix,  $V$ , whose elements are powers of  $x$ .

# polyfit

---

$$v_{i,j} = x_i^{n-j}$$

It then uses the backslash operator, `\`, to solve the least squares problem

$$Vp \cong y$$

You can modify the M-file to use other functions of  $x$  as the basis functions.

## See Also

`poly`, `polyval`, `roots`

|                    |                                                                                                                                                                                                                                                 |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Integrate polynomial analytically                                                                                                                                                                                                               |
| <b>Syntax</b>      | <code>polyint(p,k)</code><br><code>polyint(p)</code>                                                                                                                                                                                            |
| <b>Description</b> | <code>polyint(p,k)</code> returns a polynomial representing the integral of polynomial <code>p</code> , using a scalar constant of integration <code>k</code> .<br><code>polyint(p)</code> assumes a constant of integration <code>k=0</code> . |
| <b>See Also</b>    | <code>polyder</code> , <code>polyval</code> , <code>polyvalm</code> , <code>polyfit</code>                                                                                                                                                      |

# polyval

---

**Purpose** Polynomial evaluation

**Syntax**  
`y = polyval(p,x)`  
`y = polyval(p,x,[],mu)`  
`[y,delta] = polyval(p,x,S)`  
`[y,delta] = polyval(p,x,S,mu)`

**Description** `y = polyval(p,x)` returns the value of a polynomial of degree  $n$  evaluated at  $x$ . The input argument  $p$  is a vector of length  $n+1$  whose elements are the coefficients in descending powers of the polynomial to be evaluated.

$$y = p_1x^n + p_2x^{n-1} + \dots + p_nx + p_{n+1}$$

$x$  can be a matrix or a vector. In either case, `polyval` evaluates  $p$  at each element of  $x$ .

`y = polyval(p,x,[],mu)` uses  $\hat{x} = (x - \mu_1)/\mu_2$  in place of  $x$ . In this equation,  $\mu_1 = \text{mean}(x)$  and  $\mu_2 = \text{std}(x)$ . The centering and scaling parameters  $\text{mu} = [\mu_1, \mu_2]$  are optional output computed by `polyfit`.

`[y,delta] = polyval(p,x,S)` and `[y,delta] = polyval(p,x,S,mu)` use the optional output structure  $S$  generated by `polyfit` to generate error estimates,  $y \pm \text{delta}$ . If the errors in the data input to `polyfit` are independent normal with constant variance,  $y \pm \text{delta}$  contains at least 50% of the predictions.

**Remarks** The `polyvalm(p,x)` function, with  $x$  a matrix, evaluates the polynomial in a matrix sense. See `polyvalm` for more information.

**Examples** The polynomial  $p(x) = 3x^2 + 2x + 1$  is evaluated at  $x = 5, 7,$  and  $9$  with

```
p = [3 2 1];  
polyval(p,[5 7 9])
```

which results in

```
ans =
```

```
86 162 262
```

For another example, see `polyfit`.

**See Also**

`polyfit`, `polyvalm`

# polyvalm

---

**Purpose** Matrix polynomial evaluation

**Syntax** `Y = polyvalm(p,X)`

**Description** `Y = polyvalm(p,X)` evaluates a polynomial in a matrix sense. This is the same as substituting matrix `X` in the polynomial `p`.

Polynomial `p` is a vector whose elements are the coefficients of a polynomial in descending powers, and `X` must be a square matrix.

## Examples

The Pascal matrices are formed from Pascal's triangle of binomial coefficients. Here is the Pascal matrix of order 4.

```
X = pascal(4)
X =
     1     1     1     1
     1     2     3     4
     1     3     6    10
     1     4    10    20
```

Its characteristic polynomial can be generated with the `poly` function.

```
p = poly(X)
p =
     1    -29     72    -29     1
```

This represents the polynomial  $x^4 - 29x^3 + 72x^2 - 29x + 1$ .

Pascal matrices have the curious property that the vector of coefficients of the characteristic polynomial is palindromic; it is the same forward and backward.

Evaluating this polynomial at each element is not very interesting.

```
polyval(p,X)
ans =
     16     16     16     16
     16     15    -140    -563
     16    -140   -2549  -12089
```



```
16      -563  -12089  -43779
```

But evaluating it in a matrix sense is interesting.

```
polyvalm(p,X)
ans =
    0    0    0    0
    0    0    0    0
    0    0    0    0
    0    0    0    0
```

The result is the zero matrix. This is an instance of the Cayley-Hamilton theorem: a matrix satisfies its own characteristic equation.

## See Also

`polyfit`, `polyval`

# pow2

---

**Purpose** Base 2 power and scale floating-point numbers

**Syntax**  
`X = pow2(Y)`  
`X = pow2(F,E)`

**Description** `X = pow2(Y)` returns an array `X` whose elements are 2 raised to the power `Y`.

`X = pow2(F,E)` computes  $x = f * 2^e$  for corresponding elements of `F` and `E`. The result is computed quickly by simply adding `E` to the floating-point exponent of `F`. Arguments `F` and `E` are real and integer arrays, respectively.

**Remarks** This function corresponds to the ANSI C function `ldexp()` and the IEEE floating-point standard function `scalbn()`.

**Examples** For IEEE arithmetic, the statement `X = pow2(F,E)` yields the values:

| F       | E     | X       |
|---------|-------|---------|
| 1/2     | 1     | 1       |
| pi/4    | 2     | pi      |
| -3/4    | 2     | -3      |
| 1/2     | -51   | eps     |
| 1-eps/2 | 1024  | realmax |
| 1/2     | -1021 | realmin |

**See Also** `log2`, `exp`, `hex2num`, `realmax`, `realmin`  
The arithmetic operators `^` and `.^`

**Purpose** Array power

**Syntax**  $Z = X.^Y$

**Description**  $Z = X.^Y$  denotes element-by-element powers.  $X$  and  $Y$  must have the same dimensions unless one is a scalar. A scalar is expanded to an array of the same size as the other input.

$C = \text{power}(A,B)$  is called for the syntax ' $A .^ B$ ' when  $A$  or  $B$  is an object.

Note that for a negative value  $X$  and a non-integer value  $Y$ , if the  $\text{abs}(Y)$  is less than one, the power function returns the complex roots. To obtain the remaining real roots, use the `nthroot` function.

**See Also** `nthroot`, `realpow`

**Purpose** Evaluate piecewise polynomial

**Syntax** `v = ppval(pp,xx)`

**Description** `v = ppval(pp,xx)` returns the value of the piecewise polynomial  $f$ , contained in `pp`, at the entries of `xx`. You can construct `pp` using the functions `interp1`, `pchip`, `spline`, or the spline utility `mkpp`.

`v` is obtained by replacing each entry of `xx` by the value of  $f$  there. If  $f$  is scalar-valued, `v` is of the same size as `xx`. `xx` may be  $N$ -dimensional.

If `pp` was constructed by `pchip`, `spline`, or `mkpp` using the orientation of non-scalar function values specified for those functions, then:

If  $f$  is  $[D1, \dots, Dr]$ -valued, and `xx` is a vector of length  $N$ , then `V` has size  $[D1, \dots, Dr, N]$ , with `V(:, ..., :, J)` the value of  $f$  at `xx(J)`.

If  $f$  is  $[D1, \dots, Dr]$ -valued, and `xx` has size  $[N1, \dots, Ns]$ , then `V` has size  $[D1, \dots, Dr, N1, \dots, Ns]$ , with `V(:, ..., :, J1, ..., Js)` the value of  $f$  at `xx(J1, ..., Js)`.

If `pp` was constructed by `interp1` using the orientation of non-scalar function values specified for that function, then:

If  $f$  is  $[D1, \dots, Dr]$ -valued, and `xx` is a vector of length  $N$ , then `V` has size  $[N, D1, \dots, Dr]$ , with `V(J, :, ..., :)` the value of  $f$  at `xx(J)`.

If  $f$  is  $[D1, \dots, Dr]$ -valued, and `xx` has size  $[N1, \dots, Ns]$ , then `V` has size  $[N1, \dots, Ns, D1, \dots, Dr]$ , with `V(J1, ..., Js, :, ..., :)` the value of  $f$  at `xx(J1, ..., Js)`.

**Examples** Compare the results of integrating the function `cos`

```
a = 0; b = 10;
int1 = quad(@cos,a,b)
```

```
int1 =
    -0.5440
```

with the results of integrating the piecewise polynomial `pp` that approximates the cosine function by interpolating the computed values `x` and `y`.

```
x = a:b;
y = cos(x);
pp = spline(x,y);
int2 = quad(@(x)ppval(pp,x),a,b)

int2 =
    -0.5485
```

`int1` provides the integral of the cosine function over the interval `[a,b]`, while `int2` provides the integral over the same interval of the piecewise polynomial `pp`.

## See Also

`mkpp`, `spline`, `unmkpp`

# prefdir

---

**Purpose** Directory containing preferences, history, and layout files

**Syntax**

```
prefdir  
d = prefdir  
d = prefdir(1)
```

**Description** prefdir returns the directory that contains

- Preferences for MATLAB and related products (matlab.prf)
- Command history file (history.m)
- MATLAB shortcuts (shortcuts.xml)
- MATLAB desktop layout files (MATLABDesktop.xml and Your\_Saved\_LayoutMATLABLayout.xml)
- Other related files

The directory might be in a hidden folder, for example, myname/.matlab/R2007b. How to access hidden folders depends on your platform:

- On Windows, in any folder window, select **Tools > Folder Options**. Click the **View** tab, and under **Advanced** settings, select **Show hidden files and folders**. Then you should be able to see the folder returned by prefdir.
- On Macintosh platforms, in the Finder, select **Go -> Go to Folder**. In the resulting dialog box, type the path returned by prefdir and press **Enter**.

d = prefdir assigns to d the name of the directory containing preferences and related files.

d = prefdir(1) creates a directory for preferences and related files if one does not exist. If the directory does exist, the name is assigned to d.

## Remarks

The preferences directory MATLAB uses depends on the release. The preference directory naming and preference migration practice used from R13 through R14SP2 was changed starting in R14SP3 to address backwards compatibility problems. The differences are relevant primarily if you run multiple versions of MATLAB, and especially if one version is prior to R14SP3:

- For R2007b back through and including R2006a, and R14SP3, MATLAB uses the name of the release for the preference directory. For example, it uses R2007b, R2007a, ... through R14SP3. When you install R2007b, MATLAB migrates the files in the R2007a preferences directory to the R2007b preferences directory. While running R2007b through R14SP3, any changes made to files in those preferences directories (R2007b through R14SP3) are used only in their respective versions. As an example, commands you run in R2007b will *not* appear in the Command History when you run R2007a, and so on. The converse is also true.
- The R14 through R14SP2 releases all share the R14 preferences directory. While running R14SP1, for example, any changes made to files in the preferences directory, R14, are used when you run R14SP2 and R14. As another example, commands you run in R14 appear in the Command History when you run R14SP2, and the converse is also true. The preferences are not used when you run R14SP3 or later versions because those versions each use their own preferences directories.
- All R13 releases use the R13 preferences directory. While running R13SP1, for example, any changes made to files in the preferences directory, R13, are used when you run R13. As an example, commands you run in R13 will appear in the Command History when you run R13SP1, and the converse is true. The preferences are not used when you run any R14 or later releases because R14 and later releases use different preferences directories, and the converse is true.
- Upon startup, MATLAB 7.5 (R2007b) looks for and if found, uses the R2007b preferences directory. If not found, MATLAB creates an R2007b preferences directory. This happens when the R2007b

preferences directory is deleted. MATLAB then looks for the R2007a preferences directory, and if found, migrates the R2007a preferences to the R2007b preferences. If it does not find the R2007a preferences directory, it uses the default preferences for R2007b. This process also applies when starting MATLAB 7.3 through 7.1.

- If you want to use default preferences for R2007b, and do not want MATLAB to migrate preferences from R2007a, the R2007b preferences directory *must exist but be empty* when you start MATLAB. If you want to maintain some of your R2007b preferences, but restore the defaults for others, in the R2007b preferences directory, delete the files for which you want the defaults to be restored. One file you might want to maintain is `history.m`—for more information about the file, see “Viewing Statements in the Command History Window” in the MATLAB Desktop Tools and Development Environment documentation.

## Examples

Run

```
prefdir
```

MATLAB returns

```
ans =
```

```
C:\WINNT\Profiles\my_user_name\MATHWORKS\Application Data\MathWorks\MATLAB\R2007b
```

Running `dir` for the directory shows these files and others for MathWorks products:

```
.          history.m
..         matlab.prf
cwdhistory.m  MATLABDesktop.xml
shortcuts.xml MATLAB EditorDesktop.xml
```

In MATLAB, run `cd(prefdir)` to change to that directory.

On Windows platforms, go directly to the preferences directory in Explorer by running `winopen(prefdir)`.



**See Also**

preferences, winopen

Fonts, Colors, and Other Preferences in the MATLAB Desktop Tools and Development Environment documentation

# preferences

---

|                         |                                                                                                                               |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Open Preferences dialog box for MATLAB and related products                                                                   |
| <b>GUI Alternatives</b> | As an alternative to the preferences function, select <b>File &gt; Preferences</b> in the MATLAB desktop or any desktop tool. |
| <b>Syntax</b>           | preferences                                                                                                                   |
| <b>Description</b>      | preferences displays the Preferences dialog box, from which you can make changes to options for MATLAB and related products.  |
| <b>See Also</b>         | prefdir<br>Fonts, Colors, and Other Preferences in the MATLAB Desktop Tools and Development Environment documentation         |

**Purpose**           Generate list of prime numbers

**Syntax**           `p = primes(n)`

**Description**       `p = primes(n)` returns a row vector of the prime numbers less than or equal to `n`. A prime number is one that has no factors other than 1 and itself.

**Examples**           `p = primes(37)`

```
p = 2 3 5 7 11 13 17 19 23 29 31 37
```

**See Also**           factor

# print, printopt

---

**Purpose** Print figure or save to file and configure printer defaults

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Syntax

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## GUI Alternative

Use **File** ⇒ **Print** on the figure window menu to access the Print dialog and **File** ⇒ **Print Preview** to access the Print Preview GUI. For details, see How to Print or Export in the MATLAB Graphics documentation.

## Syntax

```
print
print filename
print -ddriver
print -dformat
print -dformat filename
print -smodelname
print -options
print(...)
[pcmd,dev] = printopt
```

## Description

`print` and `printopt` produce hardcopy output. All arguments to the `print` command are optional. You can use them in any combination or order.

`print` sends the contents of the current figure, including bitmap representations of any user interface controls, to the printer using the device and system printing command defined by `printopt`.

`print filename` directs the output to the PostScript file designated by `filename`. If `filename` does not include an extension, `print` appends an appropriate extension.

`print -ddriver` prints the figure using the specified printer *driver*, (such as color PostScript). If you omit `-ddriver`, `print` uses the default value stored in `printopt.m`. The “Printer Drivers” on page 2-2542 table lists all supported device types.

`print -dformat` copies the figure to the system clipboard (Windows only). To be valid, the *format* for this operation must be either `-dmeta` (Windows Enhanced Metafile) or `-dbitmap` (Windows Bitmap).

`print -dformat filename` exports the figure to the specified file using the specified graphics *format*, (such as TIFF). The table of “Graphics Format Files” on page 2-2546 lists all supported graphics file formats.

`print -smodelname` prints the current Simulink model *modelName*.

`print -options` specifies print options that modify the action of the `print` command. (For example, the `-noui` option suppresses printing of user interface controls.) The Options section lists available options.

`print(...)` is the function form of `print`. It enables you to pass variables for any input arguments. This form is useful for passing filenames and handles. See Batch Processing for an example.

`[pcmd,dev] = printopt` returns strings containing the current system-dependent printing command and output device. `printopt` is an M-file used by `print` to produce the hardcopy output. You can edit the M-file `printopt.m` to set your default printer type and destination.

`pcmd` and `dev` are platform-dependent strings. `pcmd` contains the command that `print` uses to send a file to the printer. `dev` contains the printer driver or graphics format option for the `print` command. Their defaults are platform dependent.

| Platform     | System Printing Command | Driver or Format |
|--------------|-------------------------|------------------|
| MAC and UNIX | lpr r                   | dps2             |
| Windows      | COPY /B %s LPT1:        | dwin             |

## Printer Drivers

The table below shows the more widely used printer drivers supported by MATLAB. If you do not specify a driver, MATLAB uses the default setting shown in the previous table. For a list of all supported printer drivers, type

```
print -d
```

at the MATLAB prompt. Some things to remember:

- As indicated in the “Description” on page 2-2540 section, the `-d` switch either specifies a printer driver or a graphics file format:
  - Specifying a printer driver without a filename or printer name (the `-P` option) sends the output formatted by the specified driver to your default printer, which may not be what you want to do.

---

**Note** On Windows, when you use the `-P` option to identify a printer to use, if you specify any driver other than `-dwin` or `-dwinc`, MATLAB writes the output to a file with an appropriate extension but does not send it to the printer; you can then copy that file to a printer.

---

- Specifying a `-dmeta` or a `-dbitmap` graphics format without a filename places the graphic on the system clipboard, if possible (Windows only).
- Specifying any other graphics format without a filename creates a file in the current directory with a name such as `figureN.fmt`,

where  $N$  is 1, 2, 3, ... and  $fmt$  indicates the format type, for example eps or png.

- Several of the drivers come from a product called Ghostscript, which is shipped with MATLAB. The last column indicates when Ghostscript is used.
- Some drivers are not available on all platforms. This is noted in the first column of the table.
- If you specify a particular printer with the `-P` option and do not specify a driver, a default driver for that printer is selected, either by the operating system or by MATLAB, depending on the platform:
  - On Windows, the driver associated with this particular printing device is used
  - On MAC and UNIX, the driver specified in `printop.m` is used

See [Selecting the Printer](#) in the Graphics documentation for more information.

| Printer Driver                                                    | print Command Option String | Ghostscript |
|-------------------------------------------------------------------|-----------------------------|-------------|
| <b>Canon BubbleJet BJ10e</b>                                      | -dbj10e                     | Yes         |
| <b>Canon BubbleJet BJ200 color</b>                                | -dbj200                     | Yes         |
| <b>Canon Color BubbleJet BJC-70/BJC-600/BJC-4000</b>              | -dbjc600                    | Yes         |
| <b>Canon Color BubbleJet BJC-800</b>                              | -dbjc800                    | Yes         |
| <b>Epson</b> and compatible 9- or 24-pin dot matrix print drivers | -depson                     | Yes         |

## print, printopt

---

| <b>Printer Driver</b>                                                                                                        | <b>print Command Option String</b> | <b>Ghostscript</b> |
|------------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------|
| <b>Epson</b> and compatible 9-pin with interleaved lines (triple resolution)                                                 | -deps9high                         | Yes                |
| <b>Epson LQ-2550</b> and compatible; color (not supported on HP-700)                                                         | -depsonc                           | Yes                |
| <b>Fujitsu 3400/2400/1200</b>                                                                                                | -depsonc                           | Yes                |
| <b>HP DesignJet 650C</b> color (not supported on Windows)                                                                    | -ddnj650c                          | Yes                |
| <b>HP DeskJet 500</b>                                                                                                        | -ddjet500                          | Yes                |
| <b>HP DeskJet 500C</b> (creates black and white output)                                                                      | -dcdjmono                          | Yes                |
| <b>HP DeskJet 500C</b> (with 24 bit/pixel color and high-quality Floyd-Steinberg color dithering) (not supported on Windows) | -dcdjcolor                         | Yes                |
| <b>HP DeskJet 500C/540C</b> color (not supported on Windows)                                                                 | -dcdj500                           | Yes                |
| <b>HP Deskjet 550C</b> color (not supported on Windows)                                                                      | -dcdj550                           | Yes                |
| <b>HP DeskJet</b> and <b>DeskJet Plus</b>                                                                                    | -ddeskjet                          | Yes                |
| <b>HP LaserJet</b>                                                                                                           | -dlaserjet                         | Yes                |



| <b>Printer Driver</b>                                                                         | <b>print Command Option String</b> | <b>Ghostscript</b> |
|-----------------------------------------------------------------------------------------------|------------------------------------|--------------------|
| <b>HP LaserJet+</b>                                                                           | -dljetplus                         | Yes                |
| <b>HP LaserJet IIP</b>                                                                        | -dljet2p                           | Yes                |
| <b>HP LaserJet III</b>                                                                        | -dljet3                            | Yes                |
| <b>HP LaserJet 4.5L and 5P</b>                                                                | -dljet4                            | Yes                |
| <b>HP LaserJet 5 and 6</b>                                                                    | -dpxlmono                          | Yes                |
| <b>HP PaintJet color</b>                                                                      | -dpaintjet                         | Yes                |
| <b>HP PaintJet XL color</b>                                                                   | -dpjxl                             | Yes                |
| <b>HP PaintJet XL color</b>                                                                   | -dpjetxl                           | Yes                |
| <b>HP PaintJet XL300 color</b> (not supported on Windows)                                     | -dpjxl300                          | Yes                |
| <b>HPGL for HP 7475A and other compatible plotters.</b> (Renderer cannot be set to Z-buffer.) | -dhpgl                             | No                 |
| <b>IBM 9-pin Proprinter</b>                                                                   | -dibmpro                           | Yes                |
| <b>PostScript black and white</b>                                                             | -dps                               | No                 |
| <b>PostScript color</b>                                                                       | -dpsc                              | No                 |
| <b>PostScript Level 2 black and white</b>                                                     | -dps2                              | No                 |
| <b>PostScript Level 2 color</b>                                                               | -dpsc2                             | No                 |
| <b>Windows color</b> (Windows only)                                                           | -dwinc                             | No                 |
| <b>Windows monochrome</b> (Windows only)                                                      | -dwin                              | No                 |

---

**Note** Generally, Level 2 PostScript files are smaller and are rendered more quickly when printing than Level 1 PostScript files. However, not all PostScript printers support Level 2, so determine the capabilities of your printer before using those drivers. Level 2 PostScript is the default for UNIX. You can change this default by editing the `printopt.m` file. Likewise, if you want color PostScript to be the default instead of black-and-white PostScript, edit the line in the `printopt.m` file that reads `dev = '-dps2'`; to be `dev = '-dpsc2'`;

---

## Graphics Format Files

To save your figure as a graphics-format file, specify a format switch and filename. To set the resolution of the output file for a built-in MATLAB format, use the `-r` switch. (For example, `-r300` sets the output resolution to 300 dots per inch.) The `-r` switch is also supported for Windows Enhanced Metafiles, JPEG, TIFF and PNG files, but is not supported for Ghostscript formats. For more information, see “Printing and Exporting without a Display” on page 2-2549.

The table below shows the supported output formats for exporting from MATLAB and the switch settings to use. In some cases, a format is available both as a MATLAB output filter and as a Ghostscript output filter. All formats except for EMF are supported on both the PC and UNIX platforms.

| Graphics Format                                                      | Bitmap or Vector | print Command Option String | MATLAB or Ghostscript |
|----------------------------------------------------------------------|------------------|-----------------------------|-----------------------|
| <b>BMP</b> monochrome BMP                                            | Bitmap           | <code>-dbmpmono</code>      | Ghostscript           |
| <b>BMP</b> 24-bit BMP                                                | Bitmap           | <code>-dbmp16m</code>       | Ghostscript           |
| <b>BMP</b> 8-bit (256-color) BMP (this format uses a fixed colormap) | Bitmap           | <code>-dbmp256</code>       | Ghostscript           |

| <b>Graphics Format</b>                                      | <b>Bitmap or Vector</b> | <b>print Command Option String</b> | <b>MATLAB or Ghostscript</b> |
|-------------------------------------------------------------|-------------------------|------------------------------------|------------------------------|
| <b>BMP</b> 24-bit                                           | Bitmap                  | -dbmp                              | MATLAB                       |
| <b>EMF</b>                                                  | Vector                  | -dmeta                             | MATLAB                       |
| <b>EPS</b> black and white                                  | Vector                  | -deps                              | MATLAB                       |
| <b>EPS</b> color                                            | Vector                  | -depsc                             | MATLAB                       |
| <b>EPS</b> Level 2 black and white                          | Vector                  | -deps2                             | MATLAB                       |
| <b>EPS</b> Level 2 color                                    | Vector                  | -depsc2                            | MATLAB                       |
| <b>HDF</b> 24-bit                                           | Bitmap                  | -dhdf                              | MATLAB                       |
| <b>ILL</b> (Adobe Illustrator)                              | Vector                  | -dill                              | MATLAB                       |
| <b>JPEG</b> 24-bit                                          | Bitmap                  | -djpeg                             | MATLAB                       |
| <b>PBM</b> (plain format) 1-bit                             | Bitmap                  | -dpbm                              | Ghostscript                  |
| <b>PBM</b> (raw format) 1-bit                               | Bitmap                  | -dpbmraw                           | Ghostscript                  |
| <b>PCX</b> 1-bit                                            | Bitmap                  | -dpcxmono                          | Ghostscript                  |
| <b>PCX</b> 24-bit color PCX file format, three 8-bit planes | Bitmap                  | -dpcx24b                           | Ghostscript                  |
| <b>PCX</b> 8-bit newer color PCX file format (256-color)    | Bitmap                  | -dpcx256                           | Ghostscript                  |

## print, printopt

---

| <b>Graphics Format</b>                                     | <b>Bitmap or Vector</b> | <b>print Command Option String</b> | <b>MATLAB or Ghostscript</b> |
|------------------------------------------------------------|-------------------------|------------------------------------|------------------------------|
| <b>PCX</b> Older color PCX file format (EGA/VGA, 16-color) | Bitmap                  | -dpcx16                            | Ghostscript                  |
| <b>PDF</b> Color PDF file format                           | Vector                  | -dpdf                              | Ghostscript                  |
| <b>PGM</b> Portable Graymap (plain format)                 | Bitmap                  | -dpgm                              | Ghostscript                  |
| <b>PGM</b> Portable Graymap (raw format)                   | Bitmap                  | -dpgmraw                           | Ghostscript                  |
| <b>PNG</b> 24-bit                                          | Bitmap                  | -dpng                              | MATLAB                       |
| <b>PPM</b> Portable Pixmap (plain format)                  | Bitmap                  | -dppm                              | Ghostscript                  |
| <b>PPM</b> Portable Pixmap (raw format)                    | Bitmap                  | -dppmraw                           | Ghostscript                  |
| <b>TIFF</b> 24-bit                                         | Bitmap                  | -dtiff or -dtiffn                  | MATLAB                       |
| <b>TIFF preview</b> for EPS files                          | Bitmap                  | -tiff                              |                              |

The TIFF image format is supported on all platforms by almost all word processors for importing images. The `-dtiffn` variant writes an uncompressed TIFF. JPEG is a lossy, highly compressed format that is supported on all platforms for image processing and for inclusion into HTML documents on the World Wide Web. To create these formats, MATLAB renders the figure using the Z-buffer rendering method and the resulting bitmap is then saved to the specified file.

## Printing and Exporting without a Display

On a UNIX platform (including Macintosh), where you can start MATLAB in nodisplay mode (`matlab -nodisplay`), you can print using most of the drivers you can use with a display and export to most of the same file formats. The PostScript and Ghostscript devices all function in nodisplay mode on UNIX. The graphic devices `-djpeg`, `-dpng`, `-dtiff` (compressed TIFF bitmaps) and `-tiff` (EPS with TIFF preview) work as well, but under nodisplay they use Ghostscript to generate output instead of using the drivers built into MATLAB. However, Ghostscript ignores the `-r` option when generating `-djpeg`, `-dpng`, `-dtiff` and `-tiff` image files. This means that you cannot vary the resolution of image files when running in nodisplay mode.

Naturally, the Windows-only `-dwin` and `-dwinc` output formats cannot be used on UNIX or MAC with or without a display.

The same holds true on Windows with the `-noFigureWindows` startup option. The `-dwin`, `-dwinc`, and `-dsetup` options operate as usual under `-noFigureWindows`. However, the `printpreview` GUI does not function in this mode.

The formats which you cannot generate in nodisplay mode on UNIX and MAC are

- `bitmap (-dbitmap)` — Windows bitmap file (except for Simulink models)
- `bmp (-dbmp...)` — Monochrome and color bitmaps
- `hdf (-dhdf)` — Hierarchical Data Format
- `svg (-dsvg)` — Scalable Vector Graphics file (except for Simulink models)
- `tiffn (-dtiffn)` — TIFF image file, no compression

## Printing Options

This table summarizes options that you can specify for `print`. The second column also shows which tutorial sections contain more detailed information. The sections listed are located under Printing and Exporting Figures with MATLAB.

## print, printopt

---

| Option     | Description                                                                                                                                                      |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| -adobecset | PostScript only. Use PostScript default character set encoding. See Early PostScript 1 Printers.                                                                 |
| -append    | PostScript only. Append figure to existing PostScript file. See Settings That Are Driver Specific.                                                               |
| -cmyk      | PostScript only. Print with CMYK colors instead of RGB. See Setting CMYK Color.                                                                                  |
| -ddriver   | Printing only. Printer driver to use. See Drivers table.                                                                                                         |
| -dformat   | Exporting only. Graphics format to use. See Graphics Format Files table.                                                                                         |
| -dsetup    | Windows only. Display the (platform-specific) Print Setup dialog. Settings you make in it are saved, but nothing is printed.                                     |
| -fhandle   | Handle of figure to print. Note that you cannot specify both this option and the <i>-windowtitle</i> option. See Which Figure Is Printed.                        |
| -loose     | PostScript and Ghostscript only. Use loose bounding box for PostScript. See Producing Uncropped Figures.                                                         |
| -noui      | Suppress printing of user interface controls. See Excluding User Interface Controls.                                                                             |
| -opengl    | Render using the OpenGL algorithm. Note that you cannot specify this method in conjunction with <i>-zbuffer</i> or <i>-painters</i> . See Selecting a Renderer.  |
| -painters  | Render using the Painter's algorithm. Note that you cannot specify this method in conjunction with <i>-zbuffer</i> or <i>-opengl</i> . See Selecting a Renderer. |

| <b>Option</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                  |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| -Pprinter     | Specify name of printer to use. See Selecting the Printer.                                                                                                                                                                                                                                                          |
| -rnumber      | PostScript, JPEG, PNG, and Ghostscript only. Specify resolution in dots per inch. Defaults to 90 for Simulink, 150 for figures in image formats and when printing in Z-buffer or OpenGL mode, screen resolution for metafiles, and 864 otherwise. Use -r0 to specify screen resolution. See Setting the Resolution. |
| -swindowtitle | Specify name of Simulink system window to print. Note that you cannot specify both this option and the -fhandle option. See Which Figure Is Printed.                                                                                                                                                                |
| -v            | Windows only. Display the Windows Print dialog box. The v stands for "verbose mode."                                                                                                                                                                                                                                |
| -zbuffer      | Render using the Z-buffer algorithm. Note that you cannot specify this method in conjunction with -opengl or -painters. See Selecting a Renderer.                                                                                                                                                                   |

## **Paper Sizes**

MATLAB supports a number of standard paper sizes. You can select from the following list by setting the PaperType property of the figure or selecting a supported paper size from the Print dialog box.

| <b>Property Value</b> | <b>Size (Width by Height)</b> |
|-----------------------|-------------------------------|
| usletter              | 8.5 by 11 inches              |
| uslegal               | 11 by 14 inches               |
| tabloid               | 11 by 17 inches               |
| A0                    | 841 by 1189 mm                |
| A1                    | 594 by 841 mm                 |

| Property Value | Size (Width by Height) |
|----------------|------------------------|
| A2             | 420 by 594 mm          |
| A3             | 297 by 420 mm          |
| A4             | 210 by 297 mm          |
| A5             | 148 by 210 mm          |
| B0             | 1029 by 1456 mm        |
| B1             | 728 by 1028 mm         |
| B2             | 514 by 728 mm          |
| B3             | 364 by 514 mm          |
| B4             | 257 by 364 mm          |
| B5             | 182 by 257 mm          |
| arch-A         | 9 by 12 inches         |
| arch-B         | 12 by 18 inches        |
| arch-C         | 18 by 24 inches        |
| arch-D         | 24 by 36 inches        |
| arch-E         | 36 by 48 inches        |
| A              | 8.5 by 11 inches       |
| B              | 11 by 17 inches        |
| C              | 17 by 22 inches        |
| D              | 22 by 34 inches        |
| E              | 34 by 43 inches        |

## Printing Tips

This section includes information about specific printing issues.

### Figures with Resize Functions

The print command produces a warning when you print a figure having a callback routine defined for the figure `ResizeFcn`. To avoid the



warning, set the figure `PaperPositionMode` property to `auto` or select **Match Figure Screen Size** in the **File⇒Page Setup** dialog box.

## Troubleshooting MS Windows Printing

If you encounter problems such as segmentation violations, general protection faults, or application errors, or the output does not appear as you expect when using MS-Windows printer drivers, try the following:

- If your printer is PostScript compatible, print with one of the MATLAB built-in PostScript drivers. There are various PostScript device options that you can use with the `print` command: they all start with `-dps`.
- The behavior you are experiencing might occur only with certain versions of the print driver. Contact the print driver vendor for information on how to obtain and install a different driver.
- Try printing with one of the MATLAB built-in Ghostscript devices. These devices use Ghostscript to convert PostScript files into other formats, such as HP LaserJet, PCX, Canon BubbleJet, and so on.
- Copy the figure as a Windows Enhanced Metafile using the **Edit⇒Copy Figure** menu item on the figure window menu or the `print -dmeta` option at the command line. You can then import the file into another application for printing.

You can set copy options in the figure's **File⇒Preferences⇒Copying Options** dialog box. The Windows Enhanced Metafile clipboard format produces a better quality image than Windows Bitmap.

## Printing MATLAB GUIs

You can generally obtain better results when printing a figure window that contains MATLAB uicontrols by setting these key properties:

- Set the figure `PaperPositionMode` property to `auto`. This ensures that the printed version is the same size as the onscreen version. With `PaperPositionMode` set to `auto` MATLAB does not resize the figure to fit the current value of the `PaperPosition`. This is particularly important if you have specified a figure `ResizeFcn`,

because if MATLAB resizes the figure during the print operation, `ResizeFcn` is automatically called.

To set `PaperPositionMode` on the current figure, use the command

```
set(gcf, 'PaperPositionMode', 'auto')
```

- Set the figure `InvertHardcopy` property to `off`. By default, MATLAB changes the figure background color of printed output to white, but does not change the color of uicontrols. If you have set the background color, for example, to match the gray of the GUI devices, you must set `InvertHardcopy` to `off` to preserve the color scheme.

To set `InvertHardcopy` on the current figure, use the command

```
set(gcf, 'InvertHardcopy', 'off')
```

- Use a color device if you want lines and text that are in color on the screen to be written to the output file as colored objects. Black and white devices convert colored lines and text to black or white to provide the best contrast with the background and to avoid dithering.
- Use the print command's `-loose` option to prevent MATLAB from using a bounding box that is tightly wrapped around objects contained in the figure. This is important if you have intentionally used space between uicontrols or axes and the edge of the figure and you want to maintain this appearance in the printed output.

If you run code that adds uicontrols to a figure when the figure is invisible, the controls will not print until the figure is made visible.

### **Notes on Printing Interpolated Shading with PostScript Drivers**

MATLAB can print surface objects (such as graphs created with `surf` or `mesh`) using interpolated colors. However, only patch objects that are composed of triangular faces can be printed using interpolated shading.

Printed output is always interpolated in RGB space, not in the colormap colors. This means that if you are using indexed color and interpolated

face coloring, the printed output can look different from what is displayed on screen.

PostScript files generated for interpolated shading contain the color information of the graphics object's vertices and require the printer to perform the interpolation calculations. This can take an excessive amount of time and in some cases, printers might time out before finishing the print job. One solution to this problem is to interpolate the data and generate a greater number of faces, which can then be flat shaded.

To ensure that the printed output matches what you see on the screen, print using the `-zbuffer` option. To obtain higher resolution (for example, to make text look better), use the `-r` option to increase the resolution. There is, however, a tradeoff between the resolution and the size of the created PostScript file, which can be quite large at higher resolutions. The default resolution of 150 dpi generally produces good results. You can reduce the size of the output file by making the figure smaller before printing it and setting the figure `PaperPositionMode` to `auto`, or by just setting the `PaperPosition` property to a smaller size.

## Examples

### Specifying the Figure to Print

You can print a noncurrent figure by specifying the figure's handle. If a figure has the title "Figure 2", its handle is 2. The syntax is

```
print -fhandle
```

This example prints the figure whose handle is 2, regardless of which figure is the current figure.

```
print -f2
```

---

**Note** You must use the `-f` option if the figure's handle is hidden (i.e., its `HandleVisibility` property is set to `off`).

---

## print, printopt

---

This example saves the figure with the handle `-f2` to a PostScript file named `Figure2`, which can be printed later.

```
print -f2 -dps 'Figure2.ps'
```

If the figure uses noninteger handles, use the `figure` command to get its value, and then pass it in as the first argument.

```
h = figure('IntegerHandle','off')
print h -depson
```

You can also pass a figure handle as a variable to the function form of `print`. For example,

```
h = figure; plot(1:4,5:8)
print(h)
```

This example uses the function form of `print` to enable a filename to be passed in as a variable.

```
filename = 'mydata';
print('-f3', '-dpsc', filename);
```

(Because a filename is specified, the figure will be printed to a file.)

### Specifying the Model to Print

To print a noncurrent Simulink model, use the `-s` option with the title of the window. For example, this command prints the Simulink window titled `f14`.

```
print -sf14
```

If the window title includes any spaces, you must call the function form rather than the command form of `print`. For example, this command saves Simulink window title `Thruster Control`.

```
print('-sThruster Control')
```

To print the current system, use

```
print -s
```

For information about issues specific to printing Simulink windows, see the Simulink documentation.

## Printing Figures at Screen Size

This example prints a surface plot with interpolated shading. Setting the current figure's (gcf) PaperPositionMode to auto enables you to resize the figure window and print it at the size you see on the screen. See Options and the previous section for information on the -zbuffer and -r200 options.

```
surf(peaks)
shading interp
set(gcf, 'PaperPositionMode', 'auto')
print -dpsc2 -zbuffer -r200
```

For additional details, see Printing Images in the MATLAB Graphics documentation.

## Batch Processing

You can use the function form of print to pass variables containing file names. For example, this for loop uses filenames stored in a cell array to create a series of graphs and prints each one with a different file name.

```
fnames = {'file1', 'file2', 'file3'};
for k=1:length(fnames)
    surf(peaks)
    print('-dtiff', '-r200', fnames{k})
end
```

## Tiff Preview

The command

## print, printopt

---

```
print -depsc -tiff -r300 picture1
```

saves the current figure at 300 dpi, in a color Encapsulated PostScript file named `picture1.eps`. The `-tiff` option creates a 72 dpi TIFF preview, which many word processor applications can display on screen after you import the EPS file. This enables you to view the picture on screen within your word processor and print the document to a PostScript printer using a resolution of 300 dpi.

### See Also

`orient`, `figure`

**Purpose** Print dialog box

**Syntax**

```
printdlg  
printdlg(fig)  
printdlg('-crossplatform',fig)  
printdlg('-setup',fig)
```

**Description**

printdlg prints the current figure.

printdlg(fig) creates a modal dialog box from which you can print the figure window identified by the handle fig. Note that uimenu do not print.

printdlg('-crossplatform',fig) displays the standard cross-platform MATLAB printing dialog rather than the built-in printing dialog box for Microsoft Windows computers. Insert this option before the fig argument.

printdlg('-setup',fig) forces the printing dialog to appear in a setup mode. Here one can set the default printing options without actually printing.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. For more information, see WindowStyle in the MATLAB Figure Properties.

---

**See Also** pagesetupdlg, printpreview

# printpreview

---

**Purpose** Preview figure to print

## **Contents**

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## **GUI Alternative**

Use **File > Print Preview** on the figure window menu to access the Print Preview dialog box, described below. For details, see “Using Print Preview” in the MATLAB Graphics documentation.

## **Syntax**

```
printpreview  
printpreview(f)
```

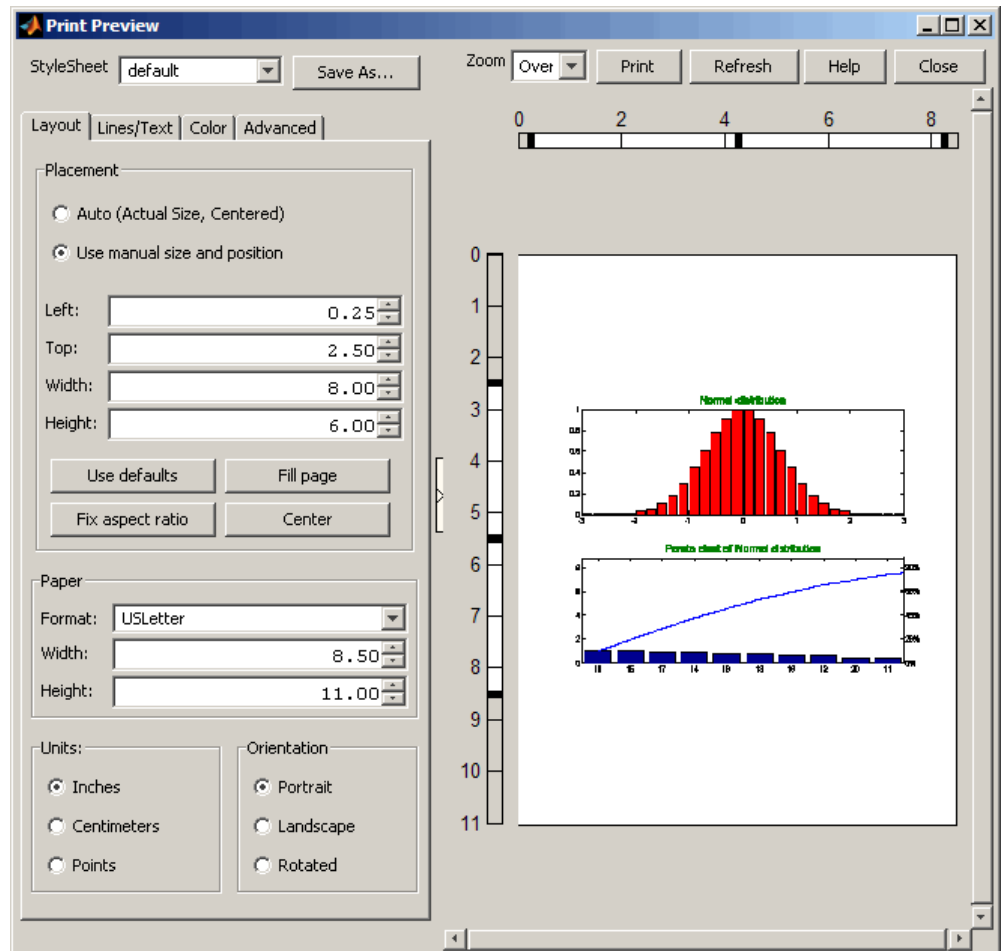
## **Description**

`printpreview` displays a dialog box showing the figure in the currently active figure window as it will print. A scaled version of the figure displays in the right-hand pane of the GUI.

`printpreview(f)` displays a dialog box showing the figure having the handle `f` as it will print.

Use the Print Preview dialog box, shown below, to control the layout and appearance of figures before sending them to a printer or print file. Controls are grouped into four tabbed panes: **Layout**, **Lines/Text**, **Color**, and **Advanced**.





## Right Pane Controls

You can position and scale plots on the printed page using the rulers in the right-hand pane of the Print Preview dialog. Use the outer ruler handlebars to change margins. Moving them changes plot proportions. Use the center ruler handlebars to change the position of the plot on the page. Plot proportions do not change, but you can move portions of

the plot off the paper. The buttons on that pane let you refresh the plot, close the dialog (preserving all current settings), print the page immediately, or obtain context-sensitive help. Use the **Zoom** box and scroll bars to view and position page elements more precisely.

## The Layout Tab

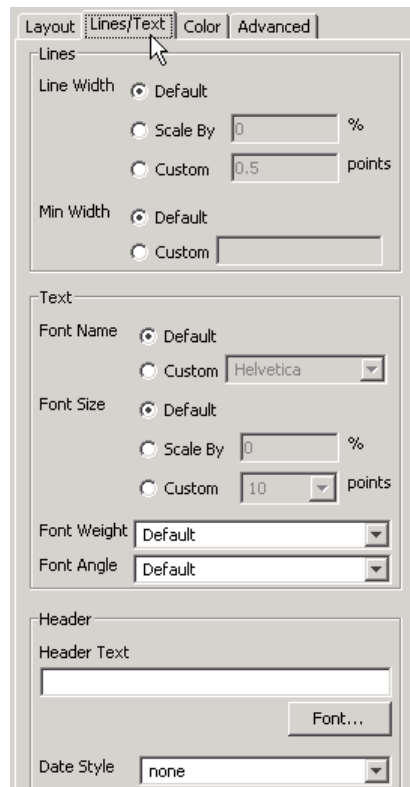
Use the **Layout** tab, shown above, to control the paper format and placement of the plot on printed pages. The following table summarizes the **Layout** options:

| Group       | Option                          | Description                                           |
|-------------|---------------------------------|-------------------------------------------------------|
| Placement   | <b>Auto</b>                     | Let MATLAB decide placement of plot on page           |
|             | <b>Use manual...</b>            | Specify position parameters for plot on page          |
|             | <b>Top, Left, Width, Height</b> | Standard position parameters in current units         |
|             | <b>Use defaults</b>             | Revert to default position                            |
|             | <b>Fill page</b>                | Expand figure to fill printable area                  |
|             | <b>Fix aspect ratio</b>         | Correct height/width ratio                            |
|             | <b>Center</b>                   | Center plot on printed page                           |
| Paper       | <b>Format</b>                   | U.S. and ISO sheet size selector                      |
|             | <b>Width, Height</b>            | Sheet size in current units                           |
| Units       | <b>Inches</b>                   | Use inches as units for dimensions and positions      |
|             | <b>Centimeters</b>              | Use centimeters as units for dimensions and positions |
|             | <b>Points</b>                   | Use points as units for dimensions and positions      |
| Orientation | <b>Portrait</b>                 | Upright paper orientation                             |

| Group | Option           | Description                            |
|-------|------------------|----------------------------------------|
|       | <b>Landscape</b> | Sideways paper orientation             |
|       | <b>Rotated</b>   | Currently the same as <b>Landscape</b> |

### The Lines/Text Tab

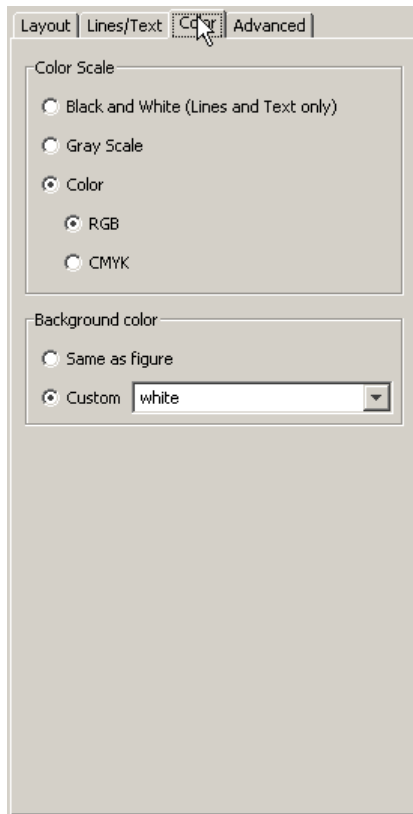
Use the **Lines/Text** tab, shown below, to control the line weights, font characteristics, and headers for printed pages. The following table summarizes the **Lines/Text** options:



| Group  | Option             | Description                                                                                                                                         |
|--------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Lines  | <b>Line Width</b>  | Scale all lines by a percentage from 0 upward (100 being no change), print lines at a specified point size, or default line widths used on the plot |
|        | <b>Min Width</b>   | Smallest line width (in points) to use when printing; defaults to 0.5 point                                                                         |
| Text   | <b>Font Name</b>   | Select a system font for all text on plot, or default to fonts currently used on the plot                                                           |
|        | <b>Font Size</b>   | Scale all text by a percentage from 0 upward (100 being no change), print text at a specified point size, or default to this                        |
|        | <b>Font Weight</b> | Select Normal ... Bold font styling for all text from drop-down menu or default to the font weights used on the plot                                |
|        | <b>Font Angle</b>  | Select Normal, Italic or Oblique font styling for all text from drop-down menu or default to the font angles used on the plot                       |
| Header | <b>Header Text</b> | Type the text to appear on the header at the upper left of printed pages, or leave blank for no header                                              |
|        | <b>Date Style</b>  | Select a date format to have today's date appear at the upper left of printed pages, or none for no date                                            |

## The Color Tab

Use the **Color** tab, shown below, to control how colors are printed for lines and backgrounds. The following table summarizes the **Color** options:

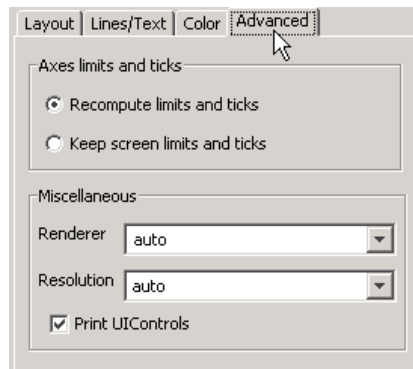


| Group       | Option                 | Description                                                                                    |
|-------------|------------------------|------------------------------------------------------------------------------------------------|
| Color Scale | <b>Black and White</b> | Select to print lines and text in black and white, but use color for patches and other objects |
|             | <b>Gray Scale</b>      | Convert colors to shades of gray on printed pages                                              |

| Group            | Option                | Description                                                                                                                      |
|------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------|
|                  | <b>Color</b>          | Print everything in color, matching colors on plot; select RGB (default) or CMYK color model for printing                        |
| Background Color | <b>Same as figure</b> | Print the figure's background color as it is                                                                                     |
|                  | <b>Custom</b>         | Select a color name, or type a colorspec for the background; white (default) implies no background color, even on colored paper. |

## The Advanced Tab

Use the **Advanced** tab, shown below, to control finer details of printing, such as limits and ticks, renderer, resolution, and the printing of UIControls. The following table summarizes the **Advanced** options:



| Group                 | Option                            | Description                                                                      |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------|
| Axes limits and ticks | <b>Recompute limits and ticks</b> | Redraw $x$ - and $y$ -axes ticks and limits based on printed plot size (default) |

| Group         | Option                       | Description                                                                                                           |
|---------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Miscellaneous | <b>Keep limits and ticks</b> | Use the $x$ - and $y$ -axes ticks and limits shown on the plot when printing the previewed figure                     |
|               | <b>Renderer</b>              | Select a rendering algorithm for printing: painters, zbuffer, opengl, or auto (default)                               |
|               | <b>Resolution</b>            | Select resolution to print at in dots per inch: 150, 300, 600, or auto (default), or type in any other positive value |
|               | <b>Print UIControls</b>      | Print all visible UIControls in the figure (default), or uncheck to exclude them from being printed                   |

**See Also**

printdlg, pagesetupdlg

For more information, see How to Print or Export in the MATLAB Graphics documentation.

# prod

---

**Purpose** Product of array elements

**Syntax**  
 $B = \text{prod}(A)$   
 $B = \text{prod}(A, \text{dim})$

**Description**  $B = \text{prod}(A)$  returns the products along different dimensions of an array.

If  $A$  is a vector,  $\text{prod}(A)$  returns the product of the elements.

If  $A$  is a matrix,  $\text{prod}(A)$  treats the columns of  $A$  as vectors, returning a row vector of the products of each column.

If  $A$  is a multidimensional array,  $\text{prod}(A)$  treats the values along the first non-singleton dimension as vectors, returning an array of row vectors.

$B = \text{prod}(A, \text{dim})$  takes the products along the dimension of  $A$  specified by scalar  $\text{dim}$ .

**Examples** The magic square of order 3 is

```
M = magic(3)
```

```
M =  
    8    1    6  
    3    5    7  
    4    9    2
```

The product of the elements in each column is

```
prod(M) =  
    96    45    84
```

The product of the elements in each row can be obtained by:

```
prod(M,2) =  
    48
```



105  
72

**See Also**      cumprod, diff, sum

# profile

---

**Purpose** Profile execution time for function

**GUI Alternatives** As an alternative to the `profile` function, select **Desktop > Profiler** to open the Profiler.

**Syntax**

```
profile on
profile on -detail level
profile on -history
profile on -nohistory
profile on -timer clock
profile on -detail level -history -timer clock
profile off
profile resume
profile clear
profile viewer
S = profile('status')
stats = profile('info')
```

**Description** The `profile` function helps you debug and optimize M-files by tracking their execution time. For each function in the M-file, `profile` records information about execution time, number of calls, parent functions, child functions, code line hit count, and code line execution time. Some people use `profile` simply to see the child functions; see also `depfun` for that purpose. To open the Profiler graphical user interface, use the `profile viewer` syntax. Profile time is CPU time. The total time reported by the Profiler is not the same as the time reported using the `tic` and `toc` functions or the time you would observe using a stopwatch. To change options, stop profiling and then start or resume profiling with new options.

`profile on` starts the Profiler, clearing previously recorded profile statistics.

`profile on -detail level` starts the Profiler, clearing previously recorded profile statistics, and specifies the set of functions you want to profile. The level applies to subsequent uses of `profile` or the Profiler, until you change it. Allowable values for `level` are

- 'builtin'—Gathers information about M-functions, M-subfunctions, and MEX-functions, plus built-in functions, such as eig.
- 'mmex'—Gathers information about M-functions, M-subfunctions, and MEX-functions. This is the default value.

`profile on -history` starts the Profiler, clearing previously recorded profile statistics, and records the exact sequence of function calls. The `profile` function records up to 10,000 function entry and exit events. For more than 10,000 events, `profile` continues to record other profile statistics, but not the sequence of calls. By default, the `history` option is not enabled.

`profile on -nohistory` starts the Profiler, clearing previously recorded profile statistics, and disables further recording of the history (exact sequence of function calls). Use the `-nohistory` option after having previously set the `-history` option. All other profiling statistics continue to accumulate.

`profile on -timer clock` starts the Profiler, clearing previously recorded profile statistics, and specifies the type of time to use. Allowable values for `clock` are

- 'cpu'—The Profiler uses compute time (the default).
- 'real'—The Profiler uses wall-clock time.

For example, `cpu` time for the `pause` function would be small, but `real` time would account for the actual time paused.

`profile on -detail level -history -timer clock` starts the Profiler using all of these specified options. Any order is acceptable, as is a subset.

`profile off` stops the Profiler.

`profile resume` restarts the Profiler without clearing previously recorded statistics.

`profile clear` clears the statistics recorded by `profile`.

# profile

---

`profile viewer` stops the Profiler and displays the results in the Profiler window. For more information, see *Profiling for Improving Performance in the Desktop Tools and Development Environment* documentation.

`S = profile('status')` returns a structure containing information about the current status of the Profiler. The table lists the fields in the order they appear in the structure.

| Field           | Values              |
|-----------------|---------------------|
| ProfilerStatus  | 'on' or 'off'       |
| DetailLevel     | 'mmex' or 'builtin' |
| Timer           | 'cpu' or 'real'     |
| HistoryTracking | 'on' or 'off'       |

`stats = profile('info')` stops the Profiler and displays a structure containing the results. Use this function to access the data generated by `profile`. The table lists the fields in the order they appear in the structure.

| Field           | Description                                                      |
|-----------------|------------------------------------------------------------------|
| FunctionTable   | Structure array containing statistics about each function called |
| FunctionHistory | Array containing function call history                           |
| ClockPrecision  | Precision of <code>profile</code> 's time measurement            |
| ClockSpeed      | Estimated clock speed of the CPU                                 |
| Name            | Name of the profiler                                             |

The `FunctionTable` field is an array of structures, where each structure contains information about one of the functions or subfunctions called during execution. The following table lists these fields in the order they appear in the structure.

| Field              | Description                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CompleteName       | Full path to FunctionName, including subfunctions                                                                                                                                                                                                                                                                                                                                                     |
| FunctionName       | Function name; includes subfunctions                                                                                                                                                                                                                                                                                                                                                                  |
| FileName           | Full path to FunctionName, with file extension, excluding subfunctions                                                                                                                                                                                                                                                                                                                                |
| Type               | M-functions, MEX-functions, and many other types of functions including M-subfunctions, nested functions, and anonymous functions                                                                                                                                                                                                                                                                     |
| NumCalls           | Number of times the function was called                                                                                                                                                                                                                                                                                                                                                               |
| TotalTime          | Total time spent in the function and its child functions                                                                                                                                                                                                                                                                                                                                              |
| TotalRecursiveTime | No longer used.                                                                                                                                                                                                                                                                                                                                                                                       |
| Children           | FunctionTable indices to child functions                                                                                                                                                                                                                                                                                                                                                              |
| Parents            | FunctionTable indices to parent functions                                                                                                                                                                                                                                                                                                                                                             |
| ExecutedLines      | <p>Array containing line-by-line details for the function being profiled.</p> <p>Column 1: Number of the line that executed. If a line was not executed, it does not appear in this matrix.</p> <p>Column 2: Number of times the line was executed</p> <p>Column 3: Total time spent on that line.<br/>Note: The sum of Column 3 entries does not necessarily add up to the function's TotalTime.</p> |

| Field       | Description                                                                                                                                                                                                  |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IsRecursive | BOOLEAN value: Logical 1 (true) if recursive, otherwise logical 0 (false)                                                                                                                                    |
| PartialData | BOOLEAN value: Logical 1 (true) if function was modified during profiling, for example by being edited or cleared. In that event, data was collected only up until the point when the function was modified. |

## Examples

### Profile and Display Results

This example profiles the MATLAB magic command and then displays the results in the Profiler window. The example then retrieves the profile data on which the HTML display is based and uses the `profsave` command to save the profile data in HTML form.

```
profile on
plot(magic(35))
profile viewer
p = profile('info');
profsave(p,'profile_results')
```

### Profile and Save Results

Another way to save profile data is to store it in a MAT-file. This example stores the profile data in a MAT-file, clears the profile data from memory, and then loads the profile data from the MAT-file. This example also shows a way to bring the reloaded profile data into the Profiler graphical interface as live profile data, not as a static HTML page.

```
p = profile('info');
save myprofiledata p
clear p
load myprofiledata
profview(0,p)
```

## Profile and Show Results Including History

This example illustrates an effective way to view the results of profiling when the history option is enabled. The history data describes the sequence of functions entered and exited during execution. The `profile` command returns history data in the `FunctionHistory` field of the structure it returns. The history data is a 2-by-n array. The first row contains Boolean values, where 0 means entrance into a function and 1 means exit from a function. The second row identifies the function being entered or exited by its index in the `FunctionTable` field. This example reads the history data and displays it in the MATLAB Command Window.

```
profile on -history
plot(magic(4));
p = profile('info');

for n = 1:size(p.FunctionHistory,2)
    if p.FunctionHistory(1,n)==0
        str = 'entering function: ';
    else
        str = 'exiting function: ';
    end
    disp([str p.FunctionTable(p.FunctionHistory(2,n)).FunctionName])
end
```

### See Also

`depsdir`, `depfun`, `mlint`, `profsave`

Profiling for Improving Performance in the MATLAB Desktop Tools and Development Environment documentation

# profsave

---

**Purpose** Save profile report in HTML format

**Syntax**

```
profsave
profsave(profinfo)
profsave(profinfo,dirname)
```

**Description** `profsave` executes the `profile('info')` function and saves the results in HTML format. `profsave` creates a separate HTML file for each function listed in the `FunctionTable` field of the structure returned by `profile`. By default, `profsave` stores the HTML files in a subdirectory of the current directory named `profile_results`.

`profsave(profinfo)` saves the profiling results, `profinfo`, in HTML format. `profinfo` is a structure of profiling information returned by the `profile('info')` function.

`profsave(profinfo,dirname)` saves the profiling results, `profinfo`, in HTML format. `profsave` creates a separate HTML file for each function listed in the `FunctionTable` field of `profinfo` and stores them in the directory specified by `dirname`.

**Examples** Run profile and save the results.

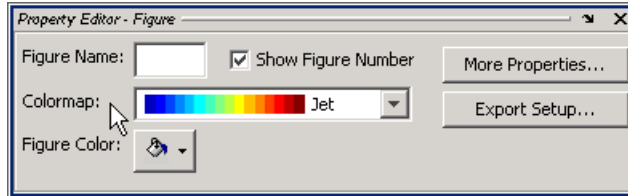
```
profile on
plot(magic(5))
profile off
profsave(profile('info'),'myprofile_results')
```

**See Also** `profile`

Profiling for Improving Performance in the MATLAB Desktop Tools and Development Environment documentation



**Purpose** Open Property Editor



**Syntax**  
`propedit`  
`propedit(handle_list)`

**Description** `propedit` starts the Property Editor, a graphical user interface to the properties of graphics objects. If no current figure exists, `propedit` will create one.

`propedit(handle_list)` edits the properties for the object (or objects) in `handle_list`.

Starting the Property Editor enables plot editing mode for the figure.

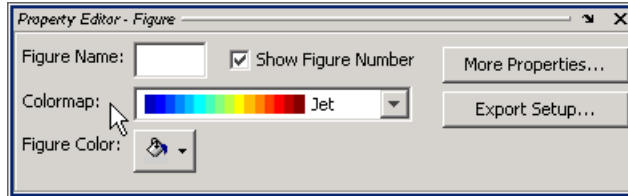
**See Also** `inspect`, `plottedit`, `propertyeditor`

# propedit (COM)



---

|                    |                                                                                                                                                                                                                                                                                 |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Open built-in property page for control                                                                                                                                                                                                                                         |
| <b>Syntax</b>      | <code>h.propedit</code><br><code>propedit(h)</code>                                                                                                                                                                                                                             |
| <b>Description</b> | <p><code>h.propedit</code> requests the control to display its built-in property page. Note that some controls do not have a built-in property page. For those controls, this command fails.</p> <p><code>propedit(h)</code> is an alternate syntax for the same operation.</p> |
| <b>Examples</b>    | <p>Create a Microsoft Calendar control and display its property page:</p> <pre>cal = actxcontrol('mscal.calendar', [0 0 500 500]); cal.propedit</pre>                                                                                                                           |
| <b>See Also</b>    | <code>inspect</code> , <code>get</code>                                                                                                                                                                                                                                         |

**Purpose** Show or hide property editor



## GUI Alternatives

Click the larger **Plotting Tools** icon  on the figure toolbar to collectively enable plotting tools, and the smaller icon  to collectively disable them. Open or close the **Property Editor** tool from the figure's **View** menu. For details, see “The Property Editor” in the MATLAB Graphics documentation.

## Syntax

```
propertyeditor('on')
propertyeditor('off')
propertyeditor('toggle')
propertyeditor
propertyeditor(figure_handle,...)
```

## Description

`propertyeditor('on')` displays the Property Editor on the current figure.

`propertyeditor('off')` hides the Property Editor on the current figure.

`propertyeditor('toggle')` or `propertyeditor` toggles the visibility of the property editor on the current figure.

`propertyeditor(figure_handle,...)` displays or hides the Property Editor on the figure specified by `figure_handle`.

## See Also

`plottools`, `plotbrowser`, `figurepalette`, `inspect`

**Purpose** Psi (polygamma) function

**Syntax**  
Y = psi(X)  
Y = psi(k,X)  
Y = psi(k0:k1,X)

**Description** Y = psi(X) evaluates the  $\Psi$  function for each element of array X. X must be real and nonnegative. The  $\Psi$  function, also known as the digamma function, is the logarithmic derivative of the gamma function

$$\begin{aligned}\psi(x) &= \text{digamma}(x) \\ &= \frac{d(\log(\Gamma(x)))}{dx} \\ &= \frac{d(\Gamma(x))/dx}{\Gamma(x)}\end{aligned}$$

Y = psi(k,X) evaluates the kth derivative of  $\Psi$  at the elements of X. psi(0,X) is the digamma function, psi(1,X) is the trigamma function, psi(2,X) is the tetragamma function, etc.

Y = psi(k0:k1,X) evaluates derivatives of order k0 through k1 at X. Y(k,j) is the (k-1+k0)th derivative of  $\Psi$ , evaluated at X(j).

## Examples

### Example 1

Use the psi function to calculate Euler's constant,  $\gamma$ .

```
format long
-psi(1)
ans =
    0.57721566490153

-psi(0,1)
ans =
    0.57721566490153
```

**Example 2**

The trigamma function of 2,  $\text{psi}(1,2)$ , is the same as  $(\pi^2/6) - 1$ .

```
format long
psi(1,2)
ans =
    0.64493406684823

pi^2/6 - 1
ans =
    0.64493406684823
```

**Example 3**

This code produces the first page of Table 6.1 in Abramowitz and Stegun [1].

```
x = (1:.005:1.250)';
[x gamma(x) gammaIn(x) psi(0:1,x)' x-1]
```

**Example 4**

This code produces a portion of Table 6.2 in [1].

```
psi(2:3,1:.01:2)'
```

**See Also**

gamma, gammainc, gammaIn

**References**

[1] Abramowitz, M. and I. A. Stegun, *Handbook of Mathematical Functions*, Dover Publications, 1965, Sections 6.3 and 6.4.

# publish

---

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Publish M-file containing cells, saving output to file of specified type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>GUI Alternatives</b> | As an alternative to the publish function, use the <b>File &gt; Publish To</b> menu items in the Editor/Debugger.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Syntax</b>           | <pre>publish('script') publish('script','format') publish('script',options) publish('function',options)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Description</b>      | <p><code>publish('script')</code> runs the M-file script named <code>script</code> in the base workspace one cell at a time, and saves the code, comments, and results to an HTML output file. The output file is named <code>script.html</code> and is stored, along with other supporting output files, in an <code>html</code> subdirectory in <code>script</code>'s directory.</p> <p><code>publish('script','format')</code> runs the M-file script named <code>script</code>, one cell at a time in the base workspace, and publishes the code, comments, and results to an output file using the specified <code>format</code>. Allowable values for <code>format</code> are <code>html</code> (the default), <code>xml</code>, <code>latex</code> for LaTeX, <code>doc</code> for Microsoft Word documents, and <code>ppt</code> for Microsoft PowerPoint documents. The output file is named <code>script.format</code> and is stored, along with other supporting output files, in an <code>html</code> subdirectory in <code>script</code>'s directory. The <code>doc</code> format requires the Microsoft Word application, and the <code>ppt</code> format requires PowerPoint application. When publishing to HTML, the M-file code is included at the end of published HTML file as comments, even when the <code>showCode</code> option is set to <code>false</code>. Because it is included as comments, it does not display in a Web browser. Use the <code>grabcode</code> function to extract the code from the HTML file.</p> <p><code>publish('script',options)</code> publishes using the structure <code>options</code>, which can contain any of the fields and corresponding value for each field as shown in Options for publish on page 2-2583. Create and save structures for the options you use regularly. For details about the values, see and Publishing Images preferences in the online documentation for MATLAB.</p> |

`publish('function', options)` publishes an M-file function using the structure *options*. The `evalCode` field must be set to `false` to publish a function. Publishing an M-file function essentially saves the M-file to another format, such as HTML, which allows display with formatting in a Web browser.

### Options for publish

| Field                         | Allowable Values                                                                                                                                                                                                                                                                                          |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>format</code>           | 'doc', 'html' (default), 'latex', 'ppt', 'xml'                                                                                                                                                                                                                                                            |
| <code>stylesheet</code>       | ' ' (default), XSL filename (used only when format is html, latex, or xml)                                                                                                                                                                                                                                |
| <code>outputDir</code>        | ' ' (default, a subfolder named html), full pathname                                                                                                                                                                                                                                                      |
| <code>imageFormat</code>      | 'png' (default unless format is latex), 'eps2' (default when format is latex), any format supported by <code>print</code> when <code>figureSnapMethod</code> is <code>print</code> , any format supported by <code>imwrite</code> functions when <code>figureSnapMethod</code> is <code>getframe</code> . |
| <code>figureSnapMethod</code> | 'print' (default), 'getframe'                                                                                                                                                                                                                                                                             |
| <code>useNewFigure</code>     | true (default), false                                                                                                                                                                                                                                                                                     |
| <code>maxHeight</code>        | [] (default), positive integer specifying number of pixels                                                                                                                                                                                                                                                |
| <code>maxWidth</code>         | [] (default), positive integer specifying number of pixels                                                                                                                                                                                                                                                |
| <code>showCode</code>         | true (default), false                                                                                                                                                                                                                                                                                     |
| <code>evalCode</code>         | true (default), false                                                                                                                                                                                                                                                                                     |
| <code>catchError</code>       | true (default, continues publishing and includes the error in the published file), false (displays the error and publishing ends)                                                                                                                                                                         |
| <code>stopOnError</code>      | true (default), false                                                                                                                                                                                                                                                                                     |

# publish

---

## Options for publish (Continued)

| Field           | Allowable Values                                                                                             |
|-----------------|--------------------------------------------------------------------------------------------------------------|
| createThumbnail | true (default), false                                                                                        |
| maxOutputLines  | Inf (default), nonnegative integer specifying the maximum number of output lines before truncation of output |

## Examples

### Publish to HTML Format

To publish the M-file script `d:/mymfiles/sine_wave.m` to HTML, run

```
publish('d:/mymfiles/sine_wave.m', 'html')
```

MATLAB runs the file and saves the code, comments, and results to `d:/mymfiles/html/sine_wave.html`. Open that file in the Web browser to view the published document.

### Publish with Options

This example defines the structure `options_doc_nocode`, publishes `sine_wave.m` using the defined options, and displays the resulting file. The resulting file is a Word document, `d:/nocode_output/sine_wave.doc` and includes results, but not MATLAB code.

```
options_doc_nocode.format='doc'  
options_doc_nocode.outputDir='d:/nocode_output'  
options_doc_nocode.showCode=false  
publish('d:/mymfiles/sine_wave.m',options_doc_nocode)  
winopen('d:/nocode_output/sine_wave.doc')
```

### Publish Function M-File (Save M-File as HTML)

This example defines the structure `function_options`, publishes the function `d:/collatzplot.m`, and displays the resulting file, an HTML document, `d:/html/collatzplot.html`.



```
function_options.format='html'  
function_options.evalCode=false  
publish('d:/collatzplot.m',function_options)  
web('d:/html/collatzplot.html')
```

## See Also

grabcode, notebook, web, winopen

MATLAB Desktop Tools and Development Environment documentation, specifically

- Publishing to HTML, XML, LaTeX, Word, and PowerPoint Using Cells
- Defining Cells

# PutCharArray

---

**Purpose** Store character array in server

**Syntax** **MATLAB Client**  
h.PutCharArray('varname', 'workspace', 'string')  
PutCharArray(h, 'varname', 'workspace', 'string')  
invoke(h, 'PutCharArray', 'varname', 'workspace', 'string')

**Method Signature**  
PutCharArray([in] BSTR varname, [in] BSTR workspace,  
[in] BSTR string)

**Visual Basic Client**  
PutCharArray(varname As String, workspace As String,  
string As String)

**Description** PutCharArray stores the character array in string in the specified workspace of the server attached to handle h, assigning to it the variable varname. The workspace argument can be either base or global.

**Remarks** The character array specified in the string argument can have any dimensions. However, PutCharArray changes the dimensions to a 1-by-n column-wise representation, where n is the number of characters in the array. Executing the following commands in MATLAB illustrates this behavior:

```
h = actxserver('matlab.application');  
chArr = ['abc'; 'def'; 'ghk']  
chArr =  
abc  
def  
ghk  
  
h.PutCharArray('Foo', 'base', chArr)  
tstArr = h.GetCharArray('Foo', 'base')  
tstArr =  
adgbehcfk
```

Server function names, like PutCharArray, are case sensitive when using the dot notation syntax shown in the Syntax section.

There is no difference in the operation of the three syntaxes shown above for the MATLAB client.

## Examples

Store string `str` in the base workspace of the server using PutCharArray.

### MATLAB Client

```
h = actxserver('matlab.application');
h.PutCharArray('str', 'base', ...
    'He jests at scars that never felt a wound.')

S = h.GetCharArray('str', 'base')
S =
    He jests at scars that never felt a wound.
```

### Visual Basic .NET Client

This example uses the Visual Basic MsgBox command to control flow between MATLAB and the Visual Basic Client.

```
Dim Matlab As Object
Try
    Matlab = GetObject(, "matlab.application")
Catch e As Exception
    Matlab = CreateObject("matlab.application")
End Try
MsgBox("MATLAB window created; now open it...")
```

Open the MATLAB window, then click **Ok**.

```
Matlab.PutCharArray("str", "base", _
    "He jests at scars that never felt a wound.")
MsgBox("In MATLAB, type" & vbCrLf _
    & "str")
```

# PutCharArray

---

In the MATLAB window type `str`; MATLAB displays

```
str =  
He jests at scars that never felt a wound.
```

Click **Ok**.

```
MsgBox("closing MATLAB window...")
```

Click **Ok** to close and terminate MATLAB.

```
Matlab.Quit()
```

## See Also

`GetCharArray`, `PutWorkspaceData`, `GetWorkspaceData`, `Execute`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Store matrix in server                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Syntax</b>      | <p><b>MATLAB Client</b></p> <pre>h.PutFullMatrix('varname', 'workspace', xreal, ximag) PutFullMatrix(h, 'varname', 'workspace', xreal, ximag) invoke(h, 'PutFullMatrix', 'varname', 'workspace', xreal, ximag)</pre> <p><b>Method Signature</b></p> <pre>PutFullMatrix([in] BSTR varname, [in] BSTR workspace, [in] SAFEARRAY(double) xreal, [in] SAFEARRAY(double) ximag)</pre> <p><b>Visual Basic Client</b></p> <pre>PutFullMatrix([in] varname As String, [in] workspace As String, [in] xreal As Double, [in] ximag As Double)</pre>                                                       |
| <b>Description</b> | PutFullMatrix stores a matrix in the specified workspace of the server attached to handle h, assigning to it the variable varname. Enter the real and imaginary parts of the matrix in the xreal and ximag input arguments. The workspace argument can be either base or global.                                                                                                                                                                                                                                                                                                                |
| <b>Remarks</b>     | <p>The matrix specified in the xreal and ximag arguments cannot be scalar, an empty array, or have more than two dimensions.</p> <p>Server function names, like PutFullMatrix, are case sensitive when using the first syntax shown.</p> <p>There is no difference in the operation of the three syntaxes shown above for the MATLAB client.</p> <p>For VBScript clients, use the GetWorkspaceData and PutWorkspaceData functions to pass numeric data to and from the MATLAB workspace. These functions use the variant data type instead of safearray which is not supported by VBScript.</p> |

# PutFullMatrix

---

## Examples

### Writing to the Base Workspace Example

Assign a 5-by-5 real matrix to the variable M in the base workspace of the server, and then read it back with GetFullMatrix. The real and imaginary parts are passed in through separate arrays of doubles.

#### MATLAB Client

```
h = actxserver('matlab.application');
h.PutFullMatrix('M', 'base', rand(5), zeros(5))
% One output returns real, use two for real and imag
xreal = h.GetFullMatrix('M', 'base', zeros(5), zeros(5))
xreal =
    0.9501    0.7621    0.6154    0.4057    0.0579
    0.2311    0.4565    0.7919    0.9355    0.3529
    0.6068    0.0185    0.9218    0.9169    0.8132
    0.4860    0.8214    0.7382    0.4103    0.0099
    0.8913    0.4447    0.1763    0.8936    0.1389
```

#### Visual Basic .NET Client

```
Dim MatLab As Object
Dim XReal(4, 4) As Double
Dim XImag(4, 4) As Double
Dim ZReal(4, 4) As Double
Dim ZImag(4, 4) As Double
Dim i, j As Integer

For i = 0 To 4
    For j = 0 To 4
        XReal(i, j) = Rnd() * 6
        XImag(i, j) = 0
    Next j
Next i

Matlab = CreateObject("matlab.application")
MatLab.PutFullMatrix("M", "base", XReal, XImag)
MatLab.GetFullMatrix("M", "base", ZReal, ZImag)
```

## Writing to the Global Workspace Example

Write a matrix to the global workspace of the server and then examine the server's global workspace from the client.

### MATLAB Client

```
h = actxserver('matlab.application');
h.PutFullMatrix('X', 'global', [1 3 5; 2 4 6], ...
                [1 1 1; 1 1 1])
h.invoke('Execute', 'whos global')
ans =
  Name      Size      Bytes  Class
  X         2x3         96  double array (global complex)
Grand total is 6 elements using 96 bytes
```

### Visual Basic .NET Client

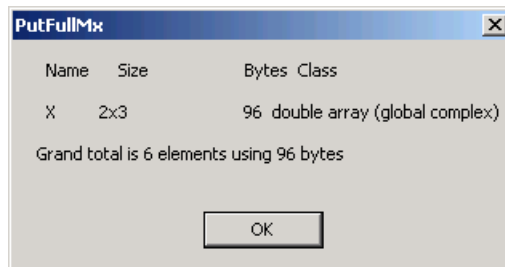
```
Dim MatLab As Object
Dim XReal(1, 2) As Double
Dim XImag(1, 2) As Double
Dim result As String
Dim i, j As Integer

For i = 0 To 1
  For j = 0 To 2
    XReal(i, j) = (j * 2 + 1) + i
    XImag(i, j) = 1
  Next j
Next i

Matlab = CreateObject("matlab.application")
MatLab.PutFullMatrix("X", "global", XReal, XImag)
result = Matlab.Execute("whos global")
MsgBox(result)
```

# PutFullMatrix

---



## See Also

GetFullMatrix, PutWorkspaceData, , GetWorkspaceDataExecute



**Purpose** Store data in server workspace

**Syntax**

**MATLAB Client**

```
h.PutWorkspaceData('varname', 'workspace', data)
PutWorkspaceData(h, 'varname', 'workspace', data)
invoke(h, 'PutWorkspaceData', 'varname', 'workspace', data)
```

**Method Signature**

```
PutWorkspaceData([in] BSTR varname, [in] BSTR workspace,
[in] VARIANT data)
```

**Visual Basic Client**

```
PutWorkspaceData(varname As String, workspace As String,
data As Object)
```

**Description**

PutWorkspaceData stores data in the specified workspace of the server attached to handle h, assigning to it the variable varname. The workspace argument can be either base or global.

---

**Note** PutWorkspaceData works on all MATLAB data types except sparse arrays, structure arrays, and function handles. Use the Execute method for these data types.

---

**Passing Character Arrays**

MATLAB enables you to define 2-D character arrays such as the following:

```
chArr = ['abc'; 'def'; 'ghk']
chArr =
abc
def
ghk

size(chArr)
ans =
     3     3
```

# PutWorkspaceData

---

However, PutWorkspaceData does not preserve the dimensions of character arrays when passing them to a COM server. 2-D arrays are converted to 1-by-n arrays of characters, where n equals the number of characters in the original array plus one newline character for each row in the original array. This means that chArr above is converted to a 1-by-12 array, but the newline characters make it display with three rows in the MATLAB command window. For example,

```
h = actxserver('matlab.application');
h.PutWorkspaceData('Foo','base',chArr);
tstArr = h.GetWorkspaceData('Foo','base')
tstArr =
abc
def
ghk

size(tstArr)
ans =
     1     12
```

## Remarks

You can use PutWorkspaceData in place of PutFullMatrix and PutCharArray to pass numeric and character array data respectively to the server.

Server function names, like PutWorkspaceData, are case sensitive when using the first syntax shown.

There is no difference in the operation of the three syntaxes shown above for the MATLAB client.

The GetWorkspaceData and PutWorkspaceData functions pass numeric data as a variant data type. These functions are especially useful for VBScript clients as VBScript does not support the safearray data type used by GetFullMatrix and PutFullMatrix.

## Examples

Create an array in the client and assign it to variable A in the base workspace of the server:

## MATLAB Client

```
h = actxserver('matlab.application');
for i = 0:6
    data(i+1) = i * 15;
end
h.PutWorkspaceData('A', 'base', data)
```

## Visual Basic .NET Client

This example uses the Visual Basic MsgBox command to control flow between MATLAB and the Visual Basic Client.

```
Dim Matlab As Object
Dim data(6) As Double
Dim i As Integer
MatLab = CreateObject("matlab.application")
For i = 0 To 6
    data(i) = i * 15
Next i
MatLab.PutWorkspaceData("A", "base", data)
MsgBox("In MATLAB, type" & vbCrLf & "A")
```

Open the MATLAB window and type A. MATLAB displays

```
A =
    0    15    30    45    60    75    90
```

Click **Ok** to close and terminate MATLAB.

## See Also


GetWorkspaceData, PutFullMatrix, , GetFullMatrix, PutCharArray, GetCharArrayExecute

See “Introduction” for more examples.

# pwd

---

**Purpose** Identify current directory

**Graphical Interface** As an alternative to the pwd function, use the “Current Directory Field”  in the MATLAB desktop toolbar.

**Syntax**

```
pwd  
s = pwd
```

**Description** pwd displays the current working directory.  
s = pwd returns the current directory to the variable s.  
On Windows platforms, go directly to the current working directory using

```
winopen(pwd)
```

**See Also** cd, dir, fileparts, mfilename, path, what, winopen

**Purpose** Quasi-minimal residual method

**Syntax**

```
x = qmr(A,b)
qmr(A,b,tol)
qmr(A,b,tol,maxit)
qmr(A,b,tol,maxit,M)
qmr(A,b,tol,maxit,M1,M2)
qmr(A,b,tol,maxit,M1,M2,x0)
[x,flag] = qmr(A,b,...)
[x,flag,relres] = qmr(A,b,...)
[x,flag,relres,iter] = qmr(A,b,...)
[x,flag,relres,iter,resvec] = qmr(A,b,...)
```

**Description** `x = qmr(A,b)` attempts to solve the system of linear equations  $A*x=b$  for  $x$ . The  $n$ -by- $n$  coefficient matrix  $A$  must be square and should be large and sparse. The column vector  $b$  must have length  $n$ .  $A$  can be a function handle `afun` such that `afun(x,'notransp')` returns  $A*x$  and `afun(x,'transp')` returns  $A'*x$ . See “Function Handles” in the MATLAB Programming documentation for more information.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `afun`, as well as the preconditioner function `mfun` described below, if necessary.

If `qmr` converges, a message to that effect is displayed. If `qmr` fails to converge after the maximum number of iterations or halts for any reason, a warning message is printed displaying the relative residual  $\text{norm}(b-A*x)/\text{norm}(b)$  and the iteration number at which the method stopped or failed.

`qmr(A,b,tol)` specifies the tolerance of the method. If `tol` is `[]`, then `qmr` uses the default,  $1e-6$ .

`qmr(A,b,tol,maxit)` specifies the maximum number of iterations. If `maxit` is `[]`, then `qmr` uses the default,  $\min(n,20)$ .

`qmr(A,b,tol,maxit,M)` and `qmr(A,b,tol,maxit,M1,M2)` use preconditioners  $M$  or  $M = M1*M2$  and effectively solve the system

$\text{inv}(M) \cdot A \cdot x = \text{inv}(M) \cdot b$  for  $x$ . If  $M$  is  $[]$  then `qmr` applies no preconditioner.  $M$  can be a function handle `mfun` such that `mfun(x, 'notransp')` returns  $M \setminus x$  and `mfun(x, 'transp')` returns  $M' \setminus x$ .

`qmr(A,b,tol,maxit,M1,M2,x0)` specifies the initial guess. If  $x_0$  is  $[]$ , then `qmr` uses the default, an all zero vector.

`[x,flag] = qmr(A,b,...)` also returns a convergence flag.

| Flag | Convergence                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------------------|
| 0    | <code>qmr</code> converged to the desired tolerance <code>tol</code> within <code>maxit</code> iterations.           |
| 1    | <code>qmr</code> iterated <code>maxit</code> times but did not converge.                                             |
| 2    | Preconditioner $M$ was ill-conditioned.                                                                              |
| 3    | The method stagnated. (Two consecutive iterates were the same.)                                                      |
| 4    | One of the scalar quantities calculated during <code>qmr</code> became too small or too large to continue computing. |

Whenever `flag` is not 0, the solution  $x$  returned is that with minimal norm residual computed over all the iterations. No messages are displayed if the `flag` output is specified.

`[x,flag,relres] = qmr(A,b,...)` also returns the relative residual norm  $\text{norm}(b-A \cdot x) / \text{norm}(b)$ . If `flag` is 0, `relres`  $\leq$  `tol`.

`[x,flag,relres,iter] = qmr(A,b,...)` also returns the iteration number at which  $x$  was computed, where  $0 \leq \text{iter} \leq \text{maxit}$ .

`[x,flag,relres,iter,resvec] = qmr(A,b,...)` also returns a vector of the residual norms at each iteration, including  $\text{norm}(b-A \cdot x_0)$ .

## Examples

### Example 1

```
n = 100;
on = ones(n,1);
```

```

A = spdiags([-2*on 4*on -on],-1:1,n,n);
b = sum(A,2);
tol = 1e-8; maxit = 15;
M1 = spdiags([on/(-2) on],-1:0,n,n);
M2 = spdiags([4*on -on],0:1,n,n);
x = qmr(A,b,tol,maxit,M1,M2);

```

displays the message

```

qmr converged at iteration 9 to a solution...
with relative residual
5.6e-009

```

## Example 2

This example replaces the matrix  $A$  in Example 1 with a handle to a matrix-vector product function `afun`. The example is contained in an M-file `run_qmr` that

- Calls `qmr` with the function handle `@afun` as its first argument.
- Contains `afun` as a nested function, so that all variables in `run_qmr` are available to `afun`.

The following shows the code for `run_qmr`:

```

function x1 = run_qmr
n = 100;
on = ones(n,1);
A = spdiags([-2*on 4*on -on],-1:1,n,n);
b = sum(A,2);
tol = 1e-8;
maxit = 15;
M1 = spdiags([on/(-2) on],-1:0,n,n);
M2 = spdiags([4*on -on],0:1,n,n);
x1 = qmr(@afun,b,tol,maxit,M1,M2);

function y = afun(x,transp_flag)
    if strcmp(transp_flag,'transp')
        % y = A'*x

```

```
        y = 4 * x;  
        y(1:n-1) = y(1:n-1) - 2 * x(2:n);  
        y(2:n) = y(2:n) - x(1:n-1);  
    elseif strcmp(transp_flag,'notransp') % y = A*x  
        y = 4 * x;  
        y(2:n) = y(2:n) - 2 * x(1:n-1);  
        y(1:n-1) = y(1:n-1) - x(2:n);  
    end  
end  
end  
end
```

When you enter

```
x1=run_qmr;
```

MATLAB displays the message

```
qmr converged at iteration 9 to a solution with relative residual  
5.6e-009
```

### **Example 3**

```
load west0479;  
A = west0479;  
b = sum(A,2);  
[x,flag] = qmr(A,b)
```

flag is 1 because qmr does not converge to the default tolerance  $1e-6$  within the default 20 iterations.

```
[L1,U1] = luinc(A,1e-5);  
[x1,flag1] = qmr(A,b,1e-6,20,L1,U1)
```

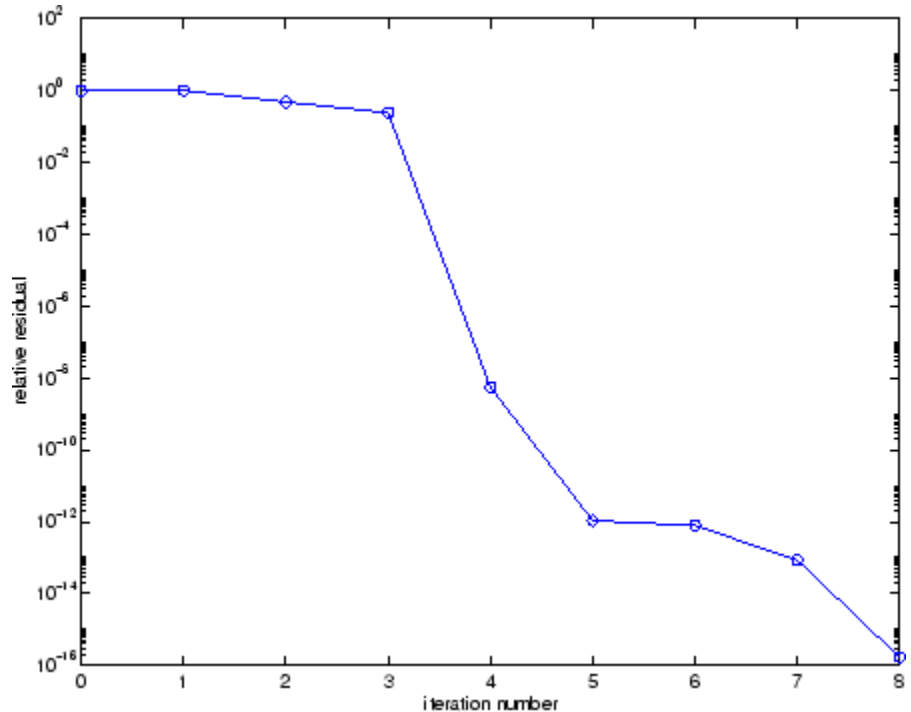
flag1 is 2 because the upper triangular  $U1$  has a zero on its diagonal, and qmr fails in the first iteration when it tries to solve a system such as  $U1*y = r$  for  $y$  using backslash.

```
[L2,U2] = luinc(A,1e-6);  
[x2,flag2,relres2,iter2,resvec2] = qmr(A,b,1e-15,10,L2,U2)
```



flag2 is 0 because qmr converges to the tolerance of  $1.6571e-016$  (the value of relres2) at the eighth iteration (the value of iter2) when preconditioned by the incomplete LU factorization with a drop tolerance of  $1e-6$ . resvec2(1) = norm(b) and resvec2(9) = norm(b-A\*x2). You can follow the progress of qmr by plotting the relative residuals at each iteration starting from the initial estimate (iterate number 0).

```
semilogy(0:iter2,resvec2/norm(b),'-o')
xlabel('iteration number')
ylabel('relative residual')
```



## See Also

bicg, bicgstab, cgs, gmres, lsqr, luinc, minres, pcg, symmlq,  
function\_handle (@), mldivide (\)

## References

- [1] Barrett, R., M. Berry, T. F. Chan, et al., *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*, SIAM, Philadelphia, 1994.
- [2] Freund, Roland W. and Noël M. Nachtigal, "QMR: A quasi-minimal residual method for non-Hermitian linear systems," *SIAM Journal: Numer. Math.* 60, 1991, pp. 315-339.

**Purpose**

Orthogonal-triangular decomposition

**Syntax**

$[Q,R] = \text{qr}(A)$       (*full and sparse matrices*)  
 $[Q,R] = \text{qr}(A,0)$     (*full and sparse matrices*)  
 $[Q,R,E] = \text{qr}(A)$      (*full matrices*)  
 $[Q,R,E] = \text{qr}(A,0)$    (*full matrices*)  
 $X = \text{qr}(A)$             (*full matrices*)  
 $R = \text{qr}(A)$             (*sparse matrices*)  
 $[C,R] = \text{qr}(A,B)$      (*sparse matrices*)  
 $R = \text{qr}(A,0)$          (*sparse matrices*)  
 $[C,R] = \text{qr}(A,B,0)$    (*sparse matrices*)

**Description**

The `qr` function performs the orthogonal-triangular decomposition of a matrix. This factorization is useful for both square and rectangular matrices. It expresses the matrix as the product of a real complex unitary matrix and an upper triangular matrix.

$[Q,R] = \text{qr}(A)$  produces an upper triangular matrix  $R$  of the same dimension as  $A$  and a unitary matrix  $Q$  so that  $A = Q*R$ . For sparse matrices,  $Q$  is often nearly full. If  $[m \ n] = \text{size}(A)$ , then  $Q$  is  $m$ -by- $m$  and  $R$  is  $m$ -by- $n$ .

$[Q,R] = \text{qr}(A,0)$  produces an “economy-size” decomposition. If  $[m \ n] = \text{size}(A)$ , and  $m > n$ , then `qr` computes only the first  $n$  columns of  $Q$  and  $R$  is  $n$ -by- $n$ . If  $m \leq n$ , it is the same as  $[Q,R] = \text{qr}(A)$ .

$[Q,R,E] = \text{qr}(A)$  for full matrix  $A$ , produces a permutation matrix  $E$ , an upper triangular matrix  $R$  with decreasing diagonal elements, and a unitary matrix  $Q$  so that  $A*E = Q*R$ . The column permutation  $E$  is chosen so that  $\text{abs}(\text{diag}(R))$  is decreasing.

$[Q,R,E] = \text{qr}(A,0)$  for full matrix  $A$ , produces an “economy-size” decomposition in which  $E$  is a permutation vector, so that  $A(:,E) = Q*R$ . The column permutation  $E$  is chosen so that  $\text{abs}(\text{diag}(R))$  is decreasing.

$X = \text{qr}(A)$  for full matrix  $A$ , returns the output of the LAPACK subroutine `DGEQRF` or `ZGEQRF`. `triu(qr(A))` is  $R$ .

$R = \text{qr}(A)$  for sparse matrix  $A$ , produces only an upper triangular matrix,  $R$ . The matrix  $R$  provides a Cholesky factorization for the matrix associated with the normal equations,

$$R' * R = A' * A$$

This approach avoids the loss of numerical information inherent in the computation of  $A' * A$ . It may be preferred to  $[Q, R] = \text{qr}(A)$  since  $Q$  is always nearly full.

$[C, R] = \text{qr}(A, B)$  for sparse matrix  $A$ , applies the orthogonal transformations to  $B$ , producing  $C = Q' * B$  without computing  $Q$ .  $B$  and  $A$  must have the same number of rows.

$R = \text{qr}(A, 0)$  and  $[C, R] = \text{qr}(A, B, 0)$  for sparse matrix  $A$ , produce “economy-size” results.

For sparse matrices, the Q-less QR factorization allows the solution of sparse least squares problems

$$\text{minimize} \|Ax - b\|$$

with two steps

$$\begin{aligned} [C, R] &= \text{qr}(A, b) \\ x &= R \setminus c \end{aligned}$$

If  $A$  is sparse but not square, MATLAB uses the two steps above for the linear equation solving backslash operator, i.e.,  $x = A \setminus b$ .

## Examples

### Example 1

Start with

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \\ 10 & 11 & 12 \end{bmatrix}$$

This is a rank-deficient matrix; the middle column is the average of the other two columns. The rank deficiency is revealed by the factorization:

$$[Q,R] = \text{qr}(A)$$

Q =

|         |         |         |         |
|---------|---------|---------|---------|
| -0.0776 | -0.8331 | 0.5444  | 0.0605  |
| -0.3105 | -0.4512 | -0.7709 | 0.3251  |
| -0.5433 | -0.0694 | -0.0913 | -0.8317 |
| -0.7762 | 0.3124  | 0.3178  | 0.4461  |

R =

|          |          |          |
|----------|----------|----------|
| -12.8841 | -14.5916 | -16.2992 |
| 0        | -1.0413  | -2.0826  |
| 0        | 0        | 0.0000   |
| 0        | 0        | 0        |

The triangular structure of R gives it zeros below the diagonal; the zero on the diagonal in R(3,3) implies that R, and consequently A, does not have full rank.

## Example 2

This example uses matrix A from the first example. The QR factorization is used to solve linear systems with more equations than unknowns. For example, let

$$b = [1;3;5;7]$$

The linear system  $Ax = b$  represents four equations in only three unknowns. The best solution in a least squares sense is computed by

$$x = A \backslash b$$

which produces

Warning: Rank deficient, rank = 2, tol = 1.4594E-014

```
x =
    0.5000
         0
    0.1667
```

The quantity `tol` is a tolerance used to decide if a diagonal element of `R` is negligible. If `[Q,R,E] = qr(A)`, then

```
tol = max(size(A))*eps*abs(R(1,1))
```

The solution `x` was computed using the factorization and the two steps

```
y = Q' * b;
x = R \ y
```

The computed solution can be checked by forming  $Ax$ . This equals  $b$  to within roundoff error, which indicates that even though the simultaneous equations  $Ax = b$  are overdetermined and rank deficient, they happen to be consistent. There are infinitely many solution vectors `x`; the QR factorization has found just one of them.

## Algorithm

### Inputs of Type Double

For inputs of type double, `qr` uses the LAPACK routines listed in the following table to compute the QR decomposition.

| Syntax                                                         | Real           | Complex        |
|----------------------------------------------------------------|----------------|----------------|
| <code>X = qr(A)</code><br><code>X = qr(A,0)</code>             | DGEQRF         | ZGEQRF         |
| <code>[Q,R] = qr(A)</code><br><code>[Q,R] = qr(A,0)</code>     | DGEQRF, DORGQR | ZGEQRF, ZUNGQR |
| <code>[Q,R,e] = qr(A)</code><br><code>[Q,R,e] = qr(A,0)</code> | DGEQP3, DORGQR | ZGEQP3, ZUNGQR |

## Inputs of Type Single

For inputs of type `single`, `qr` uses the LAPACK routines listed in the following table to compute the QR decomposition.

| Syntax                                                      | Real           | Complex        |
|-------------------------------------------------------------|----------------|----------------|
| $R = \text{qr}(A)$<br>$R = \text{qr}(A, 0)$                 | SGEQRF         | CGEQRF         |
| $[Q, R] = \text{qr}(A)$<br>$[Q, R] = \text{qr}(A, 0)$       | SGEQRF, SORGQR | CGEQRF, CUNGQR |
| $[Q, R, e] = \text{qr}(A)$<br>$[Q, R, e] = \text{qr}(A, 0)$ | SGEQP3, SORGQR | CGEQP3, CUNGQR |

## See Also

`lu`, `null`, `orth`, `qrdelete`, `qrinsert`, `qrupdate`

The arithmetic operators `\` and `/`

## References

[1] Anderson, E., Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen, *LAPACK User's Guide* ([http://www.netlib.org/lapack/lug/lapack\\_lug.html](http://www.netlib.org/lapack/lug/lapack_lug.html)), Third Edition, SIAM, Philadelphia, 1999.

# qrdelete

---

**Purpose** Remove column or row from QR factorization

**Syntax**

```
[Q1,R1] = qrdelete(Q,R,j)
[Q1,R1] = qrdelete(Q,R,j,'col')
[Q1,R1] = qrdelete(Q,R,j,'row')
```

**Description**

[Q1,R1] = qrdelete(Q,R,j) returns the QR factorization of the matrix A1, where A1 is A with the column A(:,j) removed and [Q,R] = qr(A) is the QR factorization of A.

[Q1,R1] = qrdelete(Q,R,j,'col') is the same as qrdelete(Q,R,j).

[Q1,R1] = qrdelete(Q,R,j,'row') returns the QR factorization of the matrix A1, where A1 is A with the row A(j,:) removed and [Q,R] = qr(A) is the QR factorization of A.

**Examples**

```
A = magic(5);
[Q,R] = qr(A);
j = 3;
[Q1,R1] = qrdelete(Q,R,j,'row');
```

```
Q1 =
    0.5274    -0.5197   -0.6697   -0.0578
    0.7135     0.6911    0.0158    0.1142
    0.3102   -0.1982    0.4675   -0.8037
    0.3413   -0.4616    0.5768    0.5811
```

```
R1 =
   32.2335   26.0908   19.9482   21.4063   23.3297
         0  -19.7045  -10.9891    0.4318   -1.4873
         0         0   22.7444    5.8357   -3.1977
         0         0         0  -14.5784    3.7796
```

returns a valid QR factorization, although possibly different from

```
A2 = A;
A2(j,:) = [];
[Q2,R2] = qr(A2)
```



Q2 =

|         |         |         |         |
|---------|---------|---------|---------|
| -0.5274 | 0.5197  | 0.6697  | -0.0578 |
| -0.7135 | -0.6911 | -0.0158 | 0.1142  |
| -0.3102 | 0.1982  | -0.4675 | -0.8037 |
| -0.3413 | 0.4616  | -0.5768 | 0.5811  |

R2 =

|          |          |          |          |          |
|----------|----------|----------|----------|----------|
| -32.2335 | -26.0908 | -19.9482 | -21.4063 | -23.3297 |
| 0        | 19.7045  | 10.9891  | -0.4318  | 1.4873   |
| 0        | 0        | -22.7444 | -5.8357  | 3.1977   |
| 0        | 0        | 0        | -14.5784 | 3.7796   |

## Algorithm

The `qrdelete` function uses a series of Givens rotations to zero out the appropriate elements of the factorization.

## See Also

`planerot`, `qr`, `qrinsert`

# qrinsert

---

**Purpose** Insert column or row into QR factorization

**Syntax**  
[Q1,R1] = qrinsert(Q,R,j,x)  
[Q1,R1] = qrinsert(Q,R,j,x,'col')  
[Q1,R1] = qrinsert(Q,R,j,x,'row')

**Description** [Q1,R1] = qrinsert(Q,R,j,x) returns the QR factorization of the matrix A1, where A1 is  $A = Q \cdot R$  with the column x inserted before  $A(:,j)$ . If A has n columns and  $j = n+1$ , then x is inserted after the last column of A.

[Q1,R1] = qrinsert(Q,R,j,x,'col') is the same as qrinsert(Q,R,j,x).

[Q1,R1] = qrinsert(Q,R,j,x,'row') returns the QR factorization of the matrix A1, where A1 is  $A = Q \cdot R$  with an extra row, x, inserted before  $A(j,:)$ .

## Examples

```
A = magic(5);  
[Q,R] = qr(A);  
j = 3;  
x = 1:5;  
[Q1,R1] = qrinsert(Q,R,j,x,'row')
```

```
Q1 =  
    0.5231    0.5039   -0.6750    0.1205    0.0411    0.0225  
    0.7078   -0.6966    0.0190   -0.0788    0.0833   -0.0150  
    0.0308    0.0592    0.0656    0.1169    0.1527   -0.9769  
    0.1231    0.1363    0.3542    0.6222    0.6398    0.2104  
    0.3077    0.1902    0.4100    0.4161   -0.7264   -0.0150  
    0.3385    0.4500    0.4961   -0.6366    0.1761    0.0225
```

```
R1 =  
   32.4962   26.6801   21.4795   23.8182   26.0031  
         0   19.9292   12.4403    2.1340    4.3271  
         0         0   24.4514   11.8132    3.9931  
         0         0         0   20.2382   10.3392
```

```

0      0      0      0  16.1948
0      0      0      0      0

```

returns a valid QR factorization, although possibly different from

```

A2 = [A(1:j-1,:); x; A(j:end,:)];
[Q2,R2] = qr(A2)

```

Q2 =

```

-0.5231    0.5039    0.6750   -0.1205    0.0411    0.0225
-0.7078   -0.6966   -0.0190    0.0788    0.0833   -0.0150
-0.0308    0.0592   -0.0656   -0.1169    0.1527   -0.9769
-0.1231    0.1363   -0.3542   -0.6222    0.6398    0.2104
-0.3077    0.1902   -0.4100   -0.4161   -0.7264   -0.0150
-0.3385    0.4500   -0.4961    0.6366    0.1761    0.0225

```

R2 =

```

-32.4962  -26.6801  -21.4795  -23.8182  -26.0031
         0   19.9292   12.4403    2.1340    4.3271
         0         0  -24.4514  -11.8132   -3.9931
         0         0         0  -20.2382  -10.3392
         0         0         0         0   16.1948
         0         0         0         0         0

```

## Algorithm

The `qrinsert` function inserts the values of `x` into the `j`th column (row) of `R`. It then uses a series of Givens rotations to zero out the nonzero elements of `R` on and below the diagonal in the `j`th column (row).

## See Also

`planerot`, `qr`, `qrdelete`

# qrupdate

---

**Description** Rank 1 update to QR factorization

**Syntax** `[Q1,R1] = qrupdate(Q,R,u,v)`

**Description** `[Q1,R1] = qrupdate(Q,R,u,v)` when `[Q,R] = qr(A)` is the original QR factorization of  $A$ , returns the QR factorization of  $A + u*v'$ , where  $u$  and  $v$  are column vectors of appropriate lengths.

**Remarks** `qrupdate` works only for full matrices.

**Examples** The matrix

```
mu = sqrt(eps)
```

```
mu =
```

```
1.4901e-08
```

```
A = [ones(1,4); mu*eye(4)];
```

is a well-known example in least squares that indicates the dangers of forming  $A' * A$ . Instead, we work with the QR factorization – orthonormal  $Q$  and upper triangular  $R$ .

```
[Q,R] = qr(A);
```

As we expect,  $R$  is upper triangular.

```
R =
```

```
-1.0000  -1.0000  -1.0000  -1.0000
         0   0.0000   0.0000   0.0000
         0         0   0.0000   0.0000
         0         0         0   0.0000
         0         0         0         0
```

In this case, the upper triangular entries of R, excluding the first row, are on the order of  $\sqrt{\text{eps}}$ .

Consider the update vectors

$$u = [-1 \ 0 \ 0 \ 0 \ 0]'; \quad v = \text{ones}(4,1);$$

Instead of computing the rather trivial QR factorization of this rank one update to A from scratch with

$$[QT,RT] = \text{qr}(A + u*v')$$

QT =

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \end{bmatrix}$$

RT =

1.0e-007 \*

$$\begin{bmatrix} -0.1490 & 0 & 0 & 0 \\ 0 & -0.1490 & 0 & 0 \\ 0 & 0 & -0.1490 & 0 \\ 0 & 0 & 0 & -0.1490 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

we may use qrupdate.

$$[Q1,R1] = \text{qrupdate}(Q,R,u,v)$$

Q1 =

$$\begin{bmatrix} -0.0000 & -0.0000 & -0.0000 & -0.0000 & 1.0000 \\ 1.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 \end{bmatrix}$$

# qrupdate

---

```
0.0000    1.0000   -0.0000   -0.0000    0.0000
0.0000    0.0000    1.0000   -0.0000    0.0000
-0.0000   -0.0000   -0.0000    1.0000    0.0000
```

R1 =

```
1.0e-007 *
0.1490    0.0000    0.0000    0.0000
0         0.1490    0.0000    0.0000
0         0         0.1490    0.0000
0         0         0         0.1490
0         0         0         0
```

Note that both factorizations are correct, even though they are different.

## Algorithm

qrupdate uses the algorithm in section 12.5.1 of the third edition of *Matrix Computations* by Golub and van Loan. qrupdate is useful since, if we take  $N = \max(m, n)$ , then computing the new QR factorization from scratch is roughly an  $O(N^3)$  algorithm, while simply updating the existing factors in this way is an  $O(N^2)$  algorithm.

## References

[1] Golub, Gene H. and Charles Van Loan, *Matrix Computations*, Third Edition, Johns Hopkins University Press, Baltimore, 1996

## See Also

cholupdate, qr

**Purpose** Numerically evaluate integral, adaptive Simpson quadrature

**Syntax**

```
q = quad(fun,a,b)
q = quad(fun,a,b,tol)
q = quad(fun,a,b,tol,trace)
[q,fcnt] = quad(...)
```

**Description** *Quadrature* is a numerical method used to find the area under the graph of a function, that is, to compute a definite integral.

$$q = \int_a^b f(x) dx$$

`q = quad(fun,a,b)` tries to approximate the integral of function `fun` from `a` to `b` to within an error of  $1e-6$  using recursive adaptive Simpson quadrature. `fun` is a function handle. See “Function Handles” in the MATLAB Programming documentation for more information. Limits `a` and `b` must be finite. The function `y = fun(x)` should accept a vector argument `x` and return a vector result `y`, the integrand evaluated at each element of `x`.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `fun`, if necessary.

`q = quad(fun,a,b,tol)` uses an absolute error tolerance `tol` instead of the default which is  $1.0e-6$ . Larger values of `tol` result in fewer function evaluations and faster computation, but less accurate results. In MATLAB version 5.3 and earlier, the `quad` function used a less reliable algorithm and a default relative tolerance of  $1.0e-3$ .

`q = quad(fun,a,b,tol,trace)` with non-zero `trace` shows the values of `[fcnt a b-a Q]` during the recursion.

`[q,fcnt] = quad(...)` returns the number of function evaluations.

The function `quadl` may be more efficient with high accuracies and smooth integrands.

The list below contains information to help you determine which quadrature function in MATLAB to use:

- The quad function may be most efficient for low accuracies with nonsmooth integrands.
- The quad function may be most efficient for low accuracies with nonsmooth integrands.
- The quadl function may be more efficient than quad at higher accuracies with smooth integrands.
- The quadgk function may be most efficient for high accuracies and oscillatory integrands. It supports infinite intervals and can handle moderate singularities at the endpoints. It also supports contour integration along piecewise linear paths.
- The quadv function vectorizes quad for an array-valued fun.
- If the interval is infinite,  $[a, \text{Inf})$ , then for the integral of  $\text{fun}(x)$  to exist,  $\text{fun}(x)$  must decay as  $x$  approaches infinity, and quadgk requires it to decay rapidly. Special methods should be used for oscillatory functions on infinite intervals, but quadgk can be used if  $\text{fun}(x)$  decays fast enough.
- The quadgk function will integrate functions that are singular at finite endpoints if the singularities are not too strong. For example, it will integrate functions that behave at an endpoint  $c$  like  $\log|x-c|$  or  $|x-c|^p$  for  $p \geq -1/2$ . If the function is singular at points inside  $(a, b)$ , write the integral as a sum of integrals over subintervals with the singular points as endpoints, compute them with quadgk, and add the results.

## Example

To compute the integral

$$\int_0^2 \frac{1}{x^3 - 2x - 5} dx$$

write an M-file function myfun that computes the integrand:



```
function y = myfun(x)
y = 1./(x.^3-2*x-5);
```

Then pass @myfun, a function handle to myfun, to quad, along with the limits of integration, 0 to 2:

```
Q = quad(@myfun,0,2)

Q =

    -0.4605
```

Alternatively, you can pass the integrand to quad as an anonymous function handle F:

```
F = @(x)1./(x.^3-2*x-5);
Q = quad(F,0,2);
```

## Algorithm

quad implements a low order method using an adaptive recursive Simpson's rule.

## Diagnostics

quad may issue one of the following warnings:

'Minimum step size reached' indicates that the recursive interval subdivision has produced a subinterval whose length is on the order of roundoff error in the length of the original interval. A nonintegrable singularity is possible.

'Maximum function count exceeded' indicates that the integrand has been evaluated more than 10,000 times. A nonintegrable singularity is likely.

'Infinite or Not-a-Number function value encountered' indicates a floating point overflow or division by zero during the evaluation of the integrand in the interior of the interval.

## See Also

dblquad, quadgk, quadl, quadv, trapz, triplequad, function\_handle (@), "Anonymous Functions"

## References

[1] Gander, W. and W. Gautschi, "Adaptive Quadrature – Revisited," BIT, Vol. 40, 2000, pp. 84-101. This document is also available at <http://www.inf.ethz.ch/personal/gander>.

**Purpose** Numerically evaluate integral, adaptive Gauss-Kronrod quadrature

**Syntax**

```
q = quadgk(fun,a,b)
[q,errbnd] = quadgk(fun,a,b,tol)
[q,errbnd] = quadgk(fun,a,b,param1,val1,param2,val2,...)
```

**Description** `q = quadgk(fun,a,b)` attempts to approximate the integral of a scalar-valued function `fun` from `a` to `b` using high-order global adaptive quadrature and default error tolerances. The function `y = fun(x)` should accept a vector argument `x` and return a vector result `y`. The integrand evaluated at each element of `x`. `fun` must be a function handle. See “Function Handles” in the MATLAB Programming documentation for more information. Limits `a` and `b` can be `-Inf` or `Inf`. If both are finite, they can be complex. If at least one is complex, the integral is approximated over a straight line path from `a` to `b` in the complex plane.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `fun`, if necessary.

`[q,errbnd] = quadgk(fun,a,b,tol)` returns an approximate bound on the absolute error,  $|Q - I|$ , where `I` denotes the exact value of the integral.

`[q,errbnd] = quadgk(fun,a,b,param1,val1,param2,val2,...)` performs the integration with specified values of optional parameters. The available parameters are

# quadgk

| Parameter | Description                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'AbsTol'  | Absolute error tolerance.<br>The default value of 'AbsTol' is 1.e-10 (double), 1.e-5 (single). | quadgk attempts to satisfy $errbnd \leq \max(AbsTol, RelTol *  Q )$ . This is absolute error control when $ Q $ is sufficiently small and relative error control when $ Q $ is larger. For pure absolute error control use 'AbsTol' > 0 and 'RelTol' = 0. For pure relative error control use 'AbsTol' = 0. Except when using pure absolute error control, the minimum relative tolerance is 'RelTol' >= 100*eps(class(Q)). |
| 'RelTol'  | Relative error tolerance.<br>The default value of 'RelTol' is 1.e-6 (double), 1.e-4 (single).  |                                                                                                                                                                                                                                                                                                                                                                                                                             |

| Parameter          | Description                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'Waypoints'        | Vector of integration waypoints.                                             | <p>If <math>\text{fun}(x)</math> has discontinuities in the interval of integration, the locations should be supplied as a 'Waypoints' vector. When <math>a</math>, <math>b</math>, and the waypoints are all real, the waypoints must be supplied in strictly increasing or strictly decreasing order, and only the waypoints between <math>a</math> and <math>b</math> are used. Waypoints are not intended for singularities in <math>\text{fun}(x)</math>. Singular points should be handled by making them endpoints of separate integrations and adding the results.</p> <p>If <math>a</math>, <math>b</math>, or any entry of the waypoints vector is complex, the integration is performed over a sequence of straight line paths in the complex plane, from <math>a</math> to the first waypoint, from the first waypoint to the second, and so forth, and finally from the last waypoint to <math>b</math>.</p> |
| 'MaxIntervalCount' | <p>Maximum number of intervals allowed.</p> <p>The default value is 650.</p> | <p>The 'MaxIntervalCount' parameter limits the number of intervals that quadgk uses at any one time after the first iteration. A warning is issued if quadgk returns early because</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

The list below contains information to help you determine which quadrature function in MATLAB to use:

- The quad function may be most efficient for low accuracies with nonsmooth integrands.
- The quad function may be most efficient for low accuracies with nonsmooth integrands.
- The quadl function may be more efficient than quad at higher accuracies with smooth integrands.
- The quadgk function may be most efficient for high accuracies and oscillatory integrands. It supports infinite intervals and can handle moderate singularities at the endpoints. It also supports contour integration along piecewise linear paths.
- The quadv function vectorizes quad for an array-valued fun.
- If the interval is infinite,  $[a, \text{Inf})$ , then for the integral of  $\text{fun}(x)$  to exist,  $\text{fun}(x)$  must decay as  $x$  approaches infinity, and quadgk requires it to decay rapidly. Special methods should be used for oscillatory functions on infinite intervals, but quadgk can be used if  $\text{fun}(x)$  decays fast enough.
- The quadgk function will integrate functions that are singular at finite endpoints if the singularities are not too strong. For example, it will integrate functions that behave at an endpoint  $c$  like  $\log|x-c|$  or  $|x-c|^p$  for  $p \geq -1/2$ . If the function is singular at points inside  $(a,b)$ , write the integral as a sum of integrals over subintervals with the singular points as endpoints, compute them with quadgk, and add the results.

## Examples

### Integrand with a singularity at an integration end point

Write an M-file function myfun that computes the integrand:

```
function y = myfun(x)
y = exp(x).*log(x);
```

Then pass @myfun, a function handle to myfun, to quadgk, along with the limits of integration, 0 to 1:

```
Q = quadgk(@myfun,0,1)

Q =

    -1.3179
```

Alternatively, you can pass the integrand to quadgk as an anonymous function handle F:

```
F = @(x)exp(x).*log(x);
Q = quadgk(F,0,1);
```

### Oscillatory integrand on a semi-infinite interval

Integrate over a semi-infinite interval with specified tolerances, and return the approximate error bound:

```
[q,errbnd] = quadgk(@(x)x.^5.*exp(-x).*sin(x),0,inf,'RelTol',1e-8,'

q =

    -15.0000

errbnd =

    9.4386e-009
```

### Contour integration around a pole

Use Waypoints to integrate around a pole using a piecewise linear contour:

```
Q = quadgk(@(z)1./(2*z - 1),-1-i,-1-i,'Waypoints',[1-i,1+i,-1+i])

Q =
```

# quadgk

---

0.0000 + 3.1416i

## Algorithm

quadgk implements adaptive quadrature based on a Gauss-Kronrod pair (15<sup>th</sup> and 7<sup>th</sup> order formulas).

## Diagnostics

quadgk may issue one of the following warnings:

'Minimum step size reached' indicates that interval subdivision has produced a subinterval whose length is on the order of roundoff error in the length of the original interval. A nonintegrable singularity is possible.

'Reached the limit on the maximum number of intervals in use' indicates that the integration was terminated before meeting the tolerance requirements and that continuing the integration would require more than MaxIntervalCount subintervals. The integral may not exist, or it may be difficult to approximate numerically. Increasing MaxIntervalCount usually does not help unless the tolerance requirements were nearly met when the integration was previously terminated.

'Infinite or Not-a-Number function value encountered' indicates a floating point overflow or division by zero during the evaluation of the integrand in the interior of the interval.

## References

[1] L.F. Shampine “Vectorized Adaptive Quadrature in MATLAB,” *Journal of Computational and Applied Mathematics*, to appear.

## See Also

dblquad, quadquad1, quadv, triplequad, function\_handle (@), “Anonymous Functions”



**Purpose**

Numerically evaluate integral, adaptive Lobatto quadrature

**Syntax**

```
q = quadl(fun,a,b)
q = quadl(fun,a,b,tol)
quadl(fun,a,b,tol,trace)
[q,fcnt] = quadl(...)
```

**Description**

`q = quadl(fun,a,b)` approximates the integral of function `fun` from `a` to `b`, to within an error of  $10^{-6}$  using recursive adaptive Lobatto quadrature. `fun` is a function handle. See “Function Handles” in the MATLAB Programming documentation for more information. `fun` accepts a vector `x` and returns a vector `y`, the function `fun` evaluated at each element of `x`. Limits `a` and `b` must be finite.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `fun`, if necessary.

`q = quadl(fun,a,b,tol)` uses an absolute error tolerance of `tol` instead of the default, which is  $1.0e-6$ . Larger values of `tol` result in fewer function evaluations and faster computation, but less accurate results.

`quadl(fun,a,b,tol,trace)` with non-zero `trace` shows the values of `[fcnt a b-a q]` during the recursion.

`[q,fcnt] = quadl(...)` returns the number of function evaluations.

Use array operators `.*`, `./` and `.^` in the definition of `fun` so that it can be evaluated with a vector argument.

The function `quad` may be more efficient with low accuracies or nonsmooth integrands.

The list below contains information to help you determine which quadrature function in MATLAB to use:

- The `quad` function may be most efficient for low accuracies with nonsmooth integrands.

# quadl

---

- The quad function may be most efficient for low accuracies with nonsmooth integrands.
- The quadl function may be more efficient than quad at higher accuracies with smooth integrands.
- The quadgk function may be most efficient for high accuracies and oscillatory integrands. It supports infinite intervals and can handle moderate singularities at the endpoints. It also supports contour integration along piecewise linear paths.
- The quadv function vectorizes quad for an array-valued fun.
- If the interval is infinite,  $[a, \text{Inf})$ , then for the integral of  $\text{fun}(x)$  to exist,  $\text{fun}(x)$  must decay as  $x$  approaches infinity, and quadgk requires it to decay rapidly. Special methods should be used for oscillatory functions on infinite intervals, but quadgk can be used if  $\text{fun}(x)$  decays fast enough.
- The quadgk function will integrate functions that are singular at finite endpoints if the singularities are not too strong. For example, it will integrate functions that behave at an endpoint  $c$  like  $\log|x-c|$  or  $|x-c|^p$  for  $p \geq -1/2$ . If the function is singular at points inside  $(a,b)$ , write the integral as a sum of integrals over subintervals with the singular points as endpoints, compute them with quadgk, and add the results.

## Examples

Pass M-file function handle @myfun to quadl:

```
Q = quadl(@myfun,0,2);
```

where the M-file myfun.m is

```
function y = myfun(x)
y = 1./(x.^3-2*x-5);
```

Pass anonymous function handle F to quadl:

```
F = @(x) 1./(x.^3-2*x-5);
Q = quadl(F,0,2);
```

**Algorithm**

quadl implements a high order method using an adaptive Gauss/Lobatto quadrature rule.

**Diagnostics**

quadl may issue one of the following warnings:

'Minimum step size reached' indicates that the recursive interval subdivision has produced a subinterval whose length is on the order of roundoff error in the length of the original interval. A nonintegrable singularity is possible.

'Maximum function count exceeded' indicates that the integrand has been evaluated more than 10,000 times. A nonintegrable singularity is likely.

'Infinite or Not-a-Number function value encountered' indicates a floating point overflow or division by zero during the evaluation of the integrand in the interior of the interval.

**See Also**

dblquad, quad, quadgk, triplequad, function\_handle (@), "Anonymous Functions"

**References**

[1] Gander, W. and W. Gautschi, "Adaptive Quadrature – Revisited," BIT, Vol. 40, 2000, pp. 84-101. This document is also available at <http://www.inf.ethz.ch/personal/gander>.

# quadv

---

**Purpose** Vectorized quadrature

**Syntax**  
Q = quadv(fun,a,b)  
Q = quadv(fun,a,b,tol)  
Q = quadv(fun,a,b,tol,trace)  
[Q,fcnt] = quadv(...)

**Description** Q = quadv(fun,a,b) approximates the integral of the complex array-valued function fun from a to b to within an error of  $1.e-6$  using recursive adaptive Simpson quadrature. fun is a function handle. See “Function Handles” in the MATLAB Programming documentation for more information. The function Y = fun(x) should accept a scalar argument x and return an array result Y, whose components are the integrands evaluated at x. Limits a and b must be finite.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide addition parameters to the function fun, if necessary.

Q = quadv(fun,a,b,tol) uses the absolute error tolerance tol for all the integrals instead of the default, which is  $1.e-6$ .

---

**Note** The same tolerance is used for all components, so the results obtained with quadv are usually not the same as those obtained with quad on the individual components.

---

Q = quadv(fun,a,b,tol,trace) with non-zero trace shows the values of [fcnt a b-a Q(1)] during the recursion.

[Q,fcnt] = quadv(...) returns the number of function evaluations.

The list below contains information to help you determine which quadrature function in MATLAB to use:

- The quad function may be most efficient for low accuracies with nonsmooth integrands.

- The quad function may be most efficient for low accuracies with nonsmooth integrands.
- The quadl function may be more efficient than quad at higher accuracies with smooth integrands.
- The quadgk function may be most efficient for high accuracies and oscillatory integrands. It supports infinite intervals and can handle moderate singularities at the endpoints. It also supports contour integration along piecewise linear paths.
- The quadv function vectorizes quad for an array-valued fun.
- If the interval is infinite,  $[a, \text{Inf})$ , then for the integral of  $\text{fun}(x)$  to exist,  $\text{fun}(x)$  must decay as  $x$  approaches infinity, and quadgk requires it to decay rapidly. Special methods should be used for oscillatory functions on infinite intervals, but quadgk can be used if  $\text{fun}(x)$  decays fast enough.
- The quadgk function will integrate functions that are singular at finite endpoints if the singularities are not too strong. For example, it will integrate functions that behave at an endpoint  $c$  like  $\log|x-c|$  or  $|x-c|^p$  for  $p \geq -1/2$ . If the function is singular at points inside  $(a,b)$ , write the integral as a sum of integrals over subintervals with the singular points as endpoints, compute them with quadgk, and add the results.

## Example

For the parameterized array-valued function `myarrayfun`, defined by

```
function Y = myarrayfun(x,n)
    Y = 1./((1:n)+x);
```

the following command integrates `myarrayfun`, for the parameter value  $n = 10$  between  $a = 0$  and  $b = 1$ :

```
Qv = quadv(@(x)myarrayfun(x,10),0,1);
```

The resulting array `Qv` has 10 elements estimating  $Q(k) = \log((k+1)./(k))$ , for  $k = 1:10$ .

# quadv

---

The entries in `Qv` are slightly different than if you compute the integrals using `quad` in a loop:

```
for k = 1:10
    Qs(k) = quadv(@(x)myscalarfun(x,k),0,1);
end
```

where `myscalarfun` is:

```
function y = myscalarfun(x,k)
    y = 1./(k+x);
```

## See Also

`quad`, `quadgk`, `quadl`, `dblquad`, `triplequad`, `function_handle` (@)

**Purpose**

Create and open question dialog box

**Syntax**

```
button = questdlg('qstring')
button = questdlg('qstring','title')
button = questdlg('qstring','title','default')
button = questdlg('qstring','title','str1','str2','default')
button = questdlg('qstring','title','str1','str2','str3',
    'default')
```

**Description**

`button = questdlg('qstring')` displays a modal dialog box presenting the question `'qstring'`. The dialog has three default buttons, **Yes**, **No**, and **Cancel**. If the user presses one of these three buttons, `button` is set to the name of the button pressed. If the user presses the close button on the dialog, `button` is set to the empty string. If the user presses the **Return** key, `button` is set to `'Yes'`. `'qstring'` is a cell array or a string that automatically wraps to fit within the dialog box.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. For more information, see `WindowState` in the MATLAB Figure Properties.

---

`button = questdlg('qstring','title')` displays a question dialog with `'title'` displayed in the dialog's title bar.

`button = questdlg('qstring','title','default')` specifies which push button is the default in the event that the **Return** key is pressed. `'default'` must be `'Yes'`, `'No'`, or `'Cancel'`.

`button = questdlg('qstring','title','str1','str2','default')` creates a question dialog box with two push buttons labeled `'str1'` and `'str2'`. `'default'` specifies the default button selection and must be `'str1'` or `'str2'`.

# questdlg

---

```
button =  
questdlg('qstring','title','str1','str2','str3','default')
```

creates a question dialog box with three push buttons labeled 'str1', 'str2', and 'str3'. 'default' specifies the default button selection and must be 'str1', 'str2', or 'str3'.

In all cases where 'default' is specified, if 'default' is not set to one of the button names, pressing the **Enter** key displays a warning and the dialog remains open.

## See Also

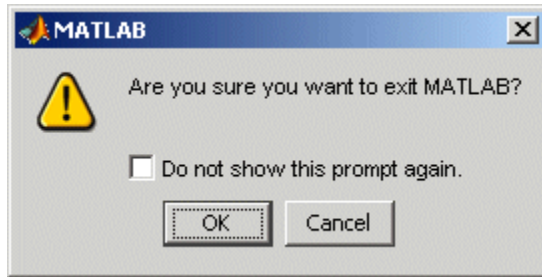
dialog, errordlg, helpdlg, inputdlg, listdlg, msgbox, warndlg  
figure, textwrap, uiwait, uiresume

“Predefined Dialog Boxes” on page 1-104 for related functions



---

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Terminate MATLAB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>GUI Alternatives</b> | As an alternative to the quit function, use the Close box or select <b>File &gt; Exit MATLAB</b> in the MATLAB desktop.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Syntax</b>           | <code>quit</code><br><code>quit <b>cancel</b></code><br><code>quit <b>force</b></code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Description</b>      | <p><code>quit</code> displays a confirmation dialog box if the confirm upon quitting preference is selected, and if confirmed or if the confirmation preference is not selected, terminates MATLAB after running <code>finish.m</code>, if <code>finish.m</code> exists. The workspace is not automatically saved by <code>quit</code>. To save the workspace or perform other actions when quitting, create a <code>finish.m</code> file to perform those actions. For example, you can display a custom dialog box to confirm quitting using a <code>finish.m</code> file—see the following examples for details. If an error occurs while <code>finish.m</code> is running, <code>quit</code> is canceled so that you can correct your <code>finish.m</code> file without losing your workspace.</p> <p><code>quit <b>cancel</b></code> is for use in <code>finish.m</code> and cancels quitting. It has no effect anywhere else.</p> <p><code>quit <b>force</b></code> bypasses <code>finish.m</code> and terminates MATLAB. Use this to override <code>finish.m</code>, for example, if an errant <code>finish.m</code> will not let you quit.</p> |
| <b>Remarks</b>          | <p>When using Handle Graphics in <code>finish.m</code>, use <code>uiwait</code>, <code>waitfor</code>, or <code>drawnow</code> so that figures are visible. See the reference pages for these functions for more information.</p> <p>If you want MATLAB to display the following confirmation dialog box after running <code>quit</code>, select <b>File &gt; Preferences &gt; General &gt; Confirmation Dialogs</b>. Then select the check box for Confirm before exiting MATLAB, and click <b>OK</b>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



## Examples

Two sample `finish.m` files are included with MATLAB. Use them to help you create your own `finish.m`, or rename one of the files to `finish.m` to use it.

- `finishesav.m`—Saves the workspace to a MAT-file when MATLAB quits.
- `finishdlg.m`—Displays a dialog allowing you to cancel quitting; it uses `quit cancel` and contains the following code:

```
button = questdlg('Ready to quit?', ...
    'Exit Dialog','Yes','No','No');
switch button
    case 'Yes',
        disp('Exiting MATLAB');
        %Save variables to matlab.mat
        save
    case 'No',
        quit cancel;
end
```

## See Also

`exit`, `finish`, `save`, `startup`

**Purpose** Terminate MATLAB server

**Syntax**

**MATLAB Client**  
h.Quit  
Quit(h)  
invoke(h, 'Quit')

**Method Signature**  
void Quit(void)

**Visual Basic Client**  
Quit

**Description** Quit terminates the MATLAB server session to which handle h is attached.

**Remarks** Server function names, like Quit, are case sensitive when using the first syntax shown.

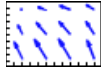
There is no difference in the operation of the three syntaxes shown above for the MATLAB client.

# quiver


---

## Purpose

Quiver or velocity plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
quiver(x,y,u,v)
quiver(u,v)
quiver(...,scale)
quiver(...,LineStyle)
quiver(...,LineStyle,'filled')
quiver(axes_handle,...)
h = quiver(...)
hlines = quiver('v6',...)
```

## Description

A quiver plot displays velocity vectors as arrows with components  $(u, v)$  at the points  $(x, y)$ .

For example, the first vector is defined by components  $u(1), v(1)$  and is displayed at the point  $x(1), y(1)$ .

`quiver(x,y,u,v)` plots vectors as arrows at the coordinates specified in each corresponding pair of elements in  $x$  and  $y$ . The matrices  $x$ ,  $y$ ,  $u$ , and  $v$  must all be the same size and contain corresponding position and velocity components. However,  $x$  and  $y$  can also be vectors, as explained in the next section. By default, the arrows are scaled to just not overlap, but you can scale them to be longer or shorter if you want.

### Expanding x- and y-Coordinates

MATLAB expands  $x$  and  $y$  if they are not matrices. This expansion is equivalent to calling `meshgrid` to generate matrices from vectors:

```
[x,y] = meshgrid(x,y);  
quiver(x,y,u,v)
```


In this case, the following must be true:

`length(x) = n` and `length(y) = m`, where `[m,n] = size(u) = size(v)`.

The vector `x` corresponds to the columns of `u` and `v`, and vector `y` corresponds to the rows of `u` and `v`.

`quiver(u,v)` draws vectors specified by `u` and `v` at equally spaced points in the  $x$ - $y$  plane.

`quiver(...,scale)` automatically scales the arrows to fit within the grid and then stretches them by the factor `scale`. `scale = 2` doubles their relative length, and `scale = 0.5` halves the length. Use `scale = 0` to plot the velocity vectors without automatic scaling. You can also tune the length of arrows after they have been drawn by choosing the **Plot**

**Edit**  tool, selecting the `quivergroup` object, opening the Property Editor, and adjusting the **Length** slider.

`quiver(...,LineStyle)` specifies line style, marker symbol, and color using any valid `LineStyle`. `quiver` draws the markers at the origin of the vectors.

`quiver(...,LineStyle,'filled')` fills markers specified by `LineStyle`.

`quiver(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes (`gca`).

`h = quiver(...)` returns the handle to the `quivergroup` object.

### Backward-Compatible Version

`hlines = quiver('v6',...)` returns the handles of line objects instead of `quivergroup` objects for compatibility with MATLAB 6.5 and earlier.

---

**Note** The v6 option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

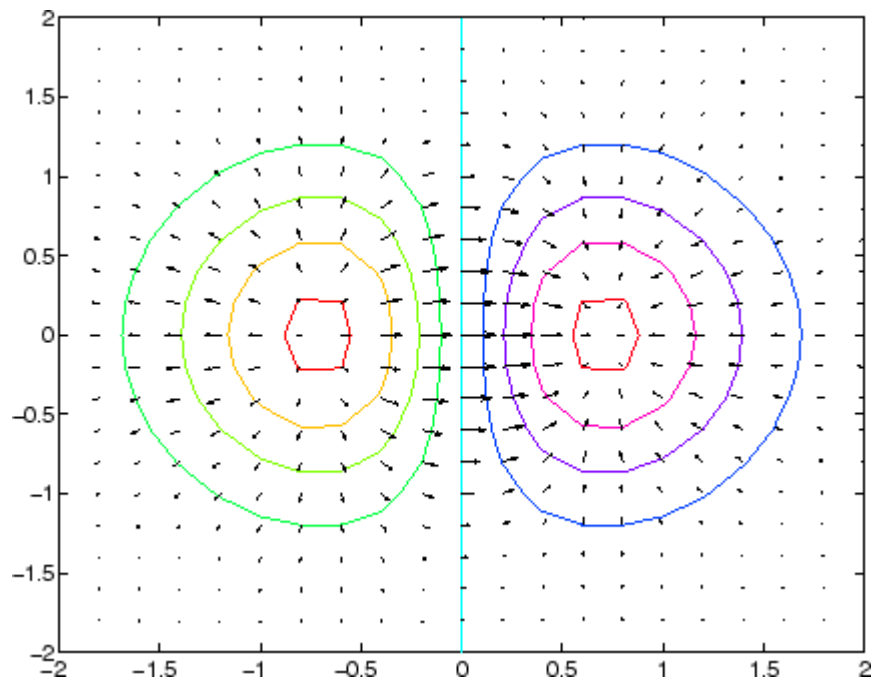
See Plot Objects and Backward Compatibility for more information.

## Examples

### Showing the Gradient with Quiver Plots

Plot the gradient field of the function  $z = xe^{(-x^2 - y^2)}$ :

```
[X,Y] = meshgrid(-2:.2:2);
Z = X.*exp(-X.^2 - Y.^2);
[DX,DY] = gradient(Z,.2,.2);
contour(X,Y,Z)
hold on
quiver(X,Y,DX,DY)
colormap hsv
hold off
```

**See Also**

`contour`, `LineStyle`, `plot`, `quiver3`

“Direction and Velocity Plots” on page 1-89 for related functions

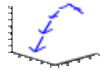
Two-Dimensional Quiver Plots for more examples

Quivergroup Properties for property descriptions


# quiver3

---

**Purpose** 3-D quiver or velocity plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
quiver3(x,y,z,u,v,w)
quiver3(z,u,v,w)
quiver3(...,scale)
quiver3(...,LineStyle)
quiver3(...,LineStyle,'filled')
quiver3(axes_handle,...)
h = quiver3(...)
```

## Description

A three-dimensional quiver plot displays vectors with components  $(u,v,w)$  at the points  $(x,y,z)$ .

`quiver3(x,y,z,u,v,w)` plots vectors with components  $(u,v,w)$  at the points  $(x,y,z)$ . The matrices  $x,y,z,u,v,w$  must all be the same size and contain the corresponding position and vector components.

`quiver3(z,u,v,w)` plots the vectors at the equally spaced surface points specified by matrix  $z$ . `quiver3` automatically scales the vectors based on the distance between them to prevent them from overlapping.

`quiver3(...,scale)` automatically scales the vectors to prevent them from overlapping, and then multiplies them by `scale`. `scale = 2` doubles their relative length, and `scale = 0.5` halves them. Use `scale = 0` to plot the vectors without the automatic scaling.

`quiver3(...,LineStyle)` specifies line type and color using any valid `LineStyle`.



`quiver3(...,LineStyle,'filled')` fills markers specified by `LineStyle`.

`quiver3(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes (`gca`).

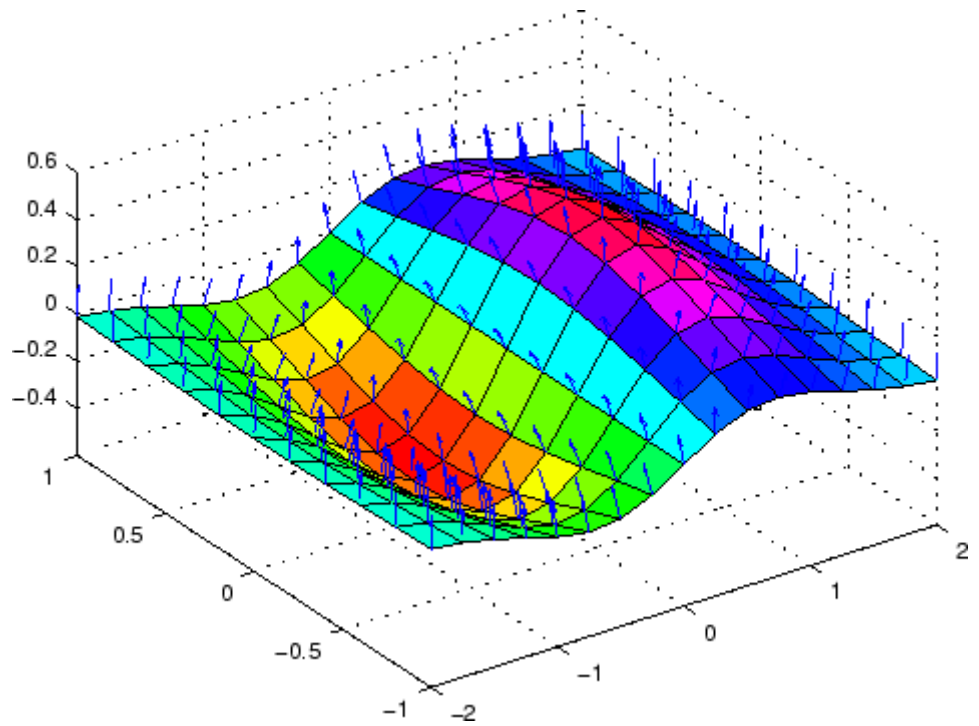
`h = quiver3(...)` returns a vector of line handles.

## Examples

Plot the surface normals of the function  $z = xe^{(-x^2 - y^2)}$ .

```
[X,Y] = meshgrid(-2:0.25:2,-1:0.2:1);
Z = X.* exp(-X.^2 - Y.^2);
[U,V,W] = surfnorm(X,Y,Z);
quiver3(X,Y,Z,U,V,W,0.5);
hold on
surf(X,Y,Z);
colormap hsv
view(-35,45)
axis([-2 2 -1 1 -.6 .6])
hold off
```

# quiver3



## See Also

axis, contour, LineSpec, plot, plot3, quiver, surfnorm, view  
“Direction and Velocity Plots” on page 1-89 for related functions  
Three-Dimensional Quiver Plots for more examples

## Purpose

Define quivergroup properties

## Modifying Properties

You can set and query graphics object properties using the set and get commands or the Property Editor (propertyeditor).

Note that you cannot define default properties for areaseries objects.

See Plot Objects for more information on quivergroup objects.

## Quivergroup Property Descriptions

This section provides a description of properties. Curly braces { } enclose default values.

Annotation

hg.Annotation object Read Only

*Control the display of quivergroup objects in legends.* The Annotation property enables you to specify whether this quivergroup object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the quivergroup object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                                                               |
|------------------------|---------------------------------------------------------------------------------------|
| on                     | Include the quivergroup object in a legend as one entry, but not its children objects |
| off                    | Do not include the quivergroup or its children in a legend (default)                  |
| children               | Include only the children of the quivergroup as separate entries in the legend        |

# Quivergroup Properties

---

## Setting the `IconDisplayStyle` property

These commands set the `IconDisplayStyle` of a graphics object with handle `hobj` to `children`, which causes each child object to have an entry in the legend:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'children')
```

## Using the `IconDisplayStyle` property

See “Controlling Legends” for more information and examples.

`AutoScale`  
{on} | off

*Autoscale arrow length.* Based on average spacing in the  $x$  and  $y$  directions, `AutoScale` scales the arrow length to fit within the grid-defined coordinate data and keeps the arrows from overlapping. After autoscaling, quiver applies the `AutoScaleFactor` to the arrow length.

`AutoScaleFactor`  
scalar (default = 0.9)

*User-specified scale factor.* When `AutoScale` is on, the quiver function applies this user-specified autoscale factor to the arrow length. A value of 2 doubles the length of the arrows; 0.5 halves the length.

`BeingDeleted`  
on | {off} Read Only

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to on when the object’s delete function callback is called

(see the `DeleteFcn` property). It remains set to `on` while the delete function executes, after which the object no longer exists.

For example, an object's delete function might call other functions that act on a number of different objects. These functions might not need to perform actions on objects if the objects are going to be deleted, and therefore, can check the object's `BeingDeleted` property before acting.

`BusyAction`  
`cancel` | `{queue}`

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callbacks. If there is a callback function executing, callbacks invoked subsequently always attempt to interrupt it.

If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

`ButtonDownFcn`  
string or function handle

*Button press callback function.* A callback that executes whenever you press a mouse button while the pointer is over this object, but not over another graphics object. See the `HitTestArea` property for information about selecting objects of this type.

# Quivergroup Properties

---

See the figure's `SelectionType` property to determine if modifier keys were also pressed.

This property can be

- A string that is a valid MATLAB expression
- The name of an M-file
- A function handle

Set this property to a function handle that references the callback. The expressions execute in the MATLAB workspace.

See “Function Handle Callbacks” for information on how to use function handles to define the callbacks.

## Children

array of graphics object handles

*Children of this object.* The handle of a patch object that is the child of this object (whether visible or not).

Note that if a child object's `HandleVisibility` property is set to `callback` or `off`, its handle does not show up in this object's `Children` property unless you set the root `ShowHiddenHandles` property to `on`:

```
set(0, 'ShowHiddenHandles', 'on')
```

## Clipping

{on} | off

*Clipping mode.* MATLAB clips graphs to the axes plot box by default. If you set `Clipping` to `off`, portions of graphs can be displayed outside the axes plot box. This can occur if you create a plot object, set `hold` to `on`, freeze axis scaling (`axis manual`), and then create a larger plot object.

## Color

### ColorSpec

*Color of the object.* A three-element RGB vector or one of the MATLAB predefined names, specifying the object's color.

See the ColorSpec reference page for more information on specifying color.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* This property defines a callback that executes when MATLAB creates an object. You must specify the callback during the creation of the object. For example,

```
area(y, 'CreateFcn', @CallbackFcn)
```

where @CallbackFcn is a function handle that references the callback function.

MATLAB executes this routine after setting all other object properties. Setting this property on an existing object has no effect.

The handle of the object whose CreateFcn is being executed is accessible only through the root CallbackObject property, which you can query using gcbo.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## DeleteFcn

string or function handle

*Callback executed during object deletion.* A callback that executes when this object is deleted (e.g., this might happen when you issue

# Quivergroup Properties

---

a `delete` command on the object, its parent axes, or the figure containing it). MATLAB executes the callback before destroying the object's properties so the callback routine can query these values.

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which can be queried using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

See the `BeingDeleted` property for related information.

`DisplayName`  
string (default is empty string)

*String used by legend for this quivergroup object.* The legend function uses the string defined by the `DisplayName` property to label this quivergroup object in the legend.

- If you specify string arguments with the legend function, `DisplayName` is set to this quivergroup object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where `n` is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call `legend` with the `toggle` or `show` option.



See “Controlling Legends” for more examples.

EraseMode

{normal} | none | xor | background

*Erase mode.* This property controls the technique MATLAB uses to draw and erase objects and their children. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- **normal** — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- **none** — Do not erase objects when they are moved or destroyed. While the objects are still visible on the screen after erasing with EraseMode none, you cannot print these objects because MATLAB stores no information about their former locations.
- **xor** — Draw and erase the object by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the object does not damage the color of the objects behind it. However, the color of the erased object depends on the color of the screen behind it and it is correctly colored only when it is over the axes background color (or the figure background color if the axes Color property is set to none). That is, it isn't erased correctly if there are objects behind it.
- **background** — Erase the graphics objects by redrawing them in the axes background color, (or the figure background color if the axes Color property is set to none). This damages other graphics objects that are behind the erased object, but the erased object is always properly colored.

## Printing with Nonnormal Erase Modes

# Quivergroup Properties

---

MATLAB always prints figures as if the `EraseMode` of all objects is `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look different on screen than on paper. On screen, MATLAB can mathematically combine layers of colors (e.g., performing an XOR on a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

Set the axes background color with the axes `Color` property. Set the figure background color with the figure `Color` property.

You can use the MATLAB `getframe` command or other screen capture applications to create an image of a figure containing nonnormal mode objects.

`HandleVisibility`  
{on} | callback | off

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. `HandleVisibility` is useful for preventing command-line users from accidentally accessing objects that you need to protect for some reason.

- `on` — Handles are always visible when `HandleVisibility` is `on`.
- `callback` — Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have access to object handles.
- `off` — Setting `HandleVisibility` to `off` makes handles invisible at all times. This might be necessary when a callback invokes a function that might potentially damage the GUI (such as evaluating a user-typed string) and so temporarily hides its own handles during the execution of that function.

## Functions Affected by Handle Visibility

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

## Properties Affected by Handle Visibility

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

## Overriding Handle Visibility

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties). See also `findall`.

## Handle Validity

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties and pass it to any function that operates on handles.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

# Quivergroup Properties

---

HitTest  
{on} | off

*Selectable by mouse click.* HitTest determines whether this object can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the objects that compose the area graph. If HitTest is off, clicking this object selects the object below it (which is usually the axes containing it).

HitTestArea  
on | {off}

*Select the object by clicking lines or area of extent.* This property enables you to select plot objects in two ways:

- Select by clicking lines or markers (default).
- Select by clicking anywhere in the extent of the plot.

When HitTestArea is off, you must click the object's lines or markers (excluding the baseline, if any) to select the object. When HitTestArea is on, you can select this object by clicking anywhere within the extent of the plot (i.e., anywhere within a rectangle that encloses it).

Interruptible  
{on} | off

*Callback routine interruption mode.* The Interruptible property controls whether an object's callback can be interrupted by callbacks invoked subsequently.

Only callbacks defined for the `ButtonDownFcn` property are affected by the Interruptible property. MATLAB checks for events that can interrupt a callback only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.

Setting `Interruptible` to `on` allows any graphics object's callback to interrupt callback routines originating from a bar property. Note that MATLAB does not save the state of variables or the display (e.g., the handle returned by the `gca` or `gcf` command) when an interruption occurs.

## LineStyle

{-} | -- | : | -. | none

*Line style.* This property specifies the line style of the object. Available line styles are shown in the following table.

| Specifier String | Line Style           |
|------------------|----------------------|
| -                | Solid line (default) |
| --               | Dashed line          |
| :                | Dotted line          |
| -.               | Dash-dot line        |
| none             | No line              |

You can use `LineStyle` `none` when you want to place a marker at each point but do not want the points connected with a line (see the `Marker` property).

## LineWidth

scalar

*The width of linear objects and edges of filled areas.* Specify this value in points (1 point =  $1/72$  inch). The default `LineWidth` is 0.5 points.

## Marker

character (see table)

*Marker symbol.* The `Marker` property specifies the type of markers that are displayed at plot vertices. You can set values for the

# Quivergroup Properties

---

Marker property independently from the `LineStyle` property. Supported markers include those shown in the following table.

| Marker Specifier | Description                   |
|------------------|-------------------------------|
| +                | Plus sign                     |
| o                | Circle                        |
| *                | Asterisk                      |
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

`MarkerEdgeColor`  
ColorSpec | none | {auto}

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles). ColorSpec defines the color to use. none specifies no color, which makes nonfilled markers invisible. auto sets MarkerEdgeColor to the same color as the Color property.

`MarkerFaceColor`  
ColorSpec | {none} | auto

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles). ColorSpec defines the color to use. none makes the interior of the marker transparent, allowing the background to show through. auto sets the fill color to the axes color, or to the figure color if the axes Color property is set to none (which is the factory default for axes objects).

MarkerSize  
size in points

*Marker size.* A scalar specifying the size of the marker in points. The default value for MarkerSize is 6 points (1 point = 1/72 inch). Note that MATLAB draws the point marker (specified by the ' .' symbol) at one-third the specified size.

MaxHeadSize  
scalar (default = 0.2)

*Maximum size of arrowhead.* A value determining the maximum size of the arrowhead relative to the length of the arrow.

Parent  
handle of parent axes, hgroup, or hgtransform

*Parent of this object.* This property contains the handle of the object's parent. The parent is normally the axes, hgroup, or hgtransform object that contains the object.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

Selected  
on | {off}

*Is object selected?* When you set this property to on, MATLAB displays selection "handles" at the corners and midpoints if the SelectionHighlight property is also on (the default). You can, for example, define the ButtonDownFcn callback to set this

# Quivergroup Properties

---

property to on, thereby indicating that this particular object is selected. This property is also set to on when an object is manually selected in plot edit mode.

SelectionHighlight  
{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is off, MATLAB does not draw the handles except when in plot edit mode and objects are selected manually.

ShowArrowHead  
{on} | off

*Display arrowheads on vectors.* When this property is on, MATLAB draws arrowheads on the vectors displayed by quiver. When you set this property to off, quiver draws the vectors as lines without arrowheads.

Tag  
string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callbacks. You can define Tag as any string.

For example, you might create an areaseries object and set the Tag property.

```
t = area(Y, 'Tag', 'area1')
```

When you want to access objects of a given type, you can use findobj to find the object's handle. The following statement changes the FaceColor property of the object whose Tag is area1.



```
set(findobj('Tag','area1'),'FaceColor','red')
```

## Type

string (read only)

*Type of graphics object.* This property contains a string that identifies the class of the graphics object. For stem objects, Type is 'hggroupp'. This statement finds all the hggroupp objects in the current axes.

```
t = findobj(gca,'Type','hggroupp');
```

## UIContextMenu

handle of a uicontextmenu object

*Associate a context menu with this object.* Assign this property the handle of a uicontextmenu object created in the object's parent figure. Use the uicontextmenu function to create the context menu. MATLAB displays the context menu whenever you right-click over the object.

## UserData

array

*User-specified data.* This property can be any data you want to associate with this object (including cell arrays and structures). The object does not set values for this property, but you can access it using the set and get functions.

## Visible

{on} | off

*Visibility of this object and its children.* By default, a new object's visibility is on. This means all children of the object are visible unless the child object's Visible property is set to off. Setting an object's Visible property to off prevents the object from being displayed. However, the object still exists and you can set and query its properties.

# Quivergroup Properties

---

UData  
matrix

*One dimension of 2-D or 3-D vector components.* UData, VData, and WData, together specify the components of the vectors displayed as arrows in the quiver graph. For example, the first vector is defined by components `UData(1)`, `VData(1)`, `WData(1)`.

UDataSource  
string (MATLAB variable)

*Link UData to MATLAB variable.* Set this property to a MATLAB variable that, by default, is evaluated in the base workspace to generate the UData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change UData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to return data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

VData  
matrix

*One dimension of 2-D or 3-D vector components.* UData, VData and WData (for 3-D) together specify the components of the vectors displayed as arrows in the quiver graph. For example, the first vector is defined by components UData(1),VData(1),WData(1).

VDataSource  
string (MATLAB variable)

*Link VData to MATLAB variable.* Set this property to a MATLAB variable that, by default, is evaluated in the base workspace to generate the VData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change VData.

You can use the refreshdata function to force an update of the object's data. refreshdata also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call refreshdata.

See the refreshdata reference page for more information.

---

**Note** If you change one data source property to return data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

WData  
matrix

*One dimension of 2-D or 3-D vector components.* UData, VData and WData (for 3-D) together specify the components of the vectors displayed as arrows in the quiver graph. For example, the first vector is defined by components UData(1),VData(1),WData(1).

# Quivergroup Properties

---

## WDataSource

string (MATLAB variable)

*Link WData to MATLAB variable.* Set this property to a MATLAB variable that, by default, is evaluated in the base workspace to generate the WData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change WData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to return data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## XData

vector or matrix

*X-axis coordinates of arrows.* The `quiver` function draws an individual arrow at each  $x$ -axis location in the XData array. XData can be either a matrix equal in size to all other data properties or for 2-D, a vector equal in length to the number of columns in UData or VData. That is, `length(XData) == size(UData,2)`.

If you do not specify XData (i.e., the input argument X), the `quiver` function uses the indices of UData to create the quiver graph. See the `XDataMode` property for related information.

## XDataMode

{auto} | manual

*Use automatic or user-specified x-axis values.* If you specify XData (by setting the XData property or specifying the input argument X), the quiver function sets this property to manual.

If you set XDataMode to auto after having specified XData, the quiver function resets the x tick-mark labels to the indices of the U, V, and W data, overwriting any previous values.

## XDataSource

string (MATLAB variable)

*Link XData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the XData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change XData.

You can use the refreshdata function to force an update of the object's data. refreshdata also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call refreshdata.

See the refreshdata reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

# Quivergroup Properties

---

## YData

vector or matrix

*Y-axis coordinates of arrows.* The quiver function draws an individual arrow at each *y*-axis location in the YData array. YData can be either a matrix equal in size to all other data properties or for 2-D, a vector equal in length to the number of rows in UData or VData. That is, `length(YData) == size(UData,1)`.

If you do not specify YData (i.e., the input argument *Y*), the quiver function uses the indices of VData to create the quiver graph. See the YDataMode property for related information.

The input argument *y* in the quiver function calling syntax assigns values to YData.

## YDataMode

{auto} | manual

*Use automatic or user-specified y-axis values.* If you specify YData (by setting the YData property or specifying the input argument *Y*), MATLAB sets this property to manual.

If you set YDataMode to auto after having specified YData, MATLAB resets the *y* tick-mark labels to the indices of the U, V, and W data, overwriting any previous values.

## YDataSource

string (MATLAB variable)

*Link YData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the YData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change YData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## ZData

vector or matrix

*Z-axis coordinates of arrows.* The `quiver` function draws an individual arrow at each *z*-axis location in the `ZData` array. `ZData` must be a matrix equal in size to `XData` and `YData`.

The input argument `z` in the `quiver3` function calling syntax assigns values to `ZData`.

**Purpose** QZ factorization for generalized eigenvalues

**Syntax**  
 $[AA, BB, Q, Z] = \text{qz}(A, B)$   
 $[AA, BB, Q, Z, V, W] = \text{qz}(A, B)$   
 $\text{qz}(A, B, \text{flag})$

**Description** The qz function gives access to intermediate results in the computation of generalized eigenvalues.

$[AA, BB, Q, Z] = \text{qz}(A, B)$  for square matrices A and B, produces upper quasitriangular matrices AA and BB, and unitary matrices Q and Z such that  $Q^*A^*Z = AA$ , and  $Q^*B^*Z = BB$ . For complex matrices, AA and BB are triangular.

$[AA, BB, Q, Z, V, W] = \text{qz}(A, B)$  also produces matrices V and W whose columns are generalized eigenvectors.

$\text{qz}(A, B, \text{flag})$  for real matrices A and B, produces one of two decompositions depending on the value of flag:

|           |                                                                                                                                    |
|-----------|------------------------------------------------------------------------------------------------------------------------------------|
| 'complex' | Produces a possibly complex decomposition with a triangular AA. For compatibility with earlier versions, 'complex' is the default. |
| 'real'    | Produces a real decomposition with a quasitriangular AA, containing 1-by-1 and 2-by-2 blocks on its diagonal.                      |

If AA is triangular, the diagonal elements of AA and BB,  $\alpha = \text{diag}(AA)$  and  $\beta = \text{diag}(BB)$ , are the generalized eigenvalues that satisfy

$$A^*V*\beta = B^*V*\alpha$$

$$\beta^*W'^*A = \alpha^*W'^*B$$

The eigenvalues produced by

$$\lambda = \text{eig}(A, B)$$

are the ratios of the  $\alpha$ s and  $\beta$ s.



$$\lambda = \alpha ./ \beta$$

If AA is triangular, the diagonal elements of AA and BB,

```
alpha = diag(AA)
beta = diag(BB)
```

are the generalized eigenvalues that satisfy

```
A*V*diag(beta) = B*V*diag(alpha)
diag(beta)*W'*A = diag(alpha)*W'*B
```

The eigenvalues produced by

```
lambda = eig(A,B)
```

are the element-wise ratios of alpha and beta.

```
lambda = alpha ./ beta
```

If AA is not triangular, it is necessary to further reduce the 2-by-2 blocks to obtain the eigenvalues of the full system.

## Algorithm

For full matrices A and B, qz uses the LAPACK routines listed in the following table.

|                | <b>A and B Real</b>                               | <b>A or B Complex</b>                             |
|----------------|---------------------------------------------------|---------------------------------------------------|
| A and B double | DGGES, DTGEVC (if you request the fifth output V) | ZGGES, ZTGEVC (if you request the fifth output V) |
| A or B single  | SGGES, STGEVC (if you request the fifth output V) | CGGES, CTGEVC (if you request the fifth output V) |

## See Also

eig

**References**

[1] Anderson, E., Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen, *LAPACK User's Guide* ([http://www.netlib.org/lapack/lug/lapack\\_lug.html](http://www.netlib.org/lapack/lug/lapack_lug.html)), Third Edition, SIAM, Philadelphia, 1999.

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Uniformly distributed pseudorandom numbers                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Syntax</b>      | <pre>Y = rand Y = rand(n) Y = rand(m,n) Y = rand([m n]) Y = rand(m,n,p,...) Y = rand([m n p...]) Y = rand(size(A)) rand(method,s) s = rand(method)</pre>                                                                                                                                                                                                                                                                                                         |
| <b>Description</b> | <p><code>Y = rand</code> returns a pseudorandom, scalar value drawn from a uniform distribution on the unit interval.</p> <p><code>Y = rand(n)</code> returns an n-by-n matrix of values derived as described above.</p> <p><code>Y = rand(m,n)</code> or <code>Y = rand([m n])</code> returns an m-by-n matrix of the same.</p> <p><code>Y = rand(m,n,p,...)</code> or <code>Y = rand([m n p...])</code> generates an m-by-n-by-p-by-... array of the same.</p> |

---

**Note** The size inputs `m`, `n`, `p`, ... should be nonnegative integers. Negative integers are treated as 0.

---

`Y = rand(size(A))` returns an array that is the same size as `A`.

`rand(method,s)` causes `rand` to use the generator determined by `method`, and initializes the state of that generator using the value of `s`.

The value of `s` is dependent upon which `method` is selected. If `method` is set to `'state'` or `'twister'`, then `s` must be either a scalar integer value from 0 to  $2^{32}-1$  or the output of `rand(method)`. If `method` is set to `'seed'`, then `s` must be either a scalar integer value from 0 to  $2^{31}-2$  or the output of `rand(method)`.

# rand

The rand and randn generators each maintain their own internal state information. Initializing the state of one has no effect on the other.

Input argument method can be any of the strings shown in the table below:

| method    | Description                                                                                                                                                                                                                                                                                                        |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'twister' | Use the Mersenne Twister algorithm by Nishimura and Matsumoto (the default in MATLAB Versions 7.4 and later). This method generates double-precision values in the closed interval $[2^{-53}, 1-2^{-53}]$ , with a period of $(2^{19937}-1)/2$ .                                                                   |
| 'state'   | Use a modified version of Marsaglia's <i>subtract with borrow</i> algorithm (the default in MATLAB versions 5 through 7.3). This method can generate all the double-precision values in the closed interval $[2^{-53}, 1-2^{-53}]$ . It theoretically can generate over $2^{1492}$ values before repeating itself. |
| 'seed'    | Use a multiplicative congruential algorithm (the default in MATLAB version 4). This method generates double-precision values in the closed interval $[1/(2^{31}-1), 1-1/(2^{31}-1)]$ , with a period of $2^{31}-2$ .                                                                                               |

For a full description of the Mersenne twister algorithm, see

<http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html>

`s = rand(method)` returns in `s` the current internal state of the generator selected by `method`. It does not change the generator being used.

## Remarks

The sequence of numbers produced by rand is determined by the internal state of the generator. Setting the generator to the same fixed state enables you to repeat computations. Setting the generator to different states leads to unique computations. It does not, however, improve statistical properties.

Because MATLAB resets the rand state at startup, rand generates the same sequence of numbers in each session unless you change the value of the state input.

## Examples

### Example 1

Make a random choice between two equally probable alternatives:

```
if rand < .5
    'heads'
else
    'tails'
end
```

### Example 2

Generate a 3-by-4 pseudorandom matrix:

```
R = rand(3,4)
R =

    0.8147    0.9134    0.2785    0.9649
    0.9058    0.6324    0.5469    0.1576
    0.1270    0.0975    0.9575    0.9706
```

### Example 3

Set rand to its default initial state:

```
rand('twister', 5489);
```

Initialize rand to a different state each time:

```
rand('twister', sum(100*clock));
```

Save the current state, generate 100 values, reset the state, and repeat the sequence:

```
s = rand('twister');
u1 = rand(100);
rand('twister',s);
```

```
u2 = rand(100); % contains exactly the same values as u1
```

## Example 4

Generate uniform integers on the set 1:n:

```
n = 75;  
f = ceil(n.*rand(100,1));
```

```
f(1:10)  
ans =
```

```
72  
37  
61  
11  
32  
69  
60  
72  
50  
3
```

## Example 5

Generate a uniform distribution of random numbers on a specified interval  $[a, b]$ . To do this, multiply the output of `rand` by  $(b-a)$ , then add  $a$ . For example, to generate a 5-by-5 array of uniformly distributed random numbers on the interval  $[10, 50]$ ,

```
a = 10; b = 50;  
x = a + (b-a) * rand(5)  
x =  
19.1591    49.8454    10.1854    25.9913    17.2739  
46.5335    13.1270    40.9964    20.3948    20.5521  
16.0951    27.7071    42.6921    42.0027    15.8216  
43.0327    14.2661    44.7478    27.2566    15.4427  
31.5337    48.4759    13.3774    46.4259    44.7717
```

**References**

- [1] Moler, C.B., "Numerical Computing with MATLAB," SIAM, (2004), 336 pp. Available online at <http://www.mathworks.com/moler>.
- [2] G. Marsaglia and A. Zaman "A New Class of Random Number Generators," *Annals of Applied Probability*, (1991), 3:462-480.
- [3] Matsumoto, M. and Nishimura, T. "Mersenne Twister: A 623-Dimensionally Equidistributed Uniform Pseudorandom Number Generator," *ACM Transactions on Modeling and Computer Simulation*, (1998), 8(1):3-30.
- [4] Park, S.K. and Miller, K.W. "Random Number Generators: Good Ones Are Hard to Find," *Communications of the ACM*, (1988), 31(10):1192-1201

**See Also**

`randn`, `randperm`, `sprand`, `sprandn`

# randn

---

**Purpose** Normally distributed random numbers

**Syntax**

```
Y = randn
Y = randn(n)
Y = randn(m,n)
Y = randn([m n])
Y = randn(m,n,p,...)
Y = randn([m n p...])
Y = randn(size(A))
randn(method,s)
s = randn(method)
```

**Description** `Y = randn` returns a pseudorandom, scalar value drawn from a normal distribution with mean 0 and standard deviation 1.

`Y = randn(n)` returns an n-by-n matrix of values derived as described above.

`Y = randn(m,n)` or `Y = randn([m n])` returns an m-by-n matrix of the same.

`Y = randn(m,n,p,...)` or `Y = randn([m n p...])` generates an m-by-n-by-p-by-... array of the same.

---

**Note** The size inputs `m`, `n`, `p`, ... should be nonnegative integers. Negative integers are treated as 0.

---

`Y = randn(size(A))` returns an array that is the same size as `A`.

`randn(method,s)` causes `randn` to use the generator determined by `method`, and initializes the state of that generator using the value of `s`.

The value of `s` is dependent upon which `method` is selected. If `method` is set to 'state', then `s` must be either a scalar integer value from 0 to  $2^{32}-1$  or the output of `rand(method)`. If `method` is set to 'seed', then `s` must be either a scalar integer value from 0 to  $2^{31}-2$  or the



output of `rand(method)`. To set the generator to its default initial state, set `s` equal to zero.

The `randn` and `rand` generators each maintain their own internal state information. Initializing the state of one has no effect on the other.

Input argument `method` can be either of the strings shown in the table below:

| method  | Description                                                                                                             |
|---------|-------------------------------------------------------------------------------------------------------------------------|
| 'state' | Use Marsaglia's ziggurat algorithm (the default in MATLAB versions 5 and later). The period is approximately $2^{64}$ . |
| 'seed'  | Use the polar algorithm (the default in MATLAB version 4). The period is approximately $(2^{31}-1) * (\pi/8)$ .         |

`s = randn(method)` returns in `s` the current internal state of the generator selected by `method`. It does not change the generator being used.

## Examples

### Example 1

`R = randn(3,4)` might produce

```
R =
    1.1650    0.3516    0.0591    0.8717
    0.6268   -0.6965    1.7971   -1.4462
    0.0751    1.6961    0.2641   -0.7012
```

For a histogram of the `randn` distribution, see `hist`.

### Example 2

Set `randn` to its default initial state:

```
randn('state', 0);
```

Initialize `randn` to a different state each time:

```
randn('state', sum(100*clock));
```

Save the current state, generate 100 values, reset the state, and repeat the sequence:

```
s = randn('state');  
u1 = randn(100);  
randn('state',s);  
u2 = randn(100);      % Contains exactly the same values as u1.
```

### Example 3

Generate a random distribution with a specific mean and variance  $\sigma^2$ . To do this, multiply the output of `randn` by the standard deviation  $\sigma$ , and then add the desired mean. For example, to generate a 5-by-5 array of random numbers with a mean of .6 that are distributed with a variance of 0.1,

```
x = .6 + sqrt(0.1) * randn(5)  
x =
```

```
    0.8713    0.4735    0.8114    0.0927    0.7672  
    0.9966    0.8182    0.9766    0.6814    0.6694  
    0.0960    0.8579    0.2197    0.2659    0.3085  
    0.1443    0.8251    0.5937    1.0475   -0.0864  
    0.7806    1.0080    0.5504    0.3454    0.5813
```

### References

- [1] Moler, C.B., “Numerical Computing with MATLAB,” SIAM, (2004), 336 pp. Available online at <http://www.mathworks.com/moler>.
- [2] Marsaglia, G. and Tsang, W.W., “The Ziggurat Method for Generating Random Variables,” *Journal of Statistical Software*, (2000), 5(8). Available online at <http://www.jstatsoft.org/v05/i08/>.
- [3] Marsaglia, G. and Tsang, W.W., “A Fast, Easily Implemented Method for Sampling from Decreasing or Symmetric Unimodal Density Functions,” *SIAM Journal of Scientific and Statistical Computing*, (1984), 5(2):349-359.

[4] Knuth, D.E., "Seminumerical Algorithms," Volume 2 of *The Art of Computer Programming*, 3rd edition Addison-Wesley (1998).

**See Also**

rand, randperm, sprand, sprandn

# randperm

---

**Purpose** Random permutation

**Syntax** `p = randperm(n)`

**Description** `p = randperm(n)` returns a random permutation of the integers 1:n.

**Remarks** The `randperm` function calls `rand` and therefore, changes `rand`'s state.

**Examples** `randperm(6)` might be the vector

```
[3 2 6 4 1 5]
```

or it might be some other permutation of 1:6.

**See Also** `permute`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Rank of matrix                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Syntax</b>      | <code>k = rank(A)</code><br><code>k = rank(A,tol)</code>                                                                                                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <p>The rank function provides an estimate of the number of linearly independent rows or columns of a full matrix.</p> <p><code>k = rank(A)</code> returns the number of singular values of A that are larger than the default tolerance, <code>max(size(A))*eps(norm(A))</code>.</p> <p><code>k = rank(A,tol)</code> returns the number of singular values of A that are larger than <code>tol</code>.</p> |
| <b>Remark</b>      | Use <code>sprank</code> to determine the structural rank of a sparse matrix.                                                                                                                                                                                                                                                                                                                               |
| <b>Algorithm</b>   | <p>There are a number of ways to compute the rank of a matrix. MATLAB uses the method based on the singular value decomposition, or SVD. The SVD algorithm is the most time consuming, but also the most reliable.</p> <p>The rank algorithm is</p> <pre>s = svd(A);<br/>tol = max(size(A))*eps(max(s));<br/>r = sum(s &gt; tol);</pre>                                                                    |
| <b>See Also</b>    | <code>sprank</code>                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>References</b>  | [1] Anderson, E., Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen, <i>LAPACK User's Guide</i> ( <a href="http://www.netlib.org/lapack/lug/lapack_lug.html">http://www.netlib.org/lapack/lug/lapack_lug.html</a> ), Third Edition, SIAM, Philadelphia, 1999.                                                                |

# rat, rats

---

**Purpose** Rational fraction approximation

**Syntax**

```
[N,D] = rat(X)
[N,D] = rat(X,tol)
rat(X)
S = rats(X,strlen)
S = rats(X)
```

**Description** Even though all floating-point numbers are rational numbers, it is sometimes desirable to approximate them by simple rational numbers, which are fractions whose numerator and denominator are small integers. The `rat` function attempts to do this. Rational approximations are generated by truncating continued fraction expansions. The `rats` function calls `rat`, and returns strings.

`[N,D] = rat(X)` returns arrays `N` and `D` so that `N./D` approximates `X` to within the default tolerance, `1.e-6*norm(X(:),1)`.

`[N,D] = rat(X,tol)` returns `N./D` approximating `X` to within `tol`.

`rat(X)`, with no output arguments, simply displays the continued fraction.

`S = rats(X,strlen)` returns a string containing simple rational approximations to the elements of `X`. Asterisks are used for elements that cannot be printed in the allotted space, but are not negligible compared to the other elements in `X`. `strlen` is the length of each string element returned by the `rats` function. The default is `strlen = 13`, which allows 6 elements in 78 spaces.

`S = rats(X)` returns the same results as those printed by MATLAB with `format rat`.

**Examples** Ordinarily, the statement

```
s = 1 - 1/2 + 1/3 - 1/4 + 1/5 - 1/6 + 1/7
```

produces

```
s =
```

```
0.7595
```

However, with

```
format rat
```

or with

```
rats(s)
```

the printed result is

```
s =  
319/420
```

This is a simple rational number. Its denominator is 420, the least common multiple of the denominators of the terms involved in the original expression. Even though the quantity  $s$  is stored internally as a binary floating-point number, the desired rational form can be reconstructed.

To see how the rational approximation is generated, the statement `rat(s)` produces

```
1 + 1/(-4 + 1/(-6 + 1/(-3 + 1/(-5))))
```

And the statement

```
[n,d] = rat(s)
```

produces

```
n = 319, d = 420
```

The mathematical quantity  $\pi$  is certainly not a rational number, but the MATLAB quantity `pi` that approximates it is a rational number. `pi` is the ratio of a large integer and  $2^{52}$ :

```
14148475504056880/4503599627370496
```

## rat, rats

---

However, this is not a simple rational number. The value printed for pi with `format rat`, or with `rats(pi)`, is

355/113

This approximation was known in Euclid's time. Its decimal representation is

3.14159292035398

and so it agrees with pi to seven significant figures. The statement

`rat(pi)`

produces

$3 + 1/(7 + 1/(16))$

This shows how the 355/113 was obtained. The less accurate, but more familiar approximation 22/7 is obtained from the first two terms of this continued fraction.

### Algorithm

The `rat(X)` function approximates each element of X by a continued fraction of the form

$$\frac{n}{d} = d_1 + \frac{1}{d_2 + \frac{1}{\left(d_3 + \dots + \frac{1}{d_k}\right)}}$$

The  $d$ s are obtained by repeatedly picking off the integer part and then taking the reciprocal of the fractional part. The accuracy of the approximation increases exponentially with the number of terms and is worst when  $X = \text{sqrt}(2)$ . For  $x = \text{sqrt}(2)$ , the error with k terms is about  $2.68 * (.173)^k$ , so each additional term increases the accuracy by less than one decimal digit. It takes 21 terms to get full floating-point accuracy.



**See Also**      `format`

# rbbox

---

**Purpose** Create rubberband box for area selection

**Syntax**

```
rbbox
rbbox(initialRect)
rbbox(initialRect, fixedPoint)
rbbox(initialRect, fixedPoint, stepSize)
finalRect = rbbox(...)
```

**Description** `rbbox` initializes and tracks a rubberband box in the current figure. It sets the initial rectangular size of the box to 0, anchors the box at the figure's `CurrentPoint`, and begins tracking from this point.

`rbbox(initialRect)` specifies the initial location and size of the rubberband box as `[x y width height]`, where `x` and `y` define the lower left corner, and `width` and `height` define the size. `initialRect` is in the units specified by the current figure's `Units` property, and measured from the lower left corner of the figure window. The corner of the box closest to the pointer position follows the pointer until `rbbox` receives a button-up event.

`rbbox(initialRect, fixedPoint)` specifies the corner of the box that remains fixed. All arguments are in the units specified by the current figure's `Units` property, and measured from the lower left corner of the figure window. `fixedPoint` is a two-element vector, `[x y]`. The tracking point is the corner diametrically opposite the anchored corner defined by `fixedPoint`.

`rbbox(initialRect, fixedPoint, stepSize)` specifies how frequently the rubberband box is updated. When the tracking point exceeds `stepSize` figure units, `rbbox` redraws the rubberband box. The default `stepSize` is 1.

`finalRect = rbbox(...)` returns a four-element vector, `[x y width height]`, where `x` and `y` are the  $x$  and  $y$  components of the lower left corner of the box, and `width` and `height` are the dimensions of the box.

**Remarks** `rbbox` is useful for defining and resizing a rectangular region:

- For box definition, `initialRect` is `[x y 0 0]`, where `(x,y)` is the figure's `CurrentPoint`.
- For box resizing, `initialRect` defines the rectangular region that you resize (e.g., a legend). `fixedPoint` is the corner diametrically opposite the tracking point.

`rbbox` returns immediately if a button is not currently pressed. Therefore, you use `rbbox` with `waitforbuttonpress` so that the mouse button is down when `rbbox` is called. `rbbox` returns when you release the mouse button.

## Examples

Assuming the current view is `view(2)`, use the current axes' `CurrentPoint` property to determine the extent of the rectangle in dataspace units:

```
k = waitforbuttonpress;
point1 = get(gca, 'CurrentPoint');    % button down detected
finalRect = rbbox;                   % return figure units
point2 = get(gca, 'CurrentPoint');    % button up detected
point1 = point1(1,1:2);              % extract x and y
point2 = point2(1,1:2);
p1 = min(point1,point2);              % calculate locations
offset = abs(point1-point2);          % and dimensions
x = [p1(1) p1(1)+offset(1) p1(1)+offset(1) p1(1) p1(1)];
y = [p1(2) p1(2) p1(2)+offset(2) p1(2)+offset(2) p1(2)];
hold on
axis manual
plot(x,y)                             % redraw in dataspace units
```

## See Also

`axis`, `dragrect`, `waitforbuttonpress`

“View Control” on page 1-99 for related functions

# rcond

---

**Purpose** Matrix reciprocal condition number estimate

**Syntax** `c = rcond(A)`

**Description** `c = rcond(A)` returns an estimate for the reciprocal of the condition of  $A$  in 1-norm using the LAPACK condition estimator. If  $A$  is well conditioned, `rcond(A)` is near 1.0. If  $A$  is badly conditioned, `rcond(A)` is near 0.0. Compared to `cond`, `rcond` is a more efficient, but less reliable, method of estimating the condition of a matrix.

**Algorithm** For full matrices  $A$ , `rcond` uses the LAPACK routines listed in the following table to compute the estimate of the reciprocal condition number.

|          | <b>Real</b>               | <b>Complex</b>            |
|----------|---------------------------|---------------------------|
| A double | DLANGE, DGETRF,<br>DGECON | ZLANGE, ZGETRF,<br>ZGECON |
| A single | SLANGE, SGETRF,<br>SGECON | CLANGE, CGETRF,<br>CGECON |

**See Also** `cond`, `condest`, `norm`, `normest`, `rank`, `svd`

**References** [1] Anderson, E., Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen, *LAPACK User's Guide* ([http://www.netlib.org/lapack/lug/lapack\\_lug.html](http://www.netlib.org/lapack/lug/lapack_lug.html)), Third Edition, SIAM, Philadelphia, 1999.

**Purpose**

Read video frame data from multimedia reader object

**Syntax**

```
video = read(obj)
video = read(obj, index)
```

**Description**

`video = read(obj)` reads in video frames from the associated file. `video` is an H-by-W-by-B-by-F matrix where H is the image frame height, W is the image frame width, B is the number of bands in the image (e.g., 3 for RGB), and F is the number of frames read in. The default behavior is to read in all frames unless an index is specified. The type of data returned is always UINT8 data representing RGB24 video frames.

`video = read(obj, index)` performs the same operation, but reads only the frame(s) specified by `index`, where the first frame number is 1. `index` can be a single index, or a two-element array representing an index range of the video stream.

For example, read only the first frame:

```
video = read(obj, 1);
```

Read the first 10 frames:

```
video = read(obj, [1 10]);
```

You can use `Inf` to represent the last frame in the file:

```
video = read(obj, Inf);
```

Read from frame 50 through the end of the file:

```
video = read(obj, [50 Inf]);
```

If an invalid `index` is specified, MATLAB throws an error.

**Examples**

Construct a multimedia reader object associated with file `xylophone.mpg` and with the user tag property set to `'myreader1'`.

# read

---

```
readerobj = mmreader('xylophone.mpg', 'tag', 'myreader1');
```

Read in all video frames from the file.

```
vidFrames = read(readerobj);
```

Determine the number of frames in the file.

```
numFrames = get(readerobj, 'NumberOfFrames');
```

Create a MATLAB movie struct from the video frames.

```
for k = 1 : numFrames
    mov(k).cdata = vidFrames(:,:,k);
    mov(k).colormap = [];
end
```

Create a figure.

```
hf = figure;
```

Resize the figure based on the video's width and height.

```
set(hf, 'position', [150 150 readerobj.Width readerobj.Height])
```

Play back the movie once at the video's frame rate.

```
movie(hf, mov, 1, readerobj.FrameRate);
```

## See Also

`get`, `mmreader`, `movie`, `set`

**Purpose** Read data asynchronously from device

**Syntax** `readasync(obj)`  
`readasync(obj, size)`

**Arguments**

|                   |                                              |
|-------------------|----------------------------------------------|
| <code>obj</code>  | A serial port object.                        |
| <code>size</code> | The number of bytes to read from the device. |

**Description** `readasync(obj)` initiates an asynchronous read operation.  
`readasync(obj, size)` asynchronously reads, at most, the number of bytes given by `size`. If `size` is greater than the difference between the `InputBufferSize` property value and the `BytesAvailable` property value, an error is returned.

**Remarks**

Before you can read data, you must connect `obj` to the device with the `open` function. A connected serial port object has a `Status` property value of `open`. An error is returned if you attempt to perform a read operation while `obj` is not connected to the device.

You should use `readasync` only when you configure the `ReadAsyncMode` property to `manual`. `readasync` is ignored if used when `ReadAsyncMode` is `continuous`.

The `TransferStatus` property indicates if an asynchronous read or write operation is in progress. You can write data while an asynchronous read is in progress because serial ports have separate read and write pins. You can stop asynchronous read and write operations with the `stopasync` function.

You can monitor the amount of data stored in the input buffer with the `BytesAvailable` property. Additionally, you can use the `BytesAvailableFcn` property to execute an M-file callback function when the terminator or the specified amount of data is read.

## Rules for Completing an Asynchronous Read Operation

An asynchronous read operation with `readasync` completes when one of these conditions is met:

- The terminator specified by the `Terminator` property is read.
- The time specified by the `Timeout` property passes.
- The specified number of bytes is read.
- The input buffer is filled (if `size` is not specified).

Because `readasync` checks for the terminator, this function can be slow. To increase speed, you might want to configure `ReadAsyncMode` to `continuous` and continuously return data to the input buffer as soon as it is available from the device.

## Example

This example creates the serial port object `s`, connects `s` to a Tektronix TDS 210 oscilloscope, configures `s` to read data asynchronously only if `readasync` is issued, and configures the instrument to return the peak-to-peak value of the signal on channel 1.

```
s = serial('COM1');  
fopen(s)  
s.ReadAsyncMode = 'manual';  
fprintf(s, 'Measurement:Meas1:Source CH1')  
fprintf(s, 'Measurement:Meas1:Type Pk2Pk')  
fprintf(s, 'Measurement:Meas1:Value?')
```

Begin reading data asynchronously from the instrument using `readasync`. When the read operation is complete, return the data to the MATLAB workspace using `fscanf`.

```
readasync(s)  
s.BytesAvailable  
ans =  
    15  
out = fscanf(s)
```



```
out =  
2.0399999619E0  
fclose(s)
```

## See Also

### Functions

fopen, stopasync

### Properties

BytesAvailable, BytesAvailableFcn, ReadAsyncMode, Status, TransferStatus

# real

---

**Purpose** Real part of complex number

**Syntax** `X = real(Z)`

**Description** `X = real(Z)` returns the real part of the elements of the complex array `Z`.

**Examples** `real(2+3*i)` is 2.

**See Also** `abs`, `angle`, `conj`, `i`, `j`, `imag`

**Purpose** Natural logarithm for nonnegative real arrays

**Syntax** `Y = reallog(X)`

**Description** `Y = reallog(X)` returns the natural logarithm of each element in array `X`. Array `X` must contain only nonnegative real numbers. The size of `Y` is the same as the size of `X`.

**Examples**

```
M = magic(4)

M =
    16     2     3    13
     5    11    10     8
     9     7     6    12
     4    14    15     1

reallog(M)

ans =
    2.7726    0.6931    1.0986    2.5649
    1.6094    2.3979    2.3026    2.0794
    2.1972    1.9459    1.7918    2.4849
    1.3863    2.6391    2.7081     0
```

**See Also** `log`, `realpow`, `realsqrt`

# realmax

---

**Purpose** Largest positive floating-point number

**Syntax** `n = realmax`

**Description** `n = realmax` returns the largest floating-point number representable on your computer. Anything larger overflows.

`realmax('double')` is the same as `realmax` with no arguments.

`realmax('single')` is the largest single precision floating point number representable on your computer. Anything larger overflows to `single(Inf)`.

**Examples** `realmax` is one bit less than  $2^{1024}$  or about `1.7977e+308`.

**Algorithm** The `realmax` function is equivalent to `pow2(2-eps,maxexp)`, where `maxexp` is the largest possible floating-point exponent.

Execute type `realmax` to see `maxexp` for various computers.

**See Also** `eps`, `realmin`, `intmax`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Smallest positive normalized floating-point number                                                                                                                                                                                                                                                                                                                                                     |
| <b>Syntax</b>      | <code>n = realmin</code>                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Description</b> | <p><code>n = realmin</code> returns the smallest positive normalized floating-point number on your computer. Anything smaller underflows or is an IEEE “denormal.”</p> <p><code>REALMIN('double')</code> is the same as <code>REALMIN</code> with no arguments.</p> <p><code>REALMIN('single')</code> is the smallest positive normalized single precision floating point number on your computer.</p> |
| <b>Examples</b>    | <code>realmin</code> is $2^{(-1022)}$ or about <code>2.2251e-308</code> .                                                                                                                                                                                                                                                                                                                              |
| <b>Algorithm</b>   | <p>The <code>realmin</code> function is equivalent to <code>pow2(1,minexp)</code> where <code>minexp</code> is the smallest possible floating-point exponent.</p> <p>Execute type <code>realmin</code> to see <code>minexp</code> for various computers.</p>                                                                                                                                           |
| <b>See Also</b>    | <code>eps</code> , <code>realmax</code> , <code>intmin</code>                                                                                                                                                                                                                                                                                                                                          |

# realpow

---

**Purpose** Array power for real-only output

**Syntax** `Z = realpow(X,Y)`

**Description** `Z = realpow(X,Y)` raises each element of array `X` to the power of its corresponding element in array `Y`. Arrays `X` and `Y` must be the same size. The range of `realpow` is the set of all real numbers, i.e., all elements of the output array `Z` must be real.

## Examples

```
X = -2*ones(3,3)
```

```
X =  
    -2    -2    -2  
    -2    -2    -2  
    -2    -2    -2
```

```
Y = pascal(3)
```

```
ans =  
     1     1     1  
     1     2     3  
     1     3     6
```

```
realpow(X,Y)
```

```
ans =  
    -2    -2    -2  
    -2     4    -8  
    -2    -8   64
```

**See Also** `reallog`, `realsqrt`, `.`<sup>^</sup> (array power operator)

**Purpose** Square root for nonnegative real arrays

**Syntax** `Y = realsqrt(X)`

**Description** `Y = realsqrt(X)` returns the square root of each element of array `X`. Array `X` must contain only nonnegative real numbers. The size of `Y` is the same as the size of `X`.

**Examples**

```
M = magic(4)
```

```
M =
```

```
    16     2     3    13
     5    11    10     8
     9     7     6    12
     4    14    15     1
```

```
realsqrt(M)
```

```
ans =
```

```
    4.0000    1.4142    1.7321    3.6056
    2.2361    3.3166    3.1623    2.8284
    3.0000    2.6458    2.4495    3.4641
    2.0000    3.7417    3.8730    1.0000
```

**See Also** `reallog`, `realpow`, `sqrt`, `sqrtm`

# record

---

**Purpose** Record data and event information to file

**Syntax** `record(obj)`  
`record(obj, 'switch')`

**Arguments**

|                       |                                          |
|-----------------------|------------------------------------------|
| <code>obj</code>      | A serial port object.                    |
| <code>'switch'</code> | Switch recording capabilities on or off. |

**Description** `record(obj)` toggles the recording state for `obj`.  
`record(obj, 'switch')` initiates or terminates recording for `obj`. `switch` can be on or off. If `switch` is on, recording is initiated. If `switch` is off, recording is terminated.

**Remarks** Before you can record information to disk, `obj` must be connected to the device with the `fopen` function. A connected serial port object has a `Status` property value of `open`. An error is returned if you attempt to record information while `obj` is not connected to the device. Each serial port object must record information to a separate file. Recording is automatically terminated when `obj` is disconnected from the device with `fclose`.

The `RecordName` and `RecordMode` properties are read-only while `obj` is recording, and must be configured before using `record`.

For a detailed description of the record file format and the properties associated with recording data and event information to a file, refer to [Debugging: Recording Information to Disk](#).

**Example** This example creates the serial port object `s`, connects `s` to the device, configures `s` to record information to a file, writes and reads text data, and then disconnects `s` from the device.

```
s = serial('COM1');  
fopen(s)  
s.RecordDetail = 'verbose';
```



```
s.RecordName = 'MySerialFile.txt';  
record(s, 'on')  
fprintf(s, '*IDN?')  
out = fscanf(s);  
record(s, 'off')  
fclose(s)
```

**See Also****Functions**

fclose, fopen

**Properties**

RecordDetail, RecordMode, RecordName, RecordStatus, Status

# rectangle

---

**Purpose** Create 2-D rectangle object

## Syntax

**Description** `rectangle` draws a rectangle with Position `[0,0,1,1]` and Curvature `[0,0]` (i.e., no curvature).

`rectangle('Position',[x,y,w,h])` draws the rectangle from the point `x,y` and having a width of `w` and a height of `h`. Specify values in axes data units.

Note that, to display a rectangle in the specified proportions, you need to set the axes data aspect ratio so that one unit is of equal length along both the `x` and `y` axes. You can do this with the command `axis equal` or `daspect([1,1,1])`.

`rectangle(...,'Curvature',[x,y])` specifies the curvature of the rectangle sides, enabling it to vary from a rectangle to an ellipse. The horizontal curvature `x` is the fraction of width of the rectangle that is curved along the top and bottom edges. The vertical curvature `y` is the fraction of the height of the rectangle that is curved along the left and right edges.

The values of `x` and `y` can range from 0 (no curvature) to 1 (maximum curvature). A value of `[0,0]` creates a rectangle with square sides. A value of `[1,1]` creates an ellipse. If you specify only one value for Curvature, then the same length (in axes data units) is curved along both horizontal and vertical sides. The amount of curvature is determined by the shorter dimension.

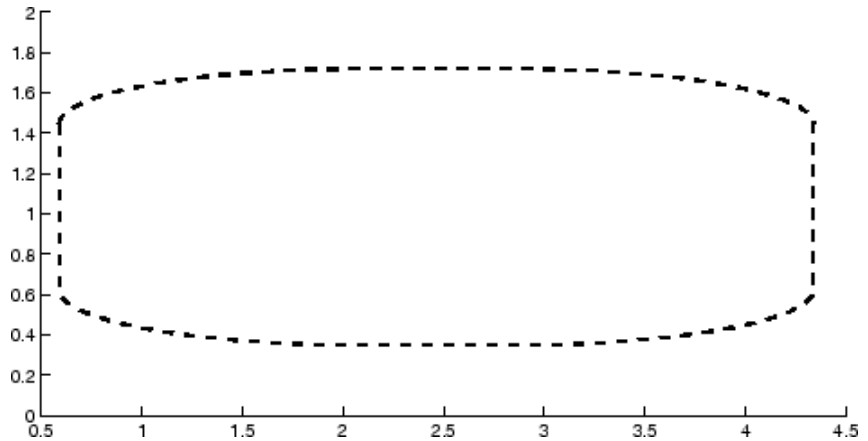
`h = rectangle(...)` returns the handle of the rectangle object created.

**Remarks** Rectangle objects are 2-D and can be drawn in an axes only if the view is `[0 90]` (i.e., `view(2)`). Rectangles are children of axes and are defined in coordinates of the axes data.

**Examples** This example sets the data aspect ratio to `[1,1,1]` so that the rectangle is displayed in the specified proportions (`daspect`). Note that the

horizontal and vertical curvature can be different. Also, note the effects of using a single value for Curvature.

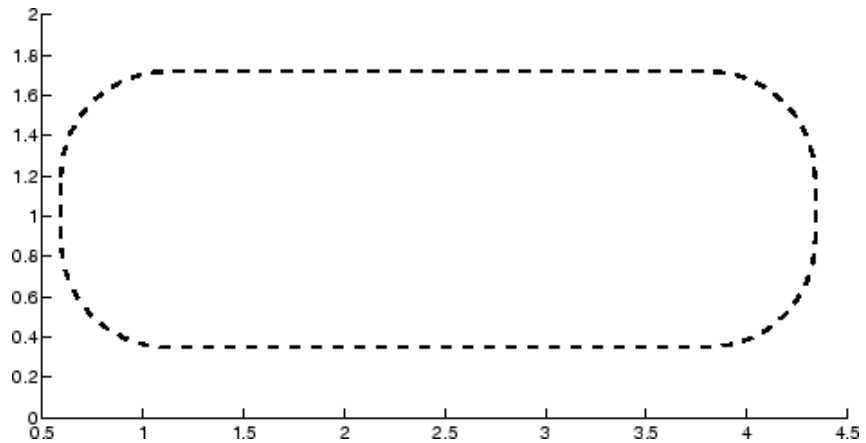
```
rectangle('Position',[0.59,0.35,3.75,1.37],...  
         'Curvature',[0.8,0.4],...  
         'LineWidth',2,'LineStyle','--')  
daspect([1,1,1])
```



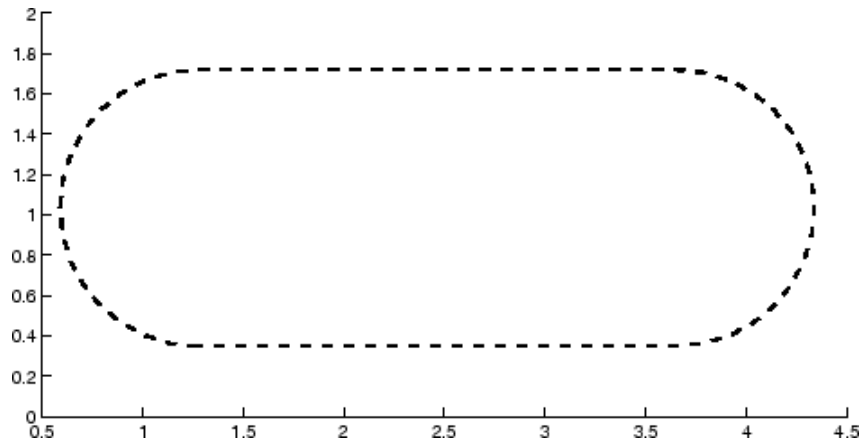
Specifying a single value of [0.4] for Curvature produces

# rectangle

---

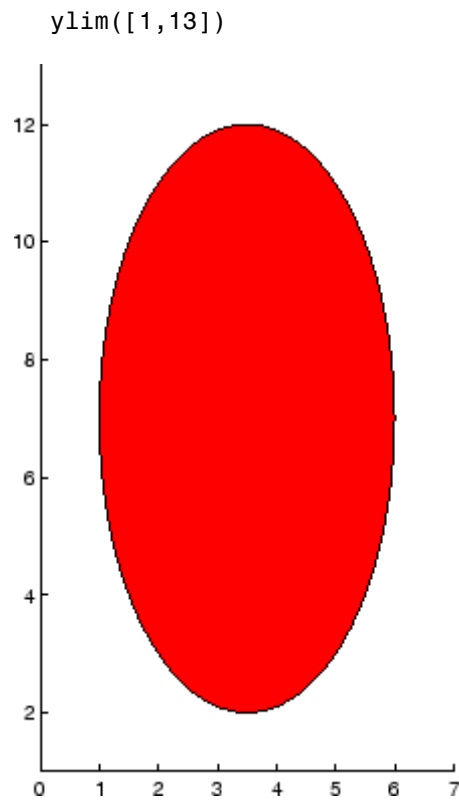


A Curvature of [1] produces a rectangle with the shortest side completely round:

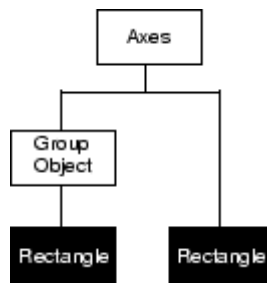


This example creates an ellipse and colors the face red.

```
rectangle('Position',[1,2,5,10],'Curvature',[1,1],...  
         'FaceColor','r')  
daspect([1,1,1])  
xlim([0,7])
```



**Object Hierarchy**



# rectangle

---

## Setting Default Properties

You can set default rectangle properties on the axes, figure, and root levels:

```
set(0, 'DefaultRectangleProperty', PropertyValue...)  
set(gcf, 'DefaultRectangleProperty', PropertyValue...)  
set(gca, 'DefaultRectangleProperty', PropertyValue...)
```

where *Property* is the name of the rectangle property whose default value you want to set and *PropertyValue* is the value you are specifying. Use `set` and `get` to access the surface properties.

## See Also

`line`, `patch`, `rectangle` properties

“Object Creation Functions” on page 1-94 for related functions

See the `annotation` function for information about the rectangle annotation object.

Rectangle Properties for property descriptions

## Purpose

Define rectangle properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- “The Property Editor” is an interactive tool that enables you to see and change object property values.
- The set and get commands enable you to set and query the values of properties.

To change the default values of properties, see “Setting Default Property Values”.

See “Core Graphics Objects” for general information about this type of object.

## Rectangle Property Descriptions

This section lists property names along with the type of values each accepts. Curly braces { } enclose default values.

Annotation

hg.Annotation object Read Only

*Control the display of rectangle objects in legends.* The Annotation property enables you to specify whether this rectangle object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the rectangle object is displayed in a figure legend:

# Rectangle Properties

---

| IconDisplayStyle Value | Purpose                                                   |
|------------------------|-----------------------------------------------------------|
| on                     | Represent this rectangle object in a legend (default)     |
| off                    | Do not include this rectangle object in a legend          |
| children               | Same as on because rectangle objects do not have children |

## Setting the IconDisplayStyle property

These commands set the IconDisplayStyle of a graphics object with handle `hobj` to off:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'off')
```

## Using the IconDisplayStyle property

See “Controlling Legends” for more information and examples.

BeingDeleted  
on | {off} read only

*This object is being deleted.* The BeingDeleted property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the BeingDeleted property to on when the object’s delete function callback is called (see the DeleteFcn property). It remains set to on while the delete function executes, after which the object no longer exists.

For example, an object’s delete function might call other functions that act on a number of different objects. These functions may not need to perform actions on objects that are going to be deleted,



and therefore, can check the object's `BeingDeleted` property before acting.

`BusyAction`  
`cancel | {queue}`

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callback routines. If there is a callback routine executing, callback routines invoked subsequently always attempt to interrupt it. If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

`ButtonDownFcn`  
functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Button press callback function.* A callback function that executes whenever you press a mouse button while the pointer is over the rectangle object.

See the figure's `SelectionType` property to determine if modifier keys were also pressed.

Set this property to a function handle that references the callback. The function must define at least two input arguments (handle of object associated with the button down event and an event structure, which is empty for this property)

# Rectangle Properties

---

```
function button_down(src, evnt)
% src - the object that is the source of the event
% evnt - empty for this property
sel_typ = get(gcf, 'SelectionType')
switch sel_typ
    case 'normal'
        disp('User clicked left-mouse button')
        set(src, 'Selected', 'on')
    case 'extend'
        disp('User did a shift-click')
        set(src, 'Selected', 'on')
    case 'alt'
        disp('User did a control-click')
        set(src, 'Selected', 'on')
        set(src, 'SelectionHighlight', 'off')
end
end
```

Suppose `h` is the handle of a rectangle object and that the `button_down` function is on your MATLAB path. The following statement assigns the function above to the `ButtonDownFcn`:

```
set(h, 'ButtonDownFcn', @button_down)
```

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

**Children**  
vector of handles

The empty matrix; rectangle objects have no children.

**Clipping**  
{on} | off

*Clipping mode.* MATLAB clips rectangles to the axes plot box by default. If you set `Clipping` to off, rectangles are displayed outside the axes plot box. This can occur if you create a rectangle,

set hold to on, freeze axis scaling (axis set to manual), and then create a larger rectangle.

## CreateFcn

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Callback function executed during object creation.* This property defines a callback function that executes when MATLAB creates a rectangle object. You must define this property as a default value for rectangles or in a call to the `rectangle` function to create a new rectangle object. For example, the statement

```
set(0, 'DefaultRectangleCreateFcn', @rect_create)
```

defines a default value for the rectangle `CreateFcn` property on the root level that sets the axes `DataAspectRatio` whenever you create a rectangle object. The callback function must be on your MATLAB path when you execute the above statement.

```
function rect_create(src, evnt)
% src - the object that is the source of the event
% evnt - empty for this property
    axh = get(src, 'Parent');
    set(axh, 'DataAspectRatio', [1,1,1])
end
```

MATLAB executes this function after setting all rectangle properties. Setting this property on an existing rectangle object has no effect. The function must define at least two input arguments (handle of object created and an event structure, which is empty for this property).

The handle of the object whose `CreateFcn` is being executed is passed by MATLAB as the first argument to the callback function and is also accessible through the root `CallbackObject` property, which you can query using `gcbo`.

# Rectangle Properties

---

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## Curvature

one- or two-element vector [x,y]

*Amount of horizontal and vertical curvature.* This property specifies the curvature of the rectangle sides, which enables the shape of the rectangle to vary from rectangular to ellipsoidal. The horizontal curvature x is the fraction of width of the rectangle that is curved along the top and bottom edges. The vertical curvature y is the fraction of the height of the rectangle that is curved along the left and right edges.

The values of x and y can range from 0 (no curvature) to 1 (maximum curvature). A value of [0,0] creates a rectangle with square sides. A value of [1,1] creates an ellipse. If you specify only one value for Curvature, then the same length (in axes data units) is curved along both horizontal and vertical sides. The amount of curvature is determined by the shorter dimension.

## DeleteFcn

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Delete rectangle callback function.* A callback function that executes when you delete the rectangle object (e.g., when you issue a delete command or clear the axes cla or figure clf). For example, the following function displays object property data before the object is deleted.

```
function delete_fcn(src,evnt)
% src - the object that is the source of the event
% evnt - empty for this property
    obj_tp = get(src,'Type');
    disp([obj_tp, ' object deleted'])
    disp('Its user data is:')
    disp(get(src,'UserData'))
```

end

MATLAB executes the function before deleting the object's properties so these values are available to the callback function. The function must define at least two input arguments (handle of object being deleted and an event structure, which is empty for this property)

The handle of the object whose `DeleteFcn` is being executed is passed by MATLAB as the first argument to the callback function and is also accessible through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

`DisplayName`

string (default is empty string)

*String used by legend for this rectangle object.* The legend function uses the string defined by the `DisplayName` property to label this rectangle object in the legend.

- If you specify string arguments with the legend function, `DisplayName` is set to this rectangle object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where *n* is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.

# Rectangle Properties

---

- To add programmatically a legend that uses the `DisplayName` string, call `legend` with the `toggle` or `show` option.

See “Controlling Legends” for more examples.

`EdgeColor`

`{ColorSpec} | none`

*Color of the rectangle edges.* This property specifies the color of the rectangle edges as a color or specifies that no edges be drawn.

`EraseMode`

`{normal} | none | xor | background`

*Erase mode.* This property controls the technique MATLAB uses to draw and erase rectangle objects. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- `normal` (the default) — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- `none` — Do not erase the rectangle when it is moved or destroyed. While the object is still visible on the screen after erasing with `EraseMode none`, you cannot print it because MATLAB stores no information about its former location.
- `xor` — Draw and erase the rectangle by performing an exclusive OR (XOR) with the color of the screen beneath it. This mode does not damage the color of the objects beneath the rectangle. However, the rectangle’s color depends on the color of whatever is beneath it on the display.
- `background` — Erase the rectangle by drawing it in the axes background `Color`, or the figure background `Color` if the axes

Color is set to none. This damages objects that are behind the erased rectangle, but rectangles are always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the `EraseMode` of all objects is `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look different on screen than on paper. On screen, MATLAB can mathematically combine layers of colors (e.g., performing an XOR of a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

You can use the MATLAB `getframe` command or other screen capture application to create an image of a figure containing nonnormal mode objects.

`FaceColor`  
`ColorSpec` | `{none}`

*Color of rectangle face.* This property specifies the color of the rectangle face, which is not colored by default.

`HandleVisibility`  
`{on}` | `callback` | `off`

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. `HandleVisibility` is useful for preventing command-line users from accidentally drawing into or deleting a figure that contains only user interface devices (such as a dialog box).

Handles are always visible when `HandleVisibility` is `on`.

Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from

# Rectangle Properties

---

the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.

Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

You can set the `Root ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties).

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties and pass it to any function that operates on handles.

`HitTest`  
{on} | off

*Selectable by mouse click.* `HitTest` determines if the rectangle can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on



the rectangle. If `HitTest` is off, clicking the rectangle selects the object below it (which may be the axes containing it).

## Interruptible

{on} | off

*Callback routine interruption mode.* The `Interruptible` property controls whether a rectangle callback routine can be interrupted by subsequently invoked callback routines. Only callback routines defined for the `ButtonDownFcn` are affected by the `Interruptible` property. MATLAB checks for events that can interrupt a callback routine only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine.

## LineStyle

{-} | -- | : | -. | none

*Line style of rectangle edge.* This property specifies the line style of the edges. The available line styles are

| Symbol | Line Style           |
|--------|----------------------|
| -      | Solid line (default) |
| --     | Dashed line          |
| :      | Dotted line          |
| -.     | Dash-dot line        |
| none   | No line              |

## LineWidth

scalar

*The width of the rectangle edge line.* Specify this value in points (1 point =  $\frac{1}{72}$  inch). The default `LineWidth` is 0.5 points.

## Parent

handle of axes, `hgroup`, or `hgtransform`

# Rectangle Properties

---

*Parent of rectangle object.* This property contains the handle of the rectangle object's parent. The parent of a rectangle object is the axes, hggroup, or hgtransform object that contains it.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

## Position

four-element vector [x,y,width,height]

*Location and size of rectangle.* This property specifies the location and size of the rectangle in the data units of the axes. The point defined by x, y specifies one corner of the rectangle, and width and height define the size in units along the *x*- and *y*-axes respectively.

## Selected

on | off

*Is object selected?* When this property is on MATLAB displays selection handles if the SelectionHighlight property is also on. You can, for example, define the ButtonDownFcn to set this property, allowing users to select the object with the mouse.

## SelectionHighlight

{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing handles at each vertex. When SelectionHighlight is off, MATLAB does not draw the handles.

## Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as

global variables or pass them as arguments between callback routines. You can define Tag as any string.

## Type

string (read only)

*Class of graphics object.* For rectangle objects, Type is always the string 'rectangle'.

## UIContextMenu

handle of a uicontextmenu object

*Associate a context menu with the rectangle.* Assign this property the handle of a uicontextmenu object created in the same figure as the rectangle. Use the uicontextmenu function to create the context menu. MATLAB displays the context menu whenever you right-click over the rectangle.

## UserData

matrix

*User-specified data.* Any data you want to associate with the rectangle object. MATLAB does not use this data, but you can access it using the set and get commands.

## Visible

{on} | off

*Rectangle visibility.* By default, all rectangles are visible. When set to off, the rectangle is not visible, but still exists, and you can get and set its properties.

# rectint

---

**Purpose** Rectangle intersection area

**Syntax** `area = rectint(A,B)`

**Description** `area = rectint(A,B)` returns the area of intersection of the rectangles specified by position vectors A and B.

If A and B each specify one rectangle, the output area is a scalar.

A and B can also be matrices, where each row is a position vector. area is then a matrix giving the intersection of all rectangles specified by A with all the rectangles specified by B. That is, if A is n-by-4 and B is m-by-4, then area is an n-by-m matrix where `area(i, j)` is the intersection area of the rectangles specified by the i<sup>th</sup> row of A and the j<sup>th</sup> row of B.

---

**Note** A position vector is a four-element vector `[x,y,width,height]`, where the point defined by x and y specifies one corner of the rectangle, and width and height define the size in units along the x and y axes respectively.

---

**See Also** `polyarea`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Set option to move deleted files to recycle folder                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Syntax</b>      | <pre>S = recycle S = recycle state S = recycle('state')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Description</b> | <p><code>S = recycle</code> returns a character array <code>S</code> that shows the current state of the MATLAB file recycling option. This state can be either on or off. When file recycling is on, MATLAB moves all files that you delete with the <code>delete</code> function to either the recycle bin on the PC or Macintosh, or a temporary directory on UNIX. (To locate this directory on UNIX, see the Remarks section below.) When file recycling is off, any files you delete are actually removed from the system.</p> <p>The default recycle state is off. You can turn recycling on for all of your MATLAB sessions using the Preferences dialog box (Select <b>File &gt; Preferences &gt; General</b>). Under the heading <b>Default behavior of the delete function</b> select <b>Move files to the Recycle Bin</b>.</p> <p><code>S = recycle state</code> sets the MATLAB recycle option to the given state, either on or off. Return value <code>S</code> shows the previous recycle state.</p> <p><code>S = recycle('state')</code> is the function format for this command.</p> |
| <b>Remarks</b>     | <p>On UNIX systems, you can locate the system temporary directory by entering the MATLAB function <code>tempdir</code>. The recycle directory is a subdirectory of this temporary directory, and is named according to the format</p> <pre>MATLAB_Files_&lt;day&gt;-&lt;mo&gt;-&lt;yr&gt;_&lt;hr&gt;_&lt;min&gt;_&lt;sec&gt;</pre> <p>For example, files recycled on a UNIX system at 2:09:28 in the afternoon of November 9, 2004 would be copied to a directory named</p> <pre>/tmp/MATLAB_Files_09-Nov-2004_14_09_28</pre> <p>To set the recycle state for all MATLAB sessions, use the <b>Preferences</b> dialog box. Open the <b>Preferences</b> dialog and select <b>General</b>. To</p>                                                                                                                                                                                                                                                                                                                                                                                                        |

# recycle

---

enable or disable recycling, click **Move files to the recycle bin** or **Delete files permanently**. See “General Preferences for MATLAB” in the Desktop Tools and Development Environment documentation for more information.

You can recycle files that are stored on your local computer system, but not files that you access over a network connection. On Windows systems, when you use the `delete` function on files accessed over a network, MATLAB removes the file entirely.

## Examples

Start from a state where file recycling has been turned off. Check the current recycle state:

```
recycle
ans =
    off
```

Turn file recycling on. Delete a file and verify that it has been transferred to the recycle bin or temporary folder:

```
recycle on;
delete myfile.txt
```

## See Also

`delete`, `dir`, `ls`, `fileparts`, `mkdir`, `rmdir`

**Purpose** Reduce number of patch faces

**Syntax**

```
nfv = reducepatch(p,r)
nfv = reducepatch(fv,r)
nfv = reducepatch(p) or nfv = reducepatch(fv)
reducepatch(...,'fast')
reducepatch(...,'verbose')
nfv = reducepatch(f,v,r)
[nf,nv] = reducepatch(...)
```

**Description** `reducepatch(p,r)` reduces the number of faces of the patch identified by handle `p`, while attempting to preserve the overall shape of the original object. MATLAB interprets the reduction factor `r` in one of two ways depending on its value:

- If `r` is less than 1, `r` is interpreted as a fraction of the original number of faces. For example, if you specify `r` as 0.2, then the number of faces is reduced to 20% of the number in the original patch.
- If `r` is greater than or equal to 1, then `r` is the target number of faces. For example, if you specify `r` as 400, then the number of faces is reduced until there are 400 faces remaining.

`nfv = reducepatch(p,r)` returns the reduced set of faces and vertices but does not set the `Faces` and `Vertices` properties of patch `p`. The struct `nfv` contains the faces and vertices after reduction.

`nfv = reducepatch(fv,r)` performs the reduction on the faces and vertices in the struct `fv`.

`nfv = reducepatch(p)` or `nfv = reducepatch(fv)` uses a reduction value of 0.5.

`reducepatch(...,'fast')` assumes the vertices are unique and does not compute shared vertices.

`reducepatch(...,'verbose')` prints progress messages to the command window as the computation progresses.

# reducepatch

---

`nfv = reducepatch(f,v,r)` performs the reduction on the faces in `f` and the vertices in `v`.

`[nf,nv] = reducepatch(...)` returns the faces and vertices in the arrays `nf` and `nv`.

## Remarks

If the patch contains nonshared vertices, MATLAB computes shared vertices before reducing the number of faces. If the faces of the patch are not triangles, MATLAB triangulates the faces before reduction. The faces returned are always defined as triangles.

The number of output triangles may not be exactly the number specified with the reduction factor argument (`r`), particularly if the faces of the original patch are not triangles.

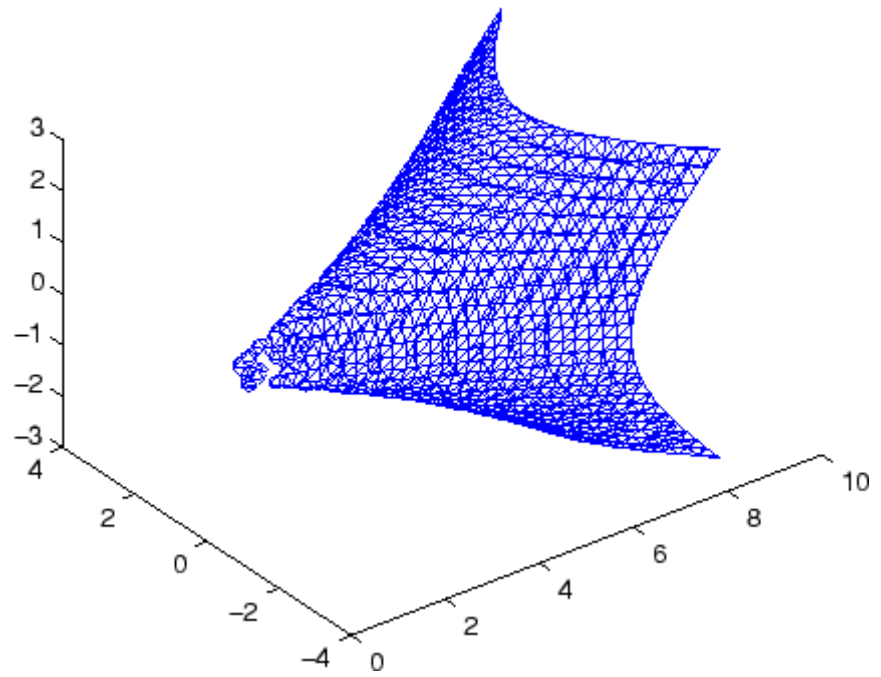
## Examples

This example illustrates the effect of reducing the number of faces to only 15% of the original value.

```
[x,y,z,v] = flow;
p = patch(isosurface(x,y,z,v,-3));
set(p,'facecolor','w','EdgeColor','b');
daspect([1,1,1])
view(3)
figure;
h = axes;
p2 = copyobj(p,h);
reducepatch(p2,0.15)
daspect([1,1,1])
view(3)
```



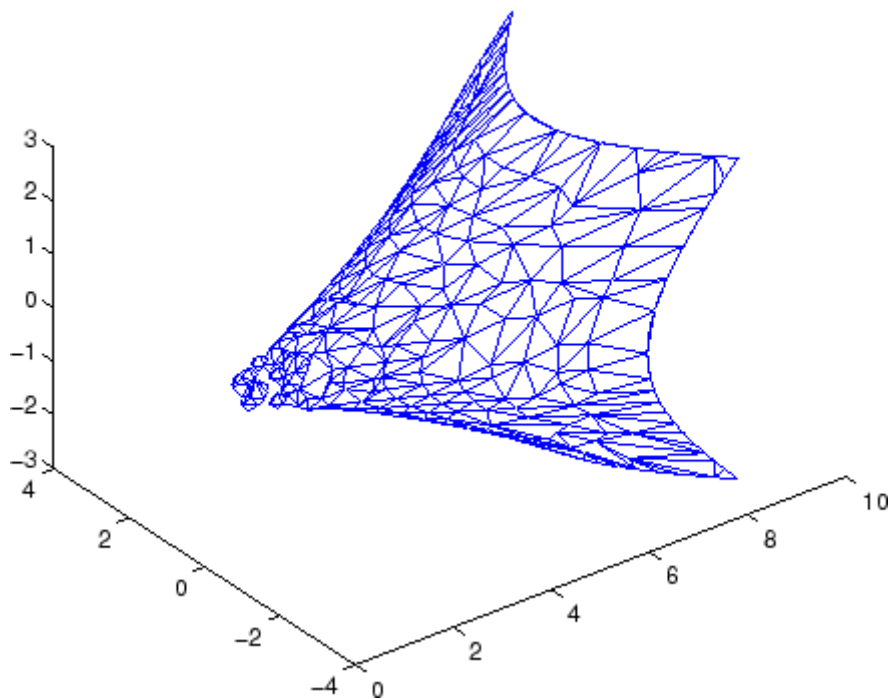
Before Reduction



# reducepatch

---

After Reduction to 15% of Original Number of Faces



## See Also

isosurface, isocaps, isonormals, smooth3, subvolume, reducevolume  
“Volume Visualization” on page 1-102 for related functions  
Vector Field Displayed with Cone Plots for another example

## Purpose

Reduce number of elements in volume data set

## Syntax

```
[nx,ny,nz,nv] = reducevolume(X,Y,Z,V,[Rx,Ry,Rz])
[nx,ny,nz,nv] = reducevolume(V,[Rx,Ry,Rz])
nv = reducevolume(...)
```

## Description

`[nx,ny,nz,nv] = reducevolume(X,Y,Z,V,[Rx,Ry,Rz])` reduces the number of elements in the volume by retaining every  $R_x^{\text{th}}$  element in the  $x$  direction, every  $R_y^{\text{th}}$  element in the  $y$  direction, and every  $R_z^{\text{th}}$  element in the  $z$  direction. If a scalar  $R$  is used to indicate the amount of reduction instead of a three-element vector, MATLAB assumes the reduction to be `[R R R]`.

The arrays  $X$ ,  $Y$ , and  $Z$  define the coordinates for the volume  $V$ . The reduced volume is returned in  $nv$ , and the coordinates of the reduced volume are returned in  $nx$ ,  $ny$ , and  $nz$ .

`[nx,ny,nz,nv] = reducevolume(V,[Rx,Ry,Rz])` assumes the arrays  $X$ ,  $Y$ , and  $Z$  are defined as `[X,Y,Z] = meshgrid(1:n,1:m,1:p)`, where `[m,n,p] = size(V)`.

`nv = reducevolume(...)` returns only the reduced volume.

## Examples

This example uses a data set that is a collection of MRI slices of a human skull. This data is processed in a variety of ways:

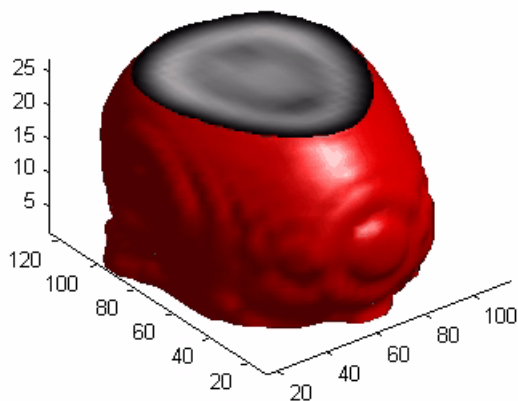
- The 4-D array is squeezed (`squeeze`) into three dimensions and then reduced (`reducevolume`) so that what remains is every fourth element in the  $x$  and  $y$  directions and every element in the  $z$  direction.
- The reduced data is smoothed (`smooth3`).
- The outline of the skull is an isosurface generated as a patch (`p1`) whose vertex normals are recalculated to improve the appearance when lighting is applied (`patch`, `isosurface`, `isonormals`).
- A second patch (`p2`) with an interpolated face color draws the end caps (`FaceColor`, `isocaps`).
- The view of the object is set (`view`, `axis`, `daspect`).

# reducevolume

---

- A 100-element grayscale colormap provides coloring for the end caps (colormap).
- Adding a light to the right of the camera illuminates the object (camlight, lighting).

```
load mri
D = squeeze(D);
[x,y,z,D] = reducevolume(D,[4,4,1]);
D = smooth3(D);
p1 = patch(isosurface(x,y,z,D, 5,'verbose'),...
    'FaceColor','red','EdgeColor','none');
isonormals(x,y,z,D,p1);
p2 = patch(isocaps(x,y,z,D, 5),...
    'FaceColor','interp','EdgeColor','none');
view(3); axis tight; daspect([1,1,.4])
colormap(gray(100))
camlight; lighting gouraud
```



## See Also

isosurface, isocaps, isonormals, smooth3, subvolume, reducepatch

“Volume Visualization” on page 1-102 for related functions

# refresh

---

|                    |                                                                                                                                          |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Redraw current figure                                                                                                                    |
| <b>Syntax</b>      | <code>refresh</code><br><code>refresh(h)</code>                                                                                          |
| <b>Description</b> | <code>refresh</code> erases and redraws the current figure.<br><code>refresh(h)</code> redraws the figure identified by <code>h</code> . |
| <b>See Also</b>    | “Figure Windows” on page 1-95 for related functions                                                                                      |

**Purpose**

Refresh data in graph when data source is specified

**Syntax**

```
refreshdata
refreshdata(figure_handle)
refreshdata(object_handles)
refreshdata(object_handles, 'workspace')
```

**Description**

`refreshdata` evaluates any data source properties (XDataSource, YDataSource, or ZDataSource) on all objects in graphs in the current figure. If the specified data source has changed, MATLAB updates the graph to reflect this change.

Note that the variable assigned to the data source property must be in the base workspace.

`refreshdata(figure_handle)` refreshes the data of the objects in the specified figure.

`refreshdata(object_handles)` refreshes the data of the objects specified in `object_handles` or the children of those objects. Therefore, `object_handles` can contain figure, axes, or plot object handles.

`refreshdata(object_handles, 'workspace')` enables you to specify whether the data source properties are evaluated in the base workspace or the workspace of the function in which `refreshdata` was called. `workspace` is a string that can be

- `base` — Evaluate the data source properties in the base workspace.
- `caller` — Evaluate the data source properties in the workspace of the function that called `refreshdata`.

**Examples**

This example creates a contour plot and changes its data source. The call to `refreshdata` causes the graph to update.

```
z = peaks(5);
[c h] = contour(z, 'ZDataSource', 'z');
drawnow
pause(3) % Wait 3 seconds and the graph will update
```

# refreshdata

---

```
z = peaks(20);  
refreshdata(h)
```

## See Also

The [X,Y,Z]DataSource properties of plot objects.



**Purpose**

Match regular expression

**Syntax**

```
regexp('str', 'expr')  
[start_idx, end_idx, extents, matches, tokens, names,  
    splits] = regexp('str', 'expr')  
[v1, v2, ...] = regexp('str', 'expr', q1, q2, ...)  
[v1 v2 ...] = regexp('str', 'expr', ..., options)
```

Each of these syntaxes apply to both `regexp` and `regexpi`. The `regexp` function is case sensitive in matching regular expressions to a string, and `regexpi` is case insensitive.

**Description**

The following descriptions apply to both `regexp` and `regexpi`:

`regexp('str', 'expr')` returns a row vector containing the starting index of each substring of `str` that matches the regular expression string `expr`. If no matches are found, `regexp` returns an empty array. The `str` and `expr` arguments can also be cell arrays of strings. See “Regular Expressions” in the MATLAB Programming documentation for more information.

To specify more than one string to parse or more than one expression to match, see the guidelines listed below under “Multiple Strings or Expressions” on page 2-2733.

`[start_idx, end_idx, extents, matches, tokens, names, splits] = regexp('str', 'expr')` returns up to six values, one for each output variable you specify, and in the default order (as shown in the table below).

---

**Note** The `str` and `expr` inputs are required and must be entered as the first and second arguments, respectively. Any other input arguments (all are described below) are optional and can be entered following the two required inputs in any order.

---

# regexp, regexpi

---

[v1, v2, ...] = regexp('str', 'expr', q1, q2, ...) returns up to six values, one for each output variable you specify, and ordered according to the order of the qualifier arguments, q1, q2, etc.

## Return Values for Regular Expressions

| Default Order | Description                                                                                                                                                                                                                                                                                                                                                                                                      | Qualifier           |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| 1             | Row vector containing the starting index of each substring of <code>str</code> that matches <code>expr</code> .                                                                                                                                                                                                                                                                                                  | <b>start</b>        |
| 2             | Row vector containing the ending index of each substring of <code>str</code> that matches <code>expr</code> .                                                                                                                                                                                                                                                                                                    | <b>end</b>          |
| 3             | Cell array containing the starting and ending indices of each substring of <code>str</code> that matches a token in <code>expr</code> . (This is a double array when used with 'once'.)                                                                                                                                                                                                                          | <b>tokenExtents</b> |
| 4             | Cell array containing the text of each substring of <code>str</code> that matches <code>expr</code> . (This is a string when used with 'once'.)                                                                                                                                                                                                                                                                  | <b>match</b>        |
| 5             | Cell array of cell arrays of strings containing the text of each token captured by <code>regexp</code> . (This is a cell array of strings when used with 'once'.)                                                                                                                                                                                                                                                | <b>tokens</b>       |
| 6             | Structure array containing the name and text of each <i>named</i> token captured by <code>regexp</code> . If there are no named tokens in <code>expr</code> , <code>regexp</code> returns a structure array with no fields.<br><br>Field names of the returned structure are set to the token names, and field values are the text of those tokens. Named tokens are generated by the expression (?<tokenname>). | <b>names</b>        |
| 7             | Cell array containing those parts of the input string that are delimited by substrings returned when using the <code>regexp</code> 'match' option.                                                                                                                                                                                                                                                               | <b>split</b>        |

**Tip** When using the `split` option, `regexp` always returns one more string than it does with the `match` option. Also, you can always put the original input string back together from the substrings obtained from both `split` and `match`. See “Example 4 — Splitting the Input String” on page 2-2735.

[v1 v2 ...] = `regexp('str', 'expr', ..., options)` calls `regexp` with one or more of the nondefault options listed in the following table. These options must follow `str` and `expr` in the input argument list.

| Option                  | Description                                                                                                                                                                     |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>mode</code>       | See the section on “Modes” on page 2-2731 below.                                                                                                                                |
| <code>'once'</code>     | Return only the first match found.                                                                                                                                              |
| <code>'warnings'</code> | Display any hidden warning messages issued by MATLAB during the execution of the command. This option only enables warnings for the one command being executed. See Example 10. |

## Modes

You can specify one or more of the following modes with the `regexp`, `regexpi`, and `regprep` functions. You can enable or disable any of these modes using the mode specifier keyword (e.g., `'lineanchors'`) or the mode flag (e.g., `(?m)`). Both are shown in the tables that follow. Use the keyword to enable or disable the mode for the entire string being parsed. Use the flag to both enable and disable the mode for selected pieces of the string.

### Case-Sensitivity Mode

Use the Case-Sensitivity mode to control whether or not MATLAB considers letter case when matching an expression to a string. Example 6 illustrates the this mode.

# regexp, regexpi

---

| Mode Keyword | Flag  | Description                                                                                |
|--------------|-------|--------------------------------------------------------------------------------------------|
| 'matchcase'  | (?-i) | Letter case must match when matching patterns to a string. (The default for regexp).       |
| 'ignorecase' | (?i)  | Do not consider letter case when matching patterns to a string. (The default for regexpi). |

## Dot Matching Mode

Use the Dot Matching mode to control whether or not MATLAB includes the newline (`\n`) character when matching the dot (`.`) metacharacter in a regular expression. Example 7 illustrates the Dot Matching mode.

| Mode Keyword       | Flag  | Description                                                                                   |
|--------------------|-------|-----------------------------------------------------------------------------------------------|
| 'dotall'           | (?s)  | Match dot ( <code>.</code> ) in the pattern string with any character. (This is the default). |
| 'dotexceptnewline' | (?-s) | Match dot in the pattern with any character that is not a newline.                            |

## Anchor Type Mode

Use the Anchor Type mode to control whether MATLAB considers the `^` and `$` metacharacters to represent the beginning and end of a string or the beginning and end of a line. Example 8 illustrates the Anchor mode.

| Mode Keyword    | Flag  | Description                                                                                    |
|-----------------|-------|------------------------------------------------------------------------------------------------|
| 'stringanchors' | (?-m) | Match the ^ and \$ metacharacters at the beginning and end of a string. (This is the default). |
| 'lineanchors'   | (?m)  | Match the ^ and \$ metacharacters at the beginning and end of a line.                          |

## Spacing Mode

Use the Spacing mode to control how MATLAB interprets space characters and comments within the string being parsed. Example 9 illustrates the Spacing mode.

| Mode Keyword     | Flag  | Description                                                                                                                                                         |
|------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'literalspacing' | (?-x) | Parse space characters and comments (the # character and any text to the right of it) in the same way as any other characters in the string. (This is the default). |
| 'freespacing'    | (?x)  | Ignore spaces and comments when parsing the string. (You must use '\ ' and '\#' to match space and # characters.)                                                   |

## Remarks

See “Regular Expressions” in the MATLAB Programming documentation for a listing of all regular expression elements supported by MATLAB.

## Multiple Strings or Expressions

Either the str or expr argument, or both, can be a cell array of strings, according to the following guidelines:

# regexp, regexpi

---

- If `str` is a cell array of strings, then each of the `regexp` outputs is a cell array having the same dimensions as `str`.
- If `str` is a single string but `expr` is a cell array of strings, then each of the `regexp` outputs is a cell array having the same dimensions as `expr`.
- If both `str` and `expr` are cell arrays of strings, these two cell arrays must contain the same number of elements.

## Examples

### Example 1 – Matching a Simple Pattern

Return a row vector of indices that match words that start with `c`, end with `t`, and contain one or more vowels between them. Make the matches insensitive to letter case (by using `regexpi`):

```
str = 'bat cat can car COAT court cut ct CAT-scan';
regexpi(str, 'c[aeiou]+t')
ans =
     5     17     28     35
```

### Example 2 – Parsing Multiple Input Strings

Return a cell array of row vectors of indices that match capital letters and white spaces in the cell array of strings `str`:

```
str = {'Madrid, Spain' 'Romeo and Juliet' 'MATLAB is great'};
s1 = regexp(str, '[A-Z]');
s2 = regexp(str, '\s');
```

Capital letters, '[A-Z]', were found at these `str` indices:

```
s1{:}
ans =
     1     9
ans =
     1    11
ans =
     1     2     3     4     5     6
```

Space characters, '\s', were found at these str indices:

```
s2{:}
ans =
     8
ans =
     6    10
ans =
     7    10
```

### Example 3 – Selecting Return Values

Return the text and the starting and ending indices of words containing the letter x:

```
str = 'regexp helps you relax';
[m s e] = regexp(str, '\w*x\w*', 'match', 'start', 'end')
m =
    'regexp'    'relax'
s =
     1    18
e =
     6    22
```

### Example 4 – Splitting the Input String

Find the substrings delimited by the ^ character:

```
s1 = ['Use REGEXP to split ^this string into ' ...
      'several ^individual pieces'];

s2 = regexp(s1, '\^', 'split');

s2{:}
ans =
    'Use REGEXP to split '
    'this string into several '
    'individual pieces'
```

# regexp, regexpi

---

The `split` option returns those parts of the input string that are not returned when using the `'match'` option. Note that when you match the beginning or ending characters in a string (as is done in this example), the first (or last) return value is always an empty string:

```
str = 'She sells sea shells by the seashore.';

[matchstr splitstr] = regexp(str, '[Ss]h.', 'match', 'split')
matchstr =
    'She'    'she'    'sho'
splitstr =
    ''      ' sells sea '    'lls by the sea'    're.'
```

For any string that has been split, you can reassemble the pieces into the initial string using the command

```
j = [splitstr; [matchstr {''}]]; [j{:}]

ans =
    She sells sea shells by the seashore.
```

## Example 5 – Using Tokens

Search a string for opening and closing HTML tags. Use the expression `<(\w+)` to find the opening tag (e.g., `'<tagname'`) and to create a token for it. Use the expression `</\1>` to find another occurrence of the same token, but formatted as a closing tag (e.g., `'</tagname>'`):

```
str = ['if <code>A</code> == x<sup>2</sup>, ' ...
      '<em>disp(x)</em>']
str =
if <code>A</code> == x<sup>2</sup>, <em>disp(x)</em>

expr = '<(\w+).*?>.*?</\1>';

[tok mat] = regexp(str, expr, 'tokens', 'match');

tok{:}
ans =
```



```
    'code'  
ans =  
    'sup'  
ans =  
    'em'  
  
mat{:}  
ans =  
    <code>A</code>  
ans =  
    <sup>2</sup>  
ans =  
    <em>disp(x)</em>
```

See “Tokens” in the MATLAB Programming documentation for information on using tokens.

## Example 6 – Using Named Capture

Enter a string containing two names, the first and last names being in a different order:

```
str = sprintf('John Davis\nRogers, James')  
str =  
    John Davis  
    Rogers, James
```

Create an expression that generates first and last name tokens, assigning the names `first` and `last` to the tokens. Call `regexp` to get the text and names of each token found:

```
expr = ...  
    '(?<first>\w+)\s+(?<last>\w+)|(?<last>\w+)\s+(?<first>\w+)';  
  
[tokens names] = regexp(str, expr, 'tokens', 'names');
```

Examine the `tokens` cell array that was returned. The first and last name tokens appear in the order in which they were generated: first name–last name, then last name–first name:

# regexp, regexpi

---

```
tokens{:}
ans =
    'John'    'Davis'
ans =
    'Rogers'  'James'
```

Now examine the names structure that was returned. First and last names appear in a more usable order:

```
names(:,1)
ans =
    first: 'John'
    last:  'Davis'

names(:,2)
ans =
    first: 'James'
    last:  'Rogers'
```

## Example 7 – Using the Case-Sensitive Mode

Given a string that has both uppercase and lowercase letters,

```
str = 'A string with UPPERCASE and lowercase text.';
```

Use the regexp default mode (case-sensitive) to locate only the lowercase instance of the word case:

```
regexp(str, 'case', 'match')
ans =
    'case'
```

Now disable case-sensitive matching to find both instances of case:

```
regexp(str, 'case', 'ignorecase', 'match')
ans =
    'CASE'    'case'
```

Match 5 letters that are followed by 'CASE'. Use the (?-i) flag to turn on case-sensitivity for the first match and (?i) to turn it off for the second:

```
M = regexp(str, {'(?-i)\w{5}(?=CASE)', ...
               '(?i)\w{5}(?=CASE)'}, 'match');
```

```
M{:}
ans =
    'UPPER'
ans =
    'UPPER'    'lower'
```

### Example 8 – Using the Dot Matching Mode

Parse the following string that contains a newline (\n) character:

```
str = sprintf('abc\ndef')
str =
    abc
    def
```

When you use the default mode, `dotall`, MATLAB includes the newline in the characters matched:

```
regexp(str, '.', 'match')
ans =
    'a'    'b'    'c'    [1x1 char]    'd'    'e'    'f'
```

When you use the `dotexceptnewline` mode, MATLAB skips the newline character:

```
regexp(str, '.', 'match', 'dotexceptnewline')
ans =
    'a'    'b'    'c'    'd'    'e'    'f'
```

### Example 9 – Using the Anchor Type Mode

Given the following two-line string,

```
str = sprintf('%s\n%s', 'Here is the first line', ...
              'followed by the second line')
str =
    Here is the first line
```

# regexp, regexpi

---

followed by the second line

In `stringanchors` mode, MATLAB interprets the `$` metacharacter as an end-of-string specifier, and thus finds the last two words of the entire *string*:

```
regexp(str, '\w+\W\w+$', 'match', 'stringanchors')
ans =
    'second line'
```

While in `lineanchors` mode, MATLAB interprets `$` as an end-of-line specifier, and finds the last two words of each *line*:

```
regexp(str, '\w+\W\w+$', 'match', 'lineanchors')
ans =
    'first line'    'second line'
```

## Example 10 – Using the Freespacing Mode

Create a file called `regexp_str.txt` containing the following text. Because the first line enables freespacing mode, MATLAB ignores all spaces and comments that appear in the file:

```
(?x)  # turn on freespacing.

# This pattern matches a string with a repeated letter.

\w*   # First, match any number of preceding word characters.

(     # Mark a token.
  \w  # Match a word character.
)     # Finish capturing said token.
\1    # Backreference to match what token #1 matched.

\w*   # Finally, match the remainder of the word.
```

Here is the string to parse:

```
str = ['Looking for words with letters that ' ...
```

```
'appear twice in succession.'];
```

Use the pattern expression read from the file to find those words that have consecutive matching letters:

```
patt = fileread('regexp_str.txt');
regexp(str, patt, 'match')
ans =
    'Looking'    'letters'    'appear'    'succession'
```

## Example 11 – Displaying Parsing Warnings

To help debug problems in parsing a string with `regexp`, `regexpi`, or `regexprep`, use the `'warnings'` option to view all warning messages:

```
regexp('$.', '[a-]', 'warnings')
Warning: Unbound range.
[a-]
|
```

## See Also

`regexprep`, `regexprtranslate`, `strfind`, `findstr`, `strmatch`, `strcmp`, `strcmpi`, `strncmp`, `strncmpi`

# regexprep

---

**Purpose** Replace string using regular expression

**Syntax**  
`s = regexprep('str', 'expr', 'repstr')`  
`s = regexprep('str', 'expr', 'repstr' options)`

**Description** `s = regexprep('str', 'expr', 'repstr')` replaces all occurrences of the regular expression `expr` in string `str` with the string `repstr`. The new string is returned in `s`. If no matches are found, return string `s` is the same as input string `str`. You can use character representations (e.g., `'\t'` for tab, or `'\n'` for newline) in replacement string `repstr`. See “Regular Expressions” in the MATLAB Programming documentation for more information.

If `str` is a cell array of strings, then the `regexprep` return value `s` is always a cell array of strings having the same dimensions as `str`.

To specify more than one expression to match or more than one replacement string, see the guidelines listed below under “Multiple Expressions or Replacement Strings” on page 2-2743.

You can capture parts of the input string as tokens and then reuse them in the replacement string. Specify the parts of the string to capture using the `(...)` operator. Specify the tokens to use in the replacement string using the operators `$1`, `$2`, `$N` to reference the first, second, and `N`th tokens captured. (See “Tokens” and the example “Using Tokens in a Replacement String” in the MATLAB Programming documentation for information on using tokens.)

`s = regexprep('str', 'expr', 'repstr' options)` By default, `regexprep` replaces all matches and is case sensitive. You can use one or more of the following options with `regexprep`.

| Option              | Description                                                                              |
|---------------------|------------------------------------------------------------------------------------------|
| <code>mode</code>   | See mode descriptions on the <code>regexp</code> reference page.                         |
| <code>N</code>      | Replace only the <code>N</code> th occurrence of <code>expr</code> in <code>str</code> . |
| <code>'once'</code> | Replace only the first occurrence of <code>expr</code> in <code>str</code> .             |

| Option         | Description                                                                                                                                                     |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'ignorecase'   | Ignore case when matching and when replacing.                                                                                                                   |
| 'preserveCase' | Ignore case when matching (as with 'ignorecase'), but override the case of replace characters with the case of corresponding characters in str when replacing.  |
| 'warnings'     | Display any hidden warning messages issued by MATLAB during the execution of the command. This option only enables warnings for the one command being executed. |

## Remarks

See “Regular Expressions” in the MATLAB Programming documentation for a listing of all regular expression metacharacters supported by MATLAB.

### Multiple Expressions or Replacement Strings

In the case of multiple expressions and/or replacement strings, regexprep attempts to make all matches and replacements. The first match is against the initial input string. Successive matches are against the string resulting from the previous replacement.

The `expr` and `repstr` inputs follow these rules:

- If `expr` is a cell array of strings and `repstr` is a single string, regexprep uses the same replacement string on each expression in `expr`.
- If `expr` is a single string and `repstr` is a cell array of N strings, regexprep attempts to make N matches and replacements.
- If both `expr` and `repstr` are cell arrays of strings, then `expr` and `repstr` must contain the same number of elements, and regexprep pairs each `repstr` element with its matching element in `expr`.

## Examples

### Example 1 – Making a Case-Sensitive Replacement

Perform a case-sensitive replacement on words starting with `m` and ending with `y`:

```
str = 'My flowers may bloom in May';
pat = 'm(\w*)y';
regexprep(str, pat, 'April')
ans =
    My flowers April bloom in May
```

Replace all words starting with `m` and ending with `y`, regardless of case, but maintain the original case in the replacement strings:

```
regexprep(str, pat, 'April', 'preservecase')
ans =
    April flowers april bloom in April
```

### Example 2 – Using Tokens In the Replacement String

Replace all variations of the words 'walk up' using the letters following `walk` as a token. In the replacement string

```
str = 'I walk up, they walked up, we are walking up.';
pat = 'walk(\w*) up';
regexprep(str, pat, 'ascend$1')
ans =
    I ascend, they ascended, we are ascending.
```

### Example 3 – Operating on Multiple Strings

This example operates on a cell array of strings. It searches for consecutive matching letters (e.g., 'oo') and uses a common replacement value ('--') for all matches. The function returns a cell array of strings having the same dimensions as the input cell array:

```
str = {
    'Whose woods these are I think I know.' ; ...
    'His house is in the village though;' ; ...
    'He will not see me stopping here' ; ...
    'To watch his woods fill up with snow.'};
```



```
a = regexprep(str, '(.)\1', '--', 'ignorecase')
a =
    'Whose w--ds these are I think I know.'
    'His house is in the vi--age though;'
    'He wi-- not s-- me sto--ing here'
    'To watch his w--ds fi-- up with snow.'
```

## See Also

regexp, regexpi, regexprtranslate, strfind, findstr, strmatch, strcmp, strcmpi, strncmp, strncmpi

# regexptranslate

---

**Purpose** Translate string into regular expression

**Syntax** `s2 = regexptranslate(type, s1)`

**Description** `s2 = regexptranslate(type, s1)` translates string `s1` into a regular expression string `s2` that you can then use as input into one of the MATLAB regular expression functions such as `regexp`. The `type` input can be either one of the following strings that define the type of translation to be performed. See “Regular Expressions” in the MATLAB Programming documentation for more information.

| Type       | Description                                                                                                                                                                                                                                                                                                                                                                    |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'escape'   | Translate all special characters (e.g., '\$', '.', '?', '[') in string <code>s1</code> so that they are treated as literal characters when used in the <code>regexp</code> and <code>regexprep</code> functions. The translation inserts an escape character ('\') before each special character in <code>s1</code> . Return the new string in <code>s2</code> .               |
| 'wildcard' | Translate all wildcard and '.' characters in string <code>s1</code> so that they are treated as literal wildcards and periods when used in the <code>regexp</code> and <code>regexprep</code> functions. The translation replaces all instances of '*' with '.', all instances of '?' with '.', and all instances of '.' with '\.'. Return the new string in <code>s2</code> . |

## Examples

### Example 1 – Using the 'escape' Option

Because `regexp` interprets the sequence `\n` as a newline character, it cannot locate the two consecutive characters `\` and `n` in this string:

```
str = 'The sequence \n generates a new line';
pat = '\n';

regexp(str, pat)
ans =
     []
```

To have `regex` interpret the expression `expr` as the characters `'\'` and `'n'`, first translate the expression using `regexptranslate`:

```
pat2 = regexptranslate('escape', pat)
pat2 =
    \n

regex(str, pat2)
ans =
    14
```

## Example 2 – Using 'escape' In a Replacement String

Replace the word 'walk' with 'ascend' in this string, treating the characters '\$1' as a token designator:

```
str = 'I walk up, they walked up, we are walking up.';
pat = 'walk(\w*) up';

regexprep(str, pat, 'ascend$1')
ans =
    I ascend, they ascended, we are ascending.
```

Make another replacement on the same string, this time treating the '\$1' as literal characters:

```
regexprep(str, pat, regexptranslate('escape', 'ascend$1'))
ans =
    I ascend$1, they ascend$1, we are ascend$1.
```

## Example 3 – Using the 'wildcard' Option

Given the following string of filenames, pick out just the MAT-files. Use `regexptranslate` to interpret the '\*' wildcard as '\w+' instead of as a regular expression quantifier:

```
files = ['test1.mat, myfile.mat, newfile.txt, ' ...
        'jan30.mat, table3.xls'];
regex(str, regexptranslate('wildcard', '*.mat'), 'match')
ans =
```

# regexprtranslate

---

```
'test1.mat' 'myfile.mat' 'jan30.mat'
```

To see the translation, you can type

```
regexprtranslate('wildcard', '*.mat')  
ans =  
    \w+\.mat
```

## See Also

regexp, regexpi, regexprep

**Purpose** Register event handler with control's event

**Syntax** `h.registerevent(event_handler)`  
`registerevent(h, event_handler)`

**Description** `h.registerevent(event_handler)` registers certain event handler routines with their corresponding events. Once an event is registered, the control responds to the occurrence of that event by invoking its event handler routine. The `event_handler` argument can be either a string that specifies the name of the event handler function, or a function handle that maps to that function. Strings used in the `event_handler` argument are not case sensitive.

`registerevent(h, event_handler)` is an alternate syntax for the same operation.

You can either register events at the time you create the control (using `actxcontrol`), or register them dynamically at any time after the control has been created (using `registerevent`). The `event_handler` argument specifies both events and event handlers (see "Writing Event Handlers" in the External Interfaces documentation).

## Examples **Register Events Using Function Name Example**

Create an `mwsamp` control and list all events associated with the control:

```
f = figure ('position', [100 200 200 200]);
h = actxcontrol ('mwsamp.mwsampctrl.2', [0 0 200 200], f);

h.events
ans =
    Click = void Click()
    DblClick = void DblClick()
    MouseDown = void MouseDown(int16 Button, int16 Shift,
        Variant x, Variant y)
```

Register all events with the same event handler routine, `sampev`. Use `eventlisteners` to see the event handler used by each event:

# registerevent

---

```
h.registerevent('sampev');
h.eventlisteners
ans =
    'click'          'sampev'
    'dblclick'      'sampev'
    'mousedown'    'sampev'

h.unregisterallevents;
```

Register the Click and DbClick events with the event handlers myclick and my2click, respectively. Note that the strings in the argument list are not case sensitive.

```
h.registerevent({'click' 'myclick'; ...
                'dblclick' 'my2click'});
h.eventlisteners
ans =
    'click'          'myclick'
    'dblclick'      'my2click'
```

## Register Events Using Function Handle Example

Register all events with the same event handler routine, sampev, but use a function handle (@sampev) instead of the function name:

```
h = actxcontrol('mwsamp.mwsampctrl.2', [0 0 200 200]);
registerevent(h, @sampev);
```

## Register Excel Workbook Events Example

Create an Excel Workbook object.

```
excel = actxserver('Excel.Application');
wbs = excel.Workbooks;
wb = wbs.Add;
```

Register all events with the same event handler routine, AllEventHandler.

```
wb.registerevent('AllEventHandler')  
wb.eventlisteners
```

MATLAB displays the list of all Workbook events, registered with AllEventHandler.

```
ans =  
  
    'Open'                'AllEventHandler'  
    'Activate'            'AllEventHandler'  
    'Deactivate'          'AllEventHandler'  
    'BeforeClose'         'AllEventHandler'  
                               .  
                               .
```

## See Also

events, eventlisteners, unregisterevent, unregisterallevents, isevent

# rehash

---

**Purpose** Refresh function and file system path caches

**Syntax**

```
rehash  
rehash path  
rehash toolbox  
rehash pathreset  
rehash toolboxreset  
rehash toolboxcache
```

**Description** `rehash` with no arguments updates the MATLAB list of known files and classes for directories on the search path that are not in `matlabroot/toolbox`. It compares the timestamps for loaded shadowed functions (functions that have been called but not cleared in the current session) against their timestamps on disk. It clears loaded functions if the files on disk are newer. All of this normally happens each time MATLAB displays the Command Window prompt. Therefore, use `rehash` with no arguments only when you run an M-file that updates another M-file, and the calling file needs to reuse the updated version before it has finished running.

`rehash path` performs the same updates as `rehash`, but uses a different technique for detecting the files and directories that require updates. If you receive a warning during MATLAB startup notifying you that MATLAB could not tell if a directory has changed and you encounter problems with MATLAB using the most current versions of your M-files, run `rehash path`.

`rehash toolbox` updates all directories in `matlabroot/toolbox`. Run this when you add or remove files in `matlabroot/toolbox` during a session by some means other than MATLAB tools.

`rehash pathreset` performs the same updates as `rehash path`, and also ensures the known files and classes list follows precedence rules for shadowed functions.

`rehash toolboxreset` performs the same updates as `rehash toolbox`, and also ensures the known files and classes list follows precedence rules for shadowed functions.



rehash **toolboxcache** performs the same updates as rehash **toolbox**, and also updates the cache file. This is the equivalent of clicking the **Update Toolbox Path Cache** button in **Preferences > General**.

## See Also

addpath, clear, path, rmpath

“Toolbox Path Caching in MATLAB” in the MATLAB Desktop Tools and Development Environment documentation

# release

---

**Purpose** Release interface

**Syntax** `h.release`  
`release(h)`

**Description** `h.release` releases the interface and all resources used by the interface. Each interface handle must be released when you are finished manipulating its properties and invoking its methods. Once an interface has been released, it is no longer valid. Subsequent operations on the MATLAB object that represents that interface will result in errors.

`release(h)` is an alternate syntax for the same operation.

---

**Note** Releasing the interface does not delete the control itself (see `delete`), since other interfaces on that object may still be active. See [Releasing Interfaces in the External Interfaces documentation](#) for more information.

---

**Examples** Create a Microsoft Calender application. Then create a `TitleFont` interface and use it to change the appearance of the font of the calendar's title:

```
f = figure('position',[300 300 500 500]);
cal = actxcontrol('mscal.calendar', [0 0 500 500], f);

TFont = cal.TitleFont
TFont =
    Interface.Standard_OLE_Types.Font

TFont.Name = 'Viva BoldExtraExtended';
TFont.Bold = 0;
```

When you're finished working with the title font, release the `TitleFont` interface:

```
TFont.release;
```

Now create a GridFont interface and use it to modify the size of the calendar's date numerals:

```
GFont = cal.GridFont
GFont =
    Interface.Standard_OLE_Types.Font

GFont.Size = 16;
```

When you're done, delete the cal object and the figure window:

```
cal.delete;
delete(f);
clear f;
```

**See Also**

delete, save, load, actxcontrol, actxserver

# rem

---

**Purpose**            Remainder after division

**Syntax**             $R = \text{rem}(X, Y)$

**Description**         $R = \text{rem}(X, Y)$  if  $Y \neq 0$ , returns  $X - n \cdot Y$  where  $n = \text{fix}(X./Y)$ . If  $Y$  is not an integer and the quotient  $X./Y$  is within roundoff error of an integer, then  $n$  is that integer. The inputs  $X$  and  $Y$  must be real arrays of the same size, or real scalars.

The following are true by convention:

- $\text{rem}(X, 0)$  is NaN
- $\text{rem}(X, X)$  for  $X \neq 0$  is 0
- $\text{rem}(X, Y)$  for  $X \neq Y$  and  $Y \neq 0$  has the same sign as  $X$ .

**Remarks**             $\text{mod}(X, Y)$  for  $X \neq Y$  and  $Y \neq 0$  has the same sign as  $Y$ .

$\text{rem}(X, Y)$  and  $\text{mod}(X, Y)$  are equal if  $X$  and  $Y$  have the same sign, but differ by  $Y$  if  $X$  and  $Y$  have different signs.

The `rem` function returns a result that is between 0 and  $\text{sign}(X) \cdot \text{abs}(Y)$ . If  $Y$  is zero, `rem` returns NaN.

**See Also**            `mod`

**Purpose** Remove timeseries objects from tscollection object

**Syntax** `tsc = removets(tsc,Name)`

**Description** `tsc = removets(tsc,Name)` removes one or more timeseries objects with the name specified in `Name` from the `tscollection` object `tsc`. `Name` can either be a string or a cell array of strings.

**Examples** The following example shows how to remove a time series from a `tscollection`.

**1** Create two timeseries objects, `ts1` and `ts2`.

```
ts1=timeseries([1.1 2.9 3.7 4.0 3.0],1:5,'name','acceleration');  
ts2=timeseries([3.2 4.2 6.2 8.5 1.1],1:5,'name','speed');
```

**2** Create a `tscollection` object `tsc`, which includes `ts1` and `ts2`.

```
tsc=tscollection({ts1 ts2});
```

**3** To view the members of `tsc`, type the following at the MATLAB prompt:

```
tsc
```

MATLAB responds with

```
Time Series Collection Object: unnamed
```

```
Time vector characteristics
```

```
Start time          1 seconds  
End time            5 seconds
```

```
Member Time Series Objects:
```

## removets

---

```
acceleration
speed
```

The members of `tsc` are listed by name at the bottom: `acceleration` and `speed`. These are the `Name` properties of `ts1` and `ts2`, respectively.

- 4 Remove `ts2` from `tsc`.

```
tsc=removets(tsc,'speed');
```

- 5 To view the current members of `tsc`, type the following at the MATLAB prompt:

```
tsc
```

MATLAB responds with

```
Time Series Collection Object: unnamed
```

```
Time vector characteristics
```

```
Start time          1 seconds
End time            5 seconds
```

```
Member Time Series Objects:
acceleration
```

The remaining member of `tsc` is `acceleration`. The timeseries `speed` has been removed.

### See Also

`addts`, `tscollection`

**Purpose** Rename file on FTP server

**Syntax** `rename(f, 'oldname', 'newname')`

**Description** `rename(f, 'oldname', 'newname')` changes the name of the file `oldname` to `newname` in the current directory of the FTP server `f`, where `f` was created using `ftp`.

**Examples** Connect to server `testsite`, view the contents, and change the name of `testfile.m` to `showresults.m`.

```
test=ftp('ftp.testsite.com');
dir(test)
.          ..          testfile.m
rename(test, 'testfile.m', 'showresults.m')
dir(test)
.          ..          showresults.m
```

**See Also** `dir (ftp)`, `delete (ftp)`, `ftp`, `mget`, `mput`

# repmat

---

**Purpose** Replicate and tile array

**Syntax**  
B = repmat(A,m,n)  
B = repmat(A,[m n])  
B = repmat(A,[m n p...])

**Description** B = repmat(A,m,n) creates a large matrix B consisting of an m-by-n tiling of copies of A. The size of B is [size(A,1)\*m, (size(A,2)\*n)]. The statement repmat(A,n) creates an n-by-n tiling.

B = repmat(A,[m n]) accomplishes the same result as repmat(A,m,n).

B = repmat(A,[m n p...]) produces a multidimensional array B composed of copies of A. The size of B is [size(A,1)\*m, size(A,2)\*n, size(A,3)\*p, ...].

**Remarks** repmat(A,m,n), when A is a scalar, produces an m-by-n matrix filled with A's value and having A's class. For certain values, you can achieve the same results using other functions, as shown by the following examples:

- repmat(NaN,m,n) returns the same result as NaN(m,n).
- repmat(single(inf),m,n) is the same as inf(m,n,'single').
- repmat(int8(0),m,n) is the same as zeros(m,n,'int8').
- repmat(uint32(1),m,n) is the same as ones(m,n,'uint32').
- repmat(eps,m,n) is the same as eps(ones(m,n)).

**Examples** In this example, repmat replicates 12 copies of the second-order identity matrix, resulting in a “checkerboard” pattern.

```
B = repmat(eye(2),3,4)
```

```
B =  
    1     0     1     0     1     0     1     0  
    0     1     0     1     0     1     0     1  
    1     0     1     0     1     0     1     0
```



```
0    1    0    1    0    1    0    1
1    0    1    0    1    0    1    0
0    1    0    1    0    1    0    1
```

The statement `N = repmat(NaN,[2 3])` creates a 2-by-3 matrix of NaNs.

**See Also**

`bsxfun`, `NaN`, `Inf`, `ones`, `zeros`

# resample (timeseries)

---

**Purpose** Select or interpolate timeseries data using new time vector

**Syntax**

```
ts = resample(ts,Time)
ts = resample(ts,Time,interp_method)
ts = resample(ts,Time,interp_method,code)
```

**Description**

`ts = resample(ts,Time)` resamples the timeseries object `ts` using the new `Time` vector. When `ts` uses date strings and `Time` is numeric, `Time` is treated as specified relative to the `ts.TimeInfo.StartDate` property and in the same units that `ts` uses. The resample operation uses the default interpolation method, which you can view by using the `getinterpmethod(ts)` syntax.

`ts = resample(ts,Time,interp_method)` resamples the timeseries object `ts` using the interpolation method given by the string `interp_method`. Valid interpolation methods include 'linear' and 'zoh' (zero-order hold).

`ts = resample(ts,Time,interp_method,code)` resamples the timeseries object `ts` using the interpolation method given by the string `interp_method`. The integer `code` is a user-defined Quality code for resampling, applied to all samples.

**Examples** The following example shows how to resample a timeseries object.

**1** Create a timeseries object.

```
ts=timeseries([1.1 2.9 3.7 4.0 3.0],1:5,'Name','speed');
```

**2** Transpose `ts` to make the data columnwise.

```
ts=transpose(ts)
```

MATLAB displays

```
Time Series Object: speed
```

```
Time vector characteristics
```

```
Length          5
Start time      1 seconds
End time        5 seconds
```

Data characteristics

```
Interpolation method linear
Size                [5 1]
Data type           double
```

| Time | Data | Quality |
|------|------|---------|
| 1    | 1.1  |         |
| 2    | 2.9  |         |
| 3    | 3.7  |         |
| 4    | 4    |         |
| 5    | 3    |         |

Note that the interpolation method is set to linear, by default.

### 3 Resample ts using its default interpolation method.

```
res_ts=resample(ts,[1 1.5 3.5 4.5 4.9])
```

MATLAB displays the resampled time series as follows:

```
Time Series Object: speed
```

Time vector characteristics

```
Length          5
Start time      1 seconds
End time        4.900000e+000 seconds
```

# resample (timeseries)

---

Data characteristics

```
Interpolation method  linear
Size                  [5 1]
Data type              double
```

| Time | Data | Quality |
|------|------|---------|
| 1    | 1.1  |         |
| 1.5  | 2    |         |
| 3.5  | 3.85 |         |
| 4.5  | 3.5  |         |
| 4.9  | 3.1  |         |

## See Also

getinterpmethod, setinterpmethod, synchronize, timeseries

**Purpose** Select or interpolate data in `tscollection` using new time vector

**Syntax**

```
tsc = resample(tsc,Time)
tsc = resample(tsc,Time,interp_method)
tsc = resample(tsc,Time,interp_method,code)
```

**Description**

`tsc = resample(tsc,Time)` resamples the `tscollection` object `tsc` on the new `Time` vector. When `tsc` uses date strings and `Time` is numeric, `Time` is treated as numerical specified relative to the `tsc.TimeInfo.StartDate` property and in the same units that `tsc` uses. The `resample` method uses the default interpolation method for each time series member.

`tsc = resample(tsc,Time,interp_method)` resamples the `tscollection` object `tsc` using the interpolation method given by the string `interp_method`. Valid interpolation methods include 'linear' and 'zoh' (zero-order hold).

`tsc = resample(tsc,Time,interp_method,code)` resamples the `tscollection` object `tsc` using the interpolation method given by the string `interp_method`. The integer `code` is a user-defined quality code for resampling, applied to all samples.

**Examples** The following example shows how to resample a `tscollection` that consists of two `timeseries` members.

**1** Create two `timeseries` objects.

```
ts1=timeseries([1.1 2.9 3.7 4.0 3.0],1:5,'name','acceleration');
ts2=timeseries([3.2 4.2 6.2 8.5 1.1],1:5,'name','speed');
```

**2** Create a `tscollection` `tsc`.

```
tsc=tscollection({ts1 ts2});
```

The time vector of the collection `tsc` is `[1:5]`, which is the same as for `ts1` and `ts2` (individually).

## resample (tscollection)

---

- 3** Get the interpolation method for acceleration by typing

```
tsc.acceleration
```

MATLAB responds with

```
Time Series Object: acceleration
```

```
Time vector characteristics
```

```
Length           5
Start time       1 seconds
End time         5 seconds
```

```
Data characteristics
```

```
Interpolation method linear
Size                [1 1 5]
Data type           double
```

- 4** Set the interpolation method for speed to zero-order hold by typing

```
setinterpmethod(tsc.speed, 'zoh')
```

MATLAB responds with

```
Time Series Object: acceleration
```

```
Time vector characteristics
```

```
Length           5
Start time       1 seconds
End time         5 seconds
```

## Data characteristics

|                      |         |
|----------------------|---------|
| Interpolation method | zoh     |
| Size                 | [1 1 5] |
| Data type            | double  |

- 5 Resample the time-series collection `tsc` by individually resampling each time-series member of the collection and using its interpolation method.

```
res_tsc=resample(tsc,[1 1.5 3.5 4.5 4.9])
```

## See Also

`getinterpmethod`, `setinterpmethod`, `tscollection`

# reset

---

**Purpose** Reset graphics object properties to their defaults

**Syntax** `reset(h)`

**Description** `reset(h)` resets all properties having factory defaults on the object identified by `h`. To see the list of factory defaults, use the statement

```
get(0, 'factory')
```

If `h` is a figure, MATLAB does not reset `Position`, `Units`, `Windowstyle`, or `PaperUnits`. If `h` is an axes, MATLAB does not reset `Position` and `Units`.

**Examples** `reset(gca)` resets the properties of the current axes.  
`reset(gcf)` resets the properties of the current figure.

**See Also** `cla`, `clf`, `gca`, `gcf`, `hold`  
“Object Manipulation” on page 1-100 for related functions



## Purpose

Reshape array

## Syntax

```
B = reshape(A,m,n)
B = reshape(A,m,n,p,...)
B = reshape(A,[m n p ...])
B = reshape(A,...,[],...)
B = reshape(A,siz)
```

## Description

`B = reshape(A,m,n)` returns the  $m$ -by- $n$  matrix `B` whose elements are taken column-wise from `A`. An error results if `A` does not have  $m*n$  elements.

`B = reshape(A,m,n,p,...)` or `B = reshape(A,[m n p ...])` returns an  $n$ -dimensional array with the same elements as `A` but reshaped to have the size  $m$ -by- $n$ -by- $p$ -by-... The product of the specified dimensions,  $m*n*p*...$ , must be the same as `prod(size(A))`.

`B = reshape(A,...,[],...)` calculates the length of the dimension represented by the placeholder `[]`, such that the product of the dimensions equals `prod(size(A))`. The value of `prod(size(A))` must be evenly divisible by the product of the specified dimensions. You can use only one occurrence of `[]`.

`B = reshape(A,siz)` returns an  $n$ -dimensional array with the same elements as `A`, but reshaped to `siz`, a vector representing the dimensions of the reshaped array. The quantity `prod(siz)` must be the same as `prod(size(A))`.

## Examples

Reshape a 3-by-4 matrix into a 2-by-6 matrix.

```
A =
     1     4     7    10
     2     5     8    11
     3     6     9    12
```

```
B = reshape(A,2,6)
```

```
B =
```

# reshape

---

```
      1   3   5   7   9  11
      2   4   6   8  10  12
B = reshape(A,2,[])
```

```
B =
      1   3   5   7   9  11
      2   4   6   8  10  12
```

## See Also

`shiftdim`, `squeeze`

The colon operator :

**Purpose** Convert between partial fraction expansion and polynomial coefficients

**Syntax**  
 $[r,p,k] = \text{residue}(b,a)$   
 $[b,a] = \text{residue}(r,p,k)$

**Description** The residue function converts a quotient of polynomials to pole-residue representation, and back again.

$[r,p,k] = \text{residue}(b,a)$  finds the residues, poles, and direct term of a partial fraction expansion of the ratio of two polynomials,  $b(s)$  and  $a(s)$ , of the form

$$\frac{b(s)}{a(s)} = \frac{b_1 s^m + b_2 s^{m-1} + b_3 s^{m-2} + \dots + b_{m+1}}{a_1 s^n + a_2 s^{n-1} + a_3 s^{n-2} + \dots + a_{n+1}}$$

where  $b_j$  and  $a_j$  are the  $j$ th elements of the input vectors  $b$  and  $a$ .

$[b,a] = \text{residue}(r,p,k)$  converts the partial fraction expansion back to the polynomials with coefficients in  $b$  and  $a$ .

**Definition** If there are no multiple roots, then

$$\frac{b(s)}{a(s)} = \frac{r_1}{s-p_1} + \frac{r_2}{s-p_2} + \dots + \frac{r_n}{s-p_n} + k(s)$$

The number of poles  $n$  is

$$n = \text{length}(a) - 1 = \text{length}(r) = \text{length}(p)$$

The direct term coefficient vector is empty if  $\text{length}(b) < \text{length}(a)$ ; otherwise

$$\text{length}(k) = \text{length}(b) - \text{length}(a) + 1$$

If  $p(j) = \dots = p(j+m-1)$  is a pole of multiplicity  $m$ , then the expansion includes terms of the form

# residue

---

$$\frac{r_j}{s - p_j} + \frac{r_{j+1}}{(s - p_j)^2} + \dots + \frac{r_{j+m-1}}{(s - p_j)^m}$$

## Arguments

- b, a      Vectors that specify the coefficients of the polynomials in descending powers of  $s$
- r          Column vector of residues
- p          Column vector of poles
- k          Row vector of direct terms

## Algorithm

It first obtains the poles with roots. Next, if the fraction is nonproper, the direct term  $k$  is found using `deconv`, which performs polynomial long division. Finally, the residues are determined by evaluating the polynomial with individual roots removed. For repeated roots, `resid2` computes the residues at the repeated root locations.

## Limitations

Numerically, the partial fraction expansion of a ratio of polynomials represents an ill-posed problem. If the denominator polynomial,  $a(s)$ , is near a polynomial with multiple roots, then small changes in the data, including roundoff errors, can make arbitrarily large changes in the resulting poles and residues. Problem formulations making use of state-space or zero-pole representations are preferable.

## Examples

If the ratio of two polynomials is expressed as

$$\frac{b(s)}{a(s)} = \frac{5s^3 + 3s^2 - 2s + 7}{-4s^3 + 8s + 3}$$

then

$$\begin{aligned} b &= [ 5 \ 3 \ -2 \ 7 ] \\ a &= [-4 \ 0 \ 8 \ 3] \end{aligned}$$

and you can calculate the partial fraction expansion as

```
[r, p, k] = residue(b,a)
```

```
r =
   -1.4167
   -0.6653
    1.3320
```

```
p =
    1.5737
   -1.1644
   -0.4093
```

```
k =
   -1.2500
```

Now, convert the partial fraction expansion back to polynomial coefficients.

```
[b,a] = residue(r,p,k)
```

```
b =
   -1.2500   -0.7500    0.5000   -1.7500
```

```
a =
    1.0000   -0.0000   -2.0000   -0.7500
```

The result can be expressed as

$$\frac{b(s)}{a(s)} = \frac{-1.25s^3 - 0.75s^2 + 0.50s - 1.75}{s^3 - 2.00s - 0.75}$$

Note that the result is normalized for the leading coefficient in the denominator.

## See Also

deconv, poly, roots

## References

- [1] Oppenheim, A.V. and R.W. Schaffer, *Digital Signal Processing*, Prentice-Hall, 1975, p. 56.

**Purpose** Restore default MATLAB search path

**Syntax** `restoredefaultpath`  
`restoredefaultpath; matlabrc`

**Description** `restoredefaultpath` sets the search path to include only installed products from The MathWorks. Run `restoredefaultpath` if you are having problems with the search path. If `restoredefaultpath` seems to correct the problem, run `savepath`. Start MATLAB again to be sure the problem does not reappear.

`restoredefaultpath; matlabrc` sets the search path to include only installed products from The MathWorks and corrects path problems encountered during startup. Run `restoredefaultpath; matlabrc` if you are having problems with the search path and `restoredefaultpath` by itself does not correct the problem. After the problem seems to be resolved, run `savepath`. Start MATLAB again to be sure the problem does not reappear.

**See Also** `addpath`, `path`, `pathdef`, `rmpath`, `savepath`

Search Path in the MATLAB Desktop Tools and Development Environment documentation

# rethrow

---

**Purpose** Reissue error

**Syntax** rethrow(err)

**Description** rethrow(err) reissues the error specified by err. The currently running M-file terminates and control returns to the keyboard (or to any enclosing catch block). The err argument must be a MATLAB structure containing at least one of the following fields.

| Fieldname  | Description                                        |
|------------|----------------------------------------------------|
| message    | Text of the error message                          |
| identifier | Message identifier of the error message            |
| stack      | Information about the error from the program stack |

See "Message Identifiers" in the MATLAB documentation for more information on the syntax and usage of message identifiers.

A convenient way to get a valid err structure for the last error issued is by using the lasterror function.

**Remarks** The err input can contain the field stack, identical in format to the output of the dbstack command. If the stack field is present, the stack of the rethrown error will be set to that value. Otherwise, the stack will be set to the line at which the rethrow occurs.

**Examples** rethrow is usually used in conjunction with try-catch statements to reissue an error from a catch block after performing catch-related operations. For example,

```
try
    do_something
catch
    do_cleanup
    rethrow(lasterror)
end
```



**See Also**      error, lasterror, try, catch, dbstop

# rethrow (MException)

---

**Purpose** Reissue existing exception

**Syntax** rethrow(ME)

**Description** rethrow(ME) terminates the currently running function, reissues an exception that is based on MException object ME that has been caught within a try-catch block, and returns control to the keyboard or to any enclosing catch block.

rethrow differs from the throw and throwAsCaller methods in that it does not modify the stack field. Call stack information in the ME object is kept as it was when the exception was first thrown.

rethrow can only issue a previously caught exception. If an exception that was not previously thrown is passed to the rethrow method, MATLAB generates a new exception.

You might use rethrow from the catch part of a try-catch block, for example, after performing some required cleanup tasks following an error.

## Examples

This variation of the MATLAB surf function catches an error in the input arguments, gives the user the opportunity to correct the error, and rethrows the error if the user does not use that opportunity:

```
function surf2(varargin)
try
    surf(varargin{:})
catch ME
    ME.message      % Display the error.
    % Give user another try to enter input arguments.
    newargs = input('\nEnter argument list: ','s');
    if ~isempty(newargs)
        surf(eval(newargs));
    else
        % If no response from user, rethrow the error.
        rethrow(ME);
    end
end
```

```
end
```

When asked to correct the error, the user presses **Enter**. MATLAB rethrows the original error:

```
surf2
ans =
Not enough input arguments.

Enter argument list:
??? Error using ==> surf at 54
Not enough input arguments.

Error in ==> surf2 at 3
    surf(varargin{:});
```

This time, the user enters valid input and MATLAB successfully displays the output plot:

```
surf2
ans =
Not enough input arguments.

Enter argument list: peaks(30)
```

### See Also

try, catch, error, assert, MException, throw(MException), throwAsCaller(MException), addCause(MException), getReport(MException), disp(MException), isequal(MException), eq(MException), ne(MException), last(MException)

# return

---

**Purpose** Return to invoking function

**Syntax** return

**Description** return causes a normal return to the invoking function or to the keyboard. It also terminates keyboard mode.

**Examples** If the determinant function were an M-file, it might use a return statement in handling the special case of an empty matrix, as follows:

```
function d = det(A)
%DET det(A) is the determinant of A.
if isempty(A)
    d = 1;
    return
else
    ...
end
```

**See Also** break, continue, disp, end, error, for, if, keyboard, switch, while

**Purpose** Convert RGB colormap to HSV colormap

**Syntax**

```
cmap = rgb2hsv(M)
hsv_image = rgb2hsv(rgb_image)
```

**Description** `cmap = rgb2hsv(M)` converts an RGB colormap `M` to an HSV colormap `cmap`. Both colormaps are  $m$ -by-3 matrices. The elements of both colormaps are in the range 0 to 1.

The columns of the input matrix `M` represent intensities of red, green, and blue, respectively. The columns of the output matrix `cmap` represent hue, saturation, and value, respectively.

`hsv_image = rgb2hsv(rgb_image)` converts the RGB image to the equivalent HSV image. RGB is an  $m$ -by- $n$ -by-3 image array whose three planes contain the red, green, and blue components for the image. HSV is returned as an  $m$ -by- $n$ -by-3 image array whose three planes contain the hue, saturation, and value components for the image.

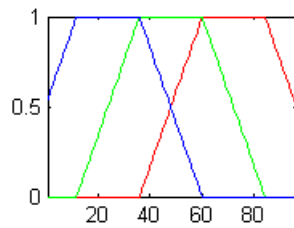
**See Also** `brighten`, `colormap`, `hsv2rgb`, `rgbplot`  
“Color Operations” on page 1-98 for related functions

# rgbplot

---

## Purpose

Plot colormap



## Syntax

```
rgbplot(cmap)
```

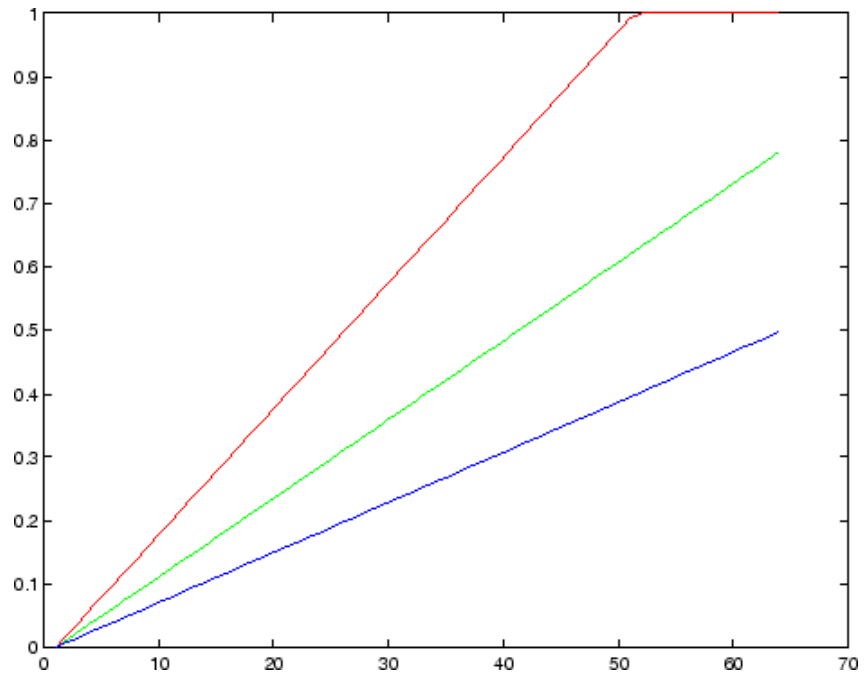
## Description

`rgbplot(cmap)` plots the three columns of `cmap`, where `cmap` is an  $m$ -by-3 colormap matrix. `rgbplot` draws the first column in red, the second in green, and the third in blue.

## Examples

Plot the RGB values of the copper colormap.

```
rgbplot(copper)
```



**See Also**

`colormap`

“Color Operations” on page 1-98 for related functions

# ribbon


---

## Purpose

Ribbon plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
ribbon(Y)
ribbon(X,Y)
ribbon(X,Y,width)
ribbon(axes_handle,...)
h = ribbon(...)
```

## Description

`ribbon(Y)` plots the columns of `Y` as separate three-dimensional ribbons using `X = 1:size(Y,1)`.

`ribbon(X,Y)` plots `X` versus the columns of `Y` as three-dimensional strips. `X` and `Y` are vectors of the same size or matrices of the same size. Additionally, `X` can be a row or a column vector, and `Y` a matrix with `length(X)` rows.

`ribbon(X,Y,width)` specifies the width of the ribbons. The default is 0.75.

`ribbon(axes_handle,...)` plots into the axes with handle `axes_handle` instead of the current axes (`gca`).

`h = ribbon(...)` returns a vector of handles to surface graphics objects. `ribbon` returns one handle per strip.

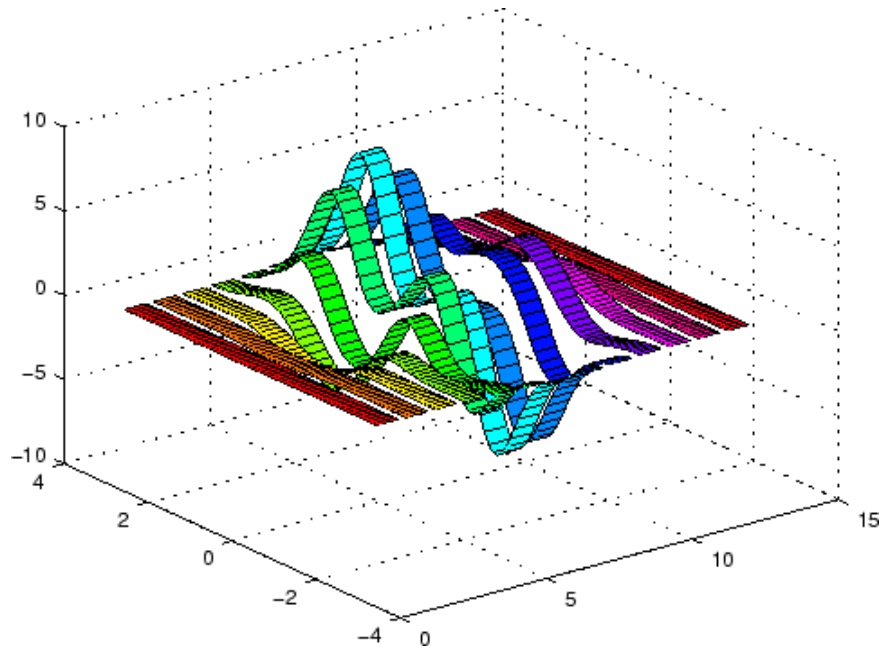
## Examples

Create a ribbon plot of the peaks function.

```
[x,y] = meshgrid(-3:.5:3,-3:.1:3);
```



```
z = peaks(x,y);  
ribbon(y,z)  
colormap hsv
```

**See Also**

plot, plot3, surface, waterfall

“Polygons and Surfaces” on page 1-90 for related functions

# rmappdata

---

**Purpose** Remove application-defined data

**Syntax** `rmappdata(h, name)`

**Description** `rmappdata(h, name)` removes the application-defined data name from the object specified by handle `h`.

**See Also** `getappdata`, `isappdata`, `setappdata`

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>             | Remove directory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Graphical Interface</b> | As an alternative to the <code>rmdir</code> function, use the delete feature in the “Current Directory Browser”.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Syntax</b>              | <pre>rmdir('dirname') rmdir('dirname','s') [status, message, messageid] = rmdir('dirname','s')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Description</b>         | <p><code>rmdir('dirname')</code> removes the directory <code>dirname</code> from the current directory. If the directory is not empty, you must use the <code>s</code> argument. If <code>dirname</code> is not in the current directory, specify the relative path to the current directory or the full path for <code>dirname</code>.</p> <p><code>rmdir('dirname','s')</code> removes the directory <code>dirname</code> and its contents from the current directory. This removes all subdirectories and files in the current directory regardless of their write permissions.</p> <p><code>[status, message, messageid] = rmdir('dirname','s')</code> removes the directory <code>dirname</code> and its contents from the current directory, returning the status, a message, and the MATLAB error message ID (see <code>error</code> and <code>lasterror</code>). Here, <code>status</code> is 1 for success and is 0 for error, and <code>message</code>, <code>messageid</code>, and the <code>s</code> input argument are optional.</p> |
| <b>Remarks</b>             | When attempting to remove multiple directories, either by including a wildcard in the directory name or by specifying the <code>'s'</code> flag in the <code>rmdir</code> command, MATLAB throws an error if it is unable to remove all directories to which the command applies. The error message contains a listing of those directories and files that MATLAB could not remove.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Examples</b>            | <b>Remove Empty Directory</b><br>To remove <code>myfiles</code> from the current directory, where <code>myfiles</code> is empty, type<br><pre>rmdir('myfiles')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

If the current directory is `matlabr13/work`, and `myfiles` is in `d:/matlabr13/work/project/`, use the relative path to `myfiles`

```
rmdir('project/myfiles')
```

or the full path to `myfiles`

```
rmdir('d:/matlabr13/work/project/myfiles')
```

## **Remove Directory and All Contents**

To remove `myfiles`, its subdirectories, and all files in the directories, assuming `myfiles` is in the current directory, type

```
rmdir('myfiles','s')
```

## **Remove Directory and Return Results**

To remove `myfiles` from the current directory, type

```
[stat, mess, id]=rmdir('myfiles')
```

MATLAB returns

```
stat =  
      0
```

```
mess =
```

```
The directory is not empty.
```

```
id =
```

```
MATLAB:RMDIR:OSError
```

indicating the directory `myfiles` is not empty.

To remove `myfiles` and its contents, run

```
[stat, mess]=rmdir('myfiles','s')
```

and MATLAB returns

```
stat =  
    1  
  
mess =  
    ''
```

indicating myfiles and its contents were removed.

## See Also

cd, copyfile, delete, dir, error, fileattrib, filebrowser, lasterror, mkdir, movefile

# rmdir (ftp)

---

**Purpose** Remove directory on FTP server

**Syntax** `rmdir(f, 'dirname')`

**Description** `rmdir(f, 'dirname')` removes the directory `dirname` from the current directory of the FTP server `f`, where `f` was created using `ftp`.

**Examples** Connect to server `testsite`, view the contents of `testdir`, and remove the directory `newdir` from the directory `testdir`.

```
test=ftp('ftp.testsite.com');
cd(test, 'testdir');
dir(test)
.          ..          newdir
dir(test, 'newdir')
.          ..
rmdir(test, 'newdir');
dir(test, 'testdir')
.          ..
```

**See Also** `cd (ftp)`, `delete (ftp)`, `dir (ftp)`, `ftp`, `mkdir (ftp)`

**Purpose** Remove fields from structure

**Syntax** `s = rmfield(s, 'fieldname')`  
`s = rmfield(s, fields)`

**Description** `s = rmfield(s, 'fieldname')` removes the specified field from the structure array `s`.

`s = rmfield(s, fields)` removes more than one field at a time. `fields` is a character array of field names or cell array of strings.

**See Also** `fieldnames`, `setfield`, `getfield`, `isfield`, `orderfields`, “Using Dynamic Field Names”

# rmpath

---

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Remove directories from MATLAB search path                                                                                                                                                                                                                                                                                                                                                                               |
| <b>GUI Alternatives</b> | As an alternative to the <code>rmpath</code> function, use the Set Path dialog box. To open it, select <b>File &gt; Set Path</b> in the MATLAB desktop.                                                                                                                                                                                                                                                                  |
| <b>Syntax</b>           | <pre>rmpath('directory')<br/>rmpath directory</pre>                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Description</b>      | <p><code>rmpath('directory')</code> removes the specified directory from the current MATLAB search path. Use the full pathname for <code>directory</code>.</p> <p><code>rmpath directory</code> is the command form of the syntax.</p>                                                                                                                                                                                   |
| <b>Examples</b>         | Remove <code>/usr/local/matlab/mytools</code> from the search path.<br><pre>rmpath /usr/local/matlab/mytools</pre>                                                                                                                                                                                                                                                                                                       |
| <b>See Also</b>         | <code>addpath</code> , <code>cd</code> , <code>dir</code> , <code>genpath</code> , <code>matlabroot</code> , <code>partialpath</code> , <code>path</code> , <code>pathdef</code> , <code>pathsep</code> , <code>pathtool</code> , <code>rehash</code> , <code>restoredefaultpath</code> , <code>savepath</code> , <code>what</code><br>Search Path in the MATLAB Desktop Tools and Development Environment documentation |



**Purpose** Remove preference

**Syntax**

```
rmpref('group','pref')  
rmpref('group',{'pref1','pref2',... 'prefn'})  
rmpref('group')
```

**Description**

`rmpref('group','pref')` removes the preference specified by `group` and `pref`. It is an error to remove a preference that does not exist.

`rmpref('group',{'pref1','pref2',... 'prefn'})` removes each preference specified in the cell array of preference names. It is an error if any of the preferences do not exist.

`rmpref('group')` removes all the preferences for the specified group. It is an error to remove a group that does not exist.

**Examples**

```
addpref('mytoolbox','version','1.0')  
rmpref('mytoolbox')
```

**See Also** `addpref`, `getpref`, `ispref`, `setpref`, `uigetpref`, `uisetpref`

# root object

---

## Purpose

Root object properties

## Description

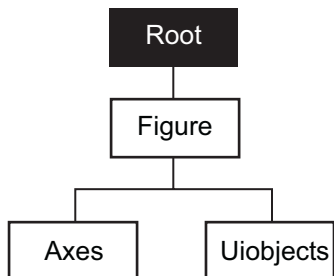
The root is a graphics object that corresponds to the computer screen. There is only one root object and it has no parent. The children of the root object are figures.

The root object exists when you start MATLAB; you never have to create it and you cannot destroy it. Use `set` and `get` to access the root properties.

## See Also

`diary`, `echo`, `figure`, `format`, `gcf`, `get`, `set`

## Object Hierarchy



## Purpose

Root properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The “The Property Editor” is an interactive tool that enables you to see and change object property values.
- The set and get commands enable you to set and query the values of properties.

To change the default values of properties, see “Setting Default Property Values”.

## Root Properties

This section lists property names along with the type of values each accepts. Curly braces { } enclose default values.

BusyAction  
cancel | {queue}

Not used by the root object.

ButtonDownFcn  
string

Not used by the root object.

CallbackObject  
handle (read only)

*Handle of current callback’s object.* This property contains the handle of the object whose callback routine is currently executing. If no callback routines are executing, this property contains the empty matrix [ ]. See also the gco command.

CaptureMatrix  
(obsolete)

This property has been superseded by the getframe command.

# Root Properties

---

CaptureRect  
(obsolete)

This property has been superseded by the `getframe` command.

Children  
vector of handles

*Handles of child objects.* A vector containing the handles of all nonhidden figure objects (see `HandleVisibility` for more information). You can change the order of the handles and thereby change the stacking order of the figures on the display.

Clipping  
{on} | off

Clipping has no effect on the root object.

CommandWindowSize  
[columns rows]

*Current size of command window.* This property contains the size of the MATLAB command window in a two-element vector. The first element is the number of columns wide and the second element is the number of rows tall.

CreateFcn  
The root does not use this property.

CurrentFigure  
figure handle

*Handle of the current figure window,* which is the one most recently created, clicked in, or made current with the statement

```
figure(h)
```

which restacks the figure to the top of the screen, or

```
set(0, 'CurrentFigure', h)
```

which does not restack the figures. In these statements, `h` is the handle of an existing figure. If there are no figure objects,

```
get(0, 'CurrentFigure')
```

returns the empty matrix. Note, however, that `gcf` always returns a figure handle, and creates one if there are no figure objects.

DeleteFcn  
string

This property is not used, because you cannot delete the root object.

Diary  
on | {off}

*Diary file mode.* When this property is on, MATLAB maintains a file (whose name is specified by the `DiaryFile` property) that saves a copy of all keyboard input and most of the resulting output. See also the `diary` command.

DiaryFile  
string

*Diary filename.* The name of the diary file. The default name is `diary`.

Echo  
on | {off}

*Script echoing mode.* When `Echo` is on, MATLAB displays each line of a script file as it executes. See also the `echo` command.

ErrorMessage  
string

*Text of last error message.* This property contains the last error message issued by MATLAB.

# Root Properties

---

FixedWidthFontName  
font name

*Fixed-width font to use for axes, text, and uicontrols whose FontName is set to FixedWidth. MATLAB uses the font name specified for this property as the value for axes, text, and uicontrol FontName properties when their FontName property is set to FixedWidth. Specifying the font name with this property eliminates the need to hardcode font names in MATLAB applications and thereby enables these applications to run without modification in locales where non-ASCII character sets are required. In these cases, MATLAB attempts to set the value of FixedWidthFontName to the correct value for a given locale.*

MATLAB application developers should not change this property, but should create axes, text, and uicontrols with FontName properties set to FixedWidth when they want to use a fixed-width font for these objects.

MATLAB end users can set this property if they do not want to use the preselected value. In locales where Latin-based characters are used, Courier is the default.

Format

short | {shortE} | long | longE | bank |  
hex | + | rat

*Output format mode.* This property sets the format used to display numbers. See also the format command.

- short — Fixed-point format with 5 digits
- shortE — Floating-point format with 5 digits
- shortG — Fixed- or floating-point format displaying as many significant figures as possible with 5 digits
- long — Scaled fixed-point format with 15 digits
- longE — Floating-point format with 15 digits

- `longG` — Fixed- or floating-point format displaying as many significant figures as possible with 15 digits
- `bank` — Fixed-format of dollars and cents
- `hex` — Hexadecimal format
- `+` — Displays + and - symbols
- `rat` — Approximation by ratio of small integers

## `FormatSpacing`

`compact` | `{loose}`

*Output format spacing* (see also `format` command).

- `compact` — Suppress extra line feeds for more compact display.
- `loose` — Display extra line feeds for a more readable display.

## `HandleVisibility`

`{on}` | `callback` | `off`

This property is not useful on the root object.

## `HitTest`

`{on}` | `off`

This property is not useful on the root object.

## `Interruptible`

`{on}` | `off`

This property is not useful on the root object.

## `Language`

`string`

System environment setting.

## `MonitorPosition`

`[x y width height;x y width height]`

# Root Properties

---

*Width and height of primary and secondary monitors, in pixels.*  
This property contains the width and height of each monitor connected to your computer. The  $x$  and  $y$  values for the primary monitor are 0, 0 and the width and height of the monitor are specified in pixels.

The secondary monitor position is specified as

```
x = primary monitor width + 1  
y = primary monitor height + 1
```

Querying the value of the figure `MonitorPosition` on a multiheaded system returns the position for each monitor on a separate line.

```
v = get(0,'MonitorPosition')  
v =  
x y width height % Primary monitor  
x y width height % Secondary monitor
```

Note that MATLAB sets the value of the `ScreenSize` property to the combined size of the monitors.

Parent  
handle

*Handle of parent object.* This property always contains the empty matrix, because the root object has no parent.

PointerLocation  
[x,y]

*Current location of pointer.* A vector containing the  $x$ - and  $y$ -coordinates of the pointer position, measured from the lower left corner of the screen. You can move the pointer by changing the values of this property. The `Units` property determines the units of this measurement.



This property always contains the current pointer location, even if the pointer is not in a MATLAB window. A callback routine querying the `PointerLocation` can get a value different from the location of the pointer when the callback was triggered. This difference results from delays in callback execution caused by competition for system resources.

On Macintosh platforms, you cannot change the pointer location using the `set` command.

`PointerWindow`  
handle (read only)

*Handle of window containing the pointer.* MATLAB sets this property to the handle of the figure window containing the pointer. If the pointer is not in a MATLAB window, the value of this property is 0. A callback routine querying the `PointerWindow` can get the wrong window handle if you move the pointer to another window before the callback executes. This error results from delays in callback execution caused by competition for system resources.

`RecursionLimit`  
integer

*Number of nested M-file calls.* This property sets a limit to the number of nested calls to M-files MATLAB will make before stopping (or potentially running out of memory). By default the value is set to a large value. Setting this property to a smaller value (something like 150, for example) should prevent MATLAB from running out of memory and will instead cause MATLAB to issue an error when the limit is reached.

`ScreenDepth`  
bits per pixel

# Root Properties

---

*Screen depth.* The depth of the display bitmap (i.e., the number of bits per pixel). The maximum number of simultaneously displayed colors on the current graphics device is 2 raised to this power.

ScreenDepth supersedes the BlackAndWhite property. To override automatic hardware checking, set this property to 1. This value causes MATLAB to assume the display is monochrome. This is useful if MATLAB is running on color hardware but is being displayed on a monochrome terminal. Such a situation can cause MATLAB to determine erroneously that the display is color.

ScreenPixelsPerInch  
Display resolution

*DPI setting for your display.* This property contains the setting of your display resolution specified in your system preferences.

ScreenSize  
four-element rectangle vector (read only)

*Screen size.* A four-element vector,  
[left,bottom,width,height]

that defines the display size. left and bottom are 0 for all Units except pixels, in which case left and bottom are 1. width and height are the screen dimensions in units specified by the Units property.

## Determining Screen Size

Note that the screen size in absolute units (e.g., inches) is determined by dividing the number of pixels in width and height by the screen DPI (see the ScreenPixelPerInch property). This value is approximate and might not represent the actual size of the screen.

Note that the `ScreenSize` property is static. Its values are read only at MATLAB startup and not updated if system display settings change. Also, the values returned might not represent the usable screen size for application developers due to the presence of other GUIs, such as the Windows task bar.

`Selected`  
on | off

This property has no effect on the root level.

`SelectionHighlight`  
{on} | off

This property has no effect on the root level.

`ShowHiddenHandles`  
on | {off}

*Show or hide handles marked as hidden.* When set to on, this property disables handle hiding and exposes all object handles regardless of the setting of an object's `HandleVisibility` property. When set to off, all objects so marked remain hidden within the graphics hierarchy.

`Tag`  
string

*User-specified object label.* The `Tag` property provides a means to identify graphics objects with a user-specified label. While it is not necessary to identify the root object with a tag (since its handle is always 0), you can use this property to store any string value that you can later retrieve using `set`.

`Type`  
string (read only)

Class of graphics object. For the root object, `Type` is always 'root'.

# Root Properties

---

UIContextMenu  
handle

This property has no effect on the root level.

Units

{pixels} | normalized | inches | centimeters  
| points | characters

*Unit of measurement.* This property specifies the units MATLAB uses to interpret size and location data. All units are measured from the lower left corner of the screen. Normalized units map the lower left corner of the screen to (0,0) and the upper right corner to (1.0,1.0). inches, centimeters, and points are absolute units (one point equals 1/72 of an inch). Characters are units defined by characters from the default system font; the width of one unit is the width of the letter x, the height of one character is the distance between the baselines of two lines of text.

This property affects the `PointerLocation` and `ScreenSize` properties. If you change the value of `Units`, it is good practice to return it to its default value after completing your operation, so as not to affect other functions that assume `Units` is set to the default value.

UserData  
matrix

*User-specified data.* This property can be any data you want to associate with the root object. MATLAB does not use this property, but you can access it using the `set` and `get` functions.

Visible  
{on} | off

*Object visibility.* This property has no effect on the root object.

|                    |                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Polynomial roots                                                                                                                                                                                                                                                                                                                                                    |
| <b>Syntax</b>      | <code>r = roots(c)</code>                                                                                                                                                                                                                                                                                                                                           |
| <b>Description</b> | <p><code>r = roots(c)</code> returns a column vector whose elements are the roots of the polynomial <code>c</code>.</p> <p>Row vector <code>c</code> contains the coefficients of a polynomial, ordered in descending powers. If <code>c</code> has <code>n+1</code> components, the polynomial it represents is <math>c_1s^n + \dots + c_n s + c_{n+1}</math>.</p> |
| <b>Remarks</b>     | <p>Note the relationship of this function to <code>p = poly(r)</code>, which returns a row vector whose elements are the coefficients of the polynomial. For vectors, <code>roots</code> and <code>poly</code> are inverse functions of each other, up to ordering, scaling, and roundoff error.</p>                                                                |
| <b>Examples</b>    | <p>The polynomial <math>s^3 - 6s^2 - 72s - 27</math> is represented in MATLAB as</p> <pre>p = [1 -6 -72 -27]</pre> <p>The roots of this polynomial are returned in a column vector by</p> <pre>r = roots(p)</pre> <pre>r =     12.1229     -5.7345     -0.3884</pre>                                                                                                |
| <b>Algorithm</b>   | <p>The algorithm simply involves computing the eigenvalues of the companion matrix:</p> <pre>A = diag(ones(n-1,1),-1); A(1,:) = -c(2:n+1)./c(1); eig(A)</pre>                                                                                                                                                                                                       |

## roots

---

It is possible to prove that the results produced are the exact eigenvalues of a matrix within roundoff error of the companion matrix  $A$ , but this does not mean that they are the exact roots of a polynomial with coefficients within roundoff error of those in  $c$ .


### **See Also**

`fzero`, `poly`, `residue`

**Purpose**

Angle histogram plot

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
rose(theta)
rose(theta,x)
rose(theta,nbins)
rose(axes_handle,...)
h = rose(...)
[tout,rout] = rose(...)
```

**Description**

`rose(theta)` creates an angle histogram, which is a polar plot showing the distribution of values grouped according to their numeric range, showing the distribution of `theta` in 20 angle bins or less. The vector `theta`, expressed in radians, determines the angle of each bin from the origin. The length of each bin reflects the number of elements in `theta` that fall within a group, which ranges from 0 to the greatest number of elements deposited in any one bin.

`rose(theta,x)` uses the vector `x` to specify the number and the locations of bins. `length(x)` is the number of bins and the values of `x` specify the center angle of each bin. For example, if `x` is a five-element vector, `rose` distributes the elements of `theta` in five bins centered at the specified `x` values.

`rose(theta,nbins)` plots `nbins` equally spaced bins in the range `[0, 2*pi]`. The default is 20.

`rose(axes_handle,...)` plots into the axes with handle `axes_handle` instead of the current axes (`gca`).

## rose

---

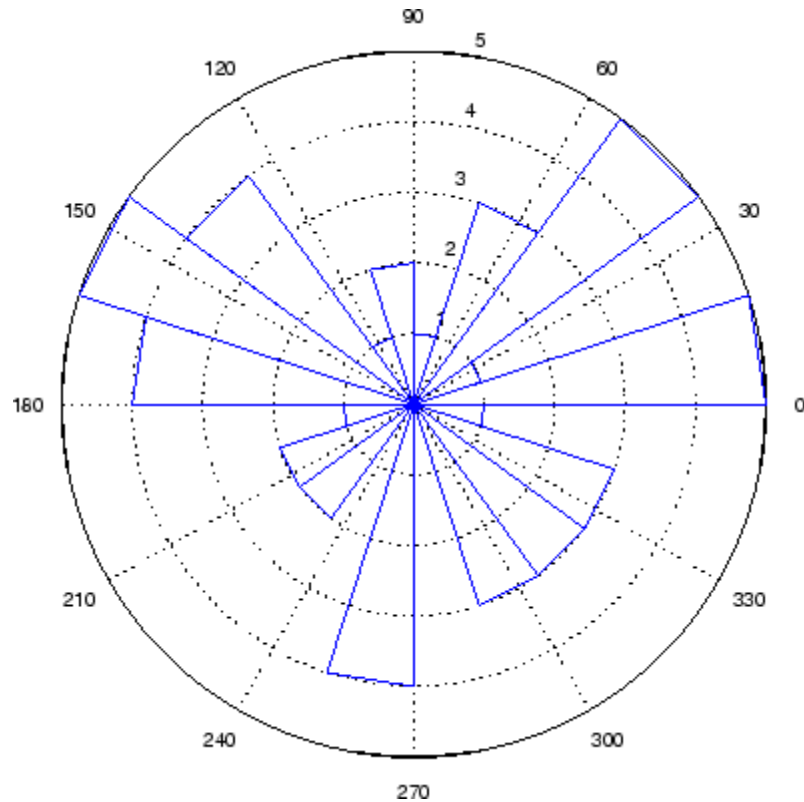
`h = rose(...)` returns the handles of the line objects used to create the graph.

`[tout,rout] = rose(...)` returns the vectors `tout` and `rout` so `polar(tout,rout)` generates the histogram for the data. This syntax does not generate a plot.

### Example

Create a rose plot showing the distribution of 50 random numbers.

```
theta = 2*pi*rand(1,50);  
rose(theta)
```





**See Also**

compass, feather, hist, line, polar

“Histograms” on page 1-90 for related functions

Histograms in Polar Coordinates for another example

# rosser

---

**Purpose** Classic symmetric eigenvalue test problem

**Syntax** A = rosser

**Description** A = rosser returns the Rosser matrix. This matrix was a challenge for many matrix eigenvalue algorithms. But LAPACK's DSYEV routine used in MATLAB has no trouble with it. The matrix is 8-by-8 with integer elements. It has:

- A double eigenvalue
- Three nearly equal eigenvalues
- Dominant eigenvalues of opposite sign
- A zero eigenvalue
- A small, nonzero eigenvalue

## Examples

```
rosser
```

```
ans =
```

```
    611    196   -192    407     -8    -52   -49    29
    196    899    113   -192    -71   -43    -8   -44
   -192    113    899    196     61    49     8    52
    407   -192    196    611     8    44    59   -23
     -8    -71     61     8    411  -599   208   208
   -52   -43    49    44  -599   411   208   208
   -49    -8     8    59   208   208    99  -911
    29   -44    52   -23   208   208  -911    99
```

**Purpose** Rotate matrix 90 degrees

**Syntax**  $B = \text{rot90}(A)$   
 $B = \text{rot90}(A, k)$

**Description**  $B = \text{rot90}(A)$  rotates matrix  $A$  counterclockwise by 90 degrees.  
 $B = \text{rot90}(A, k)$  rotates matrix  $A$  counterclockwise by  $k \cdot 90$  degrees, where  $k$  is an integer.

**Examples** The matrix

```
X =  
    1    2    3  
    4    5    6  
    7    8    9
```

rotated by 90 degrees is

```
Y = rot90(X)  
Y =  
    3    6    9  
    2    5    8  
    1    4    7
```

**See Also** `flipdim`, `fliplr`, `flipud`

# rotate

---

**Purpose** Rotate object in specified direction

**Syntax** `rotate(h,direction,alpha)`  
`rotate(...,origin)`

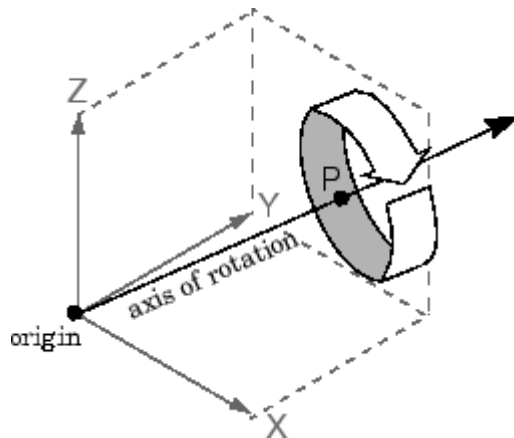
**Description** The rotate function rotates a graphics object in three-dimensional space, according to the right-hand rule.

`rotate(h,direction,alpha)` rotates the graphics object `h` by `alpha` degrees. `direction` is a two- or three-element vector that describes the axis of rotation in conjunction with the origin.

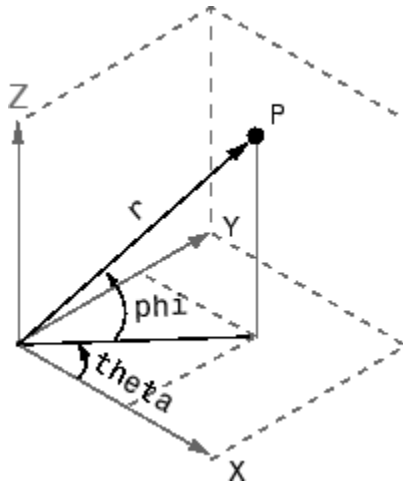
`rotate(...,origin)` specifies the origin of the axis of rotation as a three-element vector. The default origin is the center of the plot box.

**Remarks** The graphics object you want rotated must be a child of the same axes. The object's data is modified by the rotation transformation. This is in contrast to `view` and `rotate3d`, which only modify the viewpoint.

The axis of rotation is defined by an origin and a point  $P$  relative to the origin.  $P$  is expressed as the spherical coordinates `[theta phi]` or as Cartesian coordinates.



The two-element form for direction specifies the axis direction using the spherical coordinates  $[\text{theta } \text{phi}]$ .  $\text{theta}$  is the angle in the  $x$ - $y$  plane counterclockwise from the positive  $x$ -axis.  $\text{phi}$  is the elevation of the direction vector from the  $x$ - $y$  plane.



The three-element form for direction specifies the axis direction using Cartesian coordinates. The direction vector is the vector from the origin to  $(X,Y,Z)$ .

## Examples

Rotate a graphics object  $180^\circ$  about the  $x$ -axis.

```
h = surf(peaks(20));
rotate(h,[1 0 0],180)
```

Rotate a surface graphics object  $45^\circ$  about its center in the  $z$  direction.

```
h = surf(peaks(20));
zdir = [0 0 1];
center = [10 10 0];
rotate(h,zdir,45,center)
```

# rotate

---

## Remarks


rotate changes the Xdata, Ydata, and Zdata properties of the appropriate graphics object.

## See Also

rotate3d, sph2cart, view

The axes CameraPosition, CameraTarget, CameraUpVector, CameraViewAngle

“Object Manipulation” on page 1-100 for related functions

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Rotate 3-D view using mouse                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>GUI Alternatives</b> | Use the Rotate3D tool  on the figure toolbar to enable and disable rotate3D mode on a plot, or select <b>Rotate 3D</b> from the figure's <b>Tools</b> menu. For details, see “Rotate 3D — Interactive Rotation of 3-D Views” in the MATLAB Graphics documentation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Syntax</b>           | <pre>rotate3d rotate3d rotate3d rotate3d(<i>figure_handle</i>,...) rotate3d(<i>axes_handle</i>,...) h = rotate3d(<i>figure_handle</i>)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Description</b>      | <p><code>rotate3d</code> on enables mouse-base rotation on all axes within the current figure.</p> <p><code>rotate3d off</code> disables interactive axes rotation in the current figure.</p> <p><code>rotate3d</code> toggles interactive axes rotation in the current figure.</p> <p><code>rotate3d(<i>figure_handle</i>,...)</code> enables rotation within the specified figure instead of the current figure.</p> <p><code>rotate3d(<i>axes_handle</i>,...)</code> enables rotation only in the specified axes.</p> <p><code>h = rotate3d(<i>figure_handle</i>)</code> returns a <i>rotate3d mode object</i> for figure <i>figure_handle</i> for you to customize the mode's behavior.</p> <p><b>Using Rotate Mode Objects</b></p> <p>You access the following properties of rotate mode objects via <code>get</code> and modify some of them using <code>set</code>:</p> <p>FigureHandle &lt;handle&gt;</p> <p>The associated figure handle. This read-only property cannot be set.</p> <p><i>Enable</i> 'on'   'off'</p> |

Specifies whether this figure mode is currently enabled on the figure.

```
RotateStyle 'orbit'|'box'
```

Sets the method of rotation. 'orbit' rotates the entire axes; 'box' rotates a plot-box outline of the axes.

```
ButtonDownFilter <function_handle>
```

The application can inhibit the rotate operation under circumstances the programmer defines, depending on what the callback returns. The input function handle should reference a function with two implicit arguments (similar to handle callbacks):

```
function [res] = myfunction(obj,event_obj)
% OBJ      handle to the object that has been clicked on.
% EVENT_OBJ handle to event object (empty in this release).
% RES      a logical flag to determine whether the rotate
           operation should take place or the
           'ButtonDownFcn' property of the object should
           take precedence.
```

```
ActionPreCallback <function_handle>
```

Set this callback to listen to when a rotate operation will start. The input function handle should reference a function with two implicit arguments (similar to handle callbacks):

```
function myfunction(obj,event_obj)
% obj      handle to the figure that has been clicked on.
% event_obj handle to event object.
```

The event object has the following read-only property:

Axes            The handle of the axes that is being rotated.

```
ActionPostCallback <function_handle>
```



Set this callback to listen to when a rotate operation has finished. The input function handle should reference a function with two implicit arguments (similar to handle callbacks):

```
function myfunction(obj,event_obj)
% obj          handle to the figure that has been clicked on.
% event_obj    handle to event object. The object has the same
                properties as the EVENT_OBJ of the
                'ActionPreCallback' callback.
```

```
flags = isAllowAxesRotate(h,axes)
```

Calling the function `isAllowAxesRotate` on the `rotate3d` object, `h`, with a vector of axes handles, `axes`, as input will return a logical array of the same dimension as the axes handle vector which indicate whether a rotate operation is permitted on the axes objects.

```
setAllowAxesRotate(h,axes,flag)
```

Calling the function `setAllowAxesRotate` on the `rotate3d` object, `h`, with a vector of axes handles, `axes`, and a logical scalar, `flag`, will either allow or disallow a rotate operation on the axes objects.

## Examples

### Example 1

Simple 3-D rotation

```
surf(peaks);
rotate3d on
% rotate the plot using the mouse pointer.
```

### Example 2

Rotate the plot using the "Plot Box" rotate style:

```
surf(peaks);
h = rotate3d;
set(h,'RotateStyle','box','Enable','on');
% Rotate the plot.
```

## Example 3

Create two axes as subplots and then prevent one from rotating:

```
ax1 = subplot(1,2,1);
surf(peaks);
h = rotate3d;
ax2 = subplot(1,2,2);
surf(membrane);
setAllowAxesRotate(h,ax2,false);
% rotate the plots.
```

## Example 4

Create a `ButtonDown` callback for rotate mode objects to trigger. Copy the following code to a new M-file, execute it, and observe rotation behavior:

```
function demo
% Allow a line to have its own 'ButtonDownFcn' callback.
hLine = plot(rand(1,10));
set(hLine,'ButtonDownFcn','disp(''This executes'')');
set(hLine,'Tag','DoNotIgnore');
h = rotate3d;
set(h,'ButtonDownFilter',@mycallback);
set(h,'Enable','on');
% mouse-click on the line
%
function [flag] = mycallback(obj,event_obj)
% If the tag of the object is 'DoNotIgnore', then return true.
objTag = get(obj,'Tag');
if strcmpi(objTag,'DoNotIgnore')
    flag = true;
else
    flag = false;
end
```

## Example 5

Create callbacks for pre- and post-buttonDown events for rotate3D mode objects to trigger. Copy the following code to a new M-file, execute it, and observe rotation behavior:

```
function demo
% Listen to rotate events
surf(peaks);
h = rotate3d;
set(h,'ActionPreCallback',@myprecallback);
set(h,'ActionPostCallback',@mypostcallback);
set(h,'Enable','on');
%
function myprecallback(obj,evd)
disp('A rotation is about to occur.');
```

```
%
function mypostcallback(obj,evd)
newView = round(get(evd.Axes,'View'));
msgbox(sprintf('The new view is [%d %d].',newView));
```

## Remarks

When enabled, rotate3d provides continuous rotation of axes and the objects it contains through mouse movement. A numeric readout appears in the lower left corner of the figure during rotation, showing the current azimuth and elevation of the axes. Releasing the mouse button removes the animated box and the readout.

You can also enable 3-D rotation from the figure **Tools** menu or the figure toolbar.

You can create a rotate3D mode object once and use it to customize the behavior of different axes, as example 3 illustrates. You can also change its callback functions on the fly.

When you assign different 3-D rotation behaviors to different subplot axes via a mode object and then link them using the linkaxes function, the behavior of the axes you manipulate with the mouse will carry over

## rotate3d

---

to the linked axes, regardless of the behavior you previously set for the other axes.

### **See Also**

`camorbit`, `pan`, `rotate`, `view`, `zoom`

Object Manipulation for related functions

**Purpose** Round to nearest integer

**Syntax**  $Y = \text{round}(X)$

**Description**  $Y = \text{round}(X)$  rounds the elements of  $X$  to the nearest integers. For complex  $X$ , the imaginary and real parts are rounded independently.

**Examples**

```
a = [-1.9, -0.2, 3.4, 5.6, 7.0, 2.4+3.6i]
```

```
a =
Columns 1 through 4
-1.9000    -0.2000    3.4000    5.6000
Columns 5 through 6
 7.0000    2.4000 + 3.6000i
```

```
round(a)
```

```
ans =
Columns 1 through 4
-2.0000         0    3.0000    6.0000
Columns 5 through 6
 7.0000    2.0000 + 4.0000i
```

**See Also** `ceil`, `fix`, `floor`

# rref

---

**Purpose** Reduced row echelon form

**Syntax**  
`R = rref(A)`  
`[R,jb] = rref(A)`  
`[R,jb] = rref(A,tol)`

**Description** `R = rref(A)` produces the reduced row echelon form of `A` using Gauss Jordan elimination with partial pivoting. A default tolerance of `(max(size(A))*eps *norm(A,inf))` tests for negligible column elements.

`[R,jb] = rref(A)` also returns a vector `jb` such that:

- `r = length(jb)` is this algorithm's idea of the rank of `A`.
- `x(jb)` are the pivot variables in a linear system `Ax = b`.
- `A(:,jb)` is a basis for the range of `A`.
- `R(1:r,jb)` is the `r`-by-`r` identity matrix.

`[R,jb] = rref(A,tol)` uses the given tolerance in the rank tests.

Roundoff errors may cause this algorithm to compute a different value for the rank than `rank`, `orth` and `null`.

**Examples** Use `rref` on a rank-deficient magic square:

```
A = magic(4), R = rref(A)
```

```
A =  
 16   2   3  13  
  5  11  10   8  
  9   7   6  12  
  4  14  15   1
```

```
R =  
 1   0   0   1  
 0   1   0   3
```

---

$$\begin{array}{cccc} 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 0 \end{array}$$
**See Also**

inv, lu, rank

**Purpose** Convert real Schur form to complex Schur form

**Syntax** `[U,T] = rsf2csf(U,T)`

**Description** The *complex Schur form* of a matrix is upper triangular with the eigenvalues of the matrix on the diagonal. The *real Schur form* has the real eigenvalues on the diagonal and the complex eigenvalues in 2-by-2 blocks on the diagonal.

`[U,T] = rsf2csf(U,T)` converts the real Schur form to the complex form.

Arguments `U` and `T` represent the unitary and Schur forms of a matrix `A`, respectively, that satisfy the relationships:  $A = U * T * U'$  and  $U' * U = \text{eye}(\text{size}(A))$ . See `schur` for details.

## Examples

Given matrix `A`,

```
1    1    1    3
1    2    1    1
1    1    3    1
-2   1    1    4
```

with the eigenvalues

```
4.8121    1.9202 + 1.4742i    1.9202 + 1.4742i    1.3474
```

Generating the Schur form of `A` and converting to the complex Schur form

```
[u,t] = schur(A);
[U,T] = rsf2csf(u,t)
```

yields a triangular matrix `T` whose diagonal (underlined here for readability) consists of the eigenvalues of `A`.

```
U =
```



|         |                   |                   |         |
|---------|-------------------|-------------------|---------|
| -0.4916 | -0.2756 - 0.4411i | 0.2133 + 0.5699i  | -0.3428 |
| -0.4980 | -0.1012 + 0.2163i | -0.1046 + 0.2093i | 0.8001  |
| -0.6751 | 0.1842 + 0.3860i  | -0.1867 - 0.3808i | -0.4260 |
| -0.2337 | 0.2635 - 0.6481i  | 0.3134 - 0.5448i  | 0.2466  |

T =

|        |                   |                   |                  |
|--------|-------------------|-------------------|------------------|
| 4.8121 | -0.9697 + 1.0778i | -0.5212 + 2.0051i | -1.0067          |
| 0      | 1.9202 + 1.4742i  | 2.3355            | 0.1117 + 1.6547i |
| 0      | 0                 | 1.9202 - 1.4742i  | 0.8002 + 0.2310i |
| 0      | 0                 | 0                 | 1.3474           |

**See Also**

schur

# run

---

**Purpose** Run script that is not on current path

**Syntax** `run scriptname`

**Description** `run scriptname` runs the MATLAB script specified by `scriptname`. If `scriptname` contains the full pathname to the script file, then `run` changes the current directory to be the one in which the script file resides, executes the script, and sets the current directory back to what it was. The script is run within the caller's workspace.

`run` is a convenience function that runs scripts that are not currently on the path. Typically, you just type the name of a script at the MATLAB prompt to execute it. This works when the script is on your path. Use the `cd` or `addpath` function to make a script executable by entering the script name alone.

**See Also** `cd`, `addpath`

**Purpose**

Save workspace variables to disk

**Graphical Interface**

As an alternative to the save function, select **Save Workspace As** from the **File** menu in the MATLAB desktop, or use the Workspace browser.

**Syntax**

```
save
save filename
save filename content
save filename options
save filename content options
save('filename', 'var1', 'var2', ...)
```

**Description**

`save` stores all variables from the current MATLAB workspace in a MATLAB-formatted file (MAT-file) named `matlab.mat` that resides in the current working directory. Use the `load` function to retrieve data stored in MAT-files. By default, MAT-files are double-precision, binary files. You can create a MAT-file on one machine and then load it on another machine using a different floating-point format, and retaining as much accuracy and range as the different formats allow. MAT-files can also be manipulated by other programs external to MATLAB.

`save filename` stores all variables in the current workspace in the file `filename`. If you do not specify an extension to the filename, MATLAB uses `.mat`. The file must be writable. To save to another directory, use a full pathname for the `filename`.

`save filename content` stores only those variables specified by `content` in file `filename`. If `filename` is not specified, MATLAB stores the data in a file called `matlab.mat`. See the following table.

| Values for <i>content</i>        | Description                                                                                                                                                                                                                                                   |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>varlist</code>             | Save only those variables that are in <code>varlist</code> . You can use the <code>*</code> wildcard to save only those variables that match the specified pattern. For example, <code>save('A*')</code> saves all variables that start with <code>A</code> . |
| <code>-regexp exprlist</code>    | Save those variables that match any of the regular expressions in <code>exprlist</code> .                                                                                                                                                                     |
| <code>-struct s</code>           | Save as individual variables all fields of the scalar structure <code>s</code> .                                                                                                                                                                              |
| <code>-struct s fieldlist</code> | Save as individual variables only the specified fields of structure <code>s</code> .                                                                                                                                                                          |

In this table, the terms `varlist`, `exprlist`, and `fieldlist` refer to one or more variable names, regular expressions, or structure field names separated by either spaces or commas, depending on whether you are using the MATLAB command or function format. See the examples below:

Command format:

```
save firstname lastname street town
```

Function format:

```
save('firstname', 'lastname', 'street', 'town')
```

`save filename options` stores all variables from the MATLAB workspace in file `filename` according to one or more of the following options. If `filename` is not specified, MATLAB stores the data in a file called `matlab.mat`.

| Values for <i>options</i> | Description                                                                                                                                      |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>-append</b>            | Add new variables to those already stored in an existing MAT-file.                                                                               |
| <i>-format</i>            | Save using the specified binary or ASCII format. See the section on, “MAT-File Format Options” on page 2-2829, below.                            |
| <i>-version</i>           | Save in a format that can be loaded into an earlier version of MATLAB. See the section on “Version Compatibility Options” on page 2-2830, below. |

`save filename content options` stores only those variables specified by *content* in file *filename*, also applying the specified *options*. If *filename* is not specified, MATLAB stores the data in a file called `matlab.mat`.

`save('filename', 'var1', 'var2', ...)` is the function form of the syntax.

### MAT-File Format Options

The following table lists the valid *MAT-file format* options.

| <i>MAT-file format</i><br>Options | How Data Is Stored                                      |
|-----------------------------------|---------------------------------------------------------|
| <code>-ascii</code>               | Save data in 8-digit ASCII format.                      |
| <code>-ascii -tabs</code>         | Save data in 8-digit ASCII format delimited with tabs.  |
| <code>-ascii -double</code>       | Save data in 16-digit ASCII format.                     |
| <code>-ascii -double -tabs</code> | Save data in 16-digit ASCII format delimited with tabs. |
| <code>-mat</code>                 | Binary MAT-file form (default).                         |

### Version Compatibility Options

The following table lists version compatibility options. These options enable you to save your workspace data to a MAT-file that can then be loaded into an earlier version of MATLAB. The resulting MAT-file supports only those data items and features that were available in this earlier version of MATLAB. (See the second table below for what is supported in each version.)

| <i>version</i><br><b>Option</b> | <b>Use When Running ...</b> | <b>To Save a MAT-File That You Can Load In ...</b> |
|---------------------------------|-----------------------------|----------------------------------------------------|
| -v7.3                           | Version 7.3 or later        | Version 7.3 or later                               |
| -v7                             | Version 7.3 or later        | Versions 7.0 through 7.2 (or later)                |
| -v6                             | Version 7 or later          | Versions 5 and 6 (or later)                        |
| -v4                             | Version 5 or later          | Versions 1 through 4 (or later)                    |

The default version option is the value specified in the **Preferences** dialog box. Select **File > Preferences** in the Command Window, click **General**, and then **MAT-Files** to view or change the default.

The next table shows what data items and features are supported in different versions of MATLAB. You can use this information to determine which of the version compatibility options shown above to use.

| <b>MATLAB Versions</b> | <b>Data Items or Features Supported</b>                             |
|------------------------|---------------------------------------------------------------------|
| 4 and earlier          | Support for 2D double, character, and sparse                        |
| 5 and 6                | Version 4 capability plus support for ND arrays, structs, and cells |

| <b>MATLAB Versions</b> | <b>Data Items or Features Supported</b>                                               |
|------------------------|---------------------------------------------------------------------------------------|
| 7.0 through 7.2        | Version 6 capability plus support for data compression and Unicode character encoding |
| 7.3 and later          | Version 7.2 capability plus support for data items greater than or equal to 2GB       |

## Remarks

When working on 64-bit platforms, you can have data items in your workspace that occupy more than 2 GB. To save data of this size, you must use the HDF5-based version of the MATLAB MAT-file. Use the `v7.3` option to do this:

```
save -v7.3 myfile v1 v2
```

If you are running MATLAB on a 64-bit computer system and you attempt to save a variable that is too large for a version 7 (or earlier) MAT-file, that is, you save without using the `-v7.3` option, MATLAB skips that variable during the save operation and issues a warning message to that effect.

If you are running MATLAB on a 32-bit computer system and attempt to load a variable from a `-v7.3` MAT-file that is too large to fit in 32-bit address space, MATLAB skips that variable and issues a warning message to that effect.

MAT-files saved with compression and Unicode encoding cannot be loaded into versions of MATLAB prior to MATLAB Version 7.0. If you save data to a MAT-file that you intend to load using MATLAB Version 6 or earlier, you must specify the `-v6` option when saving. This disables compression and Unicode encoding for that particular save operation.

If you want to save to a file that you can then load into a Version 4 MATLAB session, you must use the `-v4` option when saving. When you use this option, variables that are incompatible with MATLAB Version 4 are not saved to the MAT-file. For example, ND arrays, structs, cells, etc. cannot be saved to a MATLAB Version 4 MAT-file. Also, variables with names that are longer than 19 characters cannot be saved to a MATLAB Version 4 MAT-file.

For information on any of the following topics related to saving to MAT-files, see in the MATLAB Programming documentation:

- Appending variables to an existing MAT-file
- Compressing data in the MAT-file
- Saving in ASCII format
- Saving in MATLAB Version 4 format
- Saving with Unicode character encoding
- Data storage requirements
- Saving from external programs

For information on saving figures, see the documentation for `hgsave` and `saveas`. For information on exporting figures to other graphics formats, see the documentation for `print`.

## Examples

### Example 1

Save all variables from the workspace in binary MAT-file `test.mat`:

```
save test.mat
```

### Example 2

Save variables `p` and `q` in binary MAT-file `test.mat`.

In this example, the file name is stored in a variable, `savefile`. You must call `save` using the function syntax of the command if you intend to reference the file name through a variable.

```
savefile = 'test.mat';  
p = rand(1, 10);  
q = ones(10);  
save(savefile, 'p', 'q')
```

### Example 3

Save the variables `vol` and `temp` in ASCII format to a file named `june10`:



```
save('d:\myfiles\june10','vol1','temp','-ASCII')
```

#### Example 4

Save the fields of structure `s1` as individual variables rather than as an entire structure.

```
s1.a = 12.7; s1.b = {'abc', [4 5; 6 7]}; s1.c = 'Hello!';
save newstruct.mat -struct s1;
clear
```

Check what was saved to `newstruct.mat`:

```
whos -file newstruct.mat
```

| Name | Size | Bytes | Class        |
|------|------|-------|--------------|
| a    | 1x1  | 8     | double array |
| b    | 1x2  | 158   | cell array   |
| c    | 1x6  | 12    | char array   |

Grand total is 16 elements using 178 bytes

Read only the `b` field into the MATLAB workspace.

```
str = load('newstruct.mat', 'b')
str =
    b: {'abc' [2x2 double]}
```

#### Example 5

Using regular expressions, save in MAT-file `mydata.mat` those variables with names that begin with `Mon`, `Tue`, or `Wed`:

```
save('mydata', '-regexp', '^Mon|^Tue|^Wed');
```

Here is another way of doing the same thing. In this case, there are three separate expression arguments:

```
save('mydata', '-regexp', '^Mon', '^Tue', '^Wed');
```

## Example 6

Save a 3000-by-3000 matrix uncompressed to file `c1.mat`, and compressed to file `c2.mat`. The compressed file uses about one quarter the disk space required to store the uncompressed data:

```
x = ones(3000);
y = uint32(rand(3000) * 100);

save -v6 c1 x y      % Save without compression
save -v7 c2 x y      % Save with compression

d1 = dir('c1.mat');
d2 = dir('c2.mat');

d1.bytes
ans =
    45000240          % Size of the uncompressed data in bytes.
d2.bytes
ans =
    11985283          % Size of the compressed data in bytes.

d2.bytes/d1.bytes
ans =
    0.2663            % Ratio of compressed to uncompressed
```

## See Also

`load`, `clear`, `diary`, `fprintf`, `fwrite`, `genvarname`, `who`, `whos`,  
`workspace`, `regexp`

**Purpose** Serialize control object to file

**Syntax** `h.save('filename')`  
`save(h, 'filename')`

**Description** `h.save('filename')` saves the COM control object, `h`, to the file specified in the string, `filename`.  
`save(h, 'filename')` is an alternate syntax for the same operation.

---

**Note** The COM save function is only supported for controls at this time.

---

**Examples** Create an `mwsamp` control and save its original state to the file `mwsample`:

```
f = figure('position', [100 200 200 200]);  
h = actxcontrol('mwsamp.mwsampctrl.2', [0 0 200 200], f);  
h.save('mwsample')
```

Now, alter the figure by changing its label and the radius of the circle:

```
h.Label = 'Circle';  
h.Radius = 50;  
h.Redraw;
```

Using the `load` function, you can restore the control to its original state:

```
h.load('mwsample');  
h.get  
ans =  
    Label: 'Label'  
    Radius: 20
```

**See Also** `load`, `actxcontrol`, `actxserver`, `release`, `delete`

# save (serial)

---

**Purpose** Save serial port objects and variables to MAT-file

**Syntax**  
`save filename`  
`save filename obj1 obj2...`

**Arguments**

|                       |                                                       |
|-----------------------|-------------------------------------------------------|
| <code>filename</code> | The MAT-file name.                                    |
| <code>obj1</code>     | Serial port objects or arrays of serial port objects. |
| <code>obj2...</code>  |                                                       |

**Description** `save filename` saves all MATLAB variables to the MAT-file `filename`. If an extension is not specified for `filename`, then the `.mat` extension is used.

`save filename obj1 obj2...` saves the serial port objects `obj1 obj2...` to the MAT-file `filename`.

**Remarks** You can use `save` in the functional form as well as the command form shown above. When using the functional form, you must specify the filename and serial port objects as strings. For example, to save the serial port object `s` to the file `MySerial.mat`

```
s = serial('COM1');  
save('MySerial','s')
```

Any data that is associated with the serial port object is not automatically stored in the MAT-file. For example, suppose there is data in the input buffer for `obj`. To save that data to a MAT-file, you must bring it into the MATLAB workspace using one of the synchronous read functions, and then save to the MAT-file using a separate variable name. You can also save data to a text file with the `record` function.

You return objects and variables to the MATLAB workspace with the `load` command. Values for read-only properties are restored to their default values upon loading. For example, the `Status` property is restored to `closed`. To determine if a property is read-only, examine its reference pages.

## Example

This example illustrates how to use the command and functional form of save.

```
s = serial('COM1');  
set(s, 'BaudRate', 2400, 'StopBits', 1)  
save MySerial1 s  
set(s, 'BytesAvailableFcn', @mycallback)  
save('MySerial2', 's')
```

## See Also

### Functions

load, record

### Properties

Status

**Purpose** Save figure or Simulink block diagram using specified format

**GUI Alternative** Use **File** → **Save As** on the figure window menu to access the Save As dialog, in which you can select a graphics format. For details, see “Exporting in a Specific Graphics Format” in the MATLAB Graphics documentation. Note that sizes of files written to image formats by this GUI and by `saveas` can differ, due to disparate resolution settings.

**Syntax**  
`saveas(h, 'filename.ext')`  
`saveas(h, 'filename', 'format')`

**Description** `saveas(h, 'filename.ext')` saves the figure or Simulink block diagram with the handle `h` to the file `filename.ext`. The format of the file is determined by the extension, `ext`. Allowable values for `ext` are listed in this table.

You can pass the handle of any Handle Graphics object to `saveas`, which then saves the parent figure to the object you specified should `h` not be a figure handle. This means that `saveas` cannot save a subplot without also saving all subplots in its parent figure.

| <b>ext Value</b> | <b>Format</b>                                       |
|------------------|-----------------------------------------------------|
| ai               | Adobe Illustrator '88                               |
| bmp              | Windows bitmap                                      |
| emf              | Enhanced metafile                                   |
| eps              | EPS Level 1                                         |
| fig              | MATLAB figure (invalid for Simulink block diagrams) |
| jpg              | JPEG image (invalid for Simulink block diagrams)    |
| m                | MATLAB M-file (invalid for Simulink block diagrams) |
| pbm              | Portable bitmap                                     |

| ext Value | Format                    |
|-----------|---------------------------|
| pcx       | Paintbrush 24-bit         |
| pdf       | Portable Document Format  |
| pgm       | Portable Graymap          |
| png       | Portable Network Graphics |
| ppm       | Portable Pixmap           |
| tif       | TIFF image, compressed    |

`saveas(h, 'filename', 'format')` saves the figure or Simulink block diagram with the handle `h` to the file called `filename` using the specified format. The filename can have an extension, but the extension is not used to define the file format. If no extension is specified, the standard extension corresponding to the specified format is automatically appended to the filename.

Allowable values for `format` are the extensions in the table above and the device drivers and graphic formats supported by `print`. The drivers and graphic formats supported by `print` include additional file formats not listed in the table above. When using a `print` device type to specify format for `saveas`, do not prefix it with `-d`.

## Remarks

You can use `open` to open files saved using `saveas` with an `m` or `fig` extension. Other `saveas` and `print` formats are not supported by `open`. Both the **Save As** and **Export** dialog boxes that you access from a figure's **File** menu use `saveas` with the `format` argument, and support all device and file types listed above.

If you want to control the size or resolution of figures saved in image (bitmapped) formats (such as BMP or JPG), use the `print` command and specify dots-per-inch resolution with the `r` switch.

## Examples

### Example 1: Specify File Extension

Save the current figure that you annotated using the Plot Editor to a file named `pred_prej` using the MATLAB `fig` format. This allows you to open the file `pred_prej.fig` at a later time and continue editing it with the Plot Editor.

```
saveas(gcf, 'pred_prej.fig')
```

### Example 2: Specify File Format but No Extension

Save the current figure, using Adobe Illustrator format, to the file `logo`. Use the `ai` extension from the above table to specify the format. The file created is `logo.ai`.

```
saveas(gcf, 'logo', 'ai')
```

This is the same as using the Adobe Illustrator format from the print devices table, which is `-dill`; use `doc print` or `help print` to see the table for print device types. The file created is `logo.ai`. MATLAB automatically appends the `ai` extension for an Illustrator format file because no extension was specified.

```
saveas(gcf, 'logo', 'ill')
```

### Example 3: Specify File Format and Extension

Save the current figure to the file `star.eps` using the Level 2 Color PostScript format. If you use `doc print` or `help print`, you can see from the table for print device types that the device type for this format is `-dpsc2`. The file created is `star.eps`.

```
saveas(gcf, 'star.eps', 'psc2')
```

In another example, save the current Simulink block diagram to the file `trans.tiff` using the TIFF format with no compression. From the table for print device types, you can see that the device type for this format is `-dtiffn`. The file created is `trans.tiff`.



```
saveas(gcf, 'trans.tiff', 'tiffn')
```

**See Also**

hgsave, open, print

“Printing” on page 1-92 for related functions

Simulink users, see also save\_system

# saveobj

---

**Purpose** User-defined extension of save function for user objects

**Syntax** B = saveobj(A)

**Description** B = saveobj(A) is called by the MATLAB save function when object A is saved to a MAT-file. This call executes the saveobj method for the object's class, if such a method exists. The return value B is subsequently used by save to populate the MAT-file.

When you issue a save command on an object, MATLAB looks for a method called saveobj in the class directory. You can overload this method to modify the object before the save operation. For example, you could define a saveobj method that saves related data along with the object.

**Remarks** saveobj can be overloaded only for user objects. save will not call saveobj for a built-in datatype, such as double, even if @double/saveobj exists.

saveobj will be separately invoked for each object to be saved.

A child object does not inherit the saveobj method of its parent class. To implement saveobj for any class, including a class that inherits from a parent, you must define a saveobj method within that class directory.

**Examples** The following example shows a saveobj method written for the portfolio class. The method determines if a portfolio object has already been assigned an account number from a previous save operation. If not, saveobj calls getAccountNumber to obtain the number and assigns it to the account\_number field. The contents of b is saved to the MAT-file.

```
function b = saveobj(a)
if isempty(a.account_number)
    a.account_number = getAccountNumber(a);
end
b = a;
```

**See Also**      save, load, loadobj

# savepath

---

**Purpose** Save current MATLAB search path to pathdef.m file

**GUI Alternatives** As an alternative to the savepath function, use the Set Path dialog box. To open it, select **File > Set Path** in the MATLAB desktop.

**Syntax**  
savepath  
savepath newfile

**Description** savepath saves the current MATLAB search path to pathdef.m. It returns

|   |                                    |
|---|------------------------------------|
| 0 | If the file was saved successfully |
| 1 | If the save failed                 |

savepath newfile saves the current MATLAB search path to newfile, where newfile is in the current directory or is a relative or absolute path.

**Examples** The statement

```
savepath myfiles/pathdef.m
```

saves the current search path to the file pathdef.m, which is located in the myfiles directory in the MATLAB current directory.

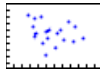
Consider using savepath in your MATLAB finish.m file to save the path when you exit MATLAB.


**See Also** addpath, cd, dir, finish, genpath, matlabroot, partialpath, pathdef, pathsep, pathtool, rehash, restoredefaultpath, rmpath, savepath, startup, what

Search Path in the MATLAB Desktop Tools and Development Environment documentation

**Purpose**

Scatter plot

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
scatter(X,Y,S,C)
scatter(X,Y)
scatter(X,Y,S)
scatter(...,markertype)
scatter(...,'filled')
scatter(...,'PropertyName',propertyvalue)
scatter(axes_handles,...)
h = scatter(...)
hpatch = scatter('v6',...)
```

**Description**

`scatter(X,Y,S,C)` displays colored circles at the locations specified by the vectors `X` and `Y` (which must be the same size).

`S` determines the area of each marker (specified in  $\text{points}^2$ ). `S` can be a vector the same length as `X` and `Y` or a scalar. If `S` is a scalar, MATLAB draws all the markers the same size. If `S` is empty, the default size is used.

`C` determines the color of each marker. When `C` is a vector the same length as `X` and `Y`, the values in `C` are linearly mapped to the colors in the current colormap. When `C` is a  $\text{length}(X)$ -by-3 matrix, it specifies the colors of the markers as RGB values. `C` can also be a color string (see `ColorSpec` for a list of color string specifiers).

`scatter(X,Y)` draws the markers in the default size and color.

# scatter

---

`scatter(X,Y,S)` draws the markers at the specified sizes (S) with a single color. This type of graph is also known as a bubble plot.

`scatter(...,markertype)` uses the marker type specified instead of 'o' (see `LineStyle` for a list of marker specifiers).

`scatter(...,'filled')` fills the markers.

`scatter(...,'PropertyName',propertyvalue)` creates the scatter graph, applying the specified property settings. See `scattergroup` properties for a description of properties.

`scatter(axes_handles,...)` plots into the axes object with handle `axes_handle` instead of the current axes object (`gca`).

`h = scatter(...)` returns the handle of the `scattergroup` object created.

## Backward-Compatible Version

`hpatch = scatter('v6',...)` returns the handles to the patch objects created by `scatter` (see `Patch Properties` for a list of properties you can specify using the object handles and `set`).

---

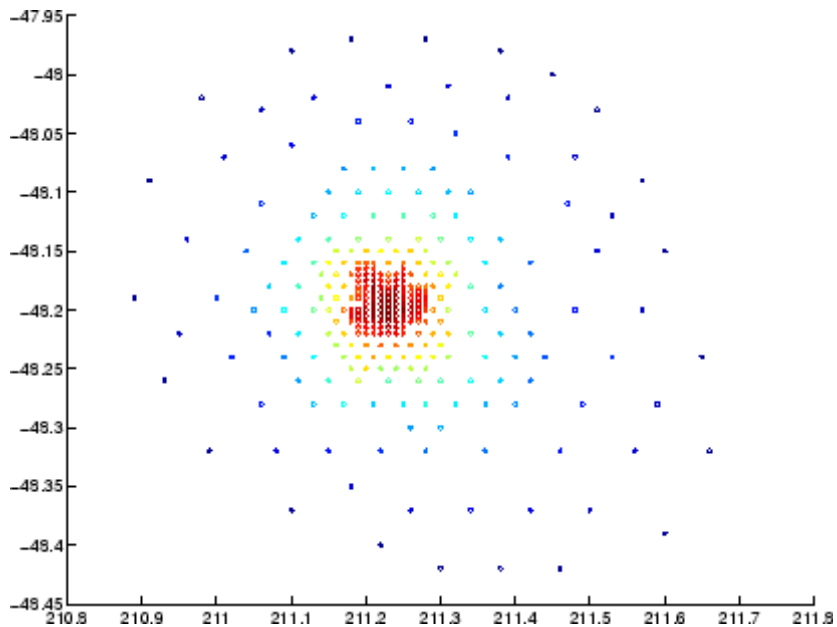
**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See `Plot Objects and Backward Compatibility` for more information.

## Example

```
load seamount
scatter(x,y,5,z)
```

**See Also**

`scatter3`, `plot3`

“Scatter/Bubble Plots” on page 1-91 for related functions

See [Triangulation and Interpolation of Scatter Data](#) for related information.

See [Scattergroup Properties](#) for property descriptions.

# scatter3


---

## Purpose

3-D scatter plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
scatter3(X,Y,Z,S,C)
scatter3(X,Y,Z)
scatter3(X,Y,Z,S)
scatter3(...,markertype)
scatter3(...,'filled')
scatter3(...,'PropertyName',propertyvalue)
h = scatter3(...)
hpatch = scatter3('v6',...)
```

## Description

`scatter3(X,Y,Z,S,C)` displays colored circles at the locations specified by the vectors  $X$ ,  $Y$ , and  $Z$  (which must all be the same size).

$S$  determines the size of each marker (specified in points).  $S$  can be a vector the same length as  $X$ ,  $Y$ , and  $Z$  or a scalar. If  $S$  is a scalar, MATLAB draws all the markers the same size.

$C$  determines the colors of each marker. When  $C$  is a vector the same length as  $X$ ,  $Y$ , and  $Z$ , the values in  $C$  are linearly mapped to the colors in the current colormap. When  $C$  is a  $\text{length}(X)$ -by-3 matrix, it specifies the colors of the markers as RGB values.  $C$  can also be a color string (see `ColorSpec` for a list of color string specifiers).

`scatter3(X,Y,Z)` draws the markers in the default size and color.

`scatter3(X,Y,Z,S)` draws markers at the specified sizes ( $S$ ) in a single color.



`scatter3(...,markertype)` uses the marker type specified instead of 'o' (see `LineStyle` for a list of marker specifiers).

`scatter3(..., 'filled')` fills the markers.

`scatter3(..., 'PropertyName', propertyvalue)` creates the scatter graph, applying the specified property settings. See `scattergroup` properties for a description of properties.

`h = scatter3(...)` returns handles to the `scattergroup` objects created by `scatter3`. See `Scattergroup Properties` for property descriptions.

### Backward-Compatible Version

`hpach = scatter3('v6',...)` returns the handles to the patch objects created by `scatter3` (see `Patch` for a list of properties you can specify using the object handles and `set`).

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See `Plot Objects and Backward Compatibility` for more information.

## Remarks

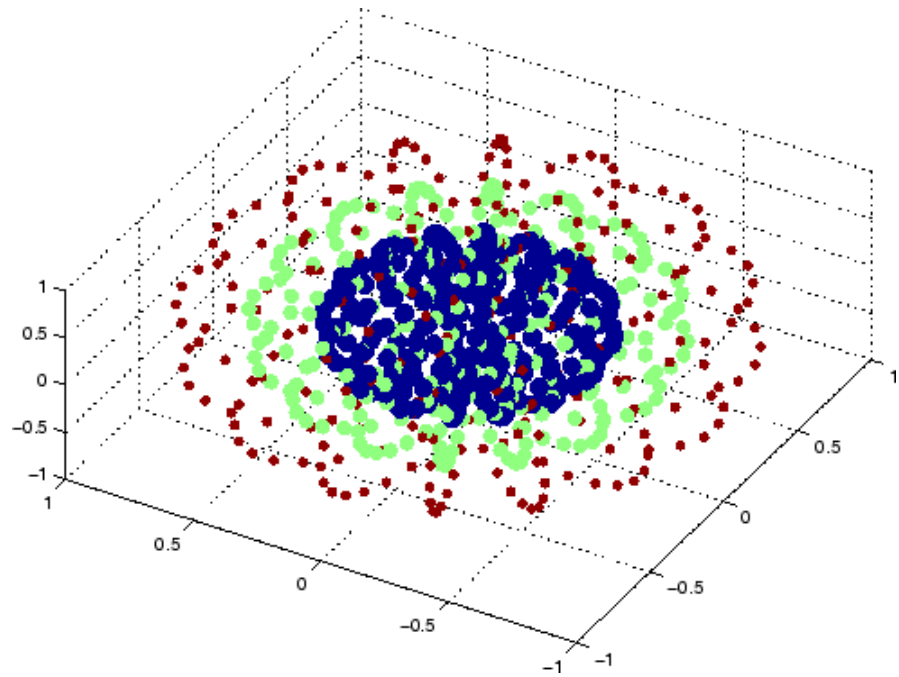
Use `plot3` for single color, single marker size 3-D scatter plots.

## Examples

```
[x,y,z] = sphere(16);
X = [x(:)*.5 x(:)*.75 x(:)];
Y = [y(:)*.5 y(:)*.75 y(:)];
Z = [z(:)*.5 z(:)*.75 z(:)];
S = repmat([1 .75 .5]*10,prod(size(x)),1);
C = repmat([1 2 3],prod(size(x)),1);
scatter3(X(:),Y(:),Z(:),S(:),C(:),'filled'), view(-60,60)
```

## scatter3

---



### See Also

`scatter`, `plot3`

See `Scattergroup` Properties for property descriptions

“Scatter/Bubble Plots” on page 1-91 for related functions

## Purpose

Define scattergroup properties

## Modifying Properties

You can set and query graphics object properties using the set and get commands or the Property Editor (propertyeditor).

Note that you cannot define default property values for scattergroup objects.

See Plot Objects for information on scattergroup objects.

## Scattergroup Property Descriptions

This section provides a description of properties. Curly braces { } enclose default values.

Annotation

hg.Annotation object Read Only

*Control the display of scattergroup objects in legends.* The Annotation property enables you to specify whether this scattergroup object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the scattergroup object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                                                                |
|------------------------|----------------------------------------------------------------------------------------|
| on                     | Include the scattergroup object in a legend as one entry, but not its children objects |

# Scattergroup Properties

---

| IconDisplayStyle Value | Purpose                                                                         |
|------------------------|---------------------------------------------------------------------------------|
| off                    | Do not include the scattergroup or its children in a legend (default)           |
| children               | Include only the children of the scattergroup as separate entries in the legend |

## Setting the IconDisplayStyle property

These commands set the `IconDisplayStyle` of a graphics object with handle `hobj` to `children`, which causes each child object to have an entry in the legend:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'children')
```

## Using the IconDisplayStyle property

See “Controlling Legends” for more information and examples.

`BeingDeleted`  
on | {off} Read Only

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to `on` when the object’s delete function callback is called (see the `DeleteFcn` property). It remains set to `on` while the delete function executes, after which the object no longer exists.

For example, an object’s delete function might call other functions that act on a number of different objects. These functions might not need to perform actions on objects if the objects are going to be deleted, and therefore, can check the object’s `BeingDeleted` property before acting.

## BusyAction

cancel | {queue}

*Callback routine interruption.* The BusyAction property enables you to control how MATLAB handles events that potentially interrupt executing callbacks. If there is a callback function executing, callbacks invoked subsequently always attempt to interrupt it.

If the Interruptible property of the object whose callback is executing is set to on (the default), then interruption occurs at the next point where the event queue is processed. If the Interruptible property is off, the BusyAction property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- cancel — Discard the event that attempted to execute a second callback routine.
- queue — Queue the event that attempted to execute a second callback routine until the current callback finishes.

## ButtonDownFcn

string or function handle

*Button press callback function.* A callback that executes whenever you press a mouse button while the pointer is over this object, but not over another graphics object. See the HitTestArea property for information about selecting objects of this type.

See the figure's SelectionType property to determine if modifier keys were also pressed.

This property can be

- A string that is a valid MATLAB expression
- The name of an M-file

# Scattergroup Properties

---

- A function handle

Set this property to a function handle that references the callback. The expressions execute in the MATLAB workspace.

See “Function Handle Callbacks” for information on how to use function handles to define the callbacks.

## CData

vector, m-by-3 matrix, ColorSpec

*Color of markers.* When CData is a vector the same length as XData and YData, the values in CData are linearly mapped to the colors in the current colormap. When CData is a length(XData)-by-3 matrix, it specifies the colors of the markers as RGB values.

## CDataSource

string (MATLAB variable)

*Link YData to MATLAB variable.* Set this property to a MATLAB variable that, by default, is evaluated in the base workspace to generate the CData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change CData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## Children

array of graphics object handles

*Children of this object.* The handle of a patch object that is the child of this object (whether visible or not).

Note that if a child object's `HandleVisibility` property is set to `callback` or `off`, its handle does not show up in this object's `Children` property unless you set the root `ShowHiddenHandles` property to `on`:

```
set(0, 'ShowHiddenHandles', 'on')
```

## Clipping

{on} | off

*Clipping mode.* MATLAB clips graphs to the axes plot box by default. If you set `Clipping` to `off`, portions of graphs can be displayed outside the axes plot box. This can occur if you create a plot object, set `hold` to `on`, freeze axis scaling (`axis manual`), and then create a larger plot object.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* This property defines a callback that executes when MATLAB creates an object. You must specify the callback during the creation of the object. For example,

```
area(y, 'CreateFcn', @CallbackFcn)
```

# Scattergroup Properties

---

where `@CallbackFcn` is a function handle that references the callback function.

MATLAB executes this routine after setting all other object properties. Setting this property on an existing object has no effect.

The handle of the object whose `CreateFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

`DeleteFcn`  
string or function handle

*Callback executed during object deletion.* A callback that executes when this object is deleted (e.g., this might happen when you issue a `delete` command on the object, its parent axes, or the figure containing it). MATLAB executes the callback before destroying the object’s properties so the callback routine can query these values.

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which can be queried using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

See the `BeingDeleted` property for related information.

`DisplayName`  
string (default is empty string)



*String used by legend for this scattergroup object.* The legend function uses the string defined by the `DisplayName` property to label this scattergroup object in the legend.

- If you specify string arguments with the legend function, `DisplayName` is set to this scattergroup object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where  $n$  is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call legend with the `toggle` or `show` option.

See “Controlling Legends” for more examples.

`EraseMode`

`{normal} | none | xor | background`

*Erase mode.* This property controls the technique MATLAB uses to draw and erase objects and their children. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- `normal` — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.

# Scattergroup Properties

---

- **none** — Do not erase objects when they are moved or destroyed. While the objects are still visible on the screen after erasing with `EraseMode none`, you cannot print these objects because MATLAB stores no information about their former locations.
- **xor** — Draw and erase the object by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the object does not damage the color of the objects behind it. However, the color of the erased object depends on the color of the screen behind it and it is correctly colored only when it is over the axes background color (or the figure background color if the axes `Color` property is set to `none`). That is, it isn't erased correctly if there are objects behind it.
- **background** — Erase the graphics objects by redrawing them in the axes background color, (or the figure background color if the axes `Color` property is set to `none`). This damages other graphics objects that are behind the erased object, but the erased object is always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the `EraseMode` of all objects is `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look different on screen than on paper. On screen, MATLAB can mathematically combine layers of colors (e.g., performing an XOR on a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

Set the axes background color with the axes `Color` property. Set the figure background color with the figure `Color` property.

You can use the MATLAB `getframe` command or other screen capture applications to create an image of a figure containing nonnormal mode objects.

HandleVisibility

{on} | callback | off

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. HandleVisibility is useful for preventing command-line users from accidentally accessing objects that you need to protect for some reason.

- on — Handles are always visible when HandleVisibility is on.
- callback — Setting HandleVisibility to callback causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have access to object handles.
- off — Setting HandleVisibility to off makes handles invisible at all times. This might be necessary when a callback invokes a function that might potentially damage the GUI (such as evaluating a user-typed string) and so temporarily hides its own handles during the execution of that function.

## Functions Affected by Handle Visibility

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

## Properties Affected by Handle Visibility

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in

# Scattergroup Properties

---

the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

## Overriding Handle Visibility

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties). See also `findall`.

## Handle Validity

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties and pass it to any function that operates on handles.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

`HitTest`  
`{on} | off`

*Selectable by mouse click.* `HitTest` determines whether this object can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the objects that compose the area graph. If `HitTest` is `off`, clicking this object selects the object below it (which is usually the axes containing it).

`HitTestArea`  
`on | {off}`

*Select the object by clicking lines or area of extent.* This property enables you to select plot objects in two ways:

- Select by clicking lines or markers (default).
- Select by clicking anywhere in the extent of the plot.

When `HitTestArea` is off, you must click the object's lines or markers (excluding the baseline, if any) to select the object. When `HitTestArea` is on, you can select this object by clicking anywhere within the extent of the plot (i.e., anywhere within a rectangle that encloses it).

`Interruptible`

{on} | off

*Callback routine interruption mode.* The `Interruptible` property controls whether an object's callback can be interrupted by callbacks invoked subsequently.

Only callbacks defined for the `ButtonDownFcn` property are affected by the `Interruptible` property. MATLAB checks for events that can interrupt a callback only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.

Setting `Interruptible` to on allows any graphics object's callback to interrupt callback routines originating from a bar property. Note that MATLAB does not save the state of variables or the display (e.g., the handle returned by the `gca` or `gcf` command) when an interruption occurs.

`LineWidth`

scalar

*The width of linear objects and edges of filled areas.* Specify this value in points (1 point =  $1/72$  inch). The default `LineWidth` is 0.5 points.

# Scattergroup Properties

---

## Marker

character (see table)

*Marker symbol.* The Marker property specifies the type of markers that are displayed at plot vertices. You can set values for the Marker property independently from the LineStyle property. Supported markers include those shown in the following table.

| Marker Specifier | Description                   |
|------------------|-------------------------------|
| +                | Plus sign                     |
| o                | Circle                        |
| *                | Asterisk                      |
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

## MarkerEdgeColor

ColorSpec | none | {auto}

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles). ColorSpec defines the color to use. none

specifies no color, which makes nonfilled markers invisible. `auto` sets `MarkerEdgeColor` to the same color as the `Color` property.

`MarkerFaceColor`

`ColorSpec` | `{none}` | `auto`

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles). `ColorSpec` defines the color to use. `none` makes the interior of the marker transparent, allowing the background to show through. `auto` sets the fill color to the axes color, or to the figure color if the axes `Color` property is set to `none` (which is the factory default for axes objects).

`Parent`

handle of parent axes, `hggroup`, or `hgtransform`

*Parent of this object.* This property contains the handle of the object's parent. The parent is normally the axes, `hggroup`, or `hgtransform` object that contains the object.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

`Selected`

`on` | `{off}`

*Is object selected?* When you set this property to `on`, MATLAB displays selection "handles" at the corners and midpoints if the `SelectionHighlight` property is also `on` (the default). You can, for example, define the `ButtonDownFcn` callback to set this property to `on`, thereby indicating that this particular object is selected. This property is also set to `on` when an object is manually selected in plot edit mode.

`SelectionHighlight`

`{on}` | `off`

# Scattergroup Properties

---

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is off, MATLAB does not draw the handles except when in plot edit mode and objects are selected manually.

## SizeData

square points

*Size of markers in square points.* This property specifies the area of the marker in the scatter graph in units of points. Since there are 72 points to one inch, to specify a marker that has an area of one square inch you would use a value of  $72^2$ .

## Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callbacks. You can define Tag as any string.

For example, you might create an areaseries object and set the Tag property.

```
t = area(Y, 'Tag', 'area1')
```

When you want to access objects of a given type, you can use findobj to find the object's handle. The following statement changes the FaceColor property of the object whose Tag is area1.

```
set(findobj('Tag', 'area1'), 'FaceColor', 'red')
```

## Type

string (read only)



*Type of graphics object.* This property contains a string that identifies the class of the graphics object. For stemseries objects, Type is 'hggroup'. The following statement finds all the hggroup objects in the current axes.

```
t = findobj(gca, 'Type', 'hggroup');
```

## UIContextMenu

handle of a uicontextmenu object

*Associate a context menu with this object.* Assign this property the handle of a uicontextmenu object created in the object's parent figure. Use the uicontextmenu function to create the context menu. MATLAB displays the context menu whenever you right-click over the object.

## UserData

array

*User-specified data.* This property can be any data you want to associate with this object (including cell arrays and structures). The object does not set values for this property, but you can access it using the set and get functions.

## Visible

{on} | off

*Visibility of this object and its children.* By default, a new object's visibility is on. This means all children of the object are visible unless the child object's Visible property is set to off. Setting an object's Visible property to off prevents the object from being displayed. However, the object still exists and you can set and query its properties.

## XData

array

*X-coordinates of scatter markers.* The scatter function draws individual markers at each *x*-axis location in the XData array. The

# Scattergroup Properties

---

input argument `x` in the scatter function calling syntax assigns values to `XData`.

`XDataSource`  
string (MATLAB variable)

*Link XData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the `XData`.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change `XData`.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

`YData`  
scalar, vector, or matrix

*Y-coordinates of scatter markers.* The scatter function draws individual markers at each *y*-axis location in the `YData` array.

The input argument `y` in the scatter function calling syntax assigns values to `YData`.

## YDataSource

string (MATLAB variable)

*Link YData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the YData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change YData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## ZData

vector of coordinates

*Z-coordinates.* A vector defining the *z*-coordinates for the graph. XData and YData must be the same length and have the same number of rows.

## ZDataSource

string (MATLAB variable)

# Scattergroup Properties

---

*Link ZData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the ZData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change ZData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

**Purpose**

Schur decomposition

**Syntax**

```
T = schur(A)
T = schur(A, flag)
[U, T] = schur(A, ...)
```

**Description**

The `schur` command computes the Schur form of a matrix.

`T = schur(A)` returns the Schur matrix `T`.

`T = schur(A, flag)` for real matrix `A`, returns a Schur matrix `T` in one of two forms depending on the value of `flag`:

|           |                                                                                                                                              |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------|
| 'complex' | <code>T</code> is triangular and is complex if <code>A</code> has complex eigenvalues.                                                       |
| 'real'    | <code>T</code> has the real eigenvalues on the diagonal and the complex eigenvalues in 2-by-2 blocks on the diagonal. 'real' is the default. |

If `A` is complex, `schur` returns the complex Schur form in matrix `T`. The complex Schur form is upper triangular with the eigenvalues of `A` on the diagonal.

The function `rsf2csf` converts the real Schur form to the complex Schur form.

`[U, T] = schur(A, ...)` also returns a unitary matrix `U` so that  $A = U^*T^*U'$  and  $U' * U = \text{eye}(\text{size}(A))$ .

**Examples**

`H` is a 3-by-3 eigenvalue test matrix:

```
H = [ -149   -50   -154
       537   180   546
       -27    -9   -25 ]
```

Its Schur form is

```
schur(H)
```

```
ans =
   1.0000   -7.1119  -815.8706
         0    2.0000  -55.0236
         0         0    3.0000
```

The eigenvalues, which in this case are 1, 2, and 3, are on the diagonal. The fact that the off-diagonal elements are so large indicates that this matrix has poorly conditioned eigenvalues; small changes in the matrix elements produce relatively large changes in its eigenvalues.

## Algorithm

### Input of Type Double

If A has type double, schur uses the LAPACK routines listed in the following table to compute the Schur form of a matrix:

| Matrix A          | Routine                                                  |
|-------------------|----------------------------------------------------------|
| Real symmetric    | DSYTRD, DSTEQR<br>DSYTRD, DORGTR, DSTEQR (with output U) |
| Real nonsymmetric | DGEHRD, DHSEQR<br>DGEHRD, DORGHR, DHSEQR (with output U) |
| Complex Hermitian | ZHETRD, ZSTEQR<br>ZHETRD, ZUNGTR, ZSTEQR (with output U) |
| Non-Hermitian     | ZGEHRD, ZHSEQR<br>ZGEHRD, ZUNGHR, ZHSEQR (with output U) |

### Input of Type Single

If A has type single, schur uses the LAPACK routines listed in the following table to compute the Schur form of a matrix:

| <b>Matrix A</b>   | <b>Routine</b>                                           |
|-------------------|----------------------------------------------------------|
| Real symmetric    | SSYTRD, SSTEQR<br>SSYTRD, SORGTR, SSTEQR (with output U) |
| Real nonsymmetric | SGEHRD, SHSEQR<br>SGEHRD, SORGHR, SHSEQR (with output U) |
| Complex Hermitian | CHETRD, CSTEQR<br>CHETRD, CUNGTR, CSTEQR (with output U) |
| Non-Hermitian     | CGEHRD, CHSEQR<br>CGEHRD, CUNGHR, CHSEQR (with output U) |

**See Also**

eig, hess, qz, rsf2csf

**References**

[1] Anderson, E., Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen, *LAPACK User's Guide* ([http://www.netlib.org/lapack/lug/lapack\\_lug.html](http://www.netlib.org/lapack/lug/lapack_lug.html)), Third Edition, SIAM, Philadelphia, 1999.

# script

---

**Purpose** Script M-file description

**Description** A script file is an external file that contains a sequence of MATLAB statements. By typing the filename, you can obtain subsequent MATLAB input from the file. Script files have a filename extension of `.m` and are often called M-files.

Scripts are the simplest kind of M-file. They are useful for automating blocks of MATLAB commands, such as computations you have to perform repeatedly from the command line. Scripts can operate on existing data in the workspace, or they can create new data on which to operate. Although scripts do not return output arguments, any variables that they create remain in the workspace, so you can use them in further computations. In addition, scripts can produce graphical output using commands like `plot`.

Scripts can contain any series of MATLAB statements. They require no declarations or begin/end delimiters.

Like any M-file, scripts can contain comments. Any text following a percent sign (`%`) on a given line is comment text. Comments can appear on lines by themselves, or you can append them to the end of any executable line.

**See Also** `echo`, `function`, `type`



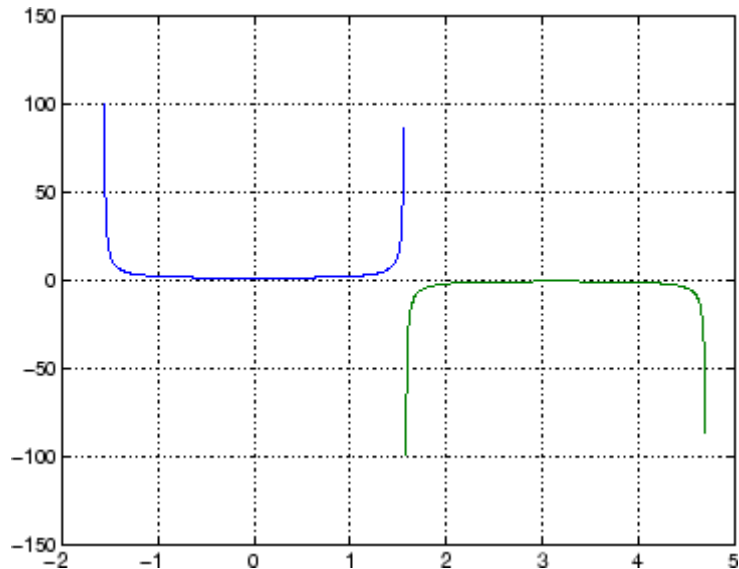
**Purpose** Secant of argument in radians

**Syntax**  $Y = \sec(X)$

**Description** The sec function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.  $Y = \sec(X)$  returns an array the same size as  $X$  containing the secant of the elements of  $X$ .

**Examples** Graph the secant over the domains  $-\pi/2 < x < \pi/2$  and  $\pi/2 < x < 3\pi/2$ .

```
x1 = -pi/2+0.01:0.01:pi/2-0.01;  
x2 = pi/2+0.01:0.01:(3*pi/2)-0.01;  
plot(x1,sec(x1),x2,sec(x2)), grid on
```



The expression  $\sec(\pi/2)$  does not evaluate as infinite but as the reciprocal of the floating-point accuracy `eps`, because `pi` is a floating-point approximation to the exact value of  $\pi$ .

**Definition**

The secant can be defined as

$$\sec(z) = \frac{1}{\cos(z)}$$

**Algorithm**

`sec` uses FDLIBM, which was developed at SunSoft, a Sun Microsystems, Inc. business, by Kwok C. Ng, and others. For information about FDLIBM, see <http://www.netlib.org>.

**See Also**

`secd`, `sech`, `asec`, `asecd`, `asech`

**Purpose** Secant of argument in degrees

**Syntax**  $Y = \text{secd}(X)$

**Description**  $Y = \text{secd}(X)$  is the secant of the elements of  $X$ , expressed in degrees. For odd integers  $n$ ,  $\text{secd}(n*90)$  is infinite, whereas  $\text{sec}(n*\pi/2)$  is large but finite, reflecting the accuracy of the floating point value of  $\pi$ .

**See Also** `sec`, `sech`, `asec`, `asecd`, `asech`

# sech

---

**Purpose** Hyperbolic secant

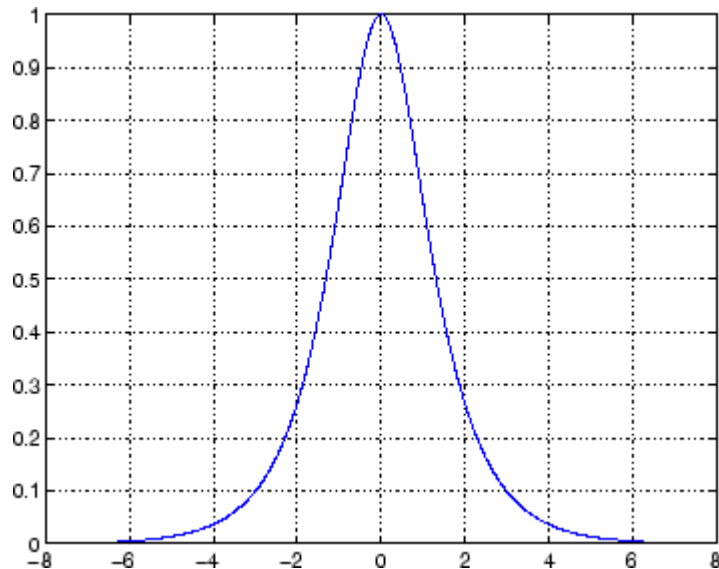
**Syntax**  $Y = \operatorname{sech}(X)$

**Description** The sech function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.

$Y = \operatorname{sech}(X)$  returns an array the same size as  $X$  containing the hyperbolic secant of the elements of  $X$ .

**Examples** Graph the hyperbolic secant over the domain  $-2\pi \leq x \leq 2\pi$ .

```
x = -2*pi:0.01:2*pi;  
plot(x,sech(x)), grid on
```



**Algorithm**      sech uses this algorithm.

$$\operatorname{sech}(z) = \frac{1}{\operatorname{cosh}(z)}$$

**Definition**      The secant can be defined as

$$\operatorname{sech}(z) = \frac{1}{\operatorname{cosh}(z)}$$

**Algorithm**      sec uses FDLIBM, which was developed at SunSoft, a Sun Microsystems, Inc. business, by Kwok C. Ng, and others. For information about FDLIBM, see <http://www.netlib.org>.

**See Also**      asec, asech, sec

# selectmoveresize

---

**Purpose** Select, move, resize, or copy axes and uicontrol graphics objects

**Syntax** `A = selectmoveresize`  
`set(gca, 'ButtonDownFcn', 'selectmoveresize')`

**Description** `selectmoveresize` is useful as the callback routine for axes and uicontrol button down functions. When executed, it selects the object and allows you to move, resize, and copy it.

`A = selectmoveresize` returns a structure array containing

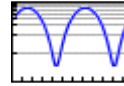
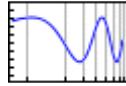
- `A.Type`: a string containing the action type, which can be `Select`, `Move`, `Resize`, or `Copy`
- `A.Handles`: a list of the selected handles, or, for a `Copy`, an `m-by-2` matrix containing the original handles in the first column and the new handles in the second column

`set(gca, 'ButtonDownFcn', 'selectmoveresize')` sets the `ButtonDownFcn` property of the current axes to `selectmoveresize`:


**See Also** The `ButtonDownFcn` property of axes and uicontrol objects  
“Object Manipulation” on page 1-100 for related functions

## Purpose

Semilogarithmic plots



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see [Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation](#) and [Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation](#).

## Syntax

```
semilogx(Y)
semilogy(...)
semilogx(X1,Y1,...)
semilogx(X1,Y1,LineStyle,...)
semilogx(...,'PropertyName',PropertyValue,...)
h = semilogx(...)
h = semilogy(...)
hlines = semilogx('v6',...)
```

## Description

`semilogx` and `semilogy` plot data as logarithmic scales for the  $x$ - and  $y$ -axis, respectively.

`semilogx(Y)` creates a plot using a base 10 logarithmic scale for the  $x$ -axis and a linear scale for the  $y$ -axis. It plots the columns of  $Y$  versus their index if  $Y$  contains real numbers. `semilogx(Y)` is equivalent to `semilogx(real(Y), imag(Y))` if  $Y$  contains complex numbers. `semilogx` ignores the imaginary component in all other uses of this function.

`semilogy(...)` creates a plot using a base 10 logarithmic scale for the  $y$ -axis and a linear scale for the  $x$ -axis.

`semilogx(X1,Y1,...)` plots all  $X_n$  versus  $Y_n$  pairs. If only  $X_n$  or  $Y_n$  is a matrix, `semilogx` plots the vector argument versus the rows or

# semilogx, semilogy

---

columns of the matrix, depending on whether the vector's row or column dimension matches the matrix.

`semilogx(X1,Y1,LineStyle,...)` plots all lines defined by the `Xn,Yn,LineStyle` triples. `LineStyle` determines line style, marker symbol, and color of the plotted lines.

`semilogx(...,'PropertyName',PropertyValue,...)` sets property values for all lineseries graphics objects created by `semilogx`.

`h = semilogx(...)` and `h = semilogy(...)` return a vector of handles to lineseries graphics objects, one handle per line.

## Backward-Compatible Version

`hlines = semilogx('v6',...)` and `hlines = semilogy('v6',...)` return the handles to line objects instead of lineseries objects.

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See Plot Objects and Backward Compatibility for more information.

## Remarks

If you do not specify a color when plotting more than one line, `semilogx` and `semilogy` automatically cycle through the colors and line styles in the order specified by the current axes `ColorOrder` and `LineStyleOrder` properties.

You can mix `Xn,Yn` pairs with `Xn,Yn,LineStyle` triples; for example,

```
semilogx(X1,Y1,X2,Y2,LineStyle,X3,Y3)
```

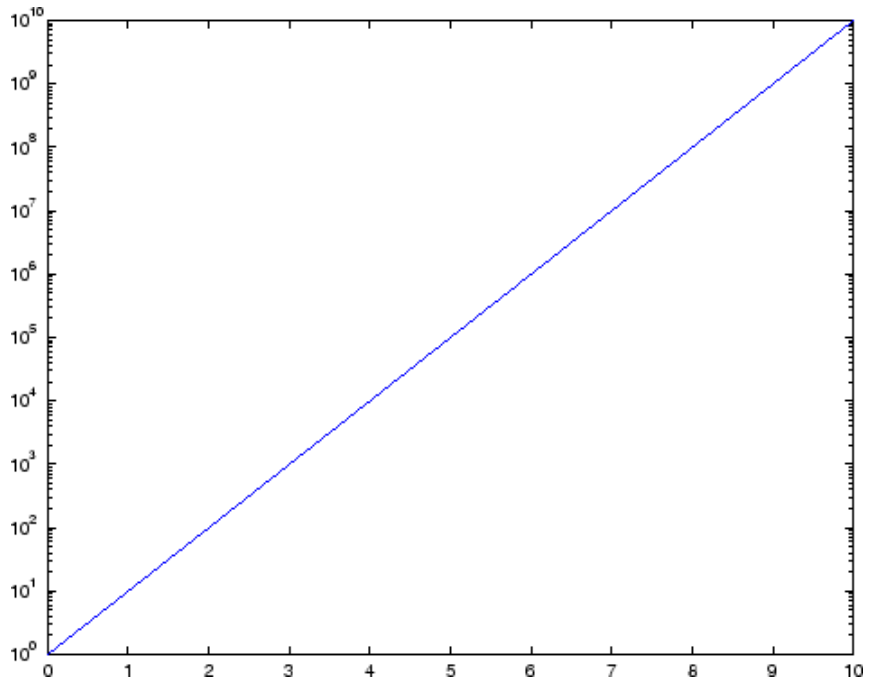
If you attempt to add a `loglog`, `semilogx`, or `semilogy` plot to a linear axis mode graph with `hold` on, the axis mode will remain as it is and the new data will plot as linear.



## Examples

Create a simple semilogy plot.

```
x = 0:.1:10;  
semilogy(x, 10.^x)
```



## See Also

line, LineSpec, loglog, plot

“Basic Plots and Graphs” on page 1-86 for related functions

# sendmail

---

**Purpose** Send e-mail message to address list

**Syntax**  
`sendmail('recipients','subject')`  
`sendmail('recipients','subject','message','attachments')`

**Description** `sendmail('recipients','subject')` sends e-mail to recipients with the specified subject. For recipients, use a string for a single address, or a cell array of strings for multiple addresses.

`sendmail('recipients','subject','message','attachments')` sends message to recipients with the specified subject. For recipients, use a string for a single address, or a cell array of strings for multiple addresses. For message, use a string or cell array. When message is a string, the text automatically wraps at 75 characters. When message is a cell array, it does not wrap but rather each cell is a new line. To force text to start on a new line in strings or cells, use 10, as shown in the “Example of sendmail with New Lines Specified” on page 2-2883. Specify attachments as a cell array of files to send along with message.

To use `sendmail`, you must set the preferences for your e-mail server (Internet SMTP server) and your e-mail address must be set. MATLAB tries to read the SMTP mail server from your system registry, but if it cannot, it results in an error. In this event, identify the outgoing mail server for your electronic mail application, which is usually listed in the application’s preferences, or, consult your e-mail system administrator. Then provide the information to MATLAB using

```
setpref('Internet','SMTP_Server','myserver.myhost.com');
```

If you cannot easily determine your e-mail server, try using `mail`, as in

```
setpref('Internet','SMTP_Server','mail');
```

which might work because `mail` is often a default for mail systems.

Similarly, if MATLAB cannot determine your e-mail address and produces an error, specify your e-mail address using

```
setpref('Internet','E_mail','myaddress@example.com');
```

---

**Note** The sendmail function does not support e-mail servers that require authentication.

---

## Examples

### Example of sendmail with Two Attachments

```
sendmail('user@otherdomain.com',...  
        'Test subject','Test message',...  
        {'directory/attach1.html','attach2.doc'});
```

### Example of sendmail with New Lines Specified

This mail message forces the message to start new lines after each 10.

```
sendmail('user@otherdomain.com','New subject', ...  
        ['Line1 of message' 10 'Line2 of message' 10 ...  
        'Line3 of message' 10 'Line4 of message']);
```

The resulting message is

```
Line1 of message  
Line2 of message  
Line3 of message  
Line4 of message
```

## See Also

getpref, setpref

# serial

---

**Purpose** Create serial port object

**Syntax**  
`obj = serial('port')`  
`obj = serial('port', 'PropertyName', PropertyValue, ...)`

**Arguments**

|                |                                                     |
|----------------|-----------------------------------------------------|
| 'port'         | The serial port name.                               |
| 'PropertyName' | A serial port property name.                        |
| PropertyValue  | A property value supported by <i>PropertyName</i> . |
| obj            | The serial port object.                             |

**Description**

`obj = serial('port')` creates a serial port object associated with the serial port specified by `port`. If `port` does not exist, or if it is in use, you will not be able to connect the serial port object to the device.

`obj = serial('port', 'PropertyName', PropertyValue, ...)` creates a serial port object with the specified property names and property values. If an invalid property name or property value is specified, an error is returned and the serial port object is not created.

**Remarks** When you create a serial port object, these property values are automatically configured:

- The `Type` property is given by `serial`.
- The `Name` property is given by concatenating `Serial` with the port specified in the `serial` function.
- The `Port` property is given by the port specified in the `serial` function.

You can specify the property names and property values using any format supported by the `set` function. For example, you can use property name/property value cell array pairs. Additionally, you can specify property names without regard to case, and you can make use

of property name completion. For example, the following commands are all valid.

```
s = serial('COM1','BaudRate',4800);
s = serial('COM1','baudrate',4800);
s = serial('COM1','BAUD',4800);
```

Refer to [Configuring Property Values](#) for a list of serial port object properties that you can use with `serial`.

Before you can communicate with the device, it must be connected to `obj` with the `fopen` function. A connected serial port object has a `Status` property value of `open`. An error is returned if you attempt a read or write operation while the object is not connected to the device. You can connect only one serial port object to a given serial port.

## Example

This example creates the serial port object `s1` associated with the serial port `COM1`.

```
s1 = serial('COM1');
```

The `Type`, `Name`, and `Port` properties are automatically configured.

```
get(s1,{'Type','Name','Port'})
ans =
    'serial'    'Serial-COM1'    'COM1'
```

To specify properties during object creation

```
s2 = serial('COM2','BaudRate',1200,'DataBits',7);
```

## See Also

### Functions

`fclose`, `fopen`

### Properties

`Name`, `Port`, `Status`, `Type`

# serialbreak

---

**Purpose** Send break to device connected to serial port

**Syntax** `serialbreak(obj)`  
`serialbreak(obj,time)`

**Arguments**

|                   |                                             |
|-------------------|---------------------------------------------|
| <code>obj</code>  | A serial port object.                       |
| <code>time</code> | The duration of the break, in milliseconds. |

**Description** `serialbreak(obj)` sends a break of 10 milliseconds to the device connected to `obj`.

`serialbreak(obj,time)` sends a break to the device with a duration, in milliseconds, specified by `time`. Note that the duration of the break might be inaccurate under some operating systems.

**Remarks** For some devices, the break signal provides a way to clear the hardware buffer.

Before you can send a break to the device, it must be connected to `obj` with the `fopen` function. A connected serial port object has a `Status` property value of `open`. An error is returned if you attempt to send a break while `obj` is not connected to the device.

`serialbreak` is a synchronous function, and blocks the command line until execution is complete.

If you issue `serialbreak` while data is being asynchronously written, an error is returned. In this case, you must call the `stopasync` function or wait for the write operation to complete.

## See Also

### Functions

`fopen`, `stopasync`

### Properties

`Status`

**Purpose**

Set object properties

**Syntax**

```
set(H, 'PropertyName', PropertyValue, ...)  
set(H, a)  
set(H, pn, pv, ...)  
set(H, pn, MxN_pv)  
a = set(h)  
a = set(h, 'Default')  
a = set(h, 'DefaultObjectTypePropertyName')  
pv = set(h, 'PropertyName')
```

**Description**

`set(H, 'PropertyName', PropertyValue, ...)` sets the named properties to the specified values on the object(s) identified by H. H can be a vector of handles, in which case `set` sets the properties' values for all the objects.

`set(H, a)` sets the named properties to the specified values on the object(s) identified by H. `a` is a structure array whose field names are the object property names and whose field values are the values of the corresponding properties.

`set(H, pn, pv, ...)` sets the named properties specified in the cell array `pn` to the corresponding value in the cell array `pv` for all objects identified in H.

`set(H, pn, MxN_pv)` sets `n` property values on each of `m` graphics objects, where `m = length(H)` and `n` is equal to the number of property names contained in the cell array `pn`. This allows you to set a given group of properties to different values on each object.

`a = set(h)` returns the user-settable properties and possible values for the object identified by `h`. `a` is a structure array whose field names are the object's property names and whose field values are the possible values of the corresponding properties. If you do not specify an output argument, MATLAB displays the information on the screen. `h` must be scalar.

`a = set(h, 'Default')` returns the names of properties having default values set on the object identified by `h`. `set` also returns the possible values if they are strings. `h` must be scalar.

`a = set(h, 'DefaultObjectTypePropertyName')` returns the possible values of the named property for the specified object type, if the values are strings. The argument `DefaultObjectTypePropertyName` is the word `Default` concatenated with the object type (e.g., `axes`) and the property name (e.g., `CameraPosition`). For example, `DefaultAxesCameraPosition`. `h` must be scalar.

`pv = set(h, 'PropertyName')` returns the possible values for the named property. If the possible values are strings, `set` returns each in a cell of the cell array `pv`. For other properties, `set` returns an empty cell array. If you do not specify an output argument, MATLAB displays the information on the screen. `h` must be scalar.

## Remarks

You can use any combination of property name/property value pairs, structure arrays, and cell arrays in one call to `set`.

### Setting Property Units

Note that if you are setting both the `FontSize` and the `FontUnits` properties in one function call, you must set the `FontUnits` property first so that MATLAB can correctly interpret the specified `FontSize`. The same applies to figure and axes units — always set the `Units` property before setting properties whose values you want to be interpreted in those units. For example,

```
f = figure('Units','characters',...
          'Position',[30 30 120 35]);
```

## Examples

Set the `Color` property of the current axes to blue.

```
set(gca,'Color','b')
```

Change all the lines in a plot to black.

```
plot(peaks)
set(findobj('Type','line'),'Color','k')
```



You can define a group of properties in a structure to better organize your code. For example, these statements define a structure called `active`, which contains a set of property definitions used for the `uicontrol` objects in a particular figure. When this figure becomes the current figure, MATLAB changes colors and enables the controls.

```
active.BackgroundColor = [.7 .7 .7];
active.Enable = 'on';
active.ForegroundColor = [0 0 0];

if gcf == control_fig_handle
    set(findobj(control_fig_handle,'Type','uicontrol'),active)
end
```

You can use cell arrays to set properties to different values on each object. For example, these statements define a cell array to set three properties,

```
PropName(1) = {'BackgroundColor'};
PropName(2) = {'Enable'};
PropName(3) = {'ForegroundColor'};
```

These statements define a cell array containing three values for each of three objects (i.e., a 3-by-3 cell array).

```
PropVal(1,1) = {[.5 .5 .5]};
PropVal(1,2) = {'off'};
PropVal(1,3) = {[.9 .9 .9]};
PropVal(2,1) = {[1 0 0]};
PropVal(2,2) = {'on'};
PropVal(2,3) = {[1 1 1]};
PropVal(3,1) = {[.7 .7 .7]};
PropVal(3,2) = {'on'};
PropVal(3,3) = {[0 0 0]};
```

Now pass the arguments to `set`,

```
set(H,PropName,PropVal)
```

where `length(H) = 3` and each element is the handle to a uicontrol.

## **Setting Different Values for the Same Property on Multiple Objects**

Suppose you want to set the value of the `Tag` property on five line objects, each to a different value. Note how the value cell array needs to be transposed to have the proper shape.

```
h = plot(rand(5));  
set(h,{'Tag'},{'line1','line2','line3','line4','line5'})
```

### **See Also**

`findobj`, `gca`, `gcf`, `gco`, `gcbo`, `get`

“Finding and Identifying Graphics Objects” on page 1-93 for related functions

**Purpose** Set object or interface property to specified value

**Syntax**

```
h.set('pname', value)
h.set('pname1', value1, 'pname2', value2, ...)
set(h, ...)
```

**Description** `h.set('pname', value)` sets the property specified in the string `pname` to the given value.

`h.set('pname1', value1, 'pname2', value2, ...)` sets each property specified in the `pname` strings to the given value.

`set(h, ...)` is an alternate syntax for the same operation.

See “Handling COM Data in MATLAB” in the External Interfaces documentation for information on how MATLAB converts workspace matrices to COM data types.

**Examples** Create an `mwsamp` control and use `set` to change the `Label` and `Radius` properties:

```
f = figure ('position', [100 200 200 200]);
h = actxcontrol ('mwsamp.mwsampctrl.1', [0 0 200 200], f);

h.set('Label', 'Click to fire event', 'Radius', 40);
h.invoke('Redraw');
```

Here is another way to do the same thing, only without `set` and `invoke`:

```
h.Label = 'Click to fire event';
h.Radius = 40;
h.Redraw;
```

**See Also** `get`, `inspect`, `isprop`, `addproperty`, `deleteproperty`

# set (serial)

---

**Purpose** Configure or display serial port object properties

**Syntax**

```
set(obj)
props = set(obj)
set(obj, 'PropertyName')
props = set(obj, 'PropertyName')
set(obj, 'PropertyName', PropertyValue, ...)
set(obj, PN, PV)
set(obj, S)
```

**Arguments**

|                |                                                                                                       |
|----------------|-------------------------------------------------------------------------------------------------------|
| obj            | A serial port object or an array of serial port objects.                                              |
| 'PropertyName' | A property name for obj.                                                                              |
| PropertyValue  | A property value supported by <i>PropertyName</i> .                                                   |
| PN             | A cell array of property names.                                                                       |
| PV             | A cell array of property values.                                                                      |
| S              | A structure with property names and property values.                                                  |
| props          | A structure array whose field names are the property names for obj, or cell array of possible values. |

**Description** `set(obj)` displays all configurable properties values for obj. If a property has a finite list of possible string values, then these values are also displayed.

`props = set(obj)` returns all configurable properties and their possible values for obj to props. props is a structure whose field names are the property names of obj, and whose values are cell arrays of possible property values. If the property does not have a finite set of possible values, then the cell array is empty.

`set(obj, 'PropertyName')` displays the valid values for *PropertyName* if it possesses a finite list of string values.

`props = set(obj, 'PropertyName')` returns the valid values for *PropertyName* to `props`. `props` is a cell array of possible string values or an empty cell array if *PropertyName* does not have a finite list of possible values.

`set(obj, 'PropertyName', PropertyValue, ...)` configures multiple property values with a single command.

`set(obj, PN, PV)` configures the properties specified in the cell array of strings `PN` to the corresponding values in the cell array `PV`. `PN` must be a vector. `PV` can be `m-by-n` where `m` is equal to the number of serial port objects in `obj` and `n` is equal to the length of `PN`.

`set(obj, S)` configures the named properties to the specified values for `obj`. `S` is a structure whose field names are serial port object properties, and whose field values are the values of the corresponding properties.

## Remarks

Refer to [Configuring Property Values](#) for a list of serial port object properties that you can configure with `set`.

You can use any combination of property name/property value pairs, structures, and cell arrays in one call to `set`. Additionally, you can specify a property name without regard to case, and you can make use of property name completion. For example, if `s` is a serial port object, then the following commands are all valid.

```
set(s, 'BaudRate')
set(s, 'baudrate')
set(s, 'BAUD')
```

If you use the `help` command to display help for `set`, then you need to supply the pathname shown below.

```
help serial/set
```

# set (serial)

---

## Examples

This example illustrates some of the ways you can use `set` to configure or return property values for the serial port object `s`.

```
s = serial('COM1');
set(s, 'BaudRate', 9600, 'Parity', 'even')
set(s, {'StopBits', 'RecordName'}, {2, 'sydney.txt'})
set(s, 'Parity')
[ {none} | odd | even | mark | space ]
```

## See Also

### Functions

`get`

**Purpose** Configure or display timer object properties

**Syntax**

```
set(obj)
prop_struct = set(obj)
set(obj, 'PropertyName')
prop_cell=set(obj, 'PropertyName')
set(obj, 'PropertyName',PropertyValue,...)
set(obj,S)
set(obj,PN,PV)
```

**Description** `set(obj)` displays property names and their possible values for all configurable properties of timer object `obj`. `obj` must be a single timer object.

`prop_struct = set(obj)` returns the property names and their possible values for all configurable properties of timer object `obj`. `obj` must be a single timer object. The return value, `prop_struct`, is a structure whose field names are the property names of `obj`, and whose values are cell arrays of possible property values or empty cell arrays if the property does not have a finite set of possible string values.

`set(obj, 'PropertyName')` displays the possible values for the specified property, *PropertyName*, of timer object `obj`. `obj` must be a single timer object.

`prop_cell=set(obj, 'PropertyName')` returns the possible values for the specified property, *PropertyName*, of timer object `obj`. `obj` must be a single timer object. The returned array, `prop_cell`, is a cell array of possible value strings or an empty cell array if the property does not have a finite set of possible string values.

`set(obj, 'PropertyName',PropertyValue,...)` configures the property, *PropertyName*, to the specified value, *PropertyValue*, for timer object `obj`. You can specify multiple property name/property value pairs in a single statement. `obj` can be a single timer object or a vector of timer objects, in which case `set` configures the property values for all the timer objects specified.

## set (timer)

---

`set(obj,S)` configures the properties of `obj`, with the values specified in `S`, where `S` is a structure whose field names are object property names.

`set(obj,PN,PV)` configures the properties specified in the cell array of strings, `PN`, to the corresponding values in the cell array `PV`, for the timer object `obj`. `PN` must be a vector. If `obj` is an array of timer objects, `PV` can be an `M`-by-`N` cell array, where `M` is equal to the length of timer object array and `N` is equal to the length of `PN`. In this case, each timer object is updated with a different set of values for the list of property names contained in `PN`.

---

**Note** When specifying parameter/value pairs, you can use any mixture of strings, structures, and cell arrays in the same call to `set`.

---

### Examples

Create a timer object.

```
t = timer;
```

Display all configurable properties and their possible values.

```
set(t)
    BusyMode: [ {drop} | queue | error ]
    ErrorFcn: string -or- function handle -or- cell array
    ExecutionMode: [ {singleShot} | fixedSpacing | fixedDelay | fixedRate ]
    Name
    ObjectVisibility: [ {on} | off ]
    Period
    StartDelay
    StartFcn: string -or- function handle -or- cell array
    StopFcn: string -or- function handle -or- cell array
    Tag
    TasksToExecute
    TimerFcn: string -or- function handle -or- cell array
    UserData
```

View the possible values of the `ExecutionMode` property.



```
set(t, 'ExecutionMode')  
[ {singleShot} | fixedSpacing | fixedDelay | fixedRate ]
```

Set the value of a specific timer object property.

```
set(t, 'ExecutionMode', 'FixedRate')
```

Set the values of several properties of the timer object.

```
set(t, 'TimerFcn', 'callbk', 'Period', 10)
```

Use a cell array to specify the names of the properties you want to set and another cell array to specify the values of these properties.

```
set(t, {'StartDelay', 'Period'}, {30, 30})
```

### See Also

timer, get(timer)

## set (timeseries)

---

**Purpose** Set properties of timeseries object

**Syntax**

```
set(ts, 'Property', Value)
set(ts, 'Property1', Value1, 'Property2', Value2, ...)
set(ts, 'Property')
set(ts)
```

**Description** `set(ts, 'Property', Value)` sets the property 'Property' of the timeseries object `ts` to the value `Value`. The following syntax is equivalent:

```
ts.Property = Value
```

`set(ts, 'Property1', Value1, 'Property2', Value2, ...)` sets multiple property values for `ts` with a single statement.

`set(ts, 'Property')` displays values for the specified property of the timeseries object `ts`.

`set(ts)` displays all properties and values of the timeseries object `ts`.

**See Also** `get (timeseries)`

**Purpose**

Set properties of tscollection object

**Syntax**

```
set(tsc, 'Property', Value)
set(tsc, 'Property1', Value1, 'Property2', Value2, ...)
set(tsc, 'Property')
```

**Description**

set(tsc, 'Property', Value) sets the property 'Property' of the tscollection tsc to the value Value. The following syntax is equivalent:

```
tsc.Property = Value
```

set(tsc, 'Property1', Value1, 'Property2', Value2, ...) sets multiple property values for tsc with a single statement.

set(tsc, 'Property') displays values for the specified property in the time-series collection tsc.

set(tsc) displays all properties and values of the tscollection object tsc.

**See Also**

get (tscollection)

# setabstime (timeseries)

---

**Purpose** Set times of timeseries object as date strings

**Syntax**  
`ts = setabstime(ts,Times)`  
`ts = setabstime(ts,Times,Format)`

**Description** `ts = setabstime(ts,Times)` sets the times in `ts` to the date strings specified in `Times`. `Times` must either be a cell array of strings, or a char array containing valid date or time values in the same date format.  
`ts = setabstime(ts,Times,Format)` explicitly specifies the date-string format used in `Times`.

**Examples** **1** Create a time-series object.

```
ts = timeseries(rand(3,1))
```

**2** Set the absolute time vector.

```
ts = setabstime(ts,{'12-DEC-2005 12:34:56',...  
                  '12-DEC-2005 13:34:56','12-DEC-2005 14:34:56'})
```

**See Also** `datestr`, `getabstime (timeseries)`, `timeseries`

**Purpose** Set times of tscollection object as date strings

**Syntax**

```
tsc = setabstime(tsc,Times)
tsc = setabstime(tsc,Times,format)
```

**Description**

`tsc = setabstime(tsc,Times)` sets the times in `tsc` using the date strings `Times`. `Times` must be either a cell array of strings, or a char array containing valid date or time values in the same date format.

`tsc = setabstime(tsc,Times,format)` specifies the date-string format used in `Times` explicitly.

**Examples**

- 1 Create a tscollection object.

```
tsc = tscollection(timeseries(rand(3,1)))
```

- 2 Set the absolute time vector.

```
tsc = setabstime(tsc,{'12-DEC-2005 12:34:56',...
'12-DEC-2005 13:34:56','12-DEC-2005 14:34:56'})
```

**See Also** `datestr`, `getabstime (tscollection)`, `tscollection`

# setappdata

---

**Purpose** Specify application-defined data

**Syntax** `setappdata(h, 'name', value)`

**Description** `setappdata(h, 'name', value)` sets application-defined data for the object with handle `h`. The application-defined data, which is created if it does not already exist, is assigned the specified name and value. The value can be any type of data.

**See Also** `getappdata`, `isappdata`, `rmappdata`

**Purpose** Find set difference of two vectors

**Syntax**

```
c = setdiff(A, B)
c = setdiff(A, B, 'rows')
[c,i] = setdiff(...)
```

**Description** `c = setdiff(A, B)` returns the values in A that are not in B. In set theory terms,  $c = A - B$ . Inputs A and B can be numeric or character vectors or cell arrays of strings. The resulting vector is sorted in ascending order.

`c = setdiff(A, B, 'rows')`, when A and B are matrices with the same number of columns, returns the rows from A that are not in B.

`[c,i] = setdiff(...)` also returns an index vector `index` such that `c = a(i)` or `c = a(i,:)`.

**Remarks** Because NaN is considered to be not equal to itself, it is always in the result c if it is in A.

**Examples**

```
A = magic(5);
B = magic(4);
[c, i] = setdiff(A(:), B(:));
c' =    17    18    19    20    21    22    23    24    25
i' =     1    10    14    18    19    23     2     6    15
```

**See Also** `intersect`, `ismember`, `issorted`, `setxor`, `union`, `unique`

# setenv

---

**Purpose** Set environment variable

**Syntax** `setenv(name, value)`  
`setenv(name)`

**Description** `setenv(name, value)` sets the value of an environment variable belonging to the underlying operating system. Inputs `name` and `value` are both strings. If `name` already exists as an environment variable, then `setenv` replaces its current value with the string given in `value`. If `name` does not exist, `setenv` creates a new environment variable called `name` and assigns `value` to it.

`setenv(name)` is equivalent to `setenv(name, '')` and assigns a null value to the variable `name`. Under the Windows operating system, this is equivalent to undefining the variable. On most UNIX-like platforms, it is possible to have an environment variable defined as empty.

The maximum number of characters in `name` is  $2^{15} - 2$  (or 32766). If `name` contains the character `=`, `setenv` throws an error. The behavior of environment variables with `=` in the name is not well-defined.

On all platforms, `setenv` passes the `name` and `value` strings to the operating system unchanged. Special characters such as `;`, `/`, `:`, `$`, `%`, etc. are left unexpanded and intact in the variable value.

Values assigned to variables using `setenv` are picked up by any process that is spawned using the MATLAB system, `unix`, `dos` or `!` functions. You can retrieve any value set with `setenv` by using `getenv(name)`.

**Examples** `% Set and retrieve a new value for the environment variable TEMP:`

```
setenv('TEMP', 'C:\TEMP');  
getenv('TEMP')
```

`% Append the Perl\bin directory to your system PATH variable:`

```
setenv('PATH', [getenv('PATH') 'D:\Perl\bin']);
```

**See Also** `getenv`, `system`, `unix`, `dos`, `!`



**Purpose**

Set value of structure array field

**Syntax**

```
s = setfield(s, 'field', v)
s = setfield(s, {i,j}, 'field', {k}, v)
```

**Description**

`s = setfield(s, 'field', v)`, where `s` is a 1-by-1 structure, sets the contents of the specified field to the value `v`. If `field` is not an existing field in structure `s`, MATLAB creates that field and assigns the value `v` to it. This is equivalent to the syntax `s.field = v`.

`s = setfield(s, {i,j}, 'field', {k}, v)` sets the contents of the specified field to the value `v`. If `field` is not an existing field in structure `s`, MATLAB creates that field and assigns the value `v` to it. This is equivalent to the syntax `s(i,j).field(k) = v`. All subscripts must be passed as cell arrays — that is, they must be enclosed in curly braces (similar to `{i,j}` and `{k}` above). Pass field references as strings.

See “Naming conventions for Structure Field Names” for guidelines to creating valid field names.

**Remarks**

In many cases, you can use dynamic field names in place of the `getfield` and `setfield` functions. Dynamic field names express structure fields as variable expressions that MATLAB evaluates at run-time. See Solution 1-19QWG for information about using dynamic field names versus the `getfield` and `setfield` functions.

**Examples**

Given the structure

```
mystr(1,1).name = 'alice';
mystr(1,1).ID = 0;
mystr(2,1).name = 'gertrude';
mystr(2,1).ID = 1;
```

You can change the name field of `mystr(2,1)` using

```
mystr = setfield(mystr, {2,1}, 'name', 'ted');
mystr(2,1).name
```

# setfield

---

```
ans =
```

```
ted
```

The following example sets fields of a structure using `setfield` with variable and quoted field names and additional subscripting arguments.

```
class = 5; student = 'John_Doe';  
grades_Doe = [85, 89, 76, 93, 85, 91, 68, 84, 95, 73];  
grades = [];  
  
grades = setfield(grades, {class}, student, 'Math', ...  
    {10, 21:30}, grades_Doe);
```

You can check the outcome using the standard structure syntax.

```
grades(class).John_Doe.Math(10, 21:30)
```

```
ans =
```

```
85 89 76 93 85 91 68 84 95 73
```

## See Also

`getfield`, `fieldnames`, `isfield`, `orderfields`, `rmfield`, “Using Dynamic Field Names”

**Purpose** Set default interpolation method for timeseries object

**Syntax**

```
ts = setinterpmethod(ts,Method)
ts = setinterpmethod(ts,FHandle)
ts = setinterpmethod(ts,InterpObj),
```

**Description** `ts = setinterpmethod(ts,Method)` sets the default interpolation method for timeseries object `ts`, where `Method` is a string. `Method` in `ts`. `Method` is either 'linear' or 'zoh' (zero-order hold). For example:

```
ts = timeseries(rand(100,1),1:100);
ts = setinterpmethod(ts,'zoh');
```

`ts = setinterpmethod(ts,FHandle)` sets the default interpolation method for timeseries object `ts`, where `FHandle` is a function handle to the interpolation method defined by the function handle `FHandle`. For example:

```
ts = timeseries(rand(100,1),1:100);
myFuncHandle = @(new_Time,Time,Data)...
               interp1(Time,Data,new_Time,...
                       'linear','extrap');
ts = setinterpmethod(ts,myFuncHandle);
ts = resample(ts,[-5:0.1:10]);
plot(ts);
```

---

**Note** For `FHandle`, you must use three input arguments. The order of input arguments must be `new_Time`, `Time`, and `Data`. The single output argument must be the interpolated data only.

---

`ts = setinterpmethod(ts,InterpObj)`, where `InterpObj` is a `tsdata.interpolation` object that directly replaces the interpolation object stored in `ts`. For example:

```
ts = timeseries(rand(100,1),1:100);
```

# setinterpmethod

---

```
myFuncHandle = @(new_Time,Time,Data)...
               interp1(Time,Data,new_Time,...
                       'linear','extrap');
myInterpObj = tsdata.interpolation(myFuncHandle);
ts = setinterpmethod(ts,myInterpObj);
```

This method is case sensitive.

## See Also

getinterpmethod, timeseries, tsprops

**Purpose** Set component position in pixels

**Syntax** `setpixelposition(handle,position)`  
`setpixelposition(handle,position,recursive)`

**Description** `setpixelposition(handle,position)` sets the position of the component specified by `handle`, to the specified pixel position relative to its parent. `position` is a four-element vector that specifies the location and size of the component: [distance from left, distance from bottom, width, height].

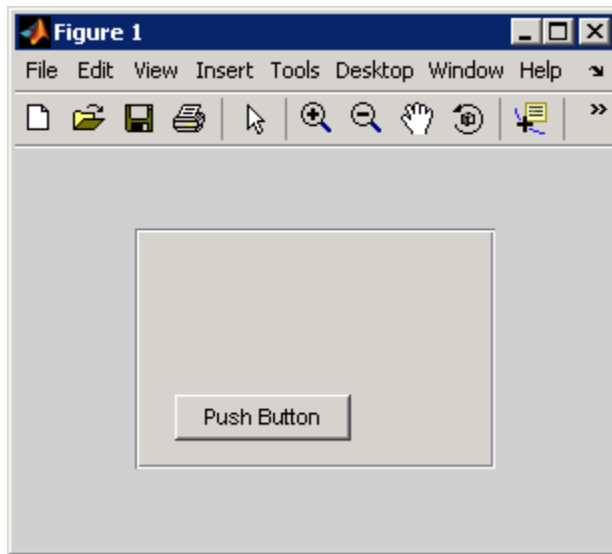
`setpixelposition(handle,position,recursive)` sets the position as above. If `recursive` is true, the position is set relative to the parent figure of `handle`.

**Example** This example first creates a push button within a panel.

```
f = figure('Position',[300 300 300 200]);
p = uipanel('Position',[.2 .2 .6 .6]);
h1 = uicontrol(p,'Style','PushButton','Units','Nomalized',...
              'String','Push Button','Position',[.1 .1 .5 .2]);
```

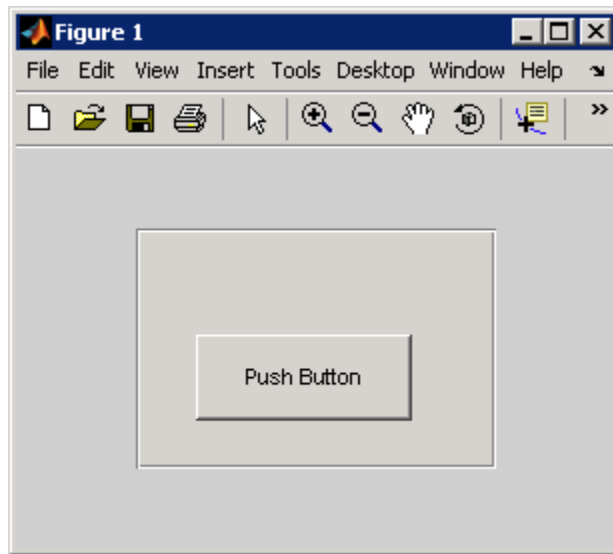
# setpixelposition

---



The example then retrieves the position of the push button and changes its position with respect to the panel.

```
pos1 = getpixelposition(h1);  
setpixelposition(h1,pos1 + [10 10 25 25]);
```



**See Also** `getpixelposition`, `uicontrol`, `uipanel`

# setpref

---

## Purpose

Set preference

## Syntax

```
setpref('group','pref',val)
setpref('group',{'pref1','pref2',...,'prefn'},{val1,val2,...,
    valn})
```

## Description

`setpref('group','pref',val)` sets the preference specified by `group` and `pref` to the value `val`. Setting a preference that does not yet exist causes it to be created.

`group` labels a related collection of preferences. You can choose any name that is a legal variable name, and is descriptive enough to be unique, e.g., `'MathWorks_GUIDE_ApplicationPrefs'`. The input argument `pref` identifies an individual preference in that group, and must be a legal variable name.

`setpref('group',{'pref1','pref2',...,'prefn'},{val1,val2,...,valn})` sets each preference specified in the cell array of names to the corresponding value.

---

**Note** Preference values are persistent and maintain their values between MATLAB sessions. Where they are stored is system dependent.

---

## Examples

```
addpref('mytoolbox','version','0.0')
setpref('mytoolbox','version','1.0')
getpref('mytoolbox','version')
```

```
ans =
    1.0
```

## See Also

`addpref`, `getpref`, `ispref`, `rmpref`, `uigetpref`, `uisetpref`



**Purpose** Set string flag

**Description** This MATLAB 4 function has been renamed char in MATLAB 5.

# settimeseriesnames

---

**Purpose** Change name of timeseries object in tscollection

**Syntax** `tsc = settimeseriesnames(tsc,old,new)`

**Description** `tsc = settimeseriesnames(tsc,old,new)` replaces the old name of timeseries object with the new name in tsc.

**See Also** `tscollection`

**Purpose**

Find set exclusive OR of two vectors

**Syntax**

```
c = setxor(A, B)
c = setxor(A, B, 'rows')
[c, ia, ib] = setxor(...)
```

**Description**

`c = setxor(A, B)` returns the values that are not in the intersection of A and B. Inputs A and B can be numeric or character vectors or cell arrays of strings. The resulting vector is sorted.

`c = setxor(A, B, 'rows')`, when A and B are matrices with the same number of columns, returns the rows that are not in the intersection of A and B.

`[c, ia, ib] = setxor(...)` also returns index vectors `ia` and `ib` such that `c` is a sorted combination of the elements `c = a(ia)` and `c = b(ib)` or, for row combinations, `c = a(ia,:)` and `c = b(ib,:)`.

**Examples**

```
a = [-1 0 1 Inf -Inf NaN];
b = [-2 pi 0 Inf];
c = setxor(a, b)
```

```
c =
    -Inf    -2.0000    -1.0000     1.0000     3.1416     NaN
```

**See Also**

`intersect`, `ismember`, `issorted`, `setdiff`, `union`, `unique`

# shading

---

**Purpose** Set color shading properties

**Syntax** shading flat  
shading faceted  
shading interp  
shading(axes\_handle,...)

**Description** The shading function controls the color shading of surface and patch graphics objects.

shading flat each mesh line segment and face has a constant color determined by the color value at the endpoint of the segment or the corner of the face that has the smallest index or indices.

shading faceted flat shading with superimposed black mesh lines. This is the default shading mode.

shading interp varies the color in each line segment and face by interpolating the colormap index or true color value across the line or face.

shading(axes\_handle,...) applies the shading type to the objects in the axes specified by axes\_handle, instead of the current axes.

**Examples** Compare a flat, faceted, and interpolated-shaded sphere.

```
subplot(3,1,1)
sphere(16)
axis square
shading flat
title('Flat Shading')
```

```
subplot(3,1,2)
sphere(16)
axis square
shading faceted
title('Faceted Shading')
```

```
subplot(3,1,3)
```

```
sphere(16)  
axis square  
shading interp  
title('Interpolated Shading')
```

## Algorithm

shading sets the EdgeColor and FaceColor properties of all surface and patch graphics objects in the current axes. shading sets the appropriate values, depending on whether the surface or patch objects represent meshes or solid surfaces.

## See Also

fill, fill3, hidden, mesh, patch, pcolor, surf

The EdgeColor and FaceColor properties for patch and surface graphics objects.

“Color Operations” on page 1-98 for related functions

# shiftdim

---

**Purpose** Shift dimensions

**Syntax** `B = shiftdim(X,n)`  
`[B,nshifts] = shiftdim(X)`

**Description** `B = shiftdim(X,n)` shifts the dimensions of `X` by `n`. When `n` is positive, `shiftdim` shifts the dimensions to the left and wraps the `n` leading dimensions to the end. When `n` is negative, `shiftdim` shifts the dimensions to the right and pads with singletons.

`[B,nshifts] = shiftdim(X)` returns the array `B` with the same number of elements as `X` but with any leading singleton dimensions removed. A singleton dimension is any dimension for which `size(A,dim) = 1`. `nshifts` is the number of dimensions that are removed.

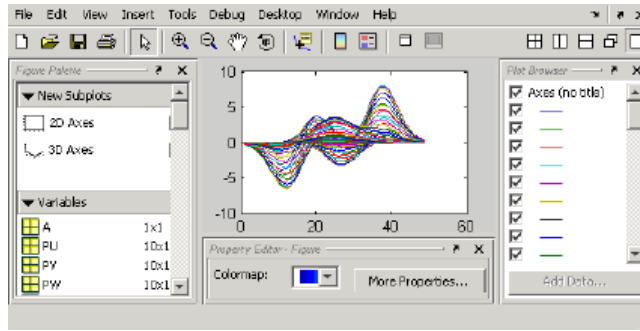
If `X` is a scalar, `shiftdim` has no effect.

**Examples** The `shiftdim` command is handy for creating functions that, like `sum` or `diff`, work along the first nonsingleton dimension.



```
a = rand(1,1,3,1,2);  
[b,n] = shiftdim(a); % b is 3-by-1-by-2 and n is 2.  
c = shiftdim(b,-n); % c == a.  
d = shiftdim(a,3); % d is 1-by-2-by-1-by-1-by-3.
```

**See Also** `circshift`, `reshape`, `squeeze`

**Purpose** Show or hide figure plot tool



## GUI Alternatives

Click the larger Plotting Tools icon  on the figure toolbar to collectively enable plotting tools, and the smaller icon  to collectively disable them. Individually select the **Figure Palette**, **Plot Browser**, and **Property Editor** tools from the figure's **View** menu. For details, see “Plotting Tools — Interactive Plotting” in the MATLAB Graphics documentation.

## Syntax

```
showplottool('tool')
showplottool('on','tool')
showplottool('off','tool')
showplottool('toggle','tool')
showplottool(figure_handle,...)
```

## Description

`showplottool('tool')` shows the specified plot tool on the current figure. `tool` can be one of the following strings:

- `figurepalette`
- `plotbrowser`
- `propertyeditor`

# showplottool

---

`showplottool('on', 'tool')` shows the specified plot tool on the current figure.

`showplottool('off', 'tool')` hides the specified plot tool on the current figure.

`showplottool('toggle', 'tool')` toggles the visibility of the specified plot tool on the current figure.

`showplottool(figure_handle, ...)` operates on the specified figure instead of the current figure.

---

**Note** When you dock, undock, resize, or reposition a plotting tool and then close it, it will still be configured as you left it the next time you open it. There is no command to reset plotting tools to their original, default locations.

---

## See Also

`figurepalette`, `plotbrowser`, `plottools`, `propertyeditor`



## Purpose

Reduce size of patch faces

## Syntax

```
shrinkfaces(p,sf)
nfv = shrinkfaces(p,sf)
nfv = shrinkfaces(fv,sf)
shrinkfaces(p)
nfv = shrinkfaces(f,v,sf)
[nf,nv] = shrinkfaces(...)
```

## Description

`shrinkfaces(p,sf)` shrinks the area of the faces in patch `p` to shrink factor `sf`. A shrink factor of 0.6 shrinks each face to 60% of its original area. If the patch contains shared vertices, MATLAB creates nonshared vertices before performing the face-area reduction.

`nfv = shrinkfaces(p,sf)` returns the face and vertex data in the struct `nfv`, but does not set the `Faces` and `Vertices` properties of patch `p`.

`nfv = shrinkfaces(fv,sf)` uses the face and vertex data from the struct `fv`.

`shrinkfaces(p)` and `shrinkfaces(fv)` (without specifying a shrink factor) assume a shrink factor of 0.3.

`nfv = shrinkfaces(f,v,sf)` uses the face and vertex data from the arrays `f` and `v`.

`[nf,nv] = shrinkfaces(...)` returns the face and vertex data in two separate arrays instead of a struct.

## Examples

This example uses the flow data set, which represents the speed profile of a submerged jet within an infinite tank (type `help flow` for more information). Two isosurfaces provide a before and after view of the effects of shrinking the face size.

- First `reducevolume` samples the flow data at every other point and then `isosurface` generates the faces and vertices data.

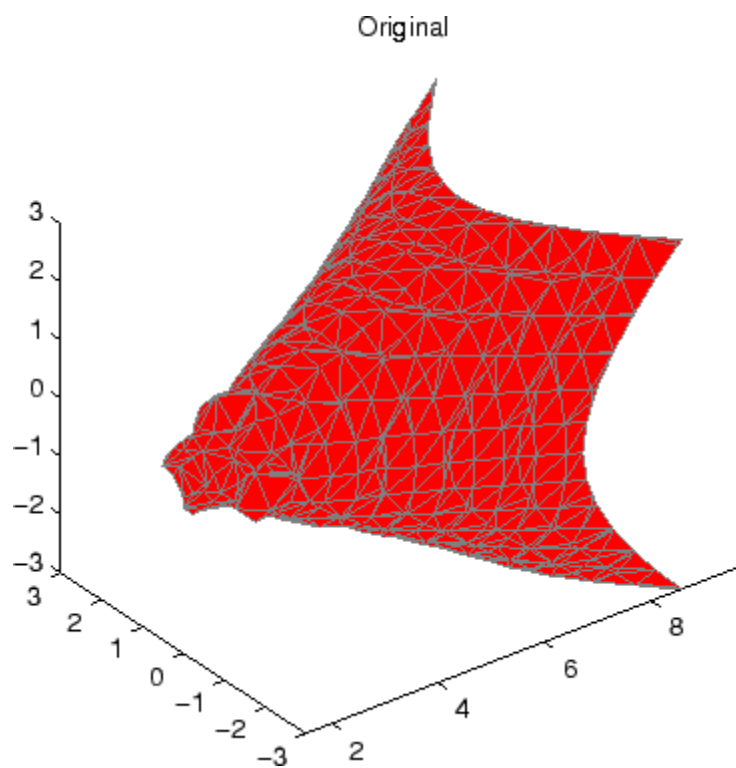
# shrinkfaces

---

- The patch command accepts the face/vertex struct and draws the first (p1) isosurface.
- Use the daspect, view, and axis commands to set up the view and then add a title.
- The shrinkfaces command modifies the face/vertex data and passes it directly to patch.

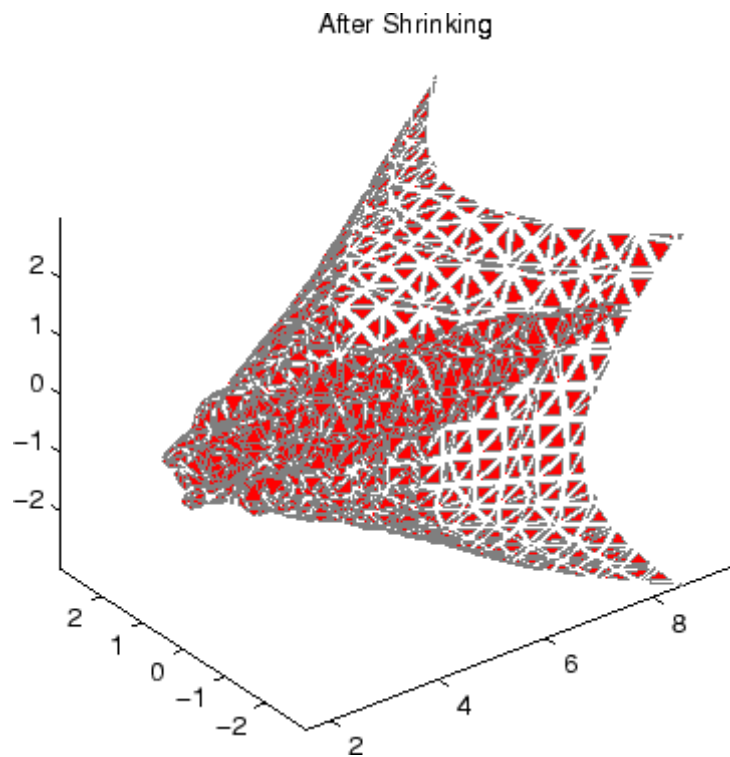
```
[x,y,z,v] = flow;  
[x,y,z,v] = reducevolume(x,y,z,v,2);  
fv = isosurface(x,y,z,v,-3);  
p1 = patch(fv);  
set(p1,'FaceColor','red','EdgeColor',[.5,.5,.5]);  
daspect([1 1 1]); view(3); axis tight  
title('Original')
```

```
figure  
p2 = patch(shrinkfaces(fv,.3));  
set(p2,'FaceColor','red','EdgeColor',[.5,.5,.5]);  
daspect([1 1 1]); view(3); axis tight  
title('After Shrinking')
```



# shrinkfaces

---



## See Also

`isosurface`, `patch`, `reducevolume`, `daspect`, `view`, `axis`  
“Volume Visualization” on page 1-102 for related functions

**Purpose** Signum function

**Syntax**  $Y = \text{sign}(X)$

**Description**  $Y = \text{sign}(X)$  returns an array  $Y$  the same size as  $X$ , where each element of  $Y$  is:

- 1 if the corresponding element of  $X$  is greater than zero
- 0 if the corresponding element of  $X$  equals zero
- -1 if the corresponding element of  $X$  is less than zero

For nonzero complex  $X$ ,  $\text{sign}(X) = X ./ \text{abs}(X)$ .

**See Also** `abs`, `conj`, `imag`, `real`

# sin

---

**Purpose** Sine of argument in radians

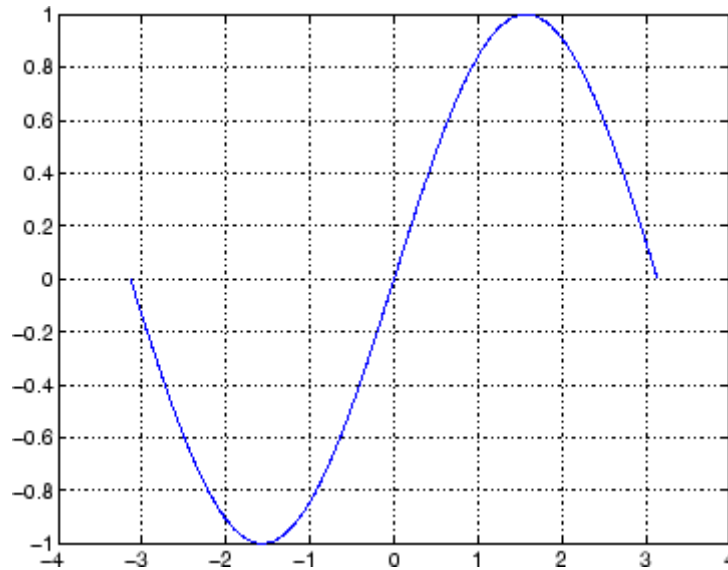
**Syntax**  $Y = \sin(X)$

**Description** The `sin` function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.

$Y = \sin(X)$  returns the circular sine of the elements of  $X$ .

**Examples** Graph the sine function over the domain  $-\pi \leq x \leq \pi$ .

```
x = -pi:0.01:pi;  
plot(x,sin(x)), grid on
```



The expression `sin(pi)` is not exactly zero, but rather a value the size of the floating-point accuracy `eps`, because `pi` is only a floating-point approximation to the exact value of  $\pi$ .

**Definition**

The sine can be defined as

$$\sin(x + iy) = \sin(x)\cosh(y) + i\cos(x)\sinh(y)$$

$$\sin(z) = \frac{e^{iz} - e^{-iz}}{2i}$$

**Algorithm**

sin uses FDLIBM, which was developed at SunSoft, a Sun Microsystems, Inc. business, by Kwok C. Ng, and others. For information about FDLIBM, see <http://www.netlib.org>.

**See Also**

sind, sinh, asin, asind, asinh

# sind

---

**Purpose** Sine of argument in degrees

**Syntax**  $Y = \text{sind}(X)$

**Description**  $Y = \text{sind}(X)$  is the sine of the elements of  $X$ , expressed in degrees. For integers  $n$ ,  $\text{sind}(n \cdot 180)$  is exactly zero, whereas  $\sin(n \cdot \pi)$  reflects the accuracy of the floating point value of  $\pi$ .

**See Also** `sin`, `sinh`, `asin`, `asind`, `asinh`



**Purpose** Convert to single precision

**Syntax** `B = single(A)`

**Description** `B = single(A)` converts the matrix `A` to single precision, returning that value in `B`. `A` can be any numeric object (such as a double). If `A` is already single precision, `single` has no effect. Single-precision quantities require less storage than double-precision quantities, but have less precision and a smaller range.

The `single` class is primarily meant to be used to store single-precision values. Hence most operations that manipulate arrays without changing their elements are defined. Examples are `reshape`, `size`, the relational operators, subscripted assignment, and subscripted reference.

You can define your own methods for the `single` class by placing the appropriately named method in an `@single` directory within a directory on your path.

## Examples

```
a = magic(4);  
b = single(a);
```

```
whos
```

| Name | Size | Bytes | Class        |
|------|------|-------|--------------|
| a    | 4x4  | 128   | double array |
| b    | 4x4  | 64    | single array |

**See Also** `double`

# sinh

---

**Purpose** Hyperbolic sine of argument in radians

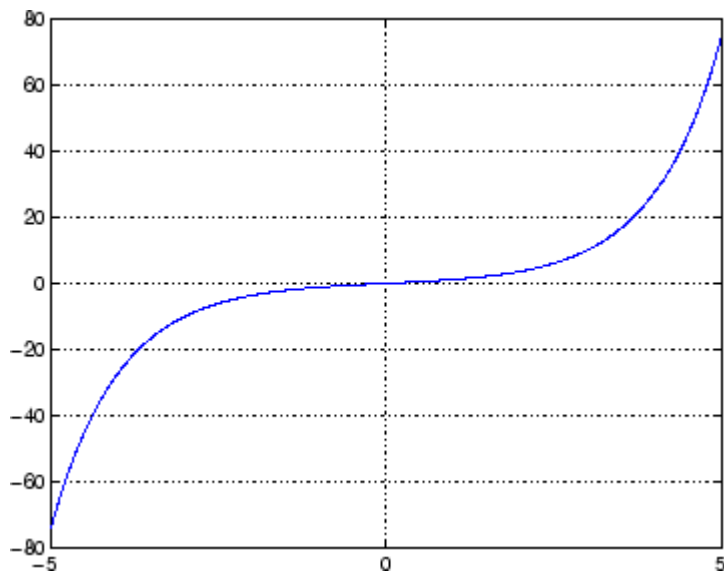
**Syntax**  $Y = \sinh(X)$

**Description** The sinh function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.

$Y = \sinh(X)$  returns the hyperbolic sine of the elements of  $X$ .

**Examples** Graph the hyperbolic sine function over the domain  $-5 \leq x \leq 5$ .

```
x = -5:0.01:5;  
plot(x, sinh(x)), grid on
```



**Definition** The hyperbolic sine can be defined as

$$\sinh(z) = \frac{e^z - e^{-z}}{2}$$

**Algorithm**

`sinh` uses FDLIBM, which was developed at SunSoft, a Sun Microsystems, Inc. business, by Kwok C. Ng, and others. For information about FDLIBM, see <http://www.netlib.org>.

**See Also**

`sin`, `sind`, `asin`, `asinh`, `asind`

# size

---

**Purpose** Array dimensions

**Syntax**

```
d = size(X)
[m,n] = size(X)
m = size(X,dim)
[d1,d2,d3,...,dn] = size(X),
```

**Description** `d = size(X)` returns the sizes of each dimension of array `X` in a vector `d` with `ndims(X)` elements. If `X` is a scalar, which MATLAB regards as a 1-by-1 array, `size(X)` returns the vector `[1 1]`.

`[m,n] = size(X)` returns the size of matrix `X` in separate variables `m` and `n`.

`m = size(X,dim)` returns the size of the dimension of `X` specified by scalar `dim`.

`[d1,d2,d3,...,dn] = size(X)`, for  $n > 1$ , returns the sizes of the dimensions of the array `X` in the variables `d1,d2,d3,...,dn`, provided the number of output arguments `n` equals `ndims(X)`. If `n` does not equal `ndims(X)`, the following exceptions hold:

$n < \text{ndims}(X)$  `di` equals the size of the  $i$ th dimension of `X` for  $1 \leq i < n$ , but `dn` equals the product of the sizes of the remaining dimensions of `X`, that is, dimensions  $n$  through `ndims(X)`.

$n > \text{ndims}(X)$  `size` returns ones in the “extra” variables, that is, those corresponding to `ndims(X)+1` through `n`.

---

**Note** For a Java array, `size` returns the length of the Java array as the number of rows. The number of columns is always 1. For a Java array of arrays, the result describes only the top level array.

---

## Examples

### Example 1

The size of the second dimension of `rand(2,3,4)` is 3.

```
m = size(rand(2,3,4),2)
```

```
m =  
    3
```

Here the size is output as a single vector.

```
d = size(rand(2,3,4))
```

```
d =  
    2    3    4
```

Here the size of each dimension is assigned to a separate variable.

```
[m,n,p] = size(rand(2,3,4))
```

```
m =  
    2
```

```
n =  
    3
```

```
p =  
    4
```

## Example 2

If  $X = \text{ones}(3,4,5)$ , then

```
[d1,d2,d3] = size(X)
```

```
d1 =    d2 =    d3 =  
    3        4        5
```

But when the number of output variables is less than `ndims(X)`:

```
[d1,d2] = size(X)
```

```
d1 =    d2 =  
    3        20
```

# size

---

The “extra” dimensions are collapsed into a single product.

If  $n > \text{ndims}(X)$ , the “extra” variables all represent singleton dimensions:

```
[d1,d2,d3,d4,d5,d6] = size(X)
```

```
d1 =      d2 =      d3 =  
    3          4          5
```

```
d4 =      d5 =      d6 =  
    1          1          1
```

## See Also

`exist`, `length`, `numel`, `whos`

**Purpose** Size of serial port object array

**Syntax**

```
d = size(obj)
[m,n] = size(obj)
[m1,m2,m3,...,mn] = size(obj)
m = size(obj,dim)
```

**Arguments**

|              |                                                                             |
|--------------|-----------------------------------------------------------------------------|
| obj          | A serial port object or an array of serial port objects.                    |
| dim          | The dimension of obj.                                                       |
| d            | The number of rows and columns in obj.                                      |
| m            | The number of rows in obj, or the length of the dimension specified by dim. |
| n            | The number of columns in obj.                                               |
| m1,m2,...,mn | The length of the first N dimensions of obj.                                |

**Description**

`d = size(obj)` returns the two-element row vector `d` containing the number of rows and columns in `obj`.

`[m,n] = size(obj)` returns the number of rows and columns in separate output variables.

`[m1,m2,m3,...,mn] = size(obj)` returns the length of the first `n` dimensions of `obj`.

`m = size(obj,dim)` returns the length of the dimension specified by the scalar `dim`. For example, `size(obj,1)` returns the number of rows.

**See Also** **Functions**

length

## size (timeseries)

---

|                    |                                                                                                                                                                                                                   |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Size of timeseries object                                                                                                                                                                                         |
| <b>Syntax</b>      | <code>size(ts)</code>                                                                                                                                                                                             |
| <b>Description</b> | <code>size(ts)</code> returns <code>[n 1]</code> , where <code>n</code> is the length of the time vector for timeseries object <code>ts</code> .                                                                  |
| <b>Remarks</b>     | <p>If you want the size of the whole data set, use the following syntax:</p> <pre>size(ts.data)</pre> <p>If you want the size of each data sample, use the following syntax:</p> <pre>getdatasamplesize(ts)</pre> |
| <b>See Also</b>    | <code>getdatasamplesize</code> , <code>isempty (timeseries)</code> , <code>length (timeseries)</code>                                                                                                             |



**Purpose** Size of tscollection object

**Syntax** `size(tsc)`

**Description** `size(tsc)` returns `[n m]`, where `n` is the length of the time vector and `m` is the number of tscollection members.

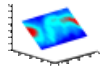
**See Also** `length (tscollection)`, `isempty (tscollection)`, `tscollection`

# slice


---

## Purpose

Volumetric slice plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
slice(V, sx, sy, sz)
slice(X, Y, Z, V, sx, sy, sz)
slice(V, XI, YI, ZI)
slice(X, Y, Z, V, XI, YI, ZI)
slice(..., 'method')
slice(axes_handle, ...)
h = slice(...)
```

## Description

`slice` displays orthogonal slice planes through volumetric data.

`slice(V, sx, sy, sz)` draws slices along the  $x$ ,  $y$ ,  $z$  directions in the volume  $V$  at the points in the vectors  $sx$ ,  $sy$ , and  $sz$ .  $V$  is an  $m$ -by- $n$ -by- $p$  volume array containing data values at the default location  $X = 1:n$ ,  $Y = 1:m$ ,  $Z = 1:p$ . Each element in the vectors  $sx$ ,  $sy$ , and  $sz$  defines a slice plane in the  $x$ -,  $y$ -, or  $z$ -axis direction.

`slice(X, Y, Z, V, sx, sy, sz)` draws slices of the volume  $V$ .  $X$ ,  $Y$ , and  $Z$  are three-dimensional arrays specifying the coordinates for  $V$ .  $X$ ,  $Y$ , and  $Z$  must be monotonic and orthogonally spaced (as if produced by the function `meshgrid`). The color at each point is determined by 3-D interpolation into the volume  $V$ .

`slice(V, XI, YI, ZI)` draws data in the volume  $V$  for the slices defined by  $XI$ ,  $YI$ , and  $ZI$ .  $XI$ ,  $YI$ , and  $ZI$  are matrices that define a surface, and the volume is evaluated at the surface points.  $XI$ ,  $YI$ , and  $ZI$  must all be the same size.

`slice(X,Y,Z,V,XI,YI,ZI)` draws slices through the volume  $V$  along the surface defined by the arrays  $XI$ ,  $YI$ ,  $ZI$ .

`slice(..., 'method')` specifies the interpolation method. *'method'* is *'linear'*, *'cubic'*, or *'nearest'*.

- *linear* specifies trilinear interpolation (the default).
- *cubic* specifies tricubic interpolation.
- *nearest* specifies nearest-neighbor interpolation.

`slice(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes object (`gca`). The axes `clim` property is set to span the finite values of  $V$ .

`h = slice(...)` returns a vector of handles to surface graphics objects.

## Remarks

The color drawn at each point is determined by interpolation into the volume  $V$ .

## Examples

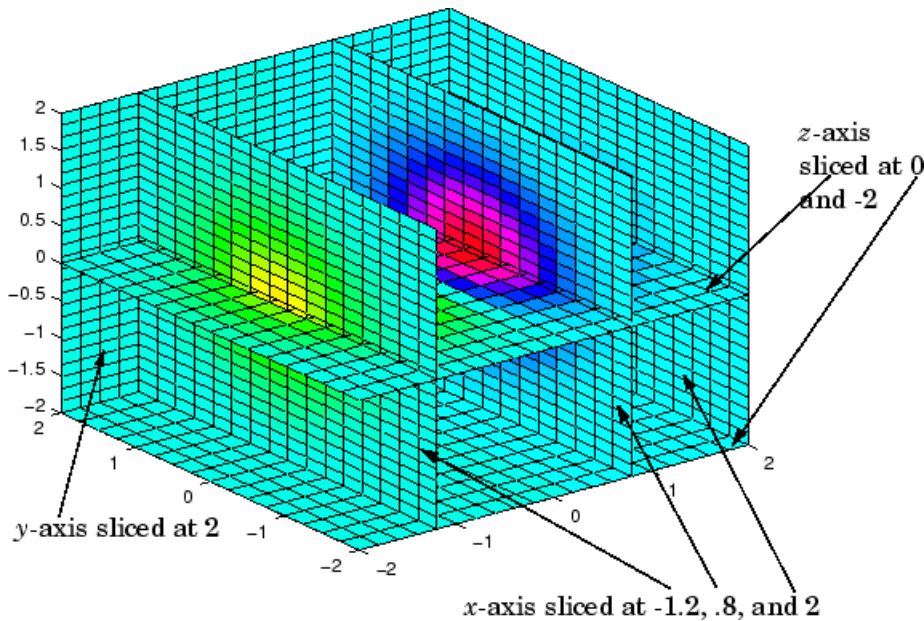
Visualize the function

$$v = xe^{(-x^2 - y^2 - z^2)}$$

over the range  $-2 \leq x \leq 2$ ,  $-2 \leq y \leq 2$ ,  $-2 \leq z \leq 2$ :

```
[x,y,z] = meshgrid(-2:.2:2,-2:.25:2,-2:.16:2);
v = x.*exp(-x.^2-y.^2-z.^2);
xslice = [-1.2,.8,2]; yslice = 2; zslice = [-2,0];
slice(x,y,z,v,xslice,yslice,zslice)
colormap hsv
```

# slice



## Slicing At Arbitrary Angles

You can also create slices that are oriented in arbitrary planes. To do this,

- Create a slice surface in the domain of the volume (`surf, linspace`).
- Orient this surface with respect to the axes (`rotate`).
- Get the `XData`, `YData`, and `ZData` of the surface (`get`).
- Use this data to draw the slice plane within the volume.

For example, these statements slice the volume in the first example with a rotated plane. Placing these commands within a for loop “passes” the plane through the volume along the `z`-axis.

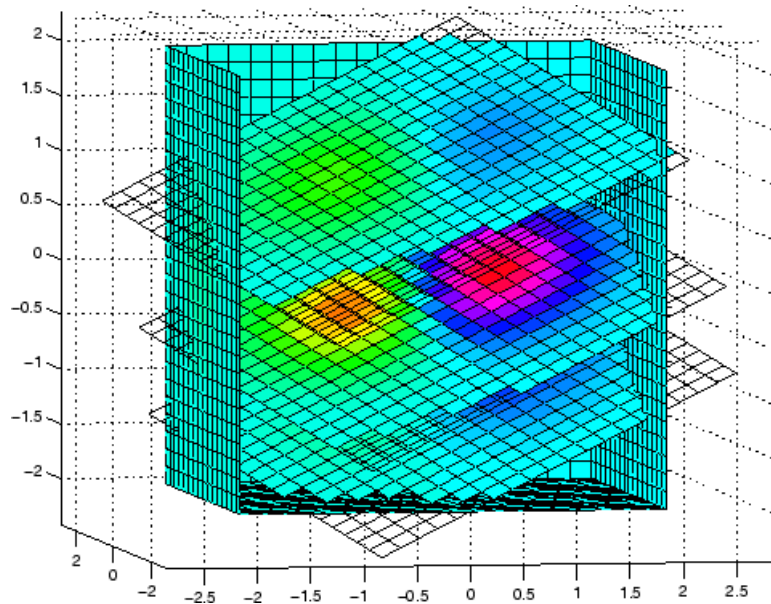
```
for i = -2:.5:2
    hsp = surf(linspace(-2,2,20),linspace(-2,2,20),zeros(20)+i);
```

```

rotate(hsp,[1,-1,1],30)
xd = get(hsp,'XData');
yd = get(hsp,'YData');
zd = get(hsp,'ZData');
delete(hsp)
slice(x,y,z,v,[-2,2],2,-2) % Draw some volume boundaries
hold on
slice(x,y,z,v,xd,yd,zd)
hold off
axis tight
view(-5,10)
drawnow
end

```

The following picture illustrates three positions of the same slice surface as it passes through the volume.



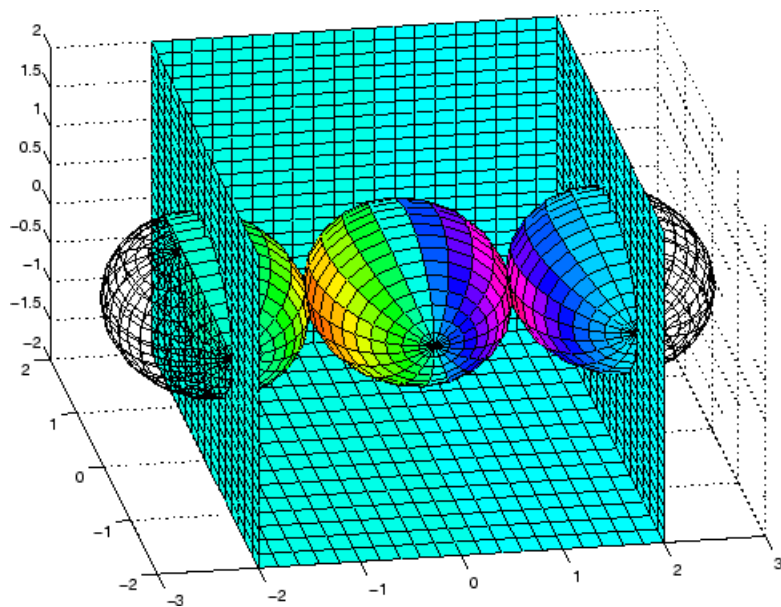
## Slicing with a Nonplanar Surface

You can slice the volume with any surface. This example probes the volume created in the previous example by passing a spherical slice surface through the volume.

```
[xsp,ysp,zsp] = sphere;
slice(x,y,z,v,[-2,2],2,-2) % Draw some volume boundaries

for i = -3:.2:3
    hsp = surface(xsp+i,ysp,zsp);
    rotate(hsp,[1 0 0],90)
    xd = get(hsp,'XData');
    yd = get(hsp,'YData');
    zd = get(hsp,'ZData');
    delete(hsp)
    hold on
    hslicer = slice(x,y,z,v,xd,yd,zd);
    axis tight
    xlim([-3,3])
    view(-10,35)
    drawnow
    delete(hslicer)
    hold off
end
```

The following picture illustrates three positions of the spherical slice surface as it passes through the volume.

**See Also**

`interp3`, `meshgrid`

“Volume Visualization” on page 1-102 for related functions

Exploring Volumes with Slice Planes for more examples

# smooth3

---

**Purpose** Smooth 3-D data

## Syntax

**Description** `W = smooth3(V)` smooths the input data `V` and returns the smoothed data in `W`.

`W = smooth3(V, 'filter')` *filter* determines the convolution kernel and can be the strings

- 'gaussian'
- 'box' (default)

`W = smooth3(V, 'filter', size)` sets the size of the convolution kernel (default is [3 3 3]). If `size` is scalar, then `size` is interpreted as [size, size, size].

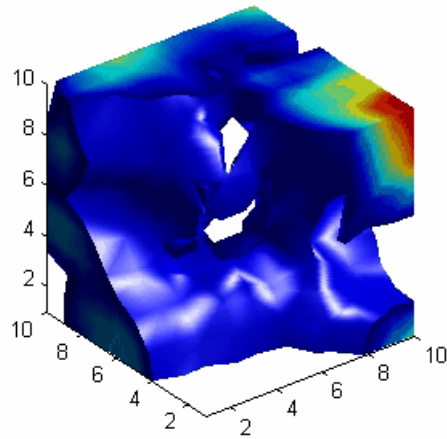
`W = smooth3(V, 'filter', size, sd)` sets an attribute of the convolution kernel. When *filter* is gaussian, `sd` is the standard deviation (default is .65).

## Examples

This example smooths some random 3-D data and then creates an isosurface with end caps.

```
rand('seed',0)
data = rand(10,10,10);
data = smooth3(data,'box',5);
p1 = patch(isosurface(data,.5), ...
    'FaceColor','blue','EdgeColor','none');
p2 = patch(isocaps(data,.5), ...
    'FaceColor','interp','EdgeColor','none');
isonormals(data,p1)
view(3); axis vis3d tight
camlight; lighting phong
```



**See Also**

isocaps, isonormals, isosurface, patch

“Volume Visualization” on page 1-102 for related functions

See Displaying an Isosurface for another example.

# sort

---

**Purpose** Sort array elements in ascending or descending order

**Syntax**

```
B = sort(A)
B = sort(A,dim)
B = sort(...,mode)
[B,IX] = sort(A,...)
```

**Description** `B = sort(A)` sorts the elements along different dimensions of an array, and arranges those elements in ascending order.

| If A is a ...          | sort(A) ...                                                                              |
|------------------------|------------------------------------------------------------------------------------------|
| Vector                 | Sorts the elements of A.                                                                 |
| Matrix                 | Sorts each column of A.                                                                  |
| Multidimensional array | Sorts A along the first non-singleton dimension, and returns an array of sorted vectors. |
| Cell array of strings  | Sorts the strings in ASCII dictionary order.                                             |

Integer, floating-point, logical, and character arrays are permitted. Floating-point arrays can be complex. For elements of A with identical values, the order of these elements is preserved in the sorted list. When A is complex, the elements are sorted by magnitude, i.e., `abs(A)`, and where magnitudes are equal, further sorted by phase angle, i.e., `angle(A)`, on the interval  $[-\pi, \pi]$ . If A includes any NaN elements, `sort` places these at the high end.

`B = sort(A,dim)` sorts the elements along the dimension of A specified by a scalar `dim`.

`B = sort(...,mode)` sorts the elements in the specified direction, depending on the value of `mode`.

'ascend' Ascending order (default)

'descend' Descending order

`[B,IX] = sort(A,...)` also returns an array of indices `IX`, where `size(IX) == size(A)`. If `A` is a vector, `B = A(IX)`. If `A` is an `m`-by-`n` matrix, then each column of `IX` is a permutation vector of the corresponding column of `A`, such that

```
for j = 1:n
    B(:,j) = A(IX(:,j),j);
end
```

If `A` has repeated elements of equal value, the returned indices preserve the original ordering.

### Sorting Complex Entries

If `A` has complex entries `r` and `s`, `sort` orders them according to the following rule: `r` appears before `s` in `sort(A)` if either of the following hold:

- `abs(r) < abs(s)`
- `abs(r) = abs(s)` and `angle(r) < angle(s)`

where  $-\pi < \text{angle}(r) \leq \pi$

For example,

```
v = [1 -1 i -i];
angle(v)

ans =

    0    3.1416    1.5708   -1.5708

sort(v)

ans =

    0 - 1.0000i    1.0000
    0 + 1.0000i   -1.0000
```

# sort

---

---

**Note** `sort` uses a different rule for ordering complex numbers than do `max` and `min`, or the relational operators `<` and `>`. See the Relational Operators reference page for more information.

---

## Examples

### Example 1

This example sorts a matrix `A` in each dimension, and then sorts it a third time, returning an array of indices for the sorted result.

```
A = [ 3 7 5
      0 4 2 ];
```

```
sort(A,1)
```

```
ans =
     0     4     2
     3     7     5
```

```
sort(A,2)
```

```
ans =
     3     5     7
     0     2     4
```

```
[B,IX] = sort(A,2)
```

```
B =
     3     5     7
     0     2     4
```

```
IX =
     1     3     2
     1     3     2
```

### Example 2

This example sorts each column of a matrix in descending order.

```
A = [ 3 7 5
      6 8 3
      0 4 2 ];

sort(A,1,'descend')
```

```
ans =
     6     8     5
     3     7     3
     0     4     2
```

This is equivalent to

```
sort(A,'descend')

ans =
     6     8     5
     3     7     3
     0     4     2
```

**See Also**

issorted, max, mean, median, min, sortrows

# sortrows

---

**Purpose** Sort rows in ascending order

**Syntax**  
B = sortrows(A)  
B = sortrows(A,column)  
[B,index] = sortrows(A,...)

**Description** B = sortrows(A) sorts the rows of A in ascending order. Argument A must be either a matrix or a column vector.

For strings, this is the familiar dictionary sort. When A is complex, the elements are sorted by magnitude, and, where magnitudes are equal, further sorted by phase angle on the interval  $[-\pi, \pi]$ .

B = sortrows(A,column) sorts the matrix based on the columns specified in the vector column. If an element of column is positive, MATLAB sorts the corresponding column of matrix A in ascending order; if an element of column is negative, MATLAB sorts the corresponding column in descending order. For example, sortrows(A,[2 -3]) sorts the rows of A first in ascending order for the second column, and then by descending order for the third column.

[B,index] = sortrows(A,...) also returns an index vector index.

If A is a column vector, then B = A(index). If A is an m-by-n matrix, then B = A(index,:).

## Examples

Start with a mostly random matrix, A:

```
rand('state',0)
A = floor(rand(6,7) * 100);
A(1:4,1)=95; A(5:6,1)=76; A(2:4,2)=7; A(3,3)=73
A =
    95    45    92    41    13     1    84
    95     7    73    89    20    74    52
    95     7    73     5    19    44    20
    95     7    40    35    60    93    67
    76    61    93    81    27    46    83
    76    79    91     0    19    41     1
```

When called with only a single input argument, `sortrows` bases the sort on the first column of the matrix. For any rows that have equal elements in a particular column, (e.g., `A(1:4,1)` for this matrix), sorting is based on the column immediately to the right, (`A(1:4,2)` in this case):

```
sortrows(A)
ans =
    76    61    93    81    27    46    83
    76    79    91     0    19    41     1
    95     7    40    35    60    93    67
    95     7    73     5    19    44    20
    95     7    73    89    20    74    52
    95    45    92    41    13     1    84
```

When called with two input arguments, `sortrows` bases the sort entirely on the column specified in the second argument. Rows that have equal elements in this column are sorted; rows with equal elements in other columns are left in their original order:

```
sortrows(A,1)
ans =
    76    61    93    81    27    46    83
    76    79    91     0    19    41     1
    95    45    92    41    13     1    84
    95     7    73    89    20    74    52
    95     7    73     5    19    44    20
    95     7    40    35    60    93    67
```

This example specifies two columns to sort by: columns 1 and 7. This tells `sortrows` to sort by column 1 first, and then for any rows with equal values in column 1, to sort by column 7:

```
sortrows(A,[1 7])
ans =
    76    79    91     0    19    41     1
    76    61    93    81    27    46    83
    95     7    73     5    19    44    20
    95     7    73    89    20    74    52
```

## sortrows

---

```
95    7    40    35    60    93    67
95   45    92    41    13     1    84
```

Sort the matrix using the values in column 4 this time and in reverse order:

```
sortrows(A, -4)
ans =
95     7    73    89    20    74    52
76    61    93    81    27    46    83
95    45    92    41    13     1    84
95     7    40    35    60    93    67
95     7    73     5    19    44    20
76    79    91     0    19    41     1
```

### See Also

issorted, sort



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Convert vector into sound                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Syntax</b>      | <code>sound(y,Fs)</code><br><code>sound(y)</code><br><code>sound(y,Fs,bits)</code>                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Description</b> | <code>sound(y,Fs)</code> sends the signal in vector <code>y</code> (with sample frequency <code>Fs</code> ) to the speaker on PC and most UNIX platforms. Values in <code>y</code> are assumed to be in the range $-1.0 \leq y \leq 1.0$ . Values outside that range are clipped. Stereo sound is played on platforms that support it when <code>y</code> is an <code>n-by-2</code> matrix. The values in column 1 are assigned to the left channel, and those in column 2 to the right. |
|                    | <hr/> <b>Note</b> The playback duration that results from setting <code>Fs</code> depends on the sound card you have installed. Most sound cards support sample frequencies of approximately 5-10 kHz to 44.1 kHz. Sample frequencies outside this range can produce unexpected results. <hr/>                                                                                                                                                                                           |
|                    | <code>sound(y)</code> plays the sound at the default sample rate or 8192 Hz.<br><code>sound(y,Fs,bits)</code> plays the sound using <code>bits</code> number of bits/sample, if possible. Most platforms support <code>bits = 8</code> or <code>bits = 16</code> .                                                                                                                                                                                                                       |
| <b>Remarks</b>     | MATLAB supports all Windows-compatible sound devices. Additional sound acquisition and generation capability is available in the Data Acquisition Toolbox. The toolbox functionality includes the ability to buffer the acquisition so that you can analyze the data as it is being acquired. See the examples on MATLAB sound acquisition and sound generation.                                                                                                                         |
| <b>See Also</b>    | <code>auread</code> , <code>auwrite</code> , <code>soundsc</code> , <code>audioplayer</code> , <code>wavread</code> , <code>wavwrite</code>                                                                                                                                                                                                                                                                                                                                              |

# soundsc

---

**Purpose** Scale data and play as sound

**Syntax** `soundsc(y,Fs)`  
`soundsc(y)`  
`soundsc(y,Fs,bits)`  
`soundsc(y,...,slim)`

**Description** `soundsc(y,Fs)` sends the signal in vector `y` (with sample frequency `Fs`) to the speaker on PC and most UNIX platforms. The signal `y` is scaled to the range  $-1.0 \leq y \leq 1.0$  before it is played, resulting in a sound that is played as loud as possible without clipping.

---

**Note** The playback duration that results from setting `Fs` depends on the sound card you have installed. Most sound cards support sample frequencies of approximately 5-10 kHz to 44.1 kHz. Sample frequencies outside this range can produce unexpected results.

---

`soundsc(y)` plays the sound at the default sample rate or 8192 Hz.

`soundsc(y,Fs,bits)` plays the sound using `bits` number of bits/sample if possible. Most platforms support `bits = 8` or `bits = 16`.

`soundsc(y,...,slim)`, where `slim = [slow shigh]`, maps the values in `y` between `slow` and `shigh` to the full sound range. The default value is `slim = [min(y) max(y)]`.

**Remarks** MATLAB supports all Windows-compatible sound devices.

**See Also** `auread`, `auwrite`, `sound`, `wavread`, `wavwrite`

**Purpose** Allocate space for sparse matrix

**Syntax** `S = spalloc(m,n,nzmax)`

**Description** `S = spalloc(m,n,nzmax)` creates an all zero sparse matrix `S` of size `m`-by-`n` with room to hold `nzmax` nonzeros. The matrix can then be generated column by column without requiring repeated storage allocation as the number of nonzeros grows.

`spalloc(m,n,nzmax)` is shorthand for

```
sparse([],[],[],m,n,nzmax)
```

**Examples** To generate efficiently a sparse matrix that has an average of at most three nonzero elements per column

```
S = spalloc(n,n,3*n);  
for j = 1:n  
    S(:,j) = [zeros(n-3,1)' round(rand(3,1))']';end
```

# sparse

---

## Purpose

Create sparse matrix

## Syntax

```
S = sparse(A)
S = sparse(i, j, s, m, n, nzmax)
S = sparse(i, j, s, m, n)
S = sparse(i, j, s)
S = sparse(m, n)
```

## Description

The `sparse` function generates matrices in the MATLAB sparse storage organization.

`S = sparse(A)` converts a full matrix to sparse form by squeezing out any zero elements. If `S` is already sparse, `sparse(S)` returns `S`.

`S = sparse(i, j, s, m, n, nzmax)` uses vectors `i`, `j`, and `s` to generate an `m`-by-`n` sparse matrix such that  $S(i(k), j(k)) = s(k)$ , with space allocated for `nzmax` nonzeros. Vectors `i`, `j`, and `s` are all the same length. Any elements of `s` that are zero are ignored, along with the corresponding values of `i` and `j`. Any elements of `s` that have duplicate values of `i` and `j` are added together.

---

**Note** If any value in `i` or `j` is larger than the maximum integer size,  $2^{31}-1$ , then the sparse matrix cannot be constructed.

---

To simplify this six-argument call, you can pass scalars for the argument `s` and one of the arguments `i` or `j`—in which case they are expanded so that `i`, `j`, and `s` all have the same length.

`S = sparse(i, j, s, m, n)` uses `nzmax = length(s)`.

`S = sparse(i, j, s)` uses `m = max(i)` and `n = max(j)`. The maxima are computed before any zeros in `s` are removed, so one of the rows of `[i j s]` might be `[m n 0]`.

`S = sparse(m, n)` abbreviates `sparse([], [], [], m, n, 0)`. This generates the ultimate sparse matrix, an `m`-by-`n` all zero matrix.

**Remarks**

All of the MATLAB built-in arithmetic, logical, and indexing operations can be applied to sparse matrices, or to mixtures of sparse and full matrices. Operations on sparse matrices return sparse matrices and operations on full matrices return full matrices.

In most cases, operations on mixtures of sparse and full matrices return full matrices. The exceptions include situations where the result of a mixed operation is structurally sparse, for example,  $A * S$  is at least as sparse as  $S$ .

**Examples**

`S = sparse(1:n,1:n,1)` generates a sparse representation of the  $n$ -by- $n$  identity matrix. The same  $S$  results from `S = sparse(eye(n,n))`, but this would also temporarily generate a full  $n$ -by- $n$  matrix with most of its elements equal to zero.

`B = sparse(10000,10000,pi)` is probably not very useful, but is legal and works; it sets up a 10000-by-10000 matrix with only one nonzero element. Don't try `full(B)`; it requires 800 megabytes of storage.

This dissects and then reassembles a sparse matrix:

```
[i,j,s] = find(S);  
[m,n] = size(S);  
S = sparse(i,j,s,m,n);
```

So does this, if the last row and column have nonzero entries:

```
[i,j,s] = find(S);  
S = sparse(i,j,s);
```

**See Also**

`diag`, `find`, `full`, `issparse`, `nnz`, `nonzeros`, `nzmax`, `spones`, `sprandn`, `sprandsym`, `spy`

The `sparfun` directory

# spaugment

---

**Purpose** Form least squares augmented system

**Syntax**  $S = \text{spaugment}(A, c)$   
 $S = \text{spaugment}(A)$

**Description**  $S = \text{spaugment}(A, c)$  creates the sparse, square, symmetric indefinite matrix  $S = [c \cdot I \ A; A' \ 0]$ . The matrix  $S$  is related to the least squares problem

$$\min \text{norm}(b - A \cdot x)$$

by

$$r = b - A \cdot x$$
$$S * [r/c; x] = [b; 0]$$

The optimum value of the residual scaling factor  $c$ , involves  $\min(\text{svd}(A))$  and  $\text{norm}(r)$ , which are usually too expensive to compute.

$S = \text{spaugment}(A)$  without a specified value of  $c$ , uses  $\max(\max(\text{abs}(A))) / 1000$ .

---

**Note** In previous versions of MATLAB, the augmented matrix was used by sparse linear equation solvers,  $\backslash$  and  $/$ , for nonsquare problems. Now, MATLAB performs a least squares solve using the qr factorization of  $A$  instead.

---

**See Also** spparms

**Purpose** Import matrix from sparse matrix external format

**Syntax** `S = spconvert(D)`

**Description** `spconvert` is used to create sparse matrices from a simple sparse format easily produced by non-MATLAB sparse programs. `spconvert` is the second step in the process:

- 1 Load an ASCII data file containing `[i, j, v]` or `[i, j, re, im]` as rows into a MATLAB variable.
- 2 Convert that variable into a MATLAB sparse matrix.

`S = spconvert(D)` converts a matrix `D` with rows containing `[i, j, s]` or `[i, j, r, s]` to the corresponding sparse matrix. `D` must have an `nnz` or `nnz+1` row and three or four columns. Three elements per row generate a real matrix and four elements per row generate a complex matrix. A row of the form `[m n 0]` or `[m n 0 0]` anywhere in `D` can be used to specify `size(S)`. If `D` is already sparse, no conversion is done, so `spconvert` can be used after `D` is loaded from either a MAT-file or an ASCII file.

**Examples** Suppose the ASCII file `uphill.dat` contains

```

1   1   1.0000000000000000
1   2   0.5000000000000000
2   2   0.3333333333333333
1   3   0.3333333333333333
2   3   0.2500000000000000
3   3   0.2000000000000000
1   4   0.2500000000000000
2   4   0.2000000000000000
3   4   0.1666666666666667
4   4   0.142857142857143
4   4   0.0000000000000000

```

Then the statements

## spconvert

---

```
load uphill.dat
H = spconvert(uphill)
```

```
H =
    (1,1)    1.0000
    (1,2)    0.5000
    (2,2)    0.3333
    (1,3)    0.3333
    (2,3)    0.2500
    (3,3)    0.2000
    (1,4)    0.2500
    (2,4)    0.2000
    (3,4)    0.1667
    (4,4)    0.1429
```

recreate `sparse(triu(hilb(4)))`, possibly with roundoff errors. In this case, the last line of the input file is not necessary because the earlier lines already specify that the matrix is at least 4-by-4.



**Purpose**

Extract and create sparse band and diagonal matrices

**Syntax**

```
B = spdiags(A)
[B,d] = spdiags(A)
B = spdiags(A,d)
A = spdiags(B,d,A)
A = spdiags(B,d,m,n)
```

**Description**

The `spdiags` function generalizes the function `diag`. Four different operations, distinguished by the number of input arguments, are possible.

`B = spdiags(A)` extracts all nonzero diagonals from the  $m$ -by- $n$  matrix  $A$ .  $B$  is a  $\min(m,n)$ -by- $p$  matrix whose columns are the  $p$  nonzero diagonals of  $A$ .

`[B,d] = spdiags(A)` returns a vector  $d$  of length  $p$ , whose integer components specify the diagonals in  $A$ .

`B = spdiags(A,d)` extracts the diagonals specified by  $d$ .

`A = spdiags(B,d,A)` replaces the diagonals specified by  $d$  with the columns of  $B$ . The output is sparse.

`A = spdiags(B,d,m,n)` creates an  $m$ -by- $n$  sparse matrix by taking the columns of  $B$  and placing them along the diagonals specified by  $d$ .

---

**Note** In this syntax, if a column of  $B$  is longer than the diagonal it is replacing, and  $m \geq n$ , `spdiags` takes elements of super-diagonals from the lower part of the column of  $B$ , and elements of sub-diagonals from the upper part of the column of  $B$ . However, if  $m < n$ , then super-diagonals are from the upper part of the column of  $B$ , and sub-diagonals from the lower part. (See “Example 5A” on page 2-2967 and “Example 5B” on page 2-2969, below).

---

**Arguments**

The `spdiags` function deals with three matrices, in various combinations, as both input and output.

- A An  $m$ -by- $n$  matrix, usually (but not necessarily) sparse, with its nonzero or specified elements located on  $p$  diagonals.
- B A  $\min(m, n)$ -by- $p$  matrix, usually (but not necessarily) full, whose columns are the diagonals of A.
- d A vector of length  $p$  whose integer components specify the diagonals in A.

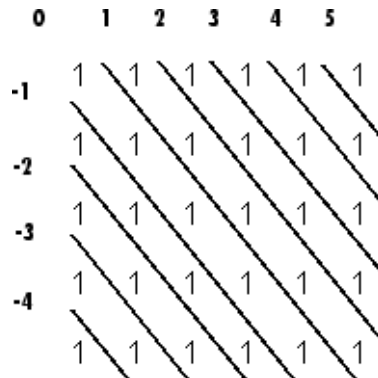
Roughly, A, B, and d are related by

```
for k = 1:p
    B(:,k) = diag(A,d(k))
end
```

Some elements of B, corresponding to positions outside of A, are not defined by these loops. They are not referenced when B is input and are set to zero when B is output.

### How the Diagonals of A are Listed in the Vector d

An  $m$ -by- $n$  matrix A has  $m+n-1$  diagonals. These are specified in the vector d using indices from  $-m+1$  to  $n-1$ . For example, if A is 5-by-6, it has 10 diagonals, which are specified in the vector d using the indices -4, -3, ..., 4, 5. The following diagram illustrates this for a vector of all ones.



**Examples****Example 1**

For the following matrix,

```
A=[0 5 0 10 0 0;...
0 0 6 0 11 0;...
3 0 0 7 0 12;...
1 4 0 0 8 0;...
0 2 5 0 0 9]
```

A =

|   |   |   |    |    |    |
|---|---|---|----|----|----|
| 0 | 5 | 0 | 10 | 0  | 0  |
| 0 | 0 | 6 | 0  | 11 | 0  |
| 3 | 0 | 0 | 7  | 0  | 12 |
| 1 | 4 | 0 | 0  | 8  | 0  |
| 0 | 2 | 5 | 0  | 0  | 9  |

the command

```
[B, d] =spdiags(A)
```

returns

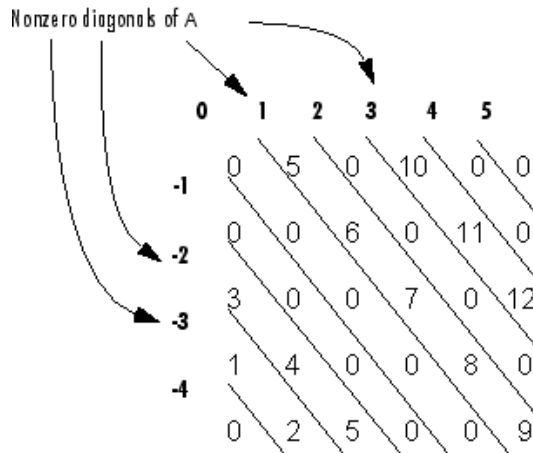
B =

|   |   |   |    |
|---|---|---|----|
| 0 | 0 | 5 | 10 |
| 0 | 0 | 6 | 11 |
| 0 | 3 | 7 | 12 |
| 1 | 4 | 8 | 0  |
| 2 | 5 | 9 | 0  |

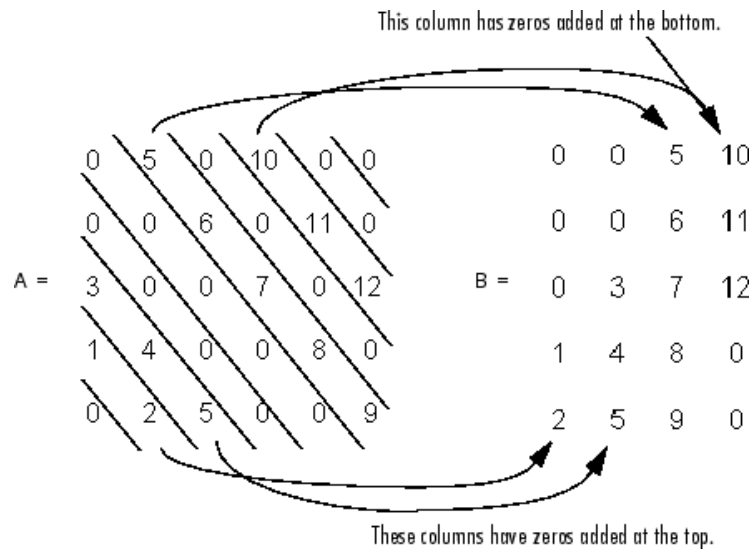
d =

```
-3
-2
1
```

The columns of the first output B contain the nonzero diagonals of A. The second output d lists the indices of the nonzero diagonals of A, as shown in the following diagram. See “How the Diagonals of A are Listed in the Vector d” on page 2-2962.



Note that the longest nonzero diagonal in A is contained in column 3 of B. The other nonzero diagonals of A have extra zeros added to their corresponding columns in B, to give all columns of B the same length. For the nonzero diagonals below the main diagonal of A, extra zeros are added at the tops of columns. For the nonzero diagonals above the main diagonal of A, extra zeros are added at the bottoms of columns. This is illustrated by the following diagram.



### Example 2

This example generates a sparse tridiagonal representation of the classic second difference operator on  $n$  points.

```
e = ones(n,1);
A = spdiags([e -2*e e], -1:1, n, n)
```

Turn it into Wilkinson's test matrix (see gallery):

```
A = spdiags(abs(-(n-1)/2:(n-1)/2)', 0, A)
```

Finally, recover the three diagonals:

```
B = spdiags(A)
```

### Example 3

The second example is not square.

```
A = [11 0 13 0
      0 22 0 24]
```

# spdiags

---

```
0 0 33 0
41 0 0 44
0 52 0 0
0 0 63 0
0 0 0 74]
```

Here  $m = 7$ ,  $n = 4$ , and  $p = 3$ .

The statement `[B,d] = spdiags(A)` produces `d = [-3 0 2]'` and

```
B = [41 11 0
      52 22 0
      63 33 13
      74 44 24]
```

Conversely, with the above B and d, the expression `spdiags(B,d,7,4)` reproduces the original A.

## Example 4

This example shows how `spdiags` creates the diagonals when the columns of B are longer than the diagonals they are replacing.

```
B = repmat((1:6)', [1 7])
```

```
B =
```

```
1 1 1 1 1 1 1
2 2 2 2 2 2 2
3 3 3 3 3 3 3
4 4 4 4 4 4 4
5 5 5 5 5 5 5
6 6 6 6 6 6 6
```

```
d = [-4 -2 -1 0 3 4 5];
```

```
A = spdiags(B,d,6,6);
```

```
full(A)
```

```
ans =
```

```

1  0  0  4  5  6
1  2  0  0  5  6
1  2  3  0  0  6
0  2  3  4  0  0
1  0  3  4  5  0
0  2  0  4  5  6

```

### Example 5A

This example illustrates the use of the syntax  $A = \text{spdiags}(B, d, m, n)$ , under three conditions:

- $m$  is equal to  $n$
- $m$  is greater than  $n$
- $m$  is less than  $n$

The command used in this example is

```
A = full(spdiags(B, [-2 0 2], m, n))
```

where  $B$  is the 5-by-3 matrix shown below. The resulting matrix  $A$  has dimensions  $m$ -by- $n$ , and has nonzero diagonals at  $[-2\ 0\ 2]$  (a sub-diagonal at  $-2$ , the main diagonal, and a super-diagonal at  $2$ ).

```

B =
   1   6  11
   2   7  12
   3   8  13
   4   9  14
   5  10  15

```

The first and third columns of matrix  $B$  are used to create the sub- and super-diagonals of  $A$  respectively. In all three cases though, these two outer columns of  $B$  are longer than the resulting diagonals of  $A$ . Because of this, only a part of the columns is used in  $A$ .

When  $m == n$  or  $m > n$ , `spdiags` takes elements of the super-diagonal in A from the lower part of the corresponding column of B, and elements of the sub-diagonal in A from the upper part of the corresponding column of B.

When  $m < n$ , `spdiags` does the opposite, taking elements of the super-diagonal in A from the upper part of the corresponding column of B, and elements of the sub-diagonal in A from the lower part of the corresponding column of B.

## Part 1 – m is equal to n.

```
A = full(spdiags(B, [-2 0 2], 5, 5))
```

| Matrix B |    |    | Matrix A |   |    |    |    |
|----------|----|----|----------|---|----|----|----|
| 1        | 6  | 11 | 6        | 0 | 13 | 0  | 0  |
| 2        | 7  | 12 | 0        | 7 | 0  | 14 | 0  |
| 3        | 8  | 13 | 1        | 0 | 8  | 0  | 15 |
| 4        | 9  | 14 | 0        | 2 | 0  | 9  | 0  |
| 5        | 10 | 15 | 0        | 0 | 3  | 0  | 10 |

A(3,1), A(4,2), and A(5,3) are taken from the upper part of B(:,1).

A(1,3), A(2,4), and A(3,5) are taken from the lower part of B(:,3).

## Part 2 – m is greater than n.

```
A = full(spdiags(B, [-2 0 2], 5, 4))
```

| Matrix B |    |    | Matrix A |   |    |    |
|----------|----|----|----------|---|----|----|
| 1        | 6  | 11 | 6        | 0 | 13 | 0  |
| 2        | 7  | 12 | 0        | 7 | 0  | 14 |
| 3        | 8  | 13 | 1        | 0 | 8  | 0  |
| 4        | 9  | 14 | 0        | 2 | 0  | 9  |
| 5        | 10 | 15 | 0        | 0 | 3  | 0  |

Same as in Part A.



**Part 3 – m is less than n.**

```
A = full(spdiags(B, [-2 0 2], 4, 5))
```

| Matrix B     |                | Matrix A               |
|--------------|----------------|------------------------|
| 1    6    11 |                | 6    0    11    0    0 |
| 2    7    12 |                | 0    7    0    12    0 |
| 3    8    13 | == spdiags ==> | 3    0    8    0    13 |
| 4    9    14 |                | 0    4    0    9    0  |
| 5    10   15 |                |                        |

A(3,1) and A(4,2) are taken from the lower part of B(:,1).

A(1,3), A(2,4), and A(3,5) are taken from the upper part of B(:,3).

**Example 5B**

Extract the diagonals from the first part of this example back into a column format using the command

```
B = spdiags(A)
```

You can see that in each case the original columns are restored (minus those elements that had overflowed the super- and sub-diagonals of matrix A).

**Part 1.**

| Matrix A               |                | Matrix B     |
|------------------------|----------------|--------------|
| 6    0    13    0    0 |                | 1    6    0  |
| 0    7    0    14    0 |                | 2    7    0  |
| 1    0    8    0    15 | == spdiags ==> | 3    8    13 |
| 0    2    0    9    0  |                | 0    9    14 |
| 0    0    3    0    10 |                | 0    10   15 |

**Part 2.**

Matrix A
Matrix B

# spdiags

---

```
6  0  13  0          1  6  0
0  7  0  14         2  7  0
1  0  8  0   == spdiags => 3  8  13
0  2  0  9          0  9  14
0  0  3  0
```

## Part 3.

```
Matrix A              Matrix B
6  0  11  0  0          0  6  11
0  7  0  12  0         0  7  12
3  0  8  0  13   == spdiags => 3  8  13
0  4  0  9  0          4  9  0
```

## See Also

diag, speye

**Purpose** Calculate specular reflectance

**Syntax** `R = specular(Nx,Ny,Nz,S,V)`

**Description** `R = specular(Nx,Ny,Nz,S,V)` returns the reflectance of a surface with normal vector components `[Nx,Ny,Nz]`. `S` and `V` specify the direction to the light source and to the viewer, respectively. You can specify these directions as three vectors `[x,y,z]` or two vectors `[Theta Phi]` (in spherical coordinates).

The specular highlight is strongest when the normal vector is in the direction of  $(S+V)/2$  where `S` is the source direction, and `V` is the view direction.

The surface spread exponent can be specified by including a sixth argument as in `specular(Nx,Ny,Nz,S,V,spread)`.

# speye

---

|                    |                                                                                                                                                                                                                                                                                                                            |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Sparse identity matrix                                                                                                                                                                                                                                                                                                     |
| <b>Syntax</b>      | <code>S = speye(m,n)</code><br><code>S = speye(n)</code>                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <code>S = speye(m,n)</code> forms an m-by-n sparse matrix with 1s on the main diagonal.<br><code>S = speye(n)</code> abbreviates <code>speye(n,n)</code> .                                                                                                                                                                 |
| <b>Examples</b>    | <code>I = speye(1000)</code> forms the sparse representation of the 1000-by-1000 identity matrix, which requires only about 16 kilobytes of storage. This is the same final result as <code>I = sparse(eye(1000,1000))</code> , but the latter requires eight megabytes for temporary storage for the full representation. |
| <b>See Also</b>    | <code>spalloc</code> , <code>spones</code> , <code>spdiags</code> , <code>sprand</code> , <code>sprandn</code>                                                                                                                                                                                                             |

**Purpose** Apply function to nonzero sparse matrix elements

**Syntax** `f = spfun(fun,S)`

**Description** The `spfun` function selectively applies a function to only the *nonzero* elements of a sparse matrix `S`, preserving the sparsity pattern of the original matrix (except for underflow or if `fun` returns zero for some nonzero elements of `S`).

`f = spfun(fun,S)` evaluates `fun(S)` on the nonzero elements of `S`. `fun` is a function handle. See “Function Handles” in the MATLAB Programming documentation for more information.

“Parameterizing Functions Called by Function Functions” in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `fun`, if necessary.

**Remarks** Functions that operate element-by-element, like those in the `elfun` directory, are the most appropriate functions to use with `spfun`.

**Examples** Given the 4-by-4 sparse diagonal matrix

```
S = spdiags([1:4] ',0,4,4)
```

```
S =
(1,1)    1
(2,2)    2
(3,3)    3
(4,4)    4
```

Because `fun` returns nonzero values for all nonzero element of `S`, `f = spfun(@exp,S)` has the same sparsity pattern as `S`.

```
f =
(1,1)    2.7183
(2,2)    7.3891
(3,3)   20.0855
(4,4)   54.5982
```

whereas `exp(S)` has 1s where `S` has 0s.

```
full(exp(S))
```

```
ans =
```

```
2.7183    1.0000    1.0000    1.0000
1.0000    7.3891    1.0000    1.0000
1.0000    1.0000   20.0855    1.0000
1.0000    1.0000    1.0000   54.5982
```

## See Also

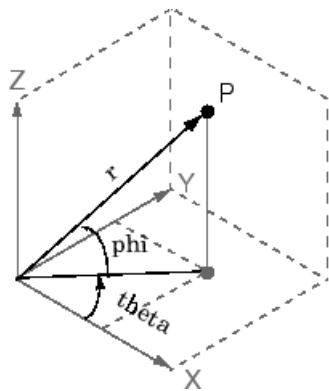
`function_handle` (@)

**Purpose** Transform spherical coordinates to Cartesian

**Syntax** `[x,y,z] = sph2cart(THETA,PHI,R)`

**Description** `[x,y,z] = sph2cart(THETA,PHI,R)` transforms the corresponding elements of spherical coordinate arrays to Cartesian, or  $xyz$ , coordinates. THETA, PHI, and R must all be the same size. THETA and PHI are angular displacements in radians from the positive  $x$ -axis and from the  $x$ - $y$  plane, respectively.

**Algorithm** The mapping from spherical coordinates to three-dimensional Cartesian coordinates is



$$\begin{aligned}x &= r \cdot \cos(\text{phi}) \cdot \cos(\text{theta}) \\y &= r \cdot \cos(\text{phi}) \cdot \sin(\text{theta}) \\z &= r \cdot \sin(\text{phi})\end{aligned}$$

**See Also** `cart2pol`, `cart2sph`, `pol2cart`

# sphere

---

## Purpose

Generate sphere



## Syntax

```
sphere
sphere(n)
[X,Y,Z] = sphere(n)
```

## Description

The sphere function generates the  $x$ -,  $y$ -, and  $z$ -coordinates of a unit sphere for use with `surf` and `mesh`.

`sphere` generates a sphere consisting of 20-by-20 faces.

`sphere(n)` draws a `surf` plot of an  $n$ -by- $n$  sphere in the current figure.

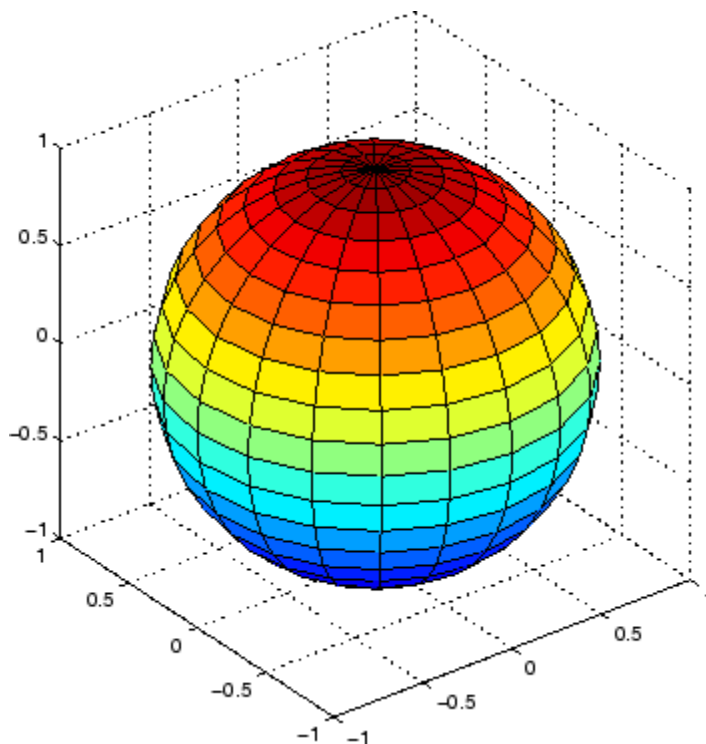
`[X,Y,Z] = sphere(n)` returns the coordinates of a sphere in three matrices that are  $(n+1)$ -by- $(n+1)$  in size. You draw the sphere with `surf(X,Y,Z)` or `mesh(X,Y,Z)`.

## Examples

Generate and plot a sphere.

```
sphere
axis equal
```





**See Also**

cylinder, axis equal

“Polygons and Surfaces” on page 1-90 for related functions

# spinmap

---

**Purpose** Spin colormap

**Syntax** spinmap  
spinmap(t)  
spinmap(t,inc)  
spinmap('inf')

**Description** The spinmap function shifts the colormap RGB values by some incremental value. For example, if the increment equals 1, color 1 becomes color 2, color 2 becomes color 3, etc.

spinmap cyclically rotates the colormap for approximately five seconds using an incremental value of 2.

spinmap(t) rotates the colormap for approximately 10\*t seconds. The amount of time specified by t depends on your hardware configuration (e.g., if you are running MATLAB over a network).

spinmap(t,inc) rotates the colormap for approximately 10\*t seconds and specifies an increment inc by which the colormap shifts. When inc is 1, the rotation appears smoother than the default (i.e., 2). Increments greater than 2 are less smooth than the default. A negative increment (e.g., -2) rotates the colormap in a negative direction.

spinmap('inf') rotates the colormap for an infinite amount of time. To break the loop, press **Ctrl+C**.

**See Also** colormap, colormapeditor

“Color Operations” on page 1-98 for related functions

**Purpose** Cubic spline data interpolation

**Syntax**  
`pp = spline(x,Y)`  
`yy = spline(x,Y,xx)`

**Description** `pp = spline(x,Y)` returns the piecewise polynomial form of the cubic spline interpolant for later use with `ppval` and the spline utility `unmkpp`. `x` must be a vector. `Y` can be a scalar, a vector, or an array of any dimension, subject to the following conditions:

- If `Y` is a scalar or vector, it must have the same length as `x`. A scalar value for `x` or `Y` is expanded to have the same length as the other. See [Exceptions \(1\)](#) for an exception to this rule, in which the not-a-knot end conditions are used.
- If `Y` is an array that is not a vector, the size of `Y` must have the form `[d1,d2,...,dk,n]`, where `n` is the length of `x`. The interpolation is performed for each `d1-by-d2-by-...-dk` value in `Y`. See [Exceptions \(2\)](#) for an exception to this rule.

`yy = spline(x,Y,xx)` is the same as `yy = ppval(spline(x,Y),xx)`, thus providing, in `yy`, the values of the interpolant at `xx`. `xx` can be a scalar, a vector, or a multidimensional array. The sizes of `xx` and `yy` are related as follows:

- If `Y` is a scalar or vector, `yy` has the same size as `xx`.
- If `Y` is an array that is not a vector,
  - If `xx` is a scalar or vector, `size(yy)` equals `[d1, d2, ..., dk, length(xx)]`.
  - If `xx` is an array of size `[m1,m2,...,mj]`, `size(yy)` equals `[d1,d2,...,dk,m1,m2,...,mj]`.

## Exceptions

- 1 If  $Y$  is a vector that contains two more values than  $x$  has entries, the first and last value in  $Y$  are used as the endslopes for the cubic spline. If  $Y$  is a vector, this means
  - $f(x) = Y(2:\text{end}-1)$
  - $df(\min(x)) = Y(1)$
  - $df(\max(x)) = Y(\text{end})$
- 2 If  $Y$  is a matrix or an  $N$ -dimensional array with  $\text{size}(Y,N)$  equal to  $\text{length}(x)+2$ , the following hold:
  - $f(x(j))$  matches the value  $Y(:, \dots, :, j+1)$  for  $j=1:\text{length}(x)$
  - $Df(\min(x))$  matches  $Y(:, :, \dots, 1)$
  - $Df(\max(x))$  matches  $Y(:, :, \dots, \text{end})$

---

**Note** You can also perform spline interpolation using the `interp1` function with the command `interp1(x,y,xx,'spline')`. Note that while `spline` performs interpolation on rows of an input matrix, `interp1` performs interpolation on columns of an input matrix.

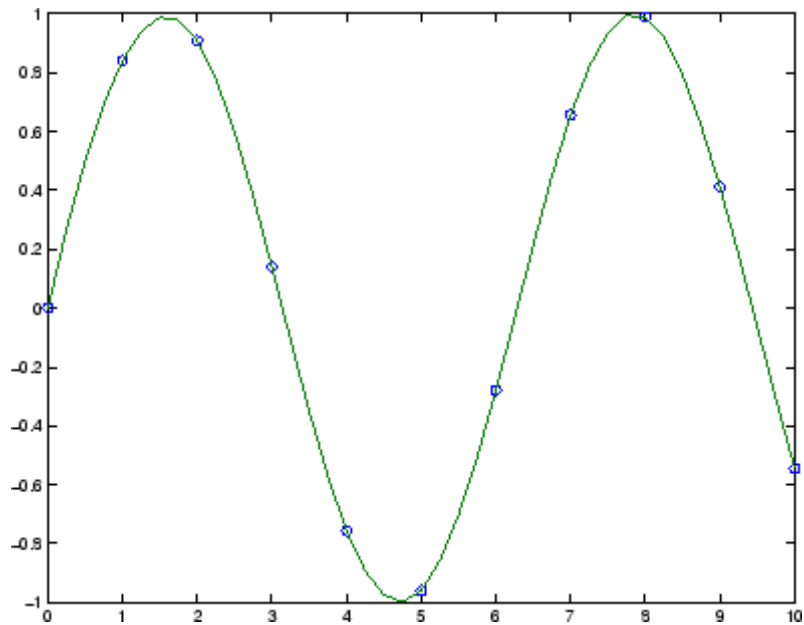
---

## Examples

### Example 1

This generates a sine curve, then samples the spline over a finer mesh.

```
x = 0:10;  
y = sin(x);  
xx = 0:.25:10;  
yy = spline(x,y,xx);  
plot(x,y,'o',xx,yy)
```



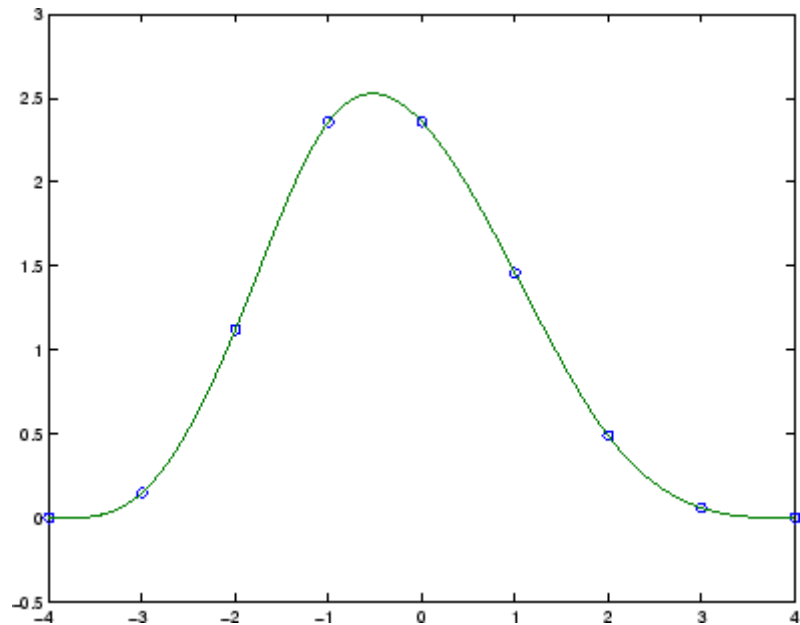
### Example 2

This illustrates the use of clamped or complete spline interpolation where end slopes are prescribed. Zero slopes at the ends of an interpolant to the values of a certain distribution are enforced.

```
x = -4:4;  
y = [0 .15 1.12 2.36 2.36 1.46 .49 .06 0];  
cs = spline(x,[0 y 0]);  
xx = linspace(-4,4,101);  
plot(x,y,'o',xx,ppval(cs,xx),'-');
```

# spline

---



### Example 3

The two vectors

```
t = 1900:10:1990;  
p = [ 75.995  91.972  105.711  123.203  131.669 ...  
      150.697  179.323  203.212  226.505  249.633 ];
```

represent the census years from 1900 to 1990 and the corresponding United States population in millions of people. The expression

```
spline(t,p,2000)
```

uses the cubic spline to extrapolate and predict the population in the year 2000. The result is

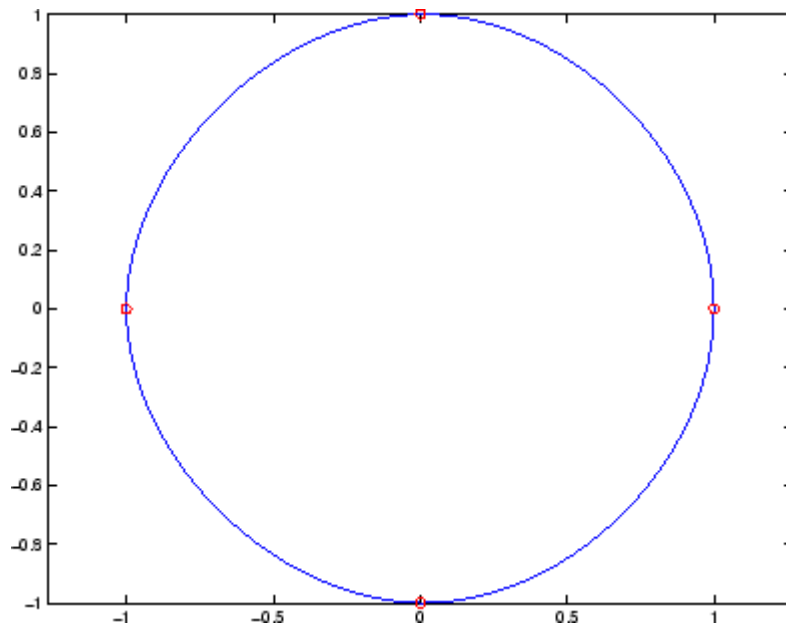
```
ans =  
    270.6060
```

### Example 4

The statements

```
x = pi*[0:.5:2];  
y = [0 1 0 -1 0 1 0;  
     1 0 1 0 -1 0 1];  
pp = spline(x,y);  
yy = ppval(pp, linspace(0,2*pi,101));  
plot(yy(1,:),yy(2,:),'-b',y(1,2:5),y(2,2:5),'or'), axis equal
```

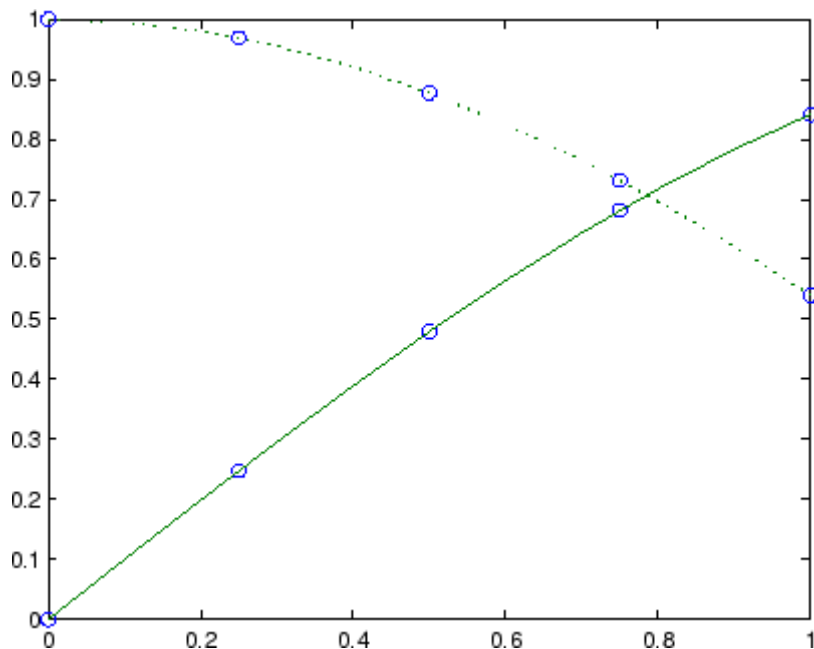
generate the plot of a circle, with the five data points  $y(:,2), \dots, y(:,6)$  marked with o's. Note that this  $y$  contains two more values (i.e., two more columns) than does  $x$ , hence  $y(:,1)$  and  $y(:,end)$  are used as endslopes.



## Example 5

The following code generates sine and cosine curves, then samples the splines over a finer mesh.

```
x = 0:.25:1;
Y = [sin(x); cos(x)];
xx = 0:.1:1;
YY = spline(x,Y,xx);
plot(x,Y(1,:), 'o',xx,YY(1,:), '-'); hold on;
plot(x,Y(2,:), 'o',xx,YY(2,:), ':'); hold off;
```



## Algorithm

A tridiagonal linear system (with, possibly, several right sides) is being solved for the information needed to describe the coefficients of the various cubic polynomials which make up the interpolating spline. spline uses the functions ppval, mkpp, and unmkpp. These routines



form a small suite of functions for working with piecewise polynomials. For access to more advanced features, see the M-file help for these functions and the Spline Toolbox.

**See Also**

`interp1`, `ppval`, `mkpp`, `pchip`, `unmkpp`

**References**

[1] de Boor, C., *A Practical Guide to Splines*, Springer-Verlag, 1978.

# spones

---

**Purpose**

Replace nonzero sparse matrix elements with ones

**Syntax**

$R = \text{spones}(S)$

**Description**

$R = \text{spones}(S)$  generates a matrix  $R$  with the same sparsity structure as  $S$ , but with 1's in the nonzero positions.

**Examples**

$c = \text{sum}(\text{spones}(S))$  is the number of nonzeros in each column.

$r = \text{sum}(\text{spones}(S'))'$  is the number of nonzeros in each row.

$\text{sum}(c)$  and  $\text{sum}(r)$  are equal, and are equal to  $\text{nnz}(S)$ .

**See Also**

`nnz`, `spalloc`, `spfun`

**Purpose** Set parameters for sparse matrix routines

**Syntax**

```
spparms('key',value)
spparms
values = spparms
[keys,values] = spparms
spparms(values)
value = spparms('key')
spparms('default')
spparms('tight')
```

**Description** spparms('key',value) sets one or more of the *tunable* parameters used in the sparse routines, particularly the minimum degree orderings, colmmd and symmmd, and also within sparse backslash. In ordinary use, you should never need to deal with this function.

The meanings of the key parameters are

|                         |                                                                                                        |
|-------------------------|--------------------------------------------------------------------------------------------------------|
| 'spumoni'               | Sparse Monitor flag:                                                                                   |
| 0                       | Produces no diagnostic output, the default                                                             |
| 1                       | Produces information about choice of algorithm based on matrix structure, and about storage allocation |
| 2                       | Also produces very detailed information about the sparse matrix algorithms                             |
| 'thr_rel',<br>'thr_abs' | Minimum degree threshold is thr_rel*mindegree + thr_abs.                                               |
| 'exact_d'               | Nonzero to use exact degrees in minimum degree. Zero to use approximate degrees.                       |
| 'supernd'               | If positive, minimum degree amalgamates the supernodes every supernd stages.                           |

# spparms

---

|           |                                                                                                                                                                                                                                                    |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'rreduce' | If positive, minimum degree does row reduction every rreduce stages.                                                                                                                                                                               |
| 'wh_frac' | Rows with density > wh_frac are ignored in colmmd.                                                                                                                                                                                                 |
| 'autommd' | Nonzero to use minimum degree (MMD) orderings with QR-based \ and /.                                                                                                                                                                               |
| 'autoamd' | Nonzero to use colamd ordering with the UMFPACK LU-based \ and /, and to use amd with CHOLMOD Cholesky-based \ and /.                                                                                                                              |
| 'piv_tol' | Pivot tolerance used by the UMFPACK LU-based \ and /.                                                                                                                                                                                              |
| 'bandden' | Band density used by LAPACK-based \ and / for banded matrices. Band density is defined as (# nonzeros in the band)/(# nonzeros in a full band). If bandden = 1.0, never use band solver. If bandden = 0.0, always use band solver. Default is 0.5. |
| 'umfpack' | Nonzero to use UMFPACK instead of the v4 LU-based solver in \ and /.                                                                                                                                                                               |
| 'sym_tol' | Symmetric pivot tolerance used by UMFPACK. See lu for more information about the role of the symmetric pivot tolerance.                                                                                                                            |

---

**Note** LU-based \ and / (UMFPACK) on square matrices use a modified colamd or amd. Cholesky-based \ and / (CHOLMOD) on symmetric positive definite matrices use amd. QR-based \ and / on rectangular matrices use colmmd.

---

spparms, by itself, prints a description of the current settings.

values = spparms returns a vector whose components give the current settings.

[keys,values] = spparms returns that vector, and also returns a character matrix whose rows are the keywords for the parameters.

spparms(values), with no output argument, sets all the parameters to the values specified by the argument vector.

value = spparms('key') returns the current setting of one parameter.

spparms('default') sets all the parameters to their default settings.

spparms('tight') sets the minimum degree ordering parameters to their *tight* settings, which can lead to orderings with less fill-in, but which make the ordering functions themselves use more execution time.

The key parameters for default and tight settings are

|            | <b>Keyword</b> | <b>Default</b> | <b>Tight</b> |
|------------|----------------|----------------|--------------|
| values(1)  | 'spumoni'      | 0.0            |              |
| values(2)  | 'thr_rel'      | 1.1            | 1.0          |
| values(3)  | 'thr_abs'      | 1.0            | 0.0          |
| values(4)  | 'exact_d'      | 0.0            | 1.0          |
| values(5)  | 'supernd'      | 3.0            | 1.0          |
| values(6)  | 'rreduce'      | 3.0            | 1.0          |
| values(7)  | 'wh_frac'      | 0.5            | 0.5          |
| values(8)  | 'autommd'      | 1.0            |              |
| values(9)  | 'autoamd'      | 1.0            |              |
| values(10) | 'piv_tol'      | 0.1            |              |
| values(11) | 'bandden'      | 0.5            |              |
| values(12) | 'umfpack'      | 1.0            |              |
| values(13) | 'sym_tol'      | 0.001          |              |

## Notes

### **Sparse $A \setminus b$ on Symmetric Positive Definite $A$**

Sparse  $A \setminus b$  on symmetric positive definite  $A$  uses CHOLMOD in conjunction with the amd reordering routine.

The parameter 'autoamd' turns the amd reordering on or off within the solver.

### **Sparse $A \setminus b$ on General Square $A$**

Sparse  $A \setminus b$  on general square  $A$  usually uses UMFPACK in conjunction with amd or a modified colamd reordering routine.

The parameter 'umfpack' turns the use of the UMFPACK software on or off within the solver.

If UMFPACK is used,

- The parameter 'piv\_tol' controls pivoting within the solver.
- The parameter 'autoamd' turns amd and the modified colamd on or off within the solver.

If UMFPACK is not used,

- An LU-based solver is used in conjunction with the colmmd reordering routine.
- If UMFPACK is not used, then the parameter 'autommd' turns the colmmd reordering routine on or off within the solver.
- If UMFPACK is not used and colmmd is used within the solver, then the minimum degree parameters affect the reordering routine within the solver.

### **Sparse $A \setminus b$ on Rectangular $A$**

Sparse  $A \setminus b$  on rectangular  $A$  uses a QR-based solve in conjunction with the colmmd reordering routine.

The parameter 'autommd' turns the colmmd reordering on or off within the solver.

If `colmmd` is used within the solver, then the minimum degree parameters affect the reordering routine within the solver.

**See Also**

`\`, `chol`, `lu`, `qr`, `colamd`, `colmmd`, `symmmd`

**References**

[1] Gilbert, John R., Cleve Moler, and Robert Schreiber, "Sparse Matrices in MATLAB: Design and Implementation," *SIAM Journal on Matrix Analysis and Applications*, Vol. 13, 1992, pp. 333-356.

[2] Davis, T. A., *UMFPACK Version 4.6 User Guide* (<http://www.cise.ufl.edu/research/sparse/umfpack/>), Dept. of Computer and Information Science and Engineering, Univ. of Florida, Gainesville, FL, 2002.

[3] Davis, T. A., *CHOLMOD Version 1.0 User Guide* (<http://www.cise.ufl.edu/research/sparse/cholmod>), Dept. of Computer and Information Science and Engineering, Univ. of Florida, Gainesville, FL, 2005.

# sprand

---

**Purpose** Sparse uniformly distributed random matrix

**Syntax**  
R = sprand(S)  
R = sprand(m,n,density)  
R = sprand(m,n,density,rc)

**Description** R = sprand(S) has the same sparsity structure as S, but uniformly distributed random entries.

R = sprand(m,n,density) is a random, m-by-n, sparse matrix with approximately  $\text{density} \cdot m \cdot n$  uniformly distributed nonzero entries ( $0 \leq \text{density} \leq 1$ ).

R = sprand(m,n,density,rc) also has reciprocal condition number approximately equal to rc. R is constructed from a sum of matrices of rank one.

If rc is a vector of length lr, where  $lr \leq \min(m,n)$ , then R has rc as its first lr singular values, all others are zero. In this case, R is generated by random plane rotations applied to a diagonal matrix with the given singular values. It has a great deal of topological and algebraic structure.

sprand uses the internal state information set with the rand function.

**See Also** sprandn, sprandsym



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Sparse normally distributed random matrix                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Syntax</b>      | <pre>R = sprandn(S) R = sprandn(m,n,density) R = sprandn(m,n,density,rc)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Description</b> | <p><code>R = sprandn(S)</code> has the same sparsity structure as <code>S</code>, but normally distributed random entries with mean 0 and variance 1.</p> <p><code>R = sprandn(m,n,density)</code> is a random, <code>m</code>-by-<code>n</code>, sparse matrix with approximately <code>density*m*n</code> normally distributed nonzero entries (<code>0 &lt;= density &lt;= 1</code>).</p> <p><code>R = sprandn(m,n,density,rc)</code> also has reciprocal condition number approximately equal to <code>rc</code>. <code>R</code> is constructed from a sum of matrices of rank one.</p> <p>If <code>rc</code> is a vector of length <code>lr</code>, where <code>lr &lt;= min(m,n)</code>, then <code>R</code> has <code>rc</code> as its first <code>lr</code> singular values, all others are zero. In this case, <code>R</code> is generated by random plane rotations applied to a diagonal matrix with the given singular values. It has a great deal of topological and algebraic structure.</p> <p><code>sprandn</code> uses the internal state information set with the <code>randn</code> function.</p> |
| <b>See Also</b>    | <code>sprand</code> , <code>sprandsym</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

# sprandsym

---

**Purpose** Sparse symmetric random matrix

**Syntax**

```
R = sprandsym(S)
R = sprandsym(n,density)
R = sprandsym(n,density,rc)
R = sprandsym(n,density,rc,kind)
```

**Description** `R = sprandsym(S)` returns a symmetric random matrix whose lower triangle and diagonal have the same structure as `S`. Its elements are normally distributed, with mean 0 and variance 1.

`R = sprandsym(n,density)` returns a symmetric random,  $n$ -by- $n$ , sparse matrix with approximately  $\text{density} \cdot n \cdot n$  nonzeros; each entry is the sum of one or more normally distributed random samples, and  $(0 \leq \text{density} \leq 1)$ .

`R = sprandsym(n,density,rc)` returns a matrix with a reciprocal condition number equal to `rc`. The distribution of entries is nonuniform; it is roughly symmetric about 0; all are in  $[-1, 1]$ .

If `rc` is a vector of length  $n$ , then `R` has eigenvalues `rc`. Thus, if `rc` is a positive (nonnegative) vector then `R` is a positive definite matrix. In either case, `R` is generated by random Jacobi rotations applied to a diagonal matrix with the given eigenvalues or condition number. It has a great deal of topological and algebraic structure.

`R = sprandsym(n,density,rc,kind)` returns a positive definite matrix. Argument `kind` can be:

- 1 to generate `R` by random Jacobi rotation of a positive definite diagonal matrix. `R` has the desired condition number exactly.
- 2 to generate an `R` that is a shifted sum of outer products. `R` has the desired condition number only approximately, but has less structure.
- 3 to generate an `R` that has the same structure as the matrix `S` and approximate condition number  $1/\text{rc}$ . `density` is ignored.

**See Also** sprand, sprandn

**Purpose** Structural rank

**Syntax** `r = sprank(A)`

**Description** `r = sprank(A)` is the structural rank of the sparse matrix `A`. For all values of `A`,

```
sprank(A) >= rank(full(A))
```

In exact arithmetic, `sprank(A) == rank(full(sprandn(A)))` with a probability of one.

### Examples

```
A = [1 0 2 0
     2 0 4 0];
```

```
A = sparse(A);
```

```
sprank(A)
```

```
ans =
     2
```

```
rank(full(A))
```

```
ans =
     1
```

**See Also** `dmperm`

# sprintf

---

**Purpose** Write formatted data to string

**Syntax** `[s, errmsg] = sprintf(format, A, ...)`

**Description** `[s, errmsg] = sprintf(format, A, ...)` formats the data in matrix `A` (and in any additional matrix arguments) under control of the specified format string and returns it in the MATLAB string variable `s`. The `sprintf` function returns an error message string `errmsg` if an error occurred. `errmsg` is an empty matrix if no error occurred.

`sprintf` is the same as `fprintf` except that it returns the data in a MATLAB string variable rather than writing it to a file.

See “Formatting Strings” in the MATLAB Programming documentation for more detailed information on using string formatting commands.

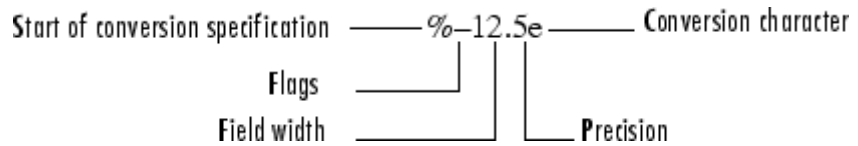
## Format String

The format argument is a string containing ordinary characters and/or C language conversion specifications. A conversion specification controls the notation, alignment, significant digits, field width, and other aspects of output format. The format string can contain escape characters to represent nonprinting characters such as newline characters and tabs.

Conversion specifications begin with the `%` character and contain these optional and required elements:

- Flags (optional)
- Width and precision fields (optional)
- A subtype specifier (optional)
- Conversion character (required)

You specify these elements in the following order:



### Flags

You can control the alignment of the output using any of these optional flags.

| Character        | Description                                        | Example |
|------------------|----------------------------------------------------|---------|
| A minus sign (-) | Left-justifies the converted argument in its field | % 5.2d  |
| A plus sign (+)  | Always prints a sign character (+ or -)            | %+5.2d  |
| Zero (0)         | Pad with zeros rather than spaces.                 | %05.2f  |

### Field Width and Precision Specifications

You can control the width and precision of the output by including these options in the format string.

| Character   | Description                                                                                                           | Example |
|-------------|-----------------------------------------------------------------------------------------------------------------------|---------|
| Field width | A digit string specifying the minimum number of digits to be printed.                                                 | %6f     |
| Precision   | A digit string including a period (.) specifying the number of digits to be printed to the right of the decimal point | %6.2f   |

## Conversion Characters

Conversion characters specify the notation of the output.

| Specifier | Description                                                                        |
|-----------|------------------------------------------------------------------------------------|
| %c        | Single character                                                                   |
| %d        | Decimal notation (signed)                                                          |
| %e        | Exponential notation (using a lowercase e as in 3.1415e+00)                        |
| %E        | Exponential notation (using an uppercase E as in 3.1415E+00)                       |
| %f        | Fixed-point notation                                                               |
| %g        | The more compact of %e or %f, as defined in [2]. Insignificant zeros do not print. |
| %G        | Same as %g, but using an uppercase E                                               |
| %O        | Octal notation (unsigned)                                                          |
| %s        | String of characters                                                               |
| %u        | Decimal notation (unsigned)                                                        |
| %x        | Hexadecimal notation (using lowercase letters a–f)                                 |
| %X        | Hexadecimal notation (using uppercase letters A–F)                                 |

The following tables describe the nonalphanumeric characters found in format specification strings.

## Escape Characters

This table lists the escape character sequences you use to specify non-printing characters in a format specification.

| Character                   | Description           |
|-----------------------------|-----------------------|
| \b                          | Backspace             |
| \f                          | Form feed             |
| \n                          | New line              |
| \r                          | Carriage return       |
| \t                          | Horizontal tab        |
| \\                          | Backslash             |
| \”r”<br>(two single quotes) | Single quotation mark |
| %%                          | Percent character     |

## Remarks

The `sprintf` function behaves like its ANSI C language namesake with these exceptions and extensions.

- If you use `sprintf` to convert a MATLAB double into an integer, and the double contains a value that cannot be represented as an integer (for example, it contains a fraction), MATLAB ignores the specified conversion and outputs the value in exponential format. To successfully perform this conversion, use the `fix`, `floor`, `ceil`, or `round` functions to change the value in the double into a value that can be represented as an integer before passing it to `sprintf`.
- The following nonstandard subtype specifiers are supported for the conversion characters `%o`, `%u`, `%x`, and `%X`.

|   |                                                                                                                                                                               |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| b | The underlying C data type is a double rather than an unsigned integer. For example, to print a double-precision value in hexadecimal, use a format like <code>'%bx'</code> . |
| t | The underlying C data type is a float rather than an unsigned integer.                                                                                                        |

# sprintf

---

For example, to print a double value in hexadecimal use the format `'%bx'`.

- The `sprintf` function is vectorized for nonscalar arguments. The function recycles the format string through the elements of `A` (columnwise) until all the elements are used up. The function then continues in a similar manner through any additional matrix arguments.
- If `%s` is used to print part of a nonscalar double argument, the following behavior occurs:
  - Successive values are printed as long as they are integers and in the range of a valid character. The first invalid character terminates the printing for this `%s` specifier and is used for a later specifier. For example, `pi` terminates the string below and is printed using `%f` format.

```
Str = [65 66 67 pi];  
sprintf('%s %f', Str)  
ans =  
ABC 3.141593
```

- If the first value to print is not a valid character, then just that value is printed for this `%s` specifier using an `e` conversion as a warning to the user. For example, `pi` is formatted by `%s` below in exponential notation, and `65`, though representing a valid character, is formatted as fixed-point (`%f`).

```
Str = [pi 65 66 67];  
sprintf('%s %f %s', Str)  
ans =  
3.141593e+000 65.000000 BC
```

- One exception is zero, which is a valid character. If zero is found first, `%s` prints nothing and the value is skipped. If zero is found after at least one valid character, it terminates the printing for this `%s` specifier and is used for a later specifier.



- sprintf prints negative zero and exponents differently on some platforms, as shown in the following tables.

### Negative Zero Printed with %e, %E, %f, %g, or %G

|          | Display of Negative Zero |           |          |
|----------|--------------------------|-----------|----------|
| Platform | %e or %E                 | %f        | %g or %G |
| PC       | 0.000000e+000            | 0.000000  | 0        |
| Others   | -0.000000e+00            | -0.000000 | -0       |

### Exponents Printed with %e, %E, %g, or %G

| Platform | Minimum Digits in Exponent | Example   |
|----------|----------------------------|-----------|
| PC       | 3                          | 1.23e+004 |
| UNIX     | 2                          | 1.23e+04  |

You can resolve this difference in exponents by postprocessing the results of sprintf. For example, to make the PC output look like that of UNIX, use

```
a = sprintf('%e', 12345.678);
if ispc, a = strrep(a, 'e+0', 'e+'); end
```

## Examples

| Command                                      | Result                 |
|----------------------------------------------|------------------------|
| <code>sprintf('%0.5g', (1+sqrt(5))/2)</code> | 1.618                  |
| <code>sprintf('%0.5g', 1/eps)</code>         | 4.5036e+15             |
| <code>sprintf('%15.5f', 1/eps)</code>        | 4503599627370496.00000 |
| <code>sprintf('%d', round(pi))</code>        | 3                      |

# sprintf

---

| Command                                           | Result                                      |
|---------------------------------------------------|---------------------------------------------|
| <code>sprintf('%s', 'hello')</code>               | hello                                       |
| <code>sprintf('The array is %dx%d.', 2, 3)</code> | The array is 2x3                            |
| <code>sprintf('\n')</code>                        | Line termination character on all platforms |

## See Also

`int2str`, `num2str`, `sscanf`

## References

[1] Kernighan, B.W., and D.M. Ritchie, *The C Programming Language, Second Edition*, Prentice-Hall, Inc., 1988.

[2] ANSI specification X3.159-1989: "Programming Language C," ANSI, 1430 Broadway, New York, NY 10018.

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Visualize sparsity pattern                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Syntax</b>      | <pre>spy(S) spy(S,markersize) spy(S,'LineStyle') spy(S,'LineStyle',markersize)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Description</b> | <p>plots the</p> <p><code>spy(S)</code> sparsity pattern of any matrix <code>S</code>.</p> <p><code>spy(S,markersize)</code>, where <code>markersize</code> is an integer, plots the sparsity pattern using markers of the specified point size.</p> <p><code>spy(S,'LineStyle')</code>, where <code>LineStyle</code> is a string, uses the specified plot marker type and color.</p> <p><code>spy(S,'LineStyle',markersize)</code> uses the specified type, color, and size for the plot markers.</p> <p><code>S</code> is usually a sparse matrix, but full matrices are acceptable, in which case the locations of the nonzero elements are plotted.</p> |

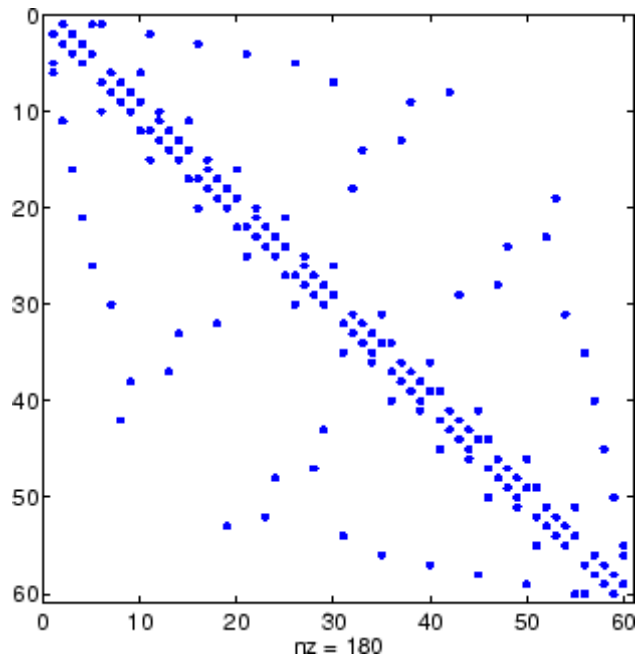
---

**Note** `spy` replaces `format +`, which takes much more space to display essentially the same information.

---

**Examples** This example plots the 60-by-60 sparse adjacency matrix of the connectivity graph of the Buckminster Fuller geodesic dome. This matrix also represents the soccer ball and the carbon-60 molecule.

```
B = bucky;
spy(B)
```



**See Also**

find, gplot, LineSpec, symamd, symrcm

---

|                    |                                                                                                                                                                                  |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Square root                                                                                                                                                                      |
| <b>Syntax</b>      | $B = \text{sqrt}(X)$                                                                                                                                                             |
| <b>Description</b> | $B = \text{sqrt}(X)$ returns the square root of each element of the array $X$ . For the elements of $X$ that are negative or complex, $\text{sqrt}(X)$ produces complex results. |
| <b>Remarks</b>     | See <code>sqrtm</code> for the matrix square root.                                                                                                                               |
| <b>Examples</b>    | <pre>sqrt((-2:2)') ans =     0 + 1.4142i     0 + 1.0000i     0     1.0000     1.4142</pre>                                                                                       |
| <b>See Also</b>    | <code>sqrtm</code> , <code>realsqrt</code>                                                                                                                                       |

# sqrtm

---

**Purpose** Matrix square root

**Syntax**  
 $X = \text{sqrtm}(A)$   
 $[X, \text{resnorm}] = \text{sqrtm}(A)$   
 $[X, \alpha, \text{condest}] = \text{sqrtm}(A)$

**Description**  $X = \text{sqrtm}(A)$  is the principal square root of the matrix  $A$ , i.e.  $X^2 = A$ .

$X$  is the unique square root for which every eigenvalue has nonnegative real part. If  $A$  has any eigenvalues with negative real parts then a complex result is produced. If  $A$  is singular then  $A$  may not have a square root. A warning is printed if exact singularity is detected.

$[X, \text{resnorm}] = \text{sqrtm}(A)$  does not print any warning, and returns the residual,  $\text{norm}(A - X^2, 'fro') / \text{norm}(A, 'fro')$ .

$[X, \alpha, \text{condest}] = \text{sqrtm}(A)$  returns a stability factor  $\alpha$  and an estimate  $\text{condest}$  of the matrix square root condition number of  $X$ . The residual  $\text{norm}(A - X^2, 'fro') / \text{norm}(A, 'fro')$  is bounded approximately by  $n * \alpha * \text{eps}$  and the Frobenius norm relative error in  $X$  is bounded approximately by  $n * \alpha * \text{condest} * \text{eps}$ , where  $n = \max(\text{size}(A))$ .

**Remarks** If  $X$  is real, symmetric and positive definite, or complex, Hermitian and positive definite, then so is the computed matrix square root.

Some matrices, like  $X = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$ , do not have any square roots, real or complex, and `sqrtm` cannot be expected to produce one.

**Examples** **Example 1**

A matrix representation of the fourth difference operator is

$$X = \begin{bmatrix} 5 & -4 & 1 & 0 & 0 \\ -4 & 6 & -4 & 1 & 0 \\ 1 & -4 & 6 & -4 & 1 \\ 0 & 1 & -4 & 6 & -4 \\ 0 & 0 & 1 & -4 & 5 \end{bmatrix}$$

This matrix is symmetric and positive definite. Its unique positive definite square root,  $Y = \text{sqrtm}(X)$ , is a representation of the second difference operator.

$$Y = \begin{bmatrix} 2 & -1 & -0 & -0 & -0 \\ -1 & 2 & -1 & 0 & -0 \\ 0 & -1 & 2 & -1 & 0 \\ -0 & 0 & -1 & 2 & -1 \\ -0 & -0 & -0 & -1 & 2 \end{bmatrix}$$

### Example 2

The matrix

$$X = \begin{bmatrix} 7 & 10 \\ 15 & 22 \end{bmatrix}$$

has four square roots. Two of them are

$$Y1 = \begin{bmatrix} 1.5667 & 1.7408 \\ 2.6112 & 4.1779 \end{bmatrix}$$

and

$$Y2 = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

The other two are  $-Y1$  and  $-Y2$ . All four can be obtained from the eigenvalues and vectors of  $X$ .

$$[V,D] = \text{eig}(X);$$

$$D = \begin{bmatrix} 0.1386 & 0 \\ 0 & 28.8614 \end{bmatrix}$$

## sqrtm

---

The four square roots of the diagonal matrix D result from the four choices of sign in

$$S = \begin{pmatrix} -0.3723 & 0 \\ 0 & -5.3723 \end{pmatrix}$$

All four Ys are of the form

$$Y = V*S/V$$

The sqrtm function chooses the two plus signs and produces Y1, even though Y2 is more natural because its entries are integers.

### See Also

expm, funm, logm



**Purpose** Remove singleton dimensions

**Syntax** `B = squeeze(A)`

**Description** `B = squeeze(A)` returns an array `B` with the same elements as `A`, but with all singleton dimensions removed. A singleton dimension is any dimension for which `size(A,dim) = 1`. Two-dimensional arrays are unaffected by `squeeze`; if `A` is a row or column vector or a scalar (1-by-1) value, then `B = A`.

**Examples** Consider the 2-by-1-by-3 array `Y = rand(2,1,3)`. This array has a singleton column dimension — that is, there's only one column per page.

`Y =`

|                           |                           |
|---------------------------|---------------------------|
| <code>Y(:, :, 1) =</code> | <code>Y(:, :, 2) =</code> |
| 0.5194                    | 0.0346                    |
| 0.8310                    | 0.0535                    |

|                           |
|---------------------------|
| <code>Y(:, :, 3) =</code> |
| 0.5297                    |
| 0.6711                    |

The command `Z = squeeze(Y)` yields a 2-by-3 matrix:

|                  |        |        |  |
|------------------|--------|--------|--|
| <code>Z =</code> |        |        |  |
| 0.5194           | 0.0346 | 0.5297 |  |
| 0.8310           | 0.0535 | 0.6711 |  |

Consider the 1-by-1-by-5 array `mat= repmat(1,[1,1,5])`. This array has only one scalar value per page.

`mat =`

|                             |                             |
|-----------------------------|-----------------------------|
| <code>mat(:, :, 1) =</code> | <code>mat(:, :, 2) =</code> |
| 1                           | 1                           |

# squeeze

---

```
mat(:,:,3) =   mat(:,:,4) =
```

```
    1    1
```

```
mat(:,:,5) =
```

```
    1
```

The command `squeeze(mat)` yields a 5-by-1 matrix:

```
squeeze(mat)
```

```
ans =
```

```
    1  
    1  
    1  
    1  
    1
```

```
size(squeeze(mat))
```

```
ans =
```

```
    5    1
```

## See Also

`reshape`, `shiftdim`

**Purpose** Convert state-space filter parameters to transfer function form

**Syntax** `[b,a] = ss2tf(A,B,C,D,iu)`

**Description** `ss2tf` converts a state-space representation of a given system to an equivalent transfer function representation.

`[b,a] = ss2tf(A,B,C,D,iu)` returns the transfer function

$$H(s) = \frac{B(s)}{A(s)} = C(sI - A)^{-1}B + D$$

of the system

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

from the `iu`-th input. Vector `a` contains the coefficients of the denominator in descending powers of  $s$ . The numerator coefficients are returned in array `b` with as many rows as there are outputs  $y$ . `ss2tf` also works with systems in discrete time, in which case it returns the  $z$ -transform representation.

The `ss2tf` function is part of the standard MATLAB language.

**Algorithm** The `ss2tf` function uses `poly` to find the characteristic polynomial  $\det(sI - A)$  and the equality:

$$H(s) = C(sI - A)^{-1}B = \frac{\det(sI - A + BC) - \det(sI - A)}{\det(sI - A)}$$

# sscanf

---

**Purpose** Read formatted data from string

**Syntax**  
`A = sscanf(s, format)`  
`A = sscanf(s, format, size)`  
`[A, count, errmsg, nextindex] = sscanf(...)`

**Description** `A = sscanf(s, format)` reads data from the MATLAB string `s`, converts it according to the specified format string, and returns it in matrix `A`. `format` is a string specifying the format of the data to be read. See "Remarks" for details. `sscanf` is the same as `fscanf` except that it reads the data from a MATLAB string rather than reading it from a file. If `s` is a character array with more than one row, `sscanf` reads the characters in column order.

`A = sscanf(s, format, size)` reads the amount of data specified by `size` and converts it according to the specified format string. `size` is an argument that determines how much data is read. Valid options are

|                    |                                                                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>n</code>     | Read at most <code>n</code> numbers, characters, or strings.                                                                                                                                       |
| <code>inf</code>   | Read to the end of the input string.                                                                                                                                                               |
| <code>[m,n]</code> | Read at most <code>(m*n)</code> numbers, characters, or strings. Fill a matrix of at most <code>m</code> rows in column order. <code>n</code> can be <code>inf</code> , but <code>m</code> cannot. |

Characteristics of the output matrix `A` depend on the values read from the input string and on the `size` argument. If `sscanf` reads only numbers, and if `size` is not of the form `[m,n]`, matrix `A` is a column vector of numbers. If `sscanf` reads only characters or strings, and if `size` is not of the form `[m,n]`, matrix `A` is a row vector of characters. See the Remarks section for more information.

`sscanf` differs from its C language namesake `scanf()` in an important respect — it is *vectorized* to return a matrix argument. The format string is cycled through the input string until the first of these conditions occurs:

- The format string fails to match the data in the input string

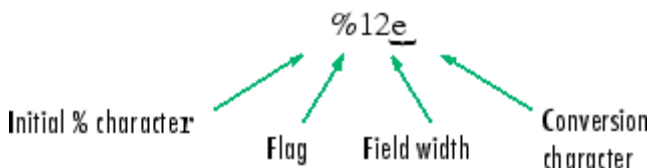
- The amount of data specified by size is read
- The end of the string is reached

[A, count, errmsg, nextindex] = sscanf(...) reads data from the MATLAB string (character array) s, converts it according to the specified format string, and returns it in matrix A. count is an optional output argument that returns the number of values successfully read. errmsg is an optional output argument that returns an error message string if an error occurred or an empty string if an error did not occur. nextindex is an optional output argument specifying one more than the number of characters scanned in s.

### Remarks

When MATLAB reads a specified string, it attempts to match the data in the input string to the format string. If a match occurs, the data is written into the output matrix. If a partial match occurs, only the matching data is written to the matrix, and the read operation stops.

The format string consists of ordinary characters and/or conversion specifications. Conversion specifications indicate the type of data to be matched and involve the character %, optional width fields, and conversion characters, organized as shown below:



Add one or more of these characters between the % and the conversion character.

|                 |                                                                                                                                                                                  |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| An asterisk (*) | Skip over the matched value and do not store it in the output matrix                                                                                                             |
| A digit string  | Maximum field width                                                                                                                                                              |
| A letter        | The size of the receiving object; for example, h for short, as in %hd for a short integer, or l for long, as in %ld for a long integer or %lg for a double floating-point number |

Valid conversion characters are as shown.

|            |                                                                                                                              |
|------------|------------------------------------------------------------------------------------------------------------------------------|
| %c         | Sequence of characters; number specified by field width                                                                      |
| %d         | Base 10 integers                                                                                                             |
| %e, %f, %g | Floating-point numbers                                                                                                       |
| %i         | Defaults to signed base 10 integers. Data starting with 0 is read as base 8. Data starting with 0x or 0X is read as base 16. |
| %o         | Signed octal integer returned as unsigned                                                                                    |
| %s         | A series of non-white-space characters                                                                                       |
| %u         | Signed decimal integer                                                                                                       |
| %x         | Signed hexadecimal integer returned as unsigned                                                                              |
| [...]      | Sequence of characters (scanlist)                                                                                            |

Format specifiers %e, %f, and %g accept the text 'inf', '-inf', 'nan', and '-nan'. This text is not case sensitive. The sscanf function converts these to the numeric representation of Inf, -Inf, NaN, and -NaN.

Use %c to read space characters, or %s to skip all white space.

For more information about format strings, refer to the scanf() and fscanf() routines in a C language reference manual.

### **Output Characteristics: Only Numeric Values Read**

Format characters that cause `sscanf` to read numbers from the input string are `%d`, `%e`, `%f`, `%g`, `%i`, `%o`, `%u`, and `%x`. When `sscanf` reads only numbers from the input string, the elements of the output matrix `A` are numbers.

When there is no `size` argument or the `size` argument is `inf`, `sscanf` reads to the end of the input string. The output matrix is a column vector with one element for each number read from the input.

When the `size` argument is a scalar `n`, `sscanf` reads at most `n` numbers from the input string. The output matrix is a column vector with one element for each number read from the input.

When the `size` argument is a matrix `[m,n]`, `sscanf` reads at most  $(m*n)$  numbers from the input string. The output matrix contains at most `m` rows and `n` columns. `sscanf` fills the output matrix in column order, using as many columns as it needs to contain all the numbers read from the input. Any unfilled elements in the final column contain zeros.

### **Output Characteristics: Only Character Values Read**

The format characters that cause `sscanf` to read characters and strings from the input string are `%c` and `%s`. When `sscanf` reads only characters and strings from the input string, the elements of the output matrix `A` are characters. When `sscanf` reads a string from the input, the output matrix includes one element for each character in the string.

When there is no `size` argument or the `size` argument is `inf`, `sscanf` reads to the end of the input string. The output matrix is a row vector with one element for each character read from the input.

When the `size` argument is a scalar `n`, `sscanf` reads at most `n` character or string values from the input string. The output matrix is a row vector with one element for each character read from the input. When string values are read from the input, the output matrix can contain more than `n` columns.

When the `size` argument is a matrix `[m,n]`, `sscanf` reads at most  $(m*n)$  character or string values from the input string. The output

matrix contains at most  $m$  rows. `sscanf` fills the output matrix in column order, using as many columns as it needs to contain all the characters read from the input. When string values are read from the input, the output matrix can contain more than  $n$  columns. Any unfilled elements in the final column contain `char(0)`.

## **Output Characteristics: Both Numeric and Character Values Read**

When `sscanf` reads a combination of numbers and either characters or strings from the input string, the elements of the output matrix  $A$  are numbers. This is true even when a format specifier such as `'%*d %s'` tells MATLAB to ignore numbers in the input string and output only characters or strings. When `sscanf` reads a string from the input, the output matrix includes one element for each character in the string. All characters are converted to their numeric equivalents in the output matrix.

When there is no size argument or the size argument is `inf`, `sscanf` reads to the end of the input string. The output matrix is a column vector with one element for each character read from the input.

When the size argument is a scalar  $n$ , `sscanf` reads at most  $n$  number, character, or string values from the input string. The output matrix contains at most  $n$  rows. `sscanf` fills the output matrix in column order, using as many columns as it needs to represent all the numbers and characters read from the input. When string values are read from the input, the output matrix can contain more than one column. Any unfilled elements in the final column contain zeros.

When the size argument is a matrix  $[m,n]$ , `sscanf` reads at most  $(m*n)$  number, character, or string values from the input string. The output matrix contains at most  $m$  rows. `sscanf` fills the output matrix in column order, using as many columns as it needs to represent all the numbers and characters read from the input. When string values are read from the input, the output matrix can contain more than  $n$  columns. Any unfilled elements in the final column contain zeros.



---

**Note** This section applies only when `sscanf` actually reads a combination of numbers and either characters or strings from the input string. Even if the format string has both format characters that would result in numbers (such as `%d`) and format characters that would result in characters or strings (such as `%s`), `sscanf` might actually read only numbers or only characters or strings. If `sscanf` reads only numbers, see “Output Characteristics: Only Numeric Values Read” on page 2-3015. If `sscanf` reads only characters or strings, see “Output Characteristics: Only Character Values Read” on page 2-3015.

---

## Examples

### Example 1

The statements

```
s = '2.7183 3.1416';
A = sscanf(s, '%f')
```

create a two-element vector containing poor approximations to `e` and `pi`.

### Example 2

When using the `%i` conversion specifier, `sscanf` reads data starting with 0 as base 8 and returns the converted value as signed:

```
sscanf('-010', '%i')
ans =
    -8
```

When using `%o`, on the other hand, `sscanf` returns the converted value as unsigned:

```
sscanf('-010', '%o')
ans =
    4.2950e+009
```

### Example 3

Create character array `A` representing both character and numeric data:

# sscanf

---

```
A = ['abc 46 6 ghi'; 'def 7 89 jkl']
A =
    abc 46 6 ghi
    def 7 89 jkl
```

Read A into 2-by-N matrix B, ignoring the character data. As stated in the Description section, sscanf reads the characters in A in column order, filling matrix B in column order:

```
B = sscanf(A, '%*s %d %d %*s', [2, inf])
B =
    476
    869
```

If you want sscanf to return the numeric data in B in the same order as in A, you can use this technique:

```
for k = 1:2
    C(k,:) = sscanf(A(k, :)', '%*s %d %d %*s', [1, inf]);
end

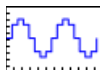
C
C =
    46     6
     7    89
```


## See Also

eval, sprintf, textread

**Purpose**

Stairstep graph

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
stairs(Y)
stairs(X,Y)
stairs(...,LineStyle)
stairs(...,'PropertyName',propertyvalue)
stairs(axes_handle,...)
h = stairs(...)
[xb,yb] = stairs(Y,...)
hlines = stairs('v6',...)
```

**Description**

Stairstep graphs are useful for drawing time-history graphs of digitally sampled data.

`stairs(Y)` draws a stairstep graph of the elements of `Y`, drawing one line per column for matrices. The axes `ColorOrder` property determines the color of the lines.

When `Y` is a vector, the  $x$ -axis scale ranges from 1 to `length(Y)`. When `Y` is a matrix, the  $x$ -axis scale ranges from 1 to the number of rows in `Y`.

`stairs(X,Y)` plots the elements in `Y` at the locations specified in `X`.

`X` must be the same size as `Y` or, if `Y` is a matrix, `X` can be a row or a column vector such that

```
length(X) = size(Y,1)
```

# stairs

---

`stairs(...,LineStyle)` specifies a line style, marker symbol, and color for the graph. (See `LineStyle` for more information.)

`stairs(..., 'PropertyName', propertyvalue)` creates the stairstep graph, applying the specified property settings. See `Stairseries` properties for a description of properties.

`stairs(axes_handle,...)` plots into the axes with the handle `axes_handle` instead of into the current axes object (`gca`).

`h = stairs(...)` returns the handles of the stairseries objects created (one per matrix column).

`[xb,yb] = stairs(Y,...)` does not draw graphs, but returns vectors `xb` and `yb` such that `plot(xb,yb)` plots the stairstep graph.

## Backward-Compatible Version

`hlines = stairs('v6',...)` returns the handles of line objects instead of stairseries objects for compatibility with MATLAB 6.5 and earlier.

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

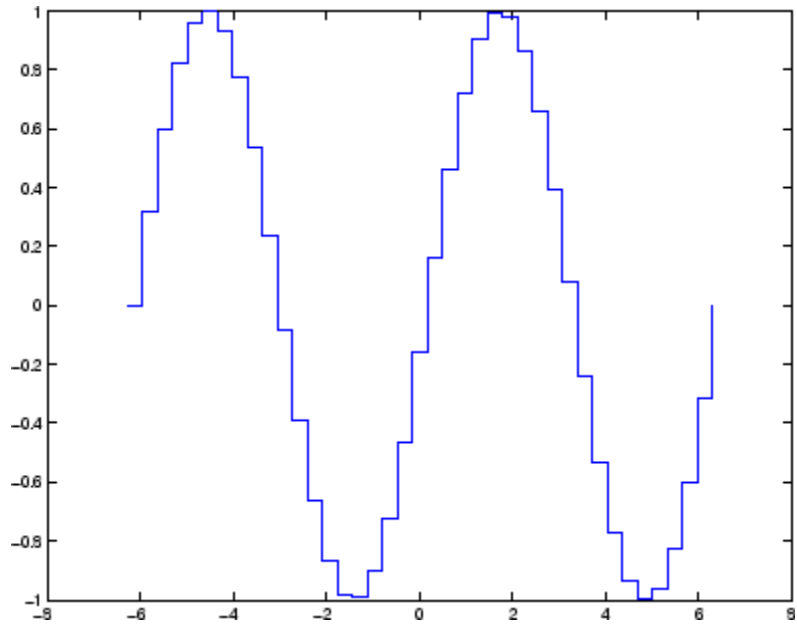
---

See [Plot Objects and Backward Compatibility](#) for more information.

## Examples

Create a stairstep plot of a sine wave.

```
x = linspace(-2*pi,2*pi,40);
stairs(x,sin(x))
```



**See Also**

bar, hist, stem

“Discrete Data Plots” on page 1-89 for related functions

Stairseries Properties for property descriptions

# Stairseries Properties

---

**Purpose** Define stairseries properties

**Modifying Properties** You can set and query graphics object properties using the set and get commands or the Property Editor (propertyeditor).

Note that you cannot define default property values for stairseries objects.

See Plot Objects for information on stairseries objects.

**Stairseries Property Descriptions** This section provides a description of properties. Curly braces { } enclose default values.

Annotation  
hg.Annotation object Read Only

*Control the display of stairseries objects in legends.* The Annotation property enables you to specify whether this stairseries object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the stairseries object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                                                               |
|------------------------|---------------------------------------------------------------------------------------|
| on                     | Include the stairseries object in a legend as one entry, but not its children objects |

| IconDisplayStyle Value | Purpose                                                                        |
|------------------------|--------------------------------------------------------------------------------|
| off                    | Do not include the stairseries or its children in a legend (default)           |
| children               | Include only the children of the stairseries as separate entries in the legend |

## Setting the IconDisplayStyle property

These commands set the `IconDisplayStyle` of a graphics object with handle `hobj` to `children`, which causes each child object to have an entry in the legend:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'children')
```

## Using the IconDisplayStyle property

See “Controlling Legends” for more information and examples.

`BeingDeleted`  
on | {off} Read Only

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to `on` when the object’s delete function callback is called (see the `DeleteFcn` property). It remains set to `on` while the delete function executes, after which the object no longer exists.

For example, an object’s delete function might call other functions that act on a number of different objects. These functions might not need to perform actions on objects if the objects are going to be deleted, and therefore, can check the object’s `BeingDeleted` property before acting.

# Stairseries Properties

---

## BusyAction

cancel | {queue}

*Callback routine interruption.* The BusyAction property enables you to control how MATLAB handles events that potentially interrupt executing callbacks. If there is a callback function executing, callbacks invoked subsequently always attempt to interrupt it.

If the Interruptible property of the object whose callback is executing is set to on (the default), then interruption occurs at the next point where the event queue is processed. If the Interruptible property is off, the BusyAction property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- cancel — Discard the event that attempted to execute a second callback routine.
- queue — Queue the event that attempted to execute a second callback routine until the current callback finishes.

## ButtonDownFcn

string or function handle

*Button press callback function.* A callback that executes whenever you press a mouse button while the pointer is over this object, but not over another graphics object. See the HitTestArea property for information about selecting objects of this type.

See the figure's SelectionType property to determine if modifier keys were also pressed.

This property can be

- A string that is a valid MATLAB expression
- The name of an M-file



- A function handle

Set this property to a function handle that references the callback. The expressions execute in the MATLAB workspace.

See “Function Handle Callbacks” for information on how to use function handles to define the callbacks.

The expression executes in the MATLAB workspace.

See Function Handle Callbacks for information on how to use function handles to define the callbacks.

## Children

array of graphics object handles

*Children of this object.* The handle of a patch object that is the child of this object (whether visible or not).

Note that if a child object’s `HandleVisibility` property is set to `callback` or `off`, its handle does not show up in this object’s `Children` property unless you set the root `ShowHiddenHandles` property to `on`:

```
set(0, 'ShowHiddenHandles', 'on')
```

## Clipping

{on} | off

*Clipping mode.* MATLAB clips graphs to the axes plot box by default. If you set `Clipping` to `off`, portions of graphs can be displayed outside the axes plot box. This can occur if you create a plot object, set `hold` to `on`, freeze axis scaling (`axis manual`), and then create a larger plot object.

## Color

ColorSpec

# Stairseries Properties

---

*Color of the object.* A three-element RGB vector or one of the MATLAB predefined names, specifying the object's color.

See the `ColorSpec` reference page for more information on specifying color.

`CreateFcn`  
string or function handle

*Callback routine executed during object creation.* This property defines a callback that executes when MATLAB creates an object. You must specify the callback during the creation of the object. For example,

```
area(y, 'CreateFcn', @CallbackFcn)
```

where `@CallbackFcn` is a function handle that references the callback function.

MATLAB executes this routine after setting all other object properties. Setting this property on an existing object has no effect.

The handle of the object whose `CreateFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

`DeleteFcn`  
string or function handle

*Callback executed during object deletion.* A callback that executes when this object is deleted (e.g., this might happen when you issue a `delete` command on the object, its parent axes, or the figure containing it). MATLAB executes the callback before destroying

the object's properties so the callback routine can query these values.

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which can be queried using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

See the `BeingDeleted` property for related information.

### `DisplayName`

string (default is empty string)

*String used by legend for this stairseries object.* The legend function uses the string defined by the `DisplayName` property to label this stairseries object in the legend.

- If you specify string arguments with the legend function, `DisplayName` is set to this stairseries object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where *n* is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call legend with the `toggle` or `show` option.

See “Controlling Legends” for more examples.

# Stairseries Properties

---

EraseMode

{normal} | none | xor | background

*Erase mode.* This property controls the technique MATLAB uses to draw and erase objects and their children. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- **normal** — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- **none** — Do not erase objects when they are moved or destroyed. While the objects are still visible on the screen after erasing with EraseMode none, you cannot print these objects because MATLAB stores no information about their former locations.
- **xor** — Draw and erase the object by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the object does not damage the color of the objects behind it. However, the color of the erased object depends on the color of the screen behind it and it is correctly colored only when it is over the axes background color (or the figure background color if the axes Color property is set to none). That is, it isn't erased correctly if there are objects behind it.
- **background** — Erase the graphics objects by redrawing them in the axes background color, (or the figure background color if the axes Color property is set to none). This damages other graphics objects that are behind the erased object, but the erased object is always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the `EraseMode` of all objects is `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look different on screen than on paper. On screen, MATLAB can mathematically combine layers of colors (e.g., performing an XOR on a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

Set the axes background color with the axes `Color` property. Set the figure background color with the figure `Color` property.

You can use the MATLAB `getframe` command or other screen capture applications to create an image of a figure containing nonnormal mode objects.

### `HandleVisibility`

`{on} | callback | off`

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. `HandleVisibility` is useful for preventing command-line users from accidentally accessing objects that you need to protect for some reason.

- `on` — Handles are always visible when `HandleVisibility` is `on`.
- `callback` — Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have access to object handles.
- `off` — Setting `HandleVisibility` to `off` makes handles invisible at all times. This might be necessary when a callback invokes a function that might potentially damage the GUI (such as evaluating a user-typed string) and so temporarily hides its own handles during the execution of that function.

# Stairseries Properties

---

## Functions Affected by Handle Visibility

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

## Properties Affected by Handle Visibility

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

## Overriding Handle Visibility

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties). See also `findall`.

## Handle Validity

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties and pass it to any function that operates on handles.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## HitTest

{on} | off

*Selectable by mouse click.* HitTest determines whether this object can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the objects that compose the area graph. If HitTest is off, clicking this object selects the object below it (which is usually the axes containing it).

## HitTestArea

on | {off}

*Select the object by clicking lines or area of extent.* This property enables you to select plot objects in two ways:

- Select by clicking lines or markers (default).
- Select by clicking anywhere in the extent of the plot.

When HitTestArea is off, you must click the object's lines or markers (excluding the baseline, if any) to select the object. When HitTestArea is on, you can select this object by clicking anywhere within the extent of the plot (i.e., anywhere within a rectangle that encloses it).

## Interruptible

{on} | off

*Callback routine interruption mode.* The Interruptible property controls whether an object's callback can be interrupted by callbacks invoked subsequently.

Only callbacks defined for the `ButtonDownFcn` property are affected by the Interruptible property. MATLAB checks for events that can interrupt a callback only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.

# Stairseries Properties

---

Setting `Interruptible` to `on` allows any graphics object's callback to interrupt callback routines originating from a bar property. Note that MATLAB does not save the state of variables or the display (e.g., the handle returned by the `gca` or `gcf` command) when an interruption occurs.

## LineStyle

{-} | -- | : | -. | none

*Line style.* This property specifies the line style of the object. Available line styles are shown in the following table.

| Specifier String | Line Style           |
|------------------|----------------------|
| -                | Solid line (default) |
| --               | Dashed line          |
| :                | Dotted line          |
| -.               | Dash-dot line        |
| none             | No line              |

You can use `LineStyle none` when you want to place a marker at each point but do not want the points connected with a line (see the `Marker` property).

## LineWidth

scalar

*The width of linear objects and edges of filled areas.* Specify this value in points (1 point =  $\frac{1}{72}$  inch). The default `LineWidth` is 0.5 points.

## Marker

character (see table)

*Marker symbol.* The `Marker` property specifies the type of markers that are displayed at plot vertices. You can set values for the



Marker property independently from the `LineStyle` property. Supported markers include those shown in the following table.

| Marker Specifier | Description                   |
|------------------|-------------------------------|
| +                | Plus sign                     |
| o                | Circle                        |
| *                | Asterisk                      |
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

`MarkerEdgeColor`

`ColorSpec | none | {auto}`

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles). `ColorSpec` defines the color to use. `none` specifies no color, which makes nonfilled markers invisible. `auto` sets `MarkerEdgeColor` to the same color as the `Color` property.

`MarkerFaceColor`

`ColorSpec | {none} | auto`

# Stairseries Properties

---

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles). ColorSpec defines the color to use. none makes the interior of the marker transparent, allowing the background to show through. auto sets the fill color to the axes color, or to the figure color if the axes Color property is set to none (which is the factory default for axes objects).

MarkerSize  
size in points

*Marker size.* A scalar specifying the size of the marker in points. The default value for MarkerSize is 6 points (1 point = 1/72 inch). Note that MATLAB draws the point marker (specified by the ' .' symbol) at one-third the specified size.

Parent  
handle of parent axes, hggroup, or hgtransform

*Parent of this object.* This property contains the handle of the object's parent. The parent is normally the axes, hggroup, or hgtransform object that contains the object.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

Selected  
on | {off}

*Is object selected?* When you set this property to on, MATLAB displays selection "handles" at the corners and midpoints if the SelectionHighlight property is also on (the default). You can, for example, define the ButtonDownFcn callback to set this property to on, thereby indicating that this particular object is selected. This property is also set to on when an object is manually selected in plot edit mode.

SelectionHighlight  
{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is off, MATLAB does not draw the handles except when in plot edit mode and objects are selected manually.

Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callbacks. You can define Tag as any string.

For example, you might create an areaseries object and set the Tag property.

```
t = area(Y, 'Tag', 'area1')
```

When you want to access objects of a given type, you can use findobj to find the object's handle. The following statement changes the FaceColor property of the object whose Tag is area1.

```
set(findobj('Tag', 'area1'), 'FaceColor', 'red')
```

Type

string (read only)

*Type of graphics object.* This property contains a string that identifies the class of the graphics object. For stairseries objects, Type is 'hggroup'. The following statement finds all the hggroup objects in the current axes object.

```
t = findobj(gca, 'Type', 'hggroup');
```

# Stairseries Properties

---

## UIContextMenu

handle of a uicontextmenu object

*Associate a context menu with this object.* Assign this property the handle of a uicontextmenu object created in the object's parent figure. Use the uicontextmenu function to create the context menu. MATLAB displays the context menu whenever you right-click over the object.

## UserData

array

*User-specified data.* This property can be any data you want to associate with this object (including cell arrays and structures). The object does not set values for this property, but you can access it using the set and get functions.

## Visible

{on} | off

*Visibility of this object and its children.* By default, a new object's visibility is on. This means all children of the object are visible unless the child object's Visible property is set to off. Setting an object's Visible property to off prevents the object from being displayed. However, the object still exists and you can set and query its properties.

## XData

array

*X-axis location of stairs.* The stairs function uses XData to label the  $x$ -axis. XData can be either a matrix equal in size to YData or a vector equal in length to the number of rows in YData. That is,  $\text{length}(\text{XData}) == \text{size}(\text{YData}, 1)$ .

If you do not specify XData (i.e., the input argument  $x$ ), the stairs function uses the indices of YData to create the stairstep graph. See the XDataMode property for related information.

XDataMode

{auto} | manual

*Use automatic or user-specified x-axis values.* If you specify XData (by setting the XData property or specifying the x input argument), MATLAB sets this property to manual and uses the specified values to label the x-axis.

If you set XDataMode to auto after having specified XData, MATLAB resets the x-axis ticks to 1:size(YData,1) or to the column indices of the ZData, overwriting any previous values for XData.

XDataSource

string (MATLAB variable)

*Link XData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the XData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change XData.

You can use the refreshdata function to force an update of the object's data. refreshdata also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call refreshdata.

See the refreshdata reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

# Stairseries Properties

---

## YData

scalar, vector, or matrix

*Stairs plot data.* YData contains the data plotted in the stairstep graph. Each value in YData is represented by a marker in the stairstep graph. If YData is a matrix, the stairs function creates a line for each column in the matrix.

The input argument *y* in the stairs function calling syntax assigns values to YData.

## YDataSource

string (MATLAB variable)

*Link YData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the YData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change YData.

You can use the refreshdata function to force an update of the object's data. refreshdata also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call refreshdata.

See the refreshdata reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

**Purpose** Start timer(s) running

**Syntax** `start(obj)`

**Description** `start(obj)` starts the timer running, represented by the timer object, `obj`. If `obj` is an array of timer objects, `start` starts all the timers. Use the `timer` function to create a timer object.

`start` sets the `Running` property of the timer object, `obj`, to `'on'`, initiates `TimerFcn` callbacks, and executes the `StartFcn` callback.

The timer stops running if one of the following conditions apply:

- The first `TimerFcn` callback completes, if `ExecutionMode` is `'singleShot'`.
- The number of `TimerFcn` callbacks specified in `TasksToExecute` have been executed.
- The `stop(obj)` command is issued.
- An error occurred while executing a `TimerFcn` callback.

**See Also** `timer`, `stop`

# startat

---

**Purpose** Start timer(s) running at specified time

**Syntax**

```
startat(obj,time)
startat(obj,S)
startat(obj,S,pivotyear)
startat(obj,Y,M,D)
startat(obj,[Y,M,D])
startat(obj,Y,M,D,H,MI,S)
startat(obj,[Y,M,D,H,MI,S])
```

**Description** `startat(obj,time)` starts the timer running, represented by the timer object `obj`, at the time specified by the serial date number `time`. If `obj` is an array of timer objects, `startat` starts all the timers running at the specified time. Use the `timer` function to create the timer object.

`startat` sets the `Running` property of the timer object, `obj`, to 'on', initiates `TimerFcn` callbacks, and executes the `StartFcn` callback.

The serial date number, `time`, indicates the number of days that have elapsed since 1-Jan-0000 (starting at 1). See `datenum` for additional information about serial date numbers.

`startat(obj,S)` starts the timer running at the time specified by the date string `S`. The date string must use date format 0, 1, 2, 6, 13, 14, 15, 16, or 23, as defined by the `datestr` function. Date strings with two-character years are interpreted to be within the 100 years centered on the current year.

`startat(obj,S,pivotyear)` uses the specified pivot year as the starting year of the 100-year range in which a two-character year resides. The default pivot year is the current year minus 50 years.

`startat(obj,Y,M,D)` `startat(obj,[Y,M,D])` start the timer at the year (`Y`), month (`M`), and day (`D`) specified. `Y`, `M`, and `D` must be arrays of the same size (or they can be a scalar).

`startat(obj,Y,M,D,H,MI,S)` `startat(obj,[Y,M,D,H,MI,S])` start the timer at the year (`Y`), month (`M`), day (`D`), hour (`H`), minute (`MI`), and second (`S`) specified. `Y`, `M`, `D`, `H`, `MI`, and `S` must be arrays of the same size (or they can be a scalar). Values outside the normal range of each array



are automatically carried to the next unit (for example, month values greater than 12 are carried to years). Month values less than 1 are set to be 1; all other units can wrap and have valid negative values.

The timer stops running if one of the following conditions apply:

- The number of `TimerFcn` callbacks specified in `TasksToExecute` have been executed.
- The `stop(obj)` command is issued.
- An error occurred while executing a `TimerFcn` callback.

## Examples

This example uses a timer object to execute a function at a specified time.

```
t1=timer('TimerFcn','disp(''it is 10 o''''clock'')');
startat(t1,'10:00:00');
```

This example uses a timer to display a message when an hour has elapsed.

```
t2=timer('TimerFcn','disp(''It has been an hour now.'')');
startat(t2,now+1/24);
```

## See Also

`datenum`, `datestr`, `now`, `timer`, `start`, `stop`

# startup

---

**Purpose** MATLAB startup M-file for user-defined options

**Syntax** startup

**Description** startup automatically executes the master M-file matlabrc.m and, if it exists, startup.m, when MATLAB starts. On multiuser or networked systems, matlabrc.m is reserved for use by the system manager. The file matlabrc.m invokes the file startup.m if it exists on the MATLAB search path.

You can create a startup.m file in your own MATLAB startup directory. The file can include physical constants, Handle Graphics defaults, engineering conversion factors, or anything else you want predefined in your workspace.

There are other ways to predefine aspects of MATLAB. See Startup Options and About Preferences in the MATLAB Desktop Tools and Development Environment documentation.

**Algorithm** Only matlabrc.m is actually invoked by MATLAB at startup. However, matlabrc.m contains the statements

```
if exist('startup')==2
    startup
end
```

that invoke startup.m. You can extend this process to create additional startup M-files, if required.

**See Also** matlabrc, matlabroot, path, quit

**Purpose**

Standard deviation

**Syntax**

```
s = std(X)
s = std(X,flag)
s = std(X,flag,dim)
```

**Definition**

There are two common textbook definitions for the standard deviation  $s$  of a data vector  $X$ .

$$(1) \quad s = \left( \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 \right)^{\frac{1}{2}}$$

$$(2) \quad s = \left( \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 \right)^{\frac{1}{2}}$$

where

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

and  $n$  is the number of elements in the sample. The two forms of the equation differ only in  $n - 1$  versus  $n$  in the divisor.

**Description**

`s = std(X)`, where  $X$  is a vector, returns the standard deviation using (1) above. The result  $s$  is the square root of an unbiased estimator of the variance of the population from which  $X$  is drawn, as long as  $X$  consists of independent, identically distributed samples.

If  $X$  is a matrix, `std(X)` returns a row vector containing the standard deviation of the elements of each column of  $X$ . If  $X$  is a multidimensional array, `std(X)` is the standard deviation of the elements along the first nonsingleton dimension of  $X$ .

# std

---

`s = std(X,flag)` for `flag = 0`, is the same as `std(X)`. For `flag = 1`, `std(X,1)` returns the standard deviation using (2) above, producing the second moment of the set of values about their mean.

`s = std(X,flag,dim)` computes the standard deviations along the dimension of `X` specified by scalar `dim`. Set `flag` to 0 to normalize `Y` by  $n-1$ ; set `flag` to 1 to normalize by  $n$ .

## Examples

For matrix `X`

```
X =
     1     5     9
     7    15    22
s = std(X,0,1)
s =
  4.2426   7.0711   9.1924
s = std(X,0,2)
s =
  4.000
  7.5056
```

## See Also

`corrcoef`, `cov`, `mean`, `median`, `var`

**Purpose** Standard deviation of timeseries data

**Syntax**

```
ts_std = std(ts)
ts_std = std(ts, 'PropertyName1', PropertyValue1, ...)
```

**Description** `ts_std = std(ts)` returns the standard deviation of the time-series data. When `ts.Data` is a vector, `ts_std` is the standard deviation of `ts.Data` values. When `ts.Data` is a matrix, `ts_std` is the standard deviation of each column of `ts.Data` (when `IsTimeFirst` is true and the first dimension of `ts` is aligned with time). For the N-dimensional `ts.Data` array, `std` always operates along the first nonsingleton dimension of `ts.Data`.

```
ts_std = std(ts, 'PropertyName1', PropertyValue1, ...)
```

specifies the following optional input arguments:

- 'MissingData' property has two possible values, 'remove' (default) or 'interpolate', indicating how to treat missing data during the calculation.
- 'Quality' values are specified by a vector of integers, indicating which quality codes represent missing samples (for vector data) or missing observations (for data arrays with two or more dimensions).
- 'Weighting' property has two possible values, 'none' (default) or 'time'. When you specify 'time', larger time values correspond to larger weights.

**Examples** 1 Load a 24-by-3 data array.

```
load count.dat
```

2 Create a timeseries object with 24 time values.

```
count_ts = timeseries(count,1:24,'Name','CountPerSecond')
```

## std (timeseries)

---

- 3** Calculate the standard deviation of each data column for this `timeseries` object.

```
std(count_ts)

ans =

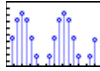
    25.3703    41.4057    68.0281
```

The standard deviation is calculated independently for each data column in the `timeseries` object.


### See Also

```
iqr (timeseries), mean (timeseries), median (timeseries), var  
(timeseries), timeseries
```

**Purpose** Plot discrete sequence data



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
stem(Y)
stem(X,Y)
stem(...,'fill')
stem(...,LineStyle)
stem(axes_handle,...)
h = stem(...)
hlines = stem('v6',...)
```

## Description

A two-dimensional stem plot displays data as lines extending from a baseline along the  $x$ -axis. A circle (the default) or other marker whose  $y$ -position represents the data value terminates each stem.

`stem(Y)` plots the data sequence  $Y$  as stems that extend from equally spaced and automatically generated values along the  $x$ -axis. When  $Y$  is a matrix, `stem` plots all elements in a row against the same  $x$  value.

`stem(X,Y)` plots  $X$  versus the columns of  $Y$ .  $X$  and  $Y$  must be vectors or matrices of the same size. Additionally,  $X$  can be a row or a column vector and  $Y$  a matrix with `length(X)` rows.

`stem(...,'fill')` specifies whether to color the circle at the end of the stem.

`stem(...,LineStyle)` specifies the line style, marker symbol, and color for the stem and top marker (the baseline is not affected). See `LineStyle` for more information.

`stem(axes_handle,...)` plots into the axes object with the handle `axes_handle` instead of into the current axes object (`gca`).

`h = stem(...)` returns a vector of stemseries object handles in `h`, one handle per column of data in `Y`.

## Backward-Compatible Version

`hlines = stem('v6',...)` returns the handles of line objects instead of stemseries objects for compatibility with MATLAB 6.5 and earlier.

`hlines` contains the handles to three line graphics objects:

- `hlines(1)` — The marker symbol at the top of each stem
- `hlines(2)` — The stem line
- `hlines(3)` — The baseline handle

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See Plot Objects and Backward Compatibility for more information.

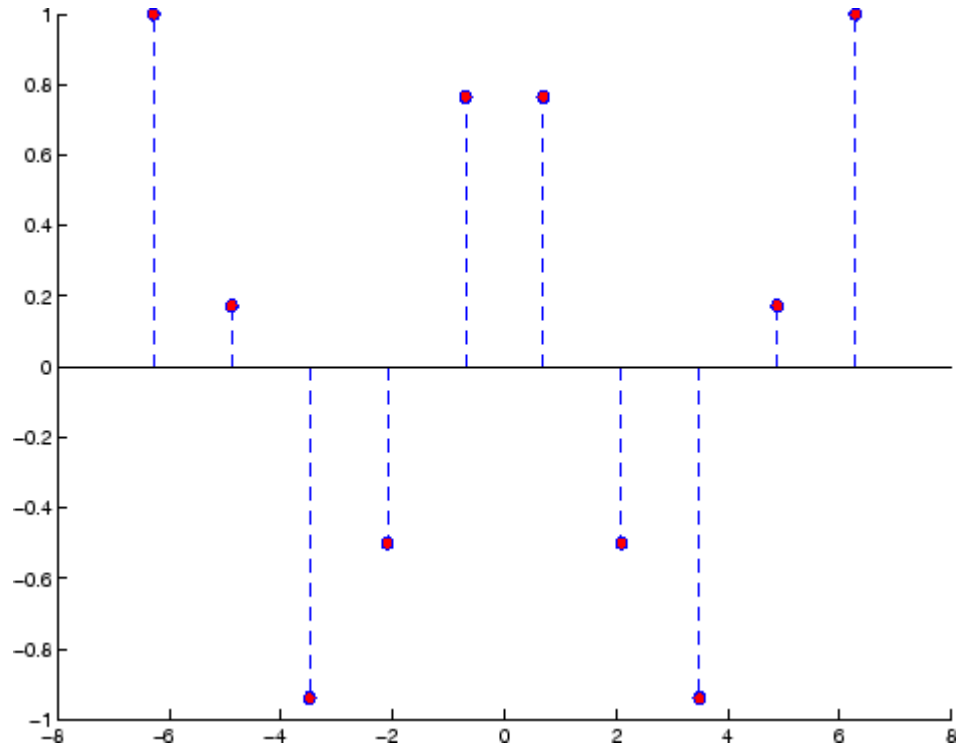
## Examples

### Single Series of Data

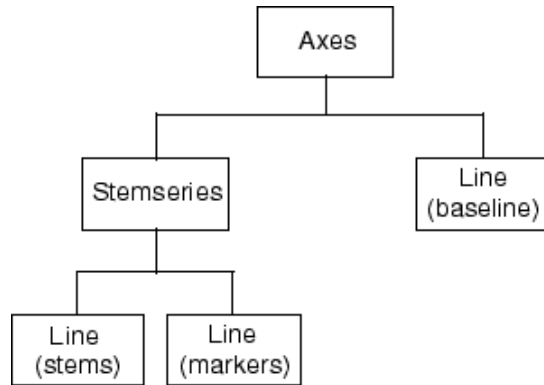
This example creates a stem plot representing the cosine of 10 values linearly spaced between 0 and  $2\pi$ . Note that the line style of the baseline is set by first getting its handle from the stemseries object's `BaseLine` property.

```
t = linspace(-2*pi,2*pi,10);
h = stem(t,cos(t),'fill','--');
set(get(h,'BaseLine'),'LineStyle',':')
set(h,'MarkerFaceColor','red')
```





The following diagram illustrates the parent-child relationship in the previous stem plot. Note that the stemsseries object contains two line objects used to draw the stem lines and the end markers. The baseline is a separate line object.

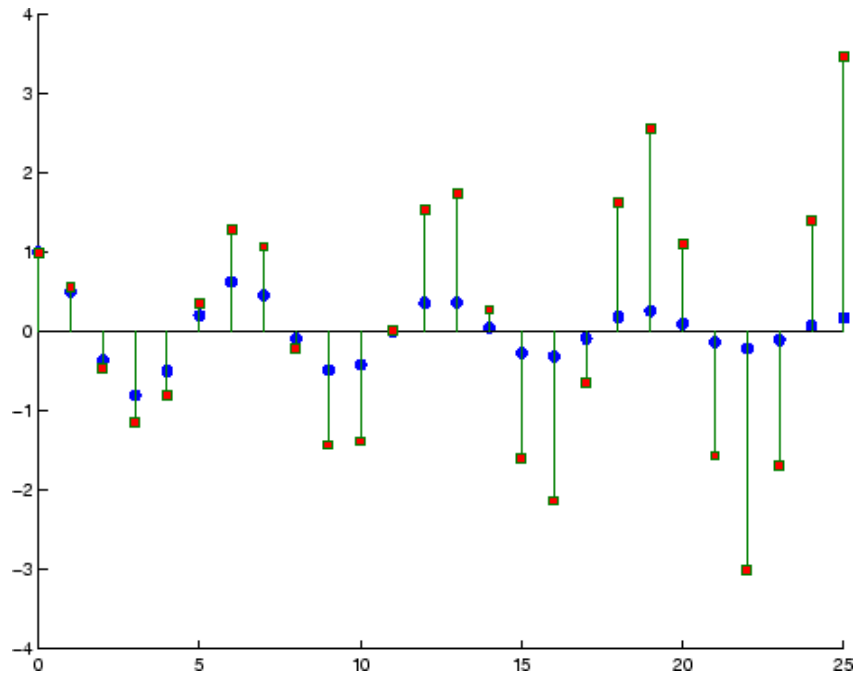


## Two Series of Data on One Graph

The following example creates a stem plot from a two-column matrix. In this case, the `stem` function creates two `stemseries` objects, one of each column of data. Both objects' handles are returned in the output argument `h`.

- `h(1)` is the handle to the `stemseries` object plotting the expression `exp(-.07*x).*cos(x)`.
- `h(2)` is the handle to the `stemseries` object plotting the expression `exp(.05*x).*cos(x)`.

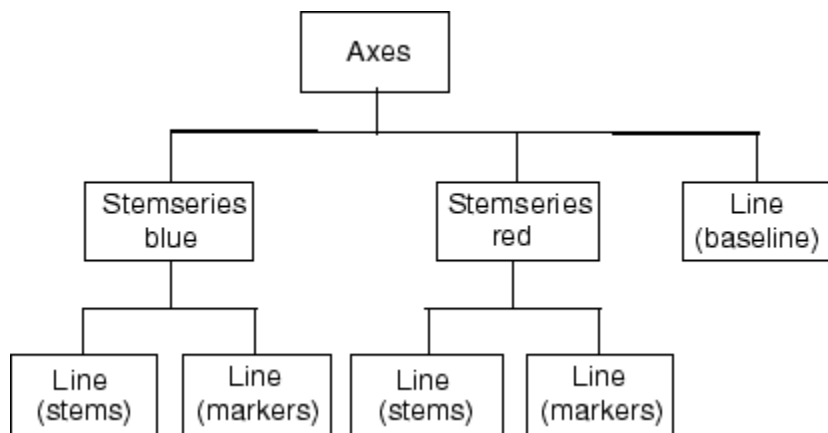
```
x = 0:25;  
y = [exp(-.07*x).*cos(x);exp(.05*x).*cos(x)]';  
h = stem(x,y);  
set(h(1),'MarkerFaceColor','blue')  
set(h(2),'MarkerFaceColor','red','Marker','square')
```



The following diagram illustrates the parent-child relationship in the previous stem plot. Note that each column in the input matrix  $y$  results in the creation of a stemseries object, which contains two line objects (one for the stems and one for the markers). The baseline is shared by both stemseries objects.

# stem

---



## See Also


bar, plot, stairs

Stemseries properties for property descriptions

**Purpose** Plot 3-D discrete sequence data



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
stem3(Z)
stem3(X,Y,Z)
stem3(...,'fill')
stem3(...,LineStyle)
h = stem3(...)
hlines = stem3('v6',...)
```

## Description

Three-dimensional stem plots display lines extending from the  $x$ - $y$  plane. A circle (the default) or other marker symbol whose  $z$ -position represents the data value terminates each stem.

`stem3(Z)` plots the data sequence  $Z$  as stems that extend from the  $x$ - $y$  plane.  $x$  and  $y$  are generated automatically. When  $Z$  is a row vector, `stem3` plots all elements at equally spaced  $x$  values against the same  $y$  value. When  $Z$  is a column vector, `stem3` plots all elements at equally spaced  $y$  values against the same  $x$  value.

`stem3(X,Y,Z)` plots the data sequence  $Z$  at values specified by  $X$  and  $Y$ .  $X$ ,  $Y$ , and  $Z$  must all be vectors or matrices of the same size.

`stem3(...,'fill')` specifies whether to color the interior of the circle at the end of the stem.

`stem3(...,LineStyle)` specifies the line style, marker symbol, and color for the stems. See `LineStyle` for more information.

`h = stem3(...)` returns handles to stems series graphics objects.

## Backward-Compatible Version

`hlines = stem3('v6',...)` returns the handles of line objects instead of stemseries objects for compatibility with MATLAB 6.5 and earlier.

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

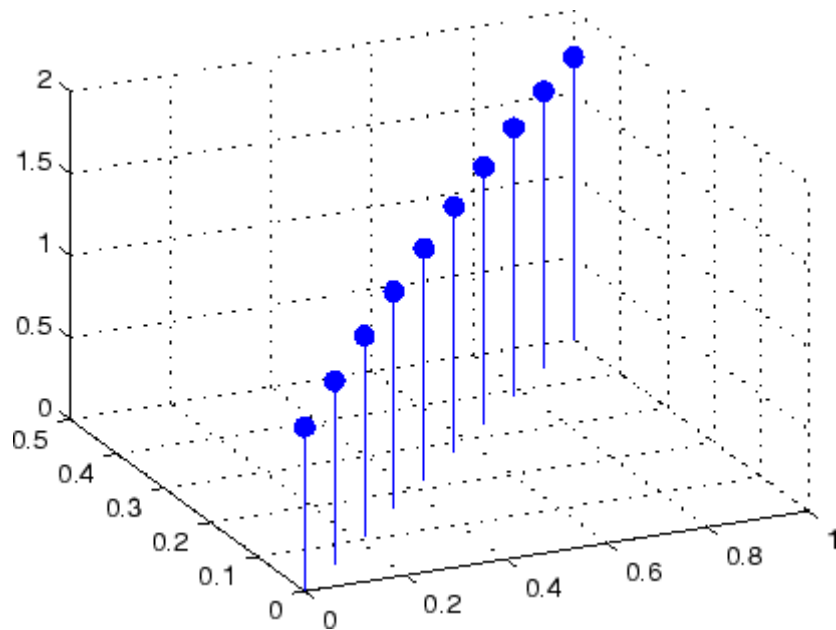
---

See Plot Objects and Backward Compatibility for more information.

## Examples

Create a three-dimensional stem plot to visualize a function of two variables.

```
X = linspace(0,1,10);
Y = X./2;
Z = sin(X) + cos(Y);
stem3(X,Y,Z,'fill')
view(-25,30)
```

**See Also**

bar, plot, stairs, stem

“Discrete Data Plots” on page 1-89 for related functions

Stemseries Properties for descriptions of properties

Three-Dimensional Stem Plots for more examples

# Stemseries Properties

---

**Purpose** Define stemseries properties

**Modifying Properties** You can set and query graphics object properties using the set and get commands or with the property editor (propertyeditor).

Note that you cannot define default properties for stemseries objects.

See Plot Objects for information on stemseries objects.

**Stemseries Property Descriptions** This section provides a description of properties. Curly braces { } enclose default values.

Annotation  
hg.Annotation object Read Only

*Control the display of stemseries objects in legends.* The Annotation property enables you to specify whether this stemseries object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the stemseries object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                                                              |
|------------------------|--------------------------------------------------------------------------------------|
| on                     | Include the stemseries object in a legend as one entry, but not its children objects |
| off                    | Do not include the stemseries or its children in a legend (default)                  |
| children               | Include only the children of the stemseries as separate entries in the legend        |



## Setting the `IconDisplayStyle` property

These commands set the `IconDisplayStyle` of a graphics object with handle `hobj` to `children`, which causes each child object to have an entry in the legend:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'children')
```

## Using the `IconDisplayStyle` property

See “Controlling Legends” for more information and examples.

### `BaseLine`

handle of baseline

*Handle of the baseline object.* This property contains the handle of the line object used as the baseline. You can set the properties of this line using its handle. For example, the following statements create a stem plot, obtain the handle of the baseline from the `stemseries` object, and then set line properties that make the baseline a dashed, red line.

```
stem_handle = stem(randn(10,1));  
baseline_handle = get(stem_handle, 'BaseLine');  
set(baseline_handle, 'LineStyle', '--', 'Color', 'red')
```

### `BaseValue`

*y*-axis value

*Y-axis value where baseline is drawn.* You can specify the value along the *y*-axis at which MATLAB draws the baseline.

### `BeingDeleted`

on | {off} Read Only

## Stemseries Properties

---

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to `on` when the object's delete function callback is called (see the `DeleteFcn` property). It remains set to `on` while the delete function executes, after which the object no longer exists.

For example, an object's delete function might call other functions that act on a number of different objects. These functions might not need to perform actions on objects if the objects are going to be deleted, and therefore, can check the object's `BeingDeleted` property before acting.

`BusyAction`  
`cancel | {queue}`

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callbacks. If there is a callback function executing, callbacks invoked subsequently always attempt to interrupt it.

If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

`ButtonDownFcn`  
string or function handle

*Button press callback function.* A callback that executes whenever you press a mouse button while the pointer is over this object, but not over another graphics object. See the `HitTestArea` property for information about selecting objects of this type.

See the figure's `SelectionType` property to determine if modifier keys were also pressed.

This property can be

- A string that is a valid MATLAB expression
- The name of an M-file
- A function handle

Set this property to a function handle that references the callback. The expressions execute in the MATLAB workspace.

See “Function Handle Callbacks” for information on how to use function handles to define the callbacks.

## Children

array of graphics object handles

*Children of this object.* The handle of a patch object that is the child of this object (whether visible or not).

Note that if a child object's `HandleVisibility` property is set to `callback` or `off`, its handle does not show up in this object's `Children` property unless you set the root `ShowHiddenHandles` property to `on`:

```
set(0, 'ShowHiddenHandles', 'on')
```

## Clipping

{on} | off

# Stemseries Properties

---

*Clipping mode.* MATLAB clips graphs to the axes plot box by default. If you set `Clipping` to `off`, portions of graphs can be displayed outside the axes plot box. This can occur if you create a plot object, set `hold` to `on`, freeze axis scaling (`axis manual`), and then create a larger plot object.

## Color

ColorSpec

*Color of stem lines.* A three-element RGB vector or one of the MATLAB predefined names, specifying the line color. See the `ColorSpec` reference page for more information on specifying color.

For example, the following statement would produce a stem plot with red lines.

```
h = stem(randn(10,1), 'Color', 'r');
```

## CreateFcn

string or function handle

*Callback routine executed during object creation.* This property defines a callback that executes when MATLAB creates an object. You must specify the callback during the creation of the object. For example,

```
area(y, 'CreateFcn', @CallbackFcn)
```

where `@CallbackFcn` is a function handle that references the callback function.

MATLAB executes this routine after setting all other object properties. Setting this property on an existing object has no effect.

The handle of the object whose `CreateFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## DeleteFcn

string or function handle

*Callback executed during object deletion.* A callback that executes when this object is deleted (e.g., this might happen when you issue a delete command on the object, its parent axes, or the figure containing it). MATLAB executes the callback before destroying the object’s properties so the callback routine can query these values.

The handle of the object whose DeleteFcn is being executed is accessible only through the root CallbackObject property, which can be queried using gcbo.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

See the BeingDeleted property for related information.

## DisplayName

string (default is empty string)

*String used by legend for this stemseries object.* The legend function uses the string defined by the DisplayName property to label this stemseries object in the legend.

- If you specify string arguments with the legend function, DisplayName is set to this stemseries object’s corresponding string and that string is used for the legend.
- If DisplayName is empty, legend creates a string of the form, ['data' *n*], where *n* is the number assigned to the object based on its location in the list of legend entries. However, legend does not set DisplayName to this string.

# Stemseries Properties

---

- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call `legend` with the `toggle` or `show` option.

See “Controlling Legends” for more examples.

## EraseMode

`{normal} | none | xor | background`

*Erase mode.* This property controls the technique MATLAB uses to draw and erase objects and their children. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- `normal` — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- `none` — Do not erase objects when they are moved or destroyed. While the objects are still visible on the screen after erasing with `EraseMode none`, you cannot print these objects because MATLAB stores no information about their former locations.
- `xor` — Draw and erase the object by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the object does not damage the color of the objects behind it. However, the color of the erased object depends on the color of the screen behind it and it is correctly colored only when it is over the axes background color (or the figure background color).

if the axes Color property is set to none). That is, it isn't erased correctly if there are objects behind it.

- background — Erase the graphics objects by redrawing them in the axes background color, (or the figure background color if the axes Color property is set to none). This damages other graphics objects that are behind the erased object, but the erased object is always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the EraseMode of all objects is normal. This means graphics objects created with EraseMode set to none, xor, or background can look different on screen than on paper. On screen, MATLAB can mathematically combine layers of colors (e.g., performing an XOR on a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

Set the axes background color with the axes Color property. Set the figure background color with the figure Color property.

You can use the MATLAB `getframe` command or other screen capture applications to create an image of a figure containing nonnormal mode objects.

`HandleVisibility`  
{on} | callback | off

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. `HandleVisibility` is useful for preventing command-line users from accidentally accessing objects that you need to protect for some reason.

- on — Handles are always visible when `HandleVisibility` is on.

# Stemseries Properties

---

- `callback` — Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have access to object handles.
- `off` — Setting `HandleVisibility` to `off` makes handles invisible at all times. This might be necessary when a callback invokes a function that might potentially damage the GUI (such as evaluating a user-typed string) and so temporarily hides its own handles during the execution of that function.

## Functions Affected by Handle Visibility

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

## Properties Affected by Handle Visibility

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

## Overriding Handle Visibility

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties). See also `findall`.

## Handle Validity



Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties and pass it to any function that operates on handles.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

HitTest  
{on} | off

*Selectable by mouse click.* HitTest determines whether this object can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the objects that compose the area graph. If HitTest is off, clicking this object selects the object below it (which is usually the axes containing it).

HitTestArea  
on | {off}

*Select the object by clicking lines or area of extent.* This property enables you to select plot objects in two ways:

- Select by clicking lines or markers (default).
- Select by clicking anywhere in the extent of the plot.

When HitTestArea is off, you must click the object's lines or markers (excluding the baseline, if any) to select the object. When HitTestArea is on, you can select this object by clicking anywhere within the extent of the plot (i.e., anywhere within a rectangle that encloses it).

Interruptible  
{on} | off

# Stemseries Properties

---

*Callback routine interruption mode.* The `Interruptible` property controls whether an object's callback can be interrupted by callbacks invoked subsequently.

Only callbacks defined for the `ButtonDownFcn` property are affected by the `Interruptible` property. MATLAB checks for events that can interrupt a callback only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.

Setting `Interruptible` to `on` allows any graphics object's callback to interrupt callback routines originating from a `bar` property. Note that MATLAB does not save the state of variables or the display (e.g., the handle returned by the `gca` or `gcf` command) when an interruption occurs.

## LineStyle

{-} | -- | : | -. | none

*Line style.* This property specifies the line style of the object. Available line styles are shown in the following table.

| Specifier String | Line Style           |
|------------------|----------------------|
| -                | Solid line (default) |
| --               | Dashed line          |
| :                | Dotted line          |
| -.               | Dash-dot line        |
| none             | No line              |

You can use `LineStyle none` when you want to place a marker at each point but do not want the points connected with a line (see the `Marker` property).

LineWidth  
scalar

*The width of linear objects and edges of filled areas.* Specify this value in points (1 point =  $1/72$  inch). The default LineWidth is 0.5 points.

Marker  
character (see table)

*Marker symbol.* The Marker property specifies the type of markers that are displayed at plot vertices. You can set values for the Marker property independently from the LineStyle property. Supported markers include those shown in the following table.

| Marker Specifier | Description                   |
|------------------|-------------------------------|
| +                | Plus sign                     |
| o                | Circle                        |
| *                | Asterisk                      |
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

# Stemseries Properties

---

## MarkerEdgeColor

ColorSpec | none | {auto}

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles). ColorSpec defines the color to use. none specifies no color, which makes nonfilled markers invisible. auto sets MarkerEdgeColor to the same color as the Color property.

## MarkerFaceColor

ColorSpec | {none} | auto

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles). ColorSpec defines the color to use. none makes the interior of the marker transparent, allowing the background to show through. auto sets the fill color to the axes color, or to the figure color if the axes Color property is set to none (which is the factory default for axes objects).

## MarkerSize

size in points

*Marker size.* A scalar specifying the size of the marker in points. The default value for MarkerSize is 6 points (1 point = 1/72 inch). Note that MATLAB draws the point marker (specified by the ' .' symbol) at one-third the specified size.

## Parent

handle of parent axes, hgggroup, or hgtransform

*Parent of this object.* This property contains the handle of the object's parent. The parent is normally the axes, hgggroup, or hgtransform object that contains the object.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

## Selected

on | {off}

*Is object selected?* When you set this property to on, MATLAB displays selection "handles" at the corners and midpoints if the SelectionHighlight property is also on (the default). You can, for example, define the ButtonDownFcn callback to set this property to on, thereby indicating that this particular object is selected. This property is also set to on when an object is manually selected in plot edit mode.

## SelectionHighlight

{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is off, MATLAB does not draw the handles except when in plot edit mode and objects are selected manually.

## Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callbacks.

For example, you might create a stemseries object and set the Tag property:

```
t = stem(Y, 'Tag', 'stem1')
```

When you want to access the stemseries object, you can use findobj to find the stemseries object's handle. The following statement changes the MarkerFaceColor property of the object whose Tag is stem1.

# Stemseries Properties

---

```
set(findobj('Tag','stem1'),'MarkerFaceColor','red')
```

## Type

string (read only)

*Type of graphics object.* This property contains a string that identifies the class of the graphics object. For stemseries objects, Type is 'hgroup'. The following statement finds all the hgroup objects in the current axes object.

```
t = findobj(gca,'Type','hgroup');
```

## UIContextMenu

handle of a uicontextmenu object

*Associate a context menu with this object.* Assign this property the handle of a uicontextmenu object created in the object's parent figure. Use the uicontextmenu function to create the context menu. MATLAB displays the context menu whenever you right-click over the object.

## UserData

array

*User-specified data.* This property can be any data you want to associate with this object (including cell arrays and structures). The object does not set values for this property, but you can access it using the set and get functions.

## Visible

{on} | off

*Visibility of this object and its children.* By default, a new object's visibility is on. This means all children of the object are visible unless the child object's Visible property is set to off. Setting an object's Visible property to off prevents the object from being displayed. However, the object still exists and you can set and query its properties.

## XData

array

*X-axis location of stems.* The stem function draws an individual stem at each  $x$ -axis location in the XData array. XData can be either a matrix equal in size to YData or a vector equal in length to the number of rows in YData. That is, `length(XData) == size(YData, 1)`. XData does not need to be monotonically increasing.

If you do not specify XData (i.e., the input argument  $x$ ), the stem function uses the indices of YData to create the stem plot. See the XDataMode property for related information.

## XDataMode

{auto} | manual

*Use automatic or user-specified x-axis values.* If you specify XData (by setting the XData property or specifying the  $x$  input argument), MATLAB sets this property to manual and uses the specified values to label the  $x$ -axis.

If you set XDataMode to auto after having specified XData, MATLAB resets the  $x$ -axis ticks to `1:size(YData, 1)` or to the column indices of the ZData, overwriting any previous values for XData.

## XDataSource

string (MATLAB variable)

*Link XData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the XData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change XData.

# Stemseries Properties

---

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## YData

scalar, vector, or matrix

*Stem plot data.* YData contains the data plotted as stems. Each value in YData is represented by a marker in the stem plot. If YData is a matrix, MATLAB creates a series of stems for each column in the matrix.

The input argument `y` in the `stem` function calling syntax assigns values to YData.

## YDataSource

string (MATLAB variable)

*Link YData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the YData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change YData.



You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## ZData

vector of coordinates

*Z-coordinates.* A data defining the stems for 3-D stem graphs. XData and YData (if specified) must be the same size.

## ZDataSource

string (MATLAB variable)

*Link ZData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the ZData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change ZData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

## Stemseries Properties

---

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

**Purpose** Stop timer(s)

**Syntax** stop(obj)

**Description** stop(obj) stops the timer, represented by the timer object, obj. If obj is an array of timer objects, the stop function stops them all. Use the timer function to create a timer object.

The stop function sets the Running property of the timer object, obj, to 'off', halts further TimerFcn callbacks, and executes the StopFcn callback.

**See Also** timer, start

# stopasync

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Stop asynchronous read and write operations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>      | <code>stopasync(obj)</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Arguments</b>   | <code>obj</code> A serial port object or an array of serial port objects.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Description</b> | <code>stopasync(obj)</code> stops any asynchronous read or write operation that is in progress for <code>obj</code> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Remarks</b>     | <p>You can write data asynchronously using the <code>fprintf</code> or <code>fwrite</code> function. You can read data asynchronously using the <code>readasync</code> function, or by configuring the <code>ReadAsyncMode</code> property to <code>continuous</code>. In-progress asynchronous operations are indicated by the <code>TransferStatus</code> property.</p> <p>If <code>obj</code> is an array of serial port objects and one of the objects cannot be stopped, the remaining objects in the array are stopped and a warning is returned. After an object stops:</p> <ul style="list-style-type: none"><li>• Its <code>TransferStatus</code> property is configured to <code>idle</code>.</li><li>• Its <code>ReadAsyncMode</code> property is configured to <code>manual</code>.</li><li>• The data in its output buffer is flushed.</li></ul> <p>Data in the input buffer is not flushed. You can return this data to the MATLAB workspace using any of the synchronous read functions. If you execute the <code>readasync</code> function, or configure the <code>ReadAsyncMode</code> property to <code>continuous</code>, then the new data is appended to the existing data in the input buffer.</p> |
| <b>See Also</b>    | <b>Functions</b><br><code>fprintf</code> , <code>fwrite</code> , <code>readasync</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

**Properties**

ReadAsyncMode, TransferStatus

# str2double

---

**Purpose** Convert string to double-precision value

**Syntax**  
`X = str2double('str')`  
`X = str2double(C)`

**Description** `X = str2double('str')` converts the string `str`, which should be an ASCII character representation of a real or complex scalar value, to the MATLAB double-precision representation. The string can contain digits, a comma (thousands separator), a decimal point, a leading + or - sign, an e preceding a power of 10 scale factor, and an i for a complex unit.

If `str` does not represent a valid scalar value, `str2double` returns NaN.

`X = str2double(C)` converts the strings in the cell array of strings `C` to double precision. The matrix `X` returned will be the same size as `C`.

**Examples** Here are some valid `str2double` conversions.

```
str2double('123.45e7')
str2double('123 + 45i')
str2double('3.14159')
str2double('2.7i - 3.14')
str2double({'2.71' '3.1415'})
str2double('1,200.34')
```

**See Also** `char`, `hex2num`, `num2str`, `str2num`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Construct function handle from function name string                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Syntax</b>      | <code>str2func('str')</code>                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Description</b> | <p><code>str2func('str')</code> constructs a function handle <code>fhandle</code> for the function named in the string <code>'str'</code>.</p> <p>You can create a function handle using either the <code>@function</code> syntax or the <code>str2func</code> command. You can create an array of function handles from strings by creating the handles individually with <code>str2func</code>, and then storing these handles in a cellarray.</p> |

## Examples

### Example 1

To convert the string, `'sin'`, into a handle for that function, type

```
fh = str2func('sin')
fh =
    @sin
```

### Example 2

If you pass a function name string in a variable, the function that receives the variable can convert the function name to a function handle using `str2func`. The example below passes the variable, `funcname`, to function `makeHandle`, which then creates a function handle. Here is the function M-file:

```
function fh = makeHandle(funcname)
    fh = str2func(funcname);
```

This is the code that calls `makeHandle` to construct the function handle:

```
makeHandle('sin')
ans =
    @sin
```

## Example 3

To call `str2func` on a cell array of strings, use the `cellfun` function. This returns a cell array of function handles:

```
fh_array = cellfun(@str2func, {'sin' 'cos' 'tan'}, ...  
                  'UniformOutput', false);
```

```
fh_array{2}(5)  
ans =  
    0.2837
```

## Example 4

In the following example, the `myminbnd` function expects to receive either a function handle or string in the first argument. If you pass a string, `myminbnd` constructs a function handle from it using `str2func`, and then uses that handle in a call to `fminbnd`:

```
function myminbnd(fhandle, lower, upper)  
if ischar(fhandle)  
    disp 'converting function string to function handle ...'  
    fhandle = str2func(fhandle);  
end  
fminbnd(fhandle, lower, upper)
```

Whether you call `myminbnd` with a function handle or function name string, the function can handle the argument appropriately:

```
myminbnd('humps', 0.3, 1)  
converting function string to function handle ...  
ans =  
    0.6370
```

## See Also

`function_handle`, `func2str`, `functions`



**Purpose** Form blank-padded character matrix from strings

**Syntax** `S = str2mat(T1, T2, T3, ...)`

**Description** `S = str2mat(T1, T2, T3, ...)` forms the matrix `S` containing the text strings `T1`, `T2`, `T3`, ... as rows. The function automatically pads each string with blanks in order to form a valid matrix. Each text parameter, `Ti`, can itself be a string matrix. This allows the creation of arbitrarily large string matrices. Empty strings are significant.

---

**Note** This routine will become obsolete in a future version. Use `char` instead.

---

**Remarks** `str2mat` differs from `strvcat` in that empty strings produce blank rows in the output. In `strvcat`, empty strings are ignored.

**Examples** `x = str2mat('36842', '39751', '38453', '90307');`

```
whos x
  Name      Size      Bytes  Class
  x         4x5         40    char array

x(2,3)

ans =

     7
```

**See Also** `char`, `strvcat`

# str2num

---

**Purpose** Convert string to number

**Syntax**  
`x = str2num('str')`  
`[x status] = str2num('str')`

**Description** `x = str2num('str')` converts the string `str`, which is an ASCII character representation of a numeric value, to numeric representation. `str2num` also converts string matrices to numeric matrices. If the input string does not represent a valid number or matrix, `str2num(str)` returns the empty matrix in `x`.

The input string can contain

- Digits
- A decimal point
- A leading + or - sign
- A letter e or d preceding a power of 10 scale factor
- A letter i or j indicating a complex or imaginary number.

`[x status] = str2num('str')` returns the status of the conversion in logical status, where `status` equals logical 1 (true) if the conversion succeeds, and logical 0 (false) otherwise. If the input string `str` does not represent a valid number or matrix, MATLAB sets `x` to the empty matrix. If the conversions fails, `status` is set to 0.

Space characters can be significant. For instance, `str2num('1+2i')` and `str2num('1 + 2i')` produce `x = 1+2i`, while `str2num('1 +2i')` produces `x = [1 2i]`. You can avoid these problems by using the `str2double` function.

---

**Note** `str2num` uses the `eval` function to convert the input argument, so side effects can occur if the string contains calls to functions. Use `str2double` to avoid such side effects, or when the input to `str2num` contains a string that represents a single number.

---

**Examples**

`str2num('3.14159e0')` is approximately  $\pi$ .

To convert a string matrix,

```
str2num(['1 2'; '3 4'])
```

```
ans =
```

```
1    2  
3    4
```

**See Also**

`num2str`, `hex2num`, `sscanf`, `sparse`, `special characters`

# strcat

---

**Purpose** Concatenate strings horizontally

**Syntax** `t = strcat(s1, s2, s3, ...)`

**Description** `t = strcat(s1, s2, s3, ...)` horizontally concatenates corresponding rows of the character arrays `s1`, `s2`, `s3`, etc. All input arrays must have the same number of rows (or any can be a single string). When the inputs are all character arrays, the output is also a character array.

When any of the inputs is a cell array of strings, `strcat` returns a cell array of strings formed by concatenating corresponding elements of `s1`, `s2`, etc. The inputs must all have the same size (or any can be a scalar). Any of the inputs can also be character arrays.

Trailing spaces in character array inputs are ignored and do not appear in the output. This is not true for inputs that are cell arrays of strings. Use the concatenation syntax `[s1 s2 s3 ...]` to preserve trailing spaces.

**Remarks** `strcat` and matrix operation are different for strings that contain trailing spaces:

```
a = 'hello '  
b = 'goodbye'  
strcat(a, b)  
ans =  
hellogoodbye  
[a b]  
ans =  
hello goodbye
```

**Examples** Given two 1-by-2 cell arrays `a` and `b`,

```
a =          b =  
'abcde'    'fghi'      'jkl'    'mn'
```

the command `t = strcat(a,b)` yields

```
t =  
    'abcdeijkl'    'fghimn'
```

Given the 1-by-1 cell array `c = {'Q'}`, the command `t = strcat(a,b,c)` yields

```
t =  
    'abcdeijklQ'    'fghimnQ'
```

**See Also**

`strvcat`, `cat`, `cellstr`

# strcmp, strcmpi

---

**Purpose** Compare strings

**Syntax**  
TF = strcmp('str1', 'str2')  
TF = strcmp('str', C)  
TF = strcmp(C1, C2)

Each of these syntaxes apply to both strcmp and strcmpi. The strcmp function is case sensitive in matching strings, while strcmpi is not.

**Description** Although the following descriptions show only strcmp, they apply to strcmpi as well. The two functions are the same except that strcmpi compares strings without sensitivity to letter case:

TF = strcmp('str1', 'str2') compares the strings str1 and str2 and returns logical 1 (true) if they are identical, and returns logical 0 (false) otherwise. str1 and str2 can be character arrays of any dimension, but strcmp does not return true unless the sizes of both arrays are equal, and the contents of the two arrays are the same.

TF = strcmp('str', C) compares string str to the each element of cell array C, where str is a character vector (or a 1-by-1 cell array) and C is a cell array of strings. The function returns TF, a logical array that is the same size as C and contains logical 1 (true) for those elements of C that are a match, and logical 0 (false) for those elements that are not. The order of the first two input arguments is not important.

TF = strcmp(C1, C2) compares each element of C1 to the same element in C2, where C1 and C2 are equal-size cell arrays of strings. Input C1 or C2 can also be a character array with the right number of rows. The function returns TF, a logical array that is the same size as C1 and C2, and contains logical 1 (true) for those elements of C1 and C2 that are a match, and logical 0 (false) for those elements that are not.

**Remarks** These functions are intended for comparison of character data. When used to compare numeric data, they return logical 0.

Any leading and trailing blanks in either of the strings are explicitly included in the comparison.

The value returned by strcmp and strcmpi is not the same as the C language convention.

strcmp and strcmpi support international character sets.

## Examples

### Example 1

Perform a simple comparison of two strings:

```
strcmp('Yes', 'No')
ans =
     0
strcmp('Yes', 'Yes')
ans =
     1
```

### Example 2

Create 3 cell arrays of strings:

```
A = {'MATLAB', 'SIMULINK'; ...
     'Toolboxes', 'The MathWorks'};

B = {'Handle Graphics', 'Real Time Workshop'; ...
     'Toolboxes', 'The MathWorks'};

C = {'handle graphics', 'Signal Processing'; ...
     ' Toolboxes', 'The MATHWORKS'};
```

Compare cell arrays A and B with sensitivity to case:

```
strcmp(A, B)
ans =
     0     0
     1     1
```

Compare cell arrays B and C without sensitivity to case. Note that 'Toolboxes' doesn't match because of the leading space characters in C{2,1} that do not appear in B{2,1}:

## strcmp, strcmpi

---

```
strcmpi(B, C)
ans =
     1     0
     0     1
```

### Example 3

Compare a string vector to a cell array of strings, a string vector to a string array, and a string array to a cell array of strings.

Start by creating a cell array of strings, a string array containing the same strings (plus padding space characters), and a string vector containing one of the strings (plus padding).

```
cellArr = {'It was the best of times'; ...
           'it was the worst of times'; ...
           'it was the age of wisdom'; ...
           'it was the age of foolishness'};

strArr = char(cellArr);

strVec = strArr(3,:)
strVec =
    it was the age of wisdom
```

Remove the space padding from the string vector and compare it to the cell array. MATLAB compares the string with each row of the cell array, finding a match on the third row:

```
strcmp(deblank(strVec), cellArr)
ans =
     0
     0
     1
     0
```

Compare the string vector with the string array. Unlike the case above, MATLAB does not compare the string vector with each row of the string



array. It compares the entire contents of one against the entire contents of the other:

```
strcmp(strVec, strArr)
ans =
    0
```

Lastly, compare each row of the four-row string array against the same rows of the cell array. MATLAB finds them all to be equivalent. Note that in this case you do not have to remove the space padding from the string array:

```
strcmp(strArr, cellArr)
ans =
    1
    1
    1
    1
```

### See Also

strncmp, strncmpi, strmatch, strfind, findstr, regexp, regexpi, regexprep, regexpttranslate

# stream2

---

**Purpose** Compute 2-D streamline data

**Syntax**

```
XY = stream2(x,y,u,v,startx,starty)
XY = stream2(u,v,startx,starty)
XY = stream2(...,options)
```

**Description** `XY = stream2(x,y,u,v,startx,starty)` computes streamlines from vector data `u` and `v`. The arrays `x` and `y` define the coordinates for `u` and `v` and must be monotonic and 2-D plaid (such as the data produced by `meshgrid`). `startx` and `starty` define the starting positions of the streamlines. The section "Specifying Starting Points for Stream Plots" provides more information on defining starting points.

The returned value `XY` contains a cell array of vertex arrays.

`XY = stream2(u,v,startx,starty)` assumes the arrays `x` and `y` are defined as `[x,y] = meshgrid(1:n,1:m)` where `[m,n] = size(u)`.

`XY = stream2(...,options)` specifies the options used when creating the streamlines. Define options as a one- or two-element vector containing the step size or the step size and the maximum number of vertices in a streamline:

```
[stepsize]
```

or

```
[stepsize, max_number_vertices]
```

If you do not specify a value, MATLAB uses the default:

- Step size = 0.1 (one tenth of a cell)
- Maximum number of vertices = 10000

Use the `streamline` command to plot the data returned by `stream2`.

**Examples** This example draws 2-D streamlines from data representing air currents over regions of North America.

```
load wind
[sx,sy] = meshgrid(80,20:10:50);
streamline(stream2(x(:,:,5),y(:,:,5),u(:,:,5),v(:,:,5),sx,sy));
```

## See Also

coneplot, stream3, streamline

“Volume Visualization” on page 1-102 for related functions

Specifying Starting Points for Stream Plots for related information

# stream3

---

**Purpose** Compute 3-D streamline data

**Syntax**

```
XYZ = stream3(X,Y,Z,U,V,W,startx,starty,startz)
XYZ = stream3(U,V,W,startx,starty,startz)
XYZ = stream3(...,options)
```

**Description** `XYZ = stream3(X,Y,Z,U,V,W,startx,starty,startz)` computes streamlines from vector data `U, V, W`. The arrays `X, Y, Z` define the coordinates for `U, V, W` and must be monotonic and 3-D plaid (such as the data produced by `meshgrid`). `startx, starty, and startz` define the starting positions of the streamlines. The section "Specifying Starting Points for Stream Plots" provides more information on defining starting points.

The returned value `XYZ` contains a cell array of vertex arrays.

`XYZ = stream3(U,V,W,startx,starty,startz)` assumes the arrays `X, Y, and Z` are defined as `[X,Y,Z] = meshgrid(1:N,1:M,1:P)` where `[M,N,P] = size(U)`.

`XYZ = stream3(...,options)` specifies the options used when creating the streamlines. Define options as a one- or two-element vector containing the step size or the step size and the maximum number of vertices in a streamline:

```
[stepsize]
```

or

```
[stepsize, max_number_vertices]
```

If you do not specify values, MATLAB uses the default:

- Step size = 0.1 (one tenth of a cell)
- Maximum number of vertices = 10000

Use the `streamline` command to plot the data returned by `stream3`.

**Examples**

This example draws 3-D streamlines from data representing air currents over regions of North America.

```
load wind
[sx sy sz] = meshgrid(80,20:10:50,0:5:15);
streamline(stream3(x,y,z,u,v,w,sx,sy,sz))
view(3)
```

**See Also**

coneplot, stream2, streamline

“Volume Visualization” on page 1-102 for related functions

Specifying Starting Points for Stream Plots for related information

# streamline


---

## Purpose

Plot streamlines from 2-D or 3-D vector data



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
streamline(X,Y,Z,U,V,W,startx,starty,startz)
streamline(U,V,W,startx,starty,startz)
streamline(XYZ)
streamline(X,Y,U,V,startx,starty)
streamline(U,V,startx,starty)
streamline(XY)
streamline(...,options)
streamline(axes_handle,...)
h = streamline(...)
```

## Description

`streamline(X,Y,Z,U,V,W,startx,starty,startz)` draws streamlines from 3-D vector data  $U, V, W$ . The arrays  $X, Y, Z$  define the coordinates for  $U, V, W$  and must be monotonic and 3-D plaid (such as the data produced by `meshgrid`). `startx, starty, startz` define the starting positions of the streamlines. The section Specifying Starting Points for Stream Plots provides more information on defining starting points.

`streamline(U,V,W,startx,starty,startz)` assumes the arrays  $X, Y,$  and  $Z$  are defined as  $[X,Y,Z] = \text{meshgrid}(1:N,1:M,1:P)$ , where  $[M,N,P] = \text{size}(U)$ .

`streamline(XYZ)` assumes  $XYZ$  is a precomputed cell array of vertex arrays (as produced by `stream3`).

`streamline(X,Y,U,V,startx,starty)` draws streamlines from 2-D vector data `U, V`. The arrays `X, Y` define the coordinates for `U, V` and must be monotonic and 2-D plaid (such as the data produced by `meshgrid`). `startx` and `starty` define the starting positions of the streamlines. The output argument `h` contains a vector of line handles, one handle for each streamline.

`streamline(U,V,startx,starty)` assumes the arrays `X` and `Y` are defined as `[X,Y] = meshgrid(1:N,1:M)`, where `[M,N] = size(U)`.

`streamline(XY)` assumes `XY` is a precomputed cell array of vertex arrays (as produced by `stream2`).

`streamline(...,options)` specifies the options used when creating the streamlines. Define options as a one- or two-element vector containing the step size or the step size and the maximum number of vertices in a streamline:

`[stepsize]`

or

`[stepsize, max_number_vertices]`

If you do not specify values, MATLAB uses the default:

- Step size = 0.1 (one tenth of a cell)
- Maximum number of vertices = 1000

`streamline(axes_handle,...)` plots into the axes object with the handle `axes_handle` instead of the into current axes object (`gca`).

`h = streamline(...)` returns a vector of line handles, one handle for each streamline.

## Examples

This example draws streamlines from data representing air currents over a region of North America. Loading the wind data set creates the variables `x, y, z, u, v,` and `w` in the MATLAB workspace.

# streamline

---

The plane of streamlines indicates the flow of air from the west to the east (the  $x$ -direction) beginning at  $x = 80$  (which is close to the minimum value of the  $x$  coordinates). The  $y$ - and  $z$ -coordinate starting points are multivalued and approximately span the range of these coordinates. `meshgrid` generates the starting positions of the streamlines.

```
load wind
[sx,sy,sz] = meshgrid(80,20:10:50,0:5:15);
h = streamline(x,y,z,u,v,w,sx,sy,sz);
set(h,'Color','red')
view(3)
```

## See Also

`coneplot`, `stream2`, `stream3`, `streamparticles`

“Volume Visualization” on page 1-102 for related functions

Specifying Starting Points for Stream Plots for related information


Stream Line Plots of Vector Data for another example



**Purpose**

Plot stream particles

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
streamparticles(vertices)
streamparticles(vertices,n)
streamparticles(...,'PropertyName',PropertyValue,...)
streamparticles(line_handle,...)
h = streamparticles(...)
```

**Description**

`streamparticles(vertices)` draws stream particles of a vector field. Stream particles are usually represented by markers and can show the position and velocity of a streamline. `vertices` is a cell array of 2-D or 3-D vertices (as if produced by `stream2` or `stream3`).

`streamparticles(vertices,n)` uses `n` to determine how many stream particles to draw. The `ParticleAlignment` property controls how `n` is interpreted.

- If `ParticleAlignment` is set to `off` (the default) and `n` is greater than 1, approximately `n` particles are drawn evenly spaced over the streamline vertices.

If `n` is less than or equal to 1, `n` is interpreted as a fraction of the original stream vertices; for example, if `n` is 0.2, approximately 20% of the vertices are used.

`n` determines the upper bound for the number of particles drawn. The actual number of particles can deviate from `n` by as much as a factor of 2.

# streamparticles

---

- If `ParticleAlignment` is on, `n` determines the number of particles on the streamline having the most vertices and sets the spacing on the other streamlines to this value. The default value is `n = 1`.

`streamparticles(..., 'PropertyName', PropertyValue, ...)` controls the stream particles using named properties and specified values. Any unspecified properties have default values. MATLAB ignores the case of property names.

## Stream Particle Properties

`Animate` — Stream particle motion [nonnegative integer]

The number of times to animate the stream particles. The default is 0, which does not animate. `Inf` animates until you enter **Ctrl+C**.

`FrameRate` — Animation frames per second [nonnegative integer]

This property specifies the number of frames per second for the animation. `Inf`, the default, draws the animation as fast as possible. Note that the speed of the animation might be limited by the speed of the computer. In such cases, the value of `FrameRate` cannot necessarily be achieved.

`ParticleAlignment` — Align particles with streamlines [ on | {off} ]

Set this property to on to draw particles at the beginning of each streamline. This property controls how `streamparticles` interprets the argument `n` (number of stream particles).

Stream particles are line objects. In addition to stream particle properties, you can specify any line object property, such as `Marker` and `EraseMode`. `streamparticles` sets the following line properties when called.

| Line Property          | Value Set by streamparticles |
|------------------------|------------------------------|
| <code>EraseMode</code> | <code>xor</code>             |
| <code>LineStyle</code> | <code>none</code>            |
| <code>Marker</code>    | <code>0</code>               |

| Line Property   | Value Set by streamparticles |
|-----------------|------------------------------|
| MarkerEdgeColor | none                         |
| MarkerFaceColor | red                          |

You can override any of these properties by specifying a property name and value as arguments to `streamparticles`. For example, this statement uses RGB values to set the `MarkerFaceColor` to medium gray:

```
streamparticles(vertices, 'MarkerFaceColor', [.5 .5 .5])
```

`streamparticles(line_handle, ...)` uses the line object identified by `line_handle` to draw the stream particles.

`h = streamparticles(...)` returns a vector of handles to the line objects it creates.

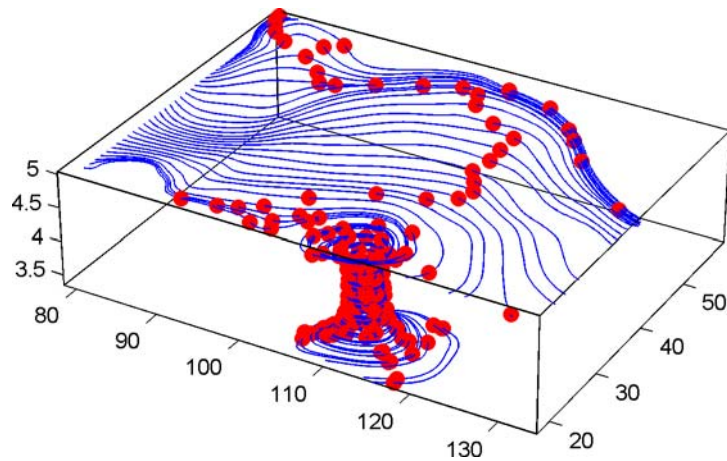
## Examples

This example combines streamlines with stream particle animation. The `interpstreamspeed` function determines the vertices along the streamlines where stream particles will be drawn during the animation, thereby controlling the speed of the animation. Setting the axes `DrawMode` property to `fast` provides faster rendering.

```
load wind
[sx sy sz] = meshgrid(80,20:1:55,5);
verts = stream3(x,y,z,u,v,w,sx,sy,sz);
sl = streamline(verts);
iverts = interpstreamspeed(x,y,z,u,v,w,verts,.025);
axis tight; view(30,30); daspect([1 1 .125])
camproj perspective; camva(8)
set(gca, 'DrawMode', 'fast')
box on
streamparticles(iverts,35, 'animate', 10, 'ParticleAlignment', 'on')
```

The following picture is a static view of the animation.

# streamparticles



This example uses the streamlines in the  $z = 5$  plane to animate the flow along these lines with streamparticles.

```
load wind
daspect([1 1 1]); view(2)
[verts averts] = streamslice(x,y,z,u,v,w,[],[],[5]);
sl = streamline([verts averts]);
axis tight off;
set(sl,'Visible','off')
iverts = interpstreamspeed(x,y,z,u,v,w,verts,.05);
set(gca,'DrawMode','fast','Position',[0 0 1 1],'ZLim',[4.9 5.1])
set(gcf,'Color','black')
streamparticles(iverts, 200, ...
    'Animate',100,'FrameRate',40, ...
    'MarkerSize',10,'MarkerFaceColor','yellow')
```

## See Also

[interpstreamspeed](#), [stream3](#), [streamline](#)

“Volume Visualization” on page 1-102 for related functions


[Creating Stream Particle Animations](#) for more details

[Specifying Starting Points for Stream Plots](#) for related information

**Purpose**

3-D stream ribbon plot from vector volume data

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
streamribbon(X,Y,Z,U,V,W,startx,starty,startz)
streamribbon(U,V,W,startx,starty,startz)
streamribbon(vertices,X,Y,Z,cav,speed)
streamribbon(vertices,cav,speed)
streamribbon(vertices,twistangle)
streamribbon(...,width)
streamribbon(axes_handle,...)
h = streamribbon(...)
```

**Description**

`streamribbon(X,Y,Z,U,V,W,startx,starty,startz)` draws stream ribbons from vector volume data  $U, V, W$ . The arrays  $X, Y, Z$  define the coordinates for  $U, V, W$  and must be monotonic and 3-D plaid (as if produced by `meshgrid`). `startx`, `starty`, and `startz` define the starting positions of the stream ribbons at the center of the ribbons. The section [Specifying Starting Points for Stream Plots](#) provides more information on defining starting points.

The twist of the ribbons is proportional to the curl of the vector field. The width of the ribbons is calculated automatically.

Generally, you should set the `DataAspectRatio` (`daspect`) before calling `streamribbon`.

`streamribbon(U,V,W,startx,starty,startz)` assumes  $X, Y$ , and  $Z$  are determined by the expression

# streamribbon

---

```
[X,Y,Z] = meshgrid(1:n,1:m,1:p)
```

where `[m,n,p] = size(U)`.

`streamribbon(vertices,X,Y,Z,cav,speed)` assumes precomputed streamline vertices, curl angular velocity, and flow speed. `vertices` is a cell array of streamline vertices (as produced by `stream3`). `X`, `Y`, `Z`, `cav`, and `speed` are 3-D arrays.

`streamribbon(vertices,cav,speed)` assumes `X`, `Y`, and `Z` are determined by the expression

```
[X,Y,Z] = meshgrid(1:n,1:m,1:p)
```

where `[m,n,p] = size(cav)`.

`streamribbon(vertices,twistangle)` uses the cell array of vectors `twistangle` for the twist of the ribbons (in radians). The size of each corresponding element of `vertices` and `twistangle` must be equal.

`streamribbon(...,width)` sets the width of the ribbons to `width`.

`streamribbon(axes_handle,...)` plots into the axes object with the handle `axes_handle` instead of into the current axes object (`gca`).

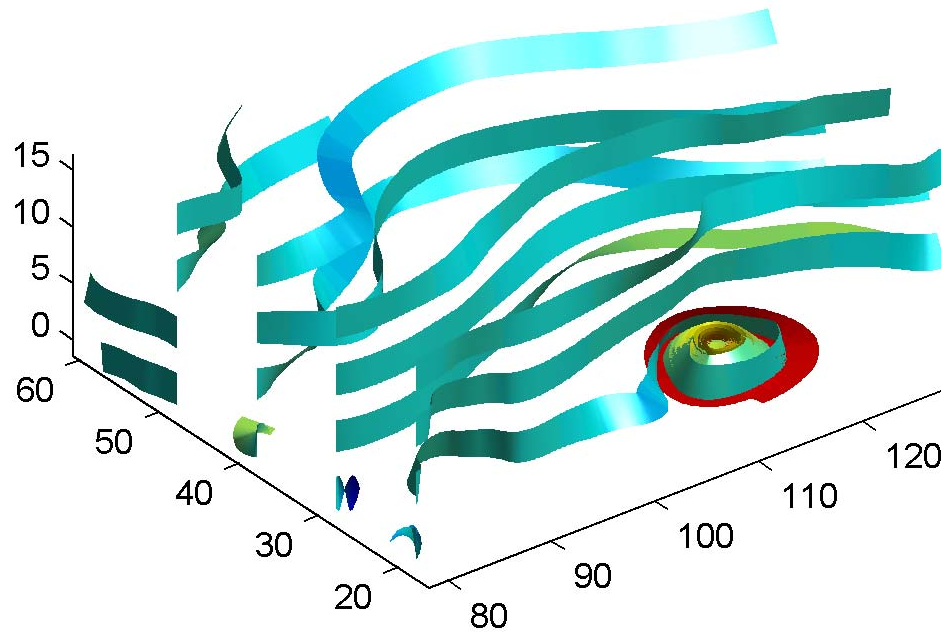
`h = streamribbon(...)` returns a vector of handles (one per start point) to surface objects.

## Examples

This example uses stream ribbons to indicate the flow in the wind data set. Inputs include the coordinates, vector field components, and starting location for the stream ribbons.

```
load wind
[sx sy sz] = meshgrid(80,20:10:50,0:5:15);
daspect([1 1 1])
streamribbon(x,y,z,u,v,w,sx,sy,sz);
%-----Define viewing and lighting
axis tight
shading interp;
view(3);
```

```
camlight; lighting gouraud
```



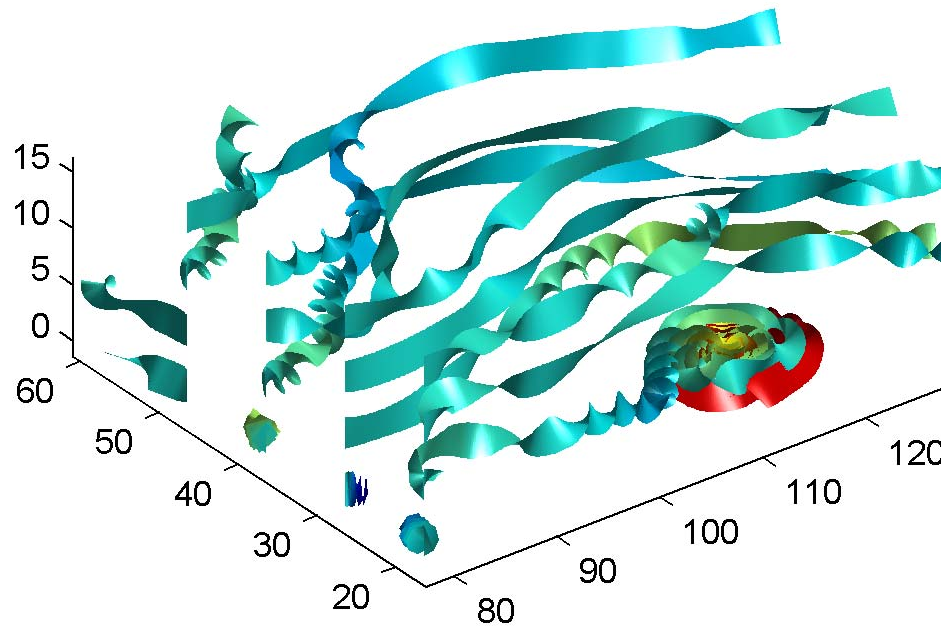
This example uses precalculated vertex data (`stream3`), curl average velocity (`curl1`), and speed  $\sqrt{u^2 + v^2 + w^2}$ . Using precalculated data enables you to use values other than those calculated from the single data source. In this case, the speed is reduced by a factor of 10 compared to the previous example.

# streamribbon

---

```
load wind
[sx sy sz] = meshgrid(80,20:10:50,0:5:15);
daspect([1 1 1])
verts = stream3(x,y,z,u,v,w,sx,sy,sz);
cav = curl(x,y,z,u,v,w);
spd = sqrt(u.^2 + v.^2 + w.^2).*0.1;
streamribbon(verts,x,y,z,cav,spd);
%-----Define viewing and lighting
axis tight
shading interp
view(3)
camlight; lighting gouraud
```





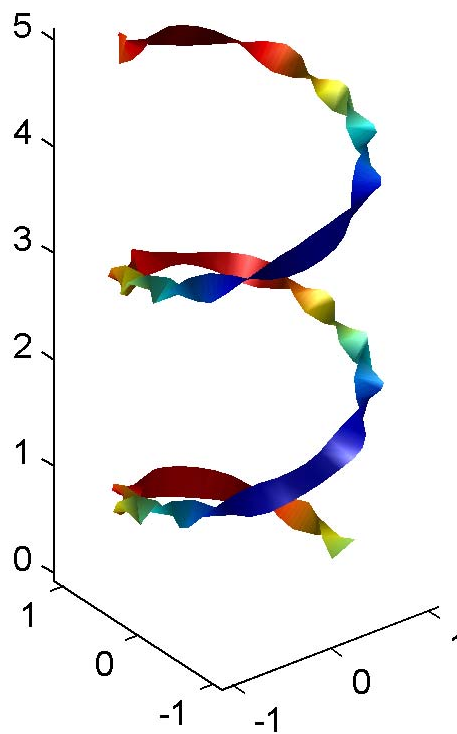
This example specifies a twist angle for the stream ribbon.

```
t = 0:.15:15;  
verts = {[cos(t)' sin(t)' (t/3)']};  
twistangle = {cos(t)'};  
daspect([1 1 1])  
streamribbon(verts,twistangle);  
%-----Define viewing and lighting
```

# streamribbon

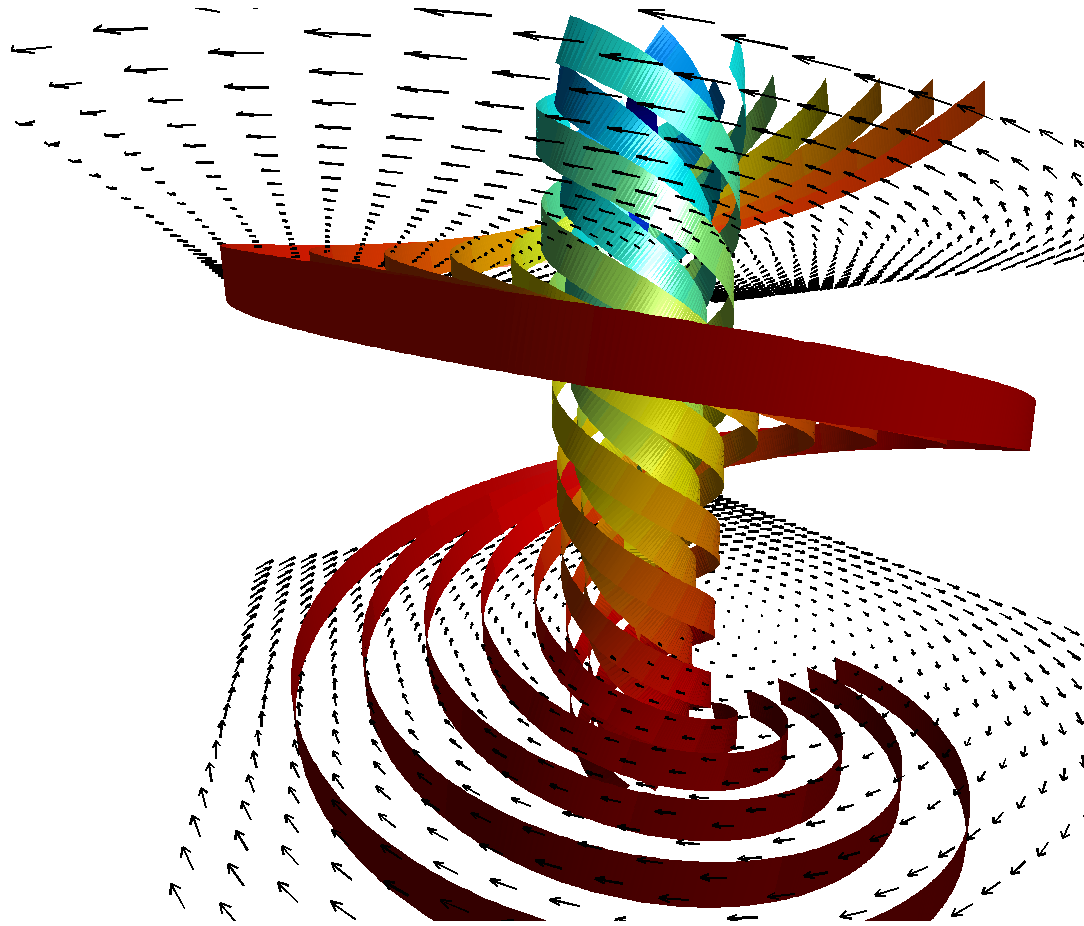
---

```
axis tight
shading interp;
view(3);
camlight; lighting gouraud
```



This example combines cone plots (coneplot) and stream ribbon plots in one graph.

```
%-----Define 3-D arrays x, y, z, u, v, w
xmin = -7; xmax = 7;
ymin = -7; ymax = 7;
zmin = -7; zmax = 7;
x = linspace(xmin,xmax,30);
y = linspace(ymin,ymax,20);
z = linspace(zmin,zmax,20);
[x y z] = meshgrid(x,y,z);
u = y; v = -x; w = 0*x+1;
daspect([1 1 1]);
[cx cy cz] = meshgrid(linspace(xmin,xmax,30),...
    linspace(ymin,ymax,30),[-3 4]);
h = coneplot(x,y,z,u,v,w,cx,cy,cz,'quiver');
set(h,'color','k');
%-----Plot two sets of streamribbons
[sx sy sz] = meshgrid([-1 0 1],[-1 0 1],-6);
streamribbon(x,y,z,u,v,w,sx,sy,sz);
[sx sy sz] = meshgrid([1:6],[0],-6);
streamribbon(x,y,z,u,v,w,sx,sy,sz);
%-----Define viewing and lighting
shading interp
view(-30,10) ; axis off tight
camproj perspective; camva(66); camlookat;
camdolly(0,0,.5,'fixtarget')
camlight
```



## See Also

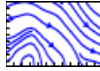
`curl`, `streamtube`, `streamline`, `stream3`

“Volume Visualization” on page 1-102 for related functions


Displaying Curl with Stream Ribbons for another example

Specifying Starting Points for Stream Plots for related information

**Purpose** Plot streamlines in slice planes



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
streamslice(X,Y,Z,U,V,W,startx,starty,startz)
streamslice(U,V,W,startx,starty,startz)
streamslice(X,Y,U,V)
streamslice(U,V)
streamslice(...,density)
streamslice(...,'arrowmode')
streamslice(...,'method')
streamslice(axes_handle,...)
h = streamslice(...)
[vertices arrowvertices] = streamslice(...)
```

## Description

`streamslice(X,Y,Z,U,V,W,startx,starty,startz)` draws well-spaced streamlines (with direction arrows) from vector data `U`, `V`, `W` in axis aligned  $x$ -,  $y$ -,  $z$ -planes starting at the points in the vectors `startx`, `starty`, `startz`. (The section [Specifying Starting Points for Stream Plots](#) provides more information on defining starting points.) The arrays `X`, `Y`, `Z` define the coordinates for `U`, `V`, `W` and must be monotonic and 3-D plaid (as if produced by `meshgrid`). `U`, `V`, `W` must be `m-by-n-by-p` volume arrays.

Do not assume that the flow is parallel to the slice plane. For example, in a stream slice at a constant  $z$ , the  $z$  component of the vector field `W` is ignored when you are calculating the streamlines for that plane.

# streamslice

---

Stream slices are useful for determining where to start streamlines, stream tubes, and stream ribbons. It is good practice is to set the axes `DataAspectRatio` to `[1 1 1]` when using `streamslice`.

`streamslice(U,V,W,startx,starty,startz)` assumes `X`, `Y`, and `Z` are determined by the expression

```
[X,Y,Z] = meshgrid(1:n,1:m,1:p)
```

where `[m,n,p] = size(U)`.

`streamslice(X,Y,U,V)` draws well-spaced streamlines (with direction arrows) from vector volume data `U`, `V`. The arrays `X`, `Y` define the coordinates for `U`, `V` and must be monotonic and 2-D plaid (as if produced by `meshgrid`).

`streamslice(U,V)` assumes `X`, `Y`, and `Z` are determined by the expression

```
[X,Y,Z] = meshgrid(1:n,1:m,1:p)
```

where `[m,n,p] = size(U)`.

`streamslice(...,density)` modifies the automatic spacing of the streamlines. `density` must be greater than 0. The default value is 1; higher values produce more streamlines on each plane. For example, 2 produces approximately twice as many streamlines, while 0.5 produces approximately half as many.

`streamslice(...,'arrowmode')` determines if direction arrows are present or not. `arrowmode` can be

- `arrows` — Draw direction arrows on the streamlines (default).
- `noarrows` — Do not draw direction arrows.

`streamslice(...,'method')` specifies the interpolation method to use. `method` can be

- `linear` — Linear interpolation (default)

- cubic — Cubic interpolation
- nearest — Nearest-neighbor interpolation

See `interp3` for more information on interpolation methods.

`streamslice(axes_handle,...)` plots into the axes object with the handle `axes_handle` instead of into the current axes object (`gca`).

`h = streamslice(...)` returns a vector of handles to the line objects created.

`[vertices arrowvertices] = streamslice(...)` returns two cell arrays of vertices for drawing the streamlines and the arrows. You can pass these values to any of the streamline drawing functions (`streamline`, `streamribbon`, `streamtube`).

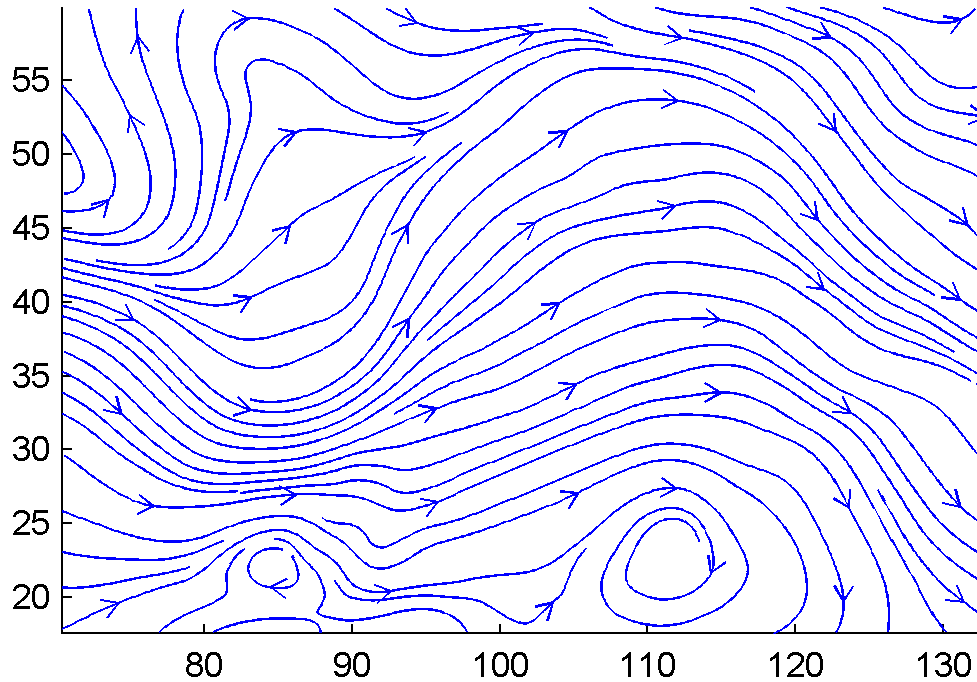
## Examples

This example creates a stream slice in the wind data set at  $z = 5$ .

```
load wind
daspect([1 1 1])
streamslice(x,y,z,u,v,w,[],[],[5])
axis tight
```

# streamslice

---



This example uses streamslice to calculate vertex data for the streamlines and the direction arrows. This data is then used by streamline to plot the lines and arrows. Slice planes illustrating with color the wind speed  $\sqrt{u^2 + v^2 + w^2}$  are drawn by slice in the same planes.

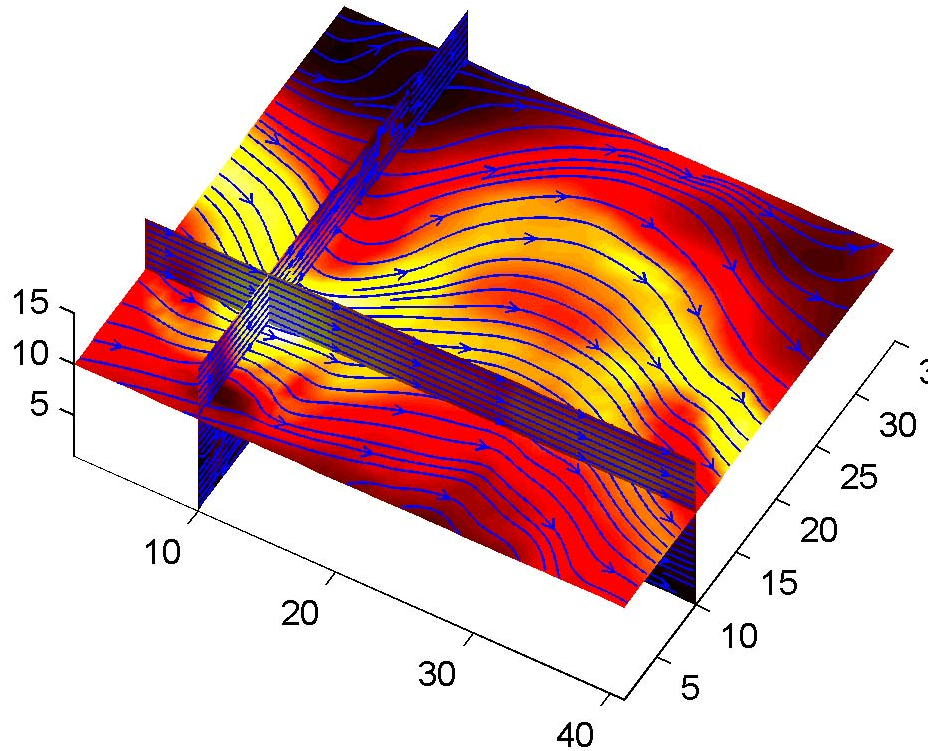
load wind



```
daspect([1 1 1])
[verts averts] = streamslice(u,v,w,10,10,10);
streamline([verts averts])
spd = sqrt(u.^2 + v.^2 + w.^2);
hold on;
slice(spd,10,10,10);
colormap(hot)
shading interp
view(30,50); axis(volumebounds(spd));
camlight; material([.5 1 0])
```

# streamslice

---



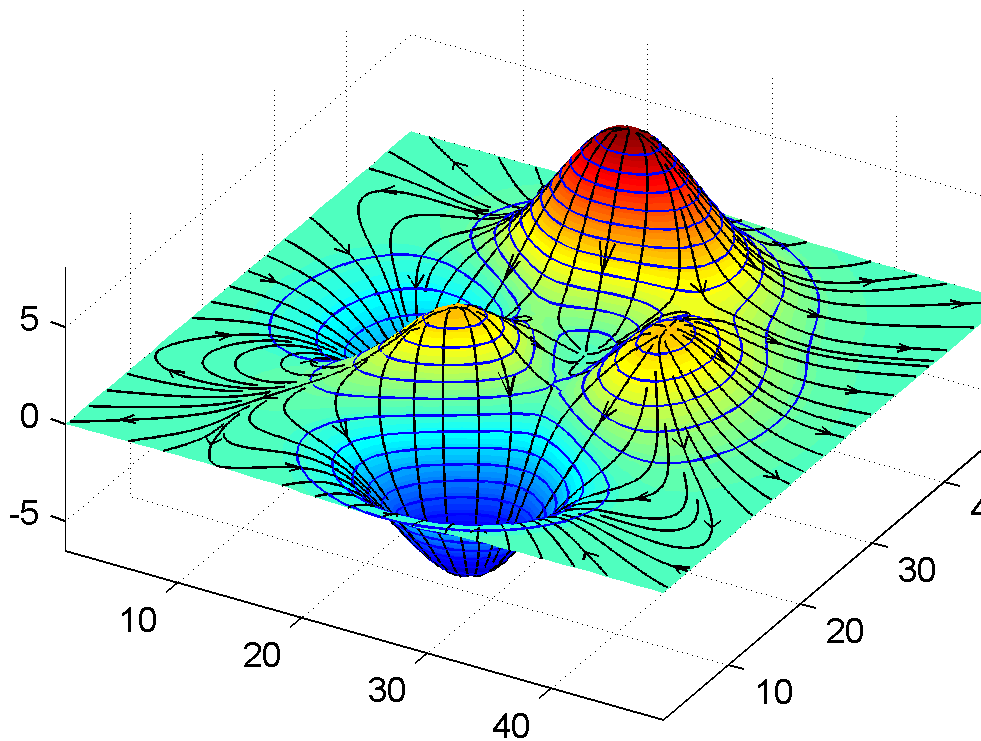
This example superimposes contour lines on a surface and then uses streamslice to draw lines that indicate the gradient of the surface. interp2 is used to find the points for the lines that lie on the surface.

```
z = peaks;  
surf(z)  
shading interp  
hold on
```

```
[c ch] = contour3(z,20); set(ch,'edgecolor','b')
[u v] = gradient(z);
h = streamslice(-u,-v);
set(h,'color','k')
for i=1:length(h);
    zi = interp2(z,get(h(i),'xdata'),get(h(i),'ydata'));
    set(h(i),'zdata',zi);
end
view(30,50); axis tight
```

# streamslice

---



## See Also

`contourslice`, `slice`, `streamline`, `volumebounds`


“Volume Visualization” on page 1-102 for related functions

Specifying Starting Points for Stream Plots for related information

**Purpose** Create 3-D stream tube plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
streamtube(X,Y,Z,U,V,W,startx,starty,startz)
streamtube(U,V,W,startx,starty,startz)
streamtube(vertices,X,Y,Z,divergence)
streamtube(vertices,divergence)
streamtube(vertices,width)
streamtube(vertices)
streamtube(...,[scale n])
streamtube(axes_handle,...)
h = streamtube(...z)
```

## Description

`streamtube(X,Y,Z,U,V,W,startx,starty,startz)` draws stream tubes from vector volume data  $U, V, W$ . The arrays  $X, Y, Z$  define the coordinates for  $U, V, W$  and must be monotonic and 3-D plaid (as if produced by `meshgrid`). `startx, starty, and startz` define the starting positions of the streamlines at the center of the tubes. The section [Specifying Starting Points for Stream Plots](#) provides more information on defining starting points.

The width of the tubes is proportional to the normalized divergence of the vector field.

Generally, you should set the `DataAspectRatio (daspect)` before calling `streamtube`.

`streamtube(U,V,W,startx,starty,startz)` assumes  $X, Y,$  and  $Z$  are determined by the expression

# streamtube

---

```
[X,Y,Z] = meshgrid(1:n,1:m,1:p)
```

where `[m,n,p] = size(U)`.

`streamtube(vertices,X,Y,Z,divergence)` assumes precomputed streamline vertices and divergence. `vertices` is a cell array of streamline vertices (as produced by `stream3`). `X`, `Y`, `Z`, and `divergence` are 3-D arrays.

`streamtube(vertices,divergence)` assumes `X`, `Y`, and `Z` are determined by the expression

```
[X,Y,Z] = meshgrid(1:n,1:m,1:p)
```

where `[m,n,p] = size(divergence)`.

`streamtube(vertices,width)` specifies the width of the tubes in the cell array of vectors, `width`. The size of each corresponding element of `vertices` and `width` must be equal. `width` can also be a scalar, specifying a single value for the width of all stream tubes.

`streamtube(vertices)` selects the width automatically.

`streamtube(...,[scale n])` scales the width of the tubes by `scale`. The default is `scale = 1`. When the stream tubes are created, using start points or divergence, specifying `scale = 0` suppresses automatic scaling. `n` is the number of points along the circumference of the tube. The default is `n = 20`.

`streamtube(axes_handle,...)` plots into the axes object with the handle `axes_handle` instead of into the current axes object (`gca`).

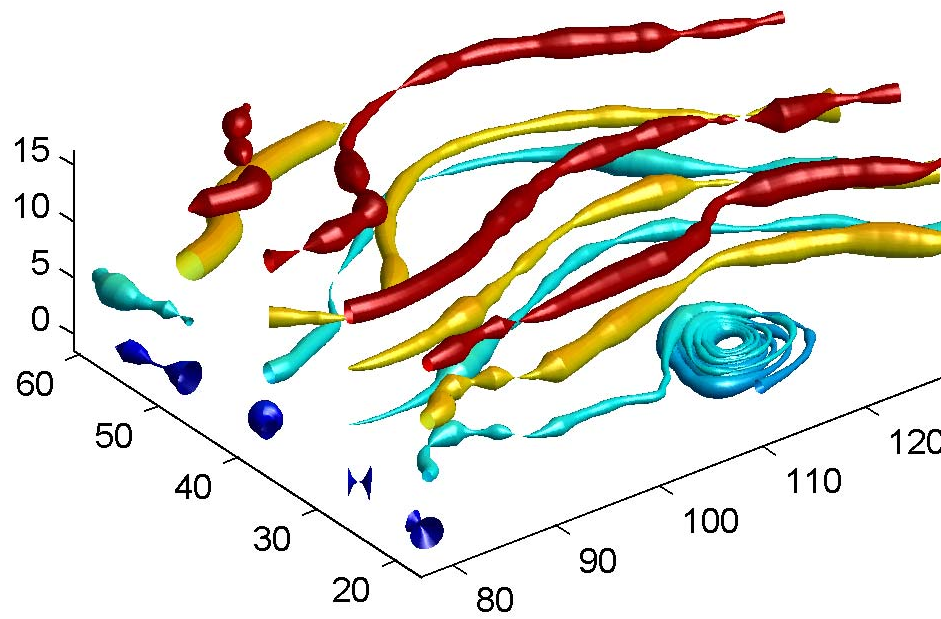
`h = streamtube(...,z)` returns a vector of handles (one per start point) to surface objects used to draw the stream tubes.

## Examples

This example uses stream tubes to indicate the flow in the wind data set. Inputs include the coordinates, vector field components, and starting location for the stream tubes.

```
load wind
[sx sy sz] = meshgrid(80,20:10:50,0:5:15);
```

```
daspect([1 1 1])  
streamtube(x,y,z,u,v,w,sx,sy,sz);  
%-----Define viewing and lighting  
view(3)  
axis tight  
shading interp;  
camlight; lighting gouraud
```



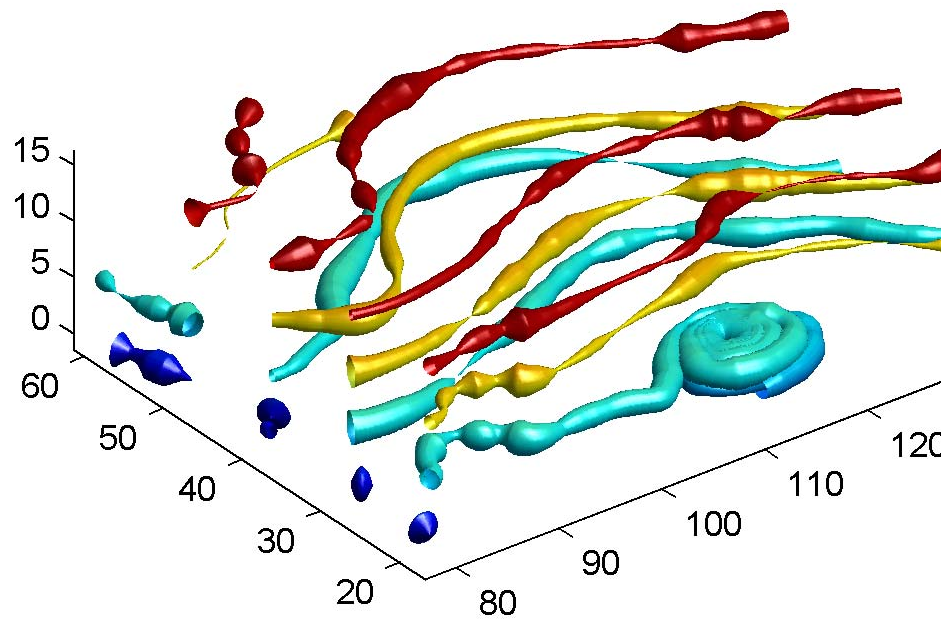
# streamtube

---

This example uses precalculated vertex data (stream3) and divergence (divergence).

```
load wind
[sx sy sz] = meshgrid(80,20:10:50,0:5:15);
daspect([1 1 1])
verts = stream3(x,y,z,u,v,w,sx,sy,sz);
div = divergence(x,y,z,u,v,w);
streamtube(verts,x,y,z,-div);
%----Define viewing and lighting
view(3)
axis tight
shading interp
camlight; lighting gouraud
```



**See Also**

`divergence`, `streamribbon`, `streamline`, `stream3`

“Volume Visualization” on page 1-102 for related functions

Displaying Divergence with Stream Tubes for another example

Specifying Starting Points for Stream Plots for related information

# strfind

---

**Purpose** Find one string within another

**Syntax**  
`k = strfind(str, pattern)`  
`k = strfind(cellstr, pattern)`

**Description** `k = strfind(str, pattern)` searches the string `str` for occurrences of a shorter string, `pattern`, and returns the starting index of each such occurrence in the double array `k`. If `pattern` is not found in `str`, or if `pattern` is longer than `str`, then `strfind` returns the empty array `[]`.

`k = strfind(cellstr, pattern)` searches each string in cell array of strings `cellstr` for occurrences of a shorter string, `pattern`, and returns the starting index of each such occurrence in cell array `k`. If `pattern` is not found in a string or if `pattern` is longer than all strings in the cell array, then `strfind` returns the empty array `[]`, for that string in the cell array.

The search performed by `strfind` is case sensitive. Any leading and trailing blanks in `pattern` or in the strings being searched are explicitly included in the comparison.

## Examples

Use `strfind` to find a two-letter pattern in string `S`:

```
S = 'Find the starting indices of the pattern string';
strfind(S, 'in')
ans =
     2     15     19     45

strfind(S, 'In')
ans =
     []

strfind(S, ' ')
ans =
     5     9     18     26     29     33     41
```

Use `strfind` on a cell array of strings:

```
cstr = {'How much wood would a woodchuck chuck';  
       'if a woodchuck could chuck wood?'};  
  
idx = strfind(cstr, 'wood');  
  
idx{:,:}  
ans =  
    10    23  
ans =  
     6    28
```

This means that 'wood' occurs at indices 10 and 23 in the first string and at indices 6 and 28 in the second.

**See Also**

findstr, strmatch, strtok, strcmp, strncmp, strcmpi, strncmpi, regexp, regexpi, regexprep

# strings

---

**Purpose** MATLAB string handling

**Syntax**  
S = 'Any Characters'  
S = [S1 S2 ...]  
S = strcat(S1, S2, ...)

**Description** S = 'Any Characters' creates a character array, or string. The string is actually a vector whose components are the numeric codes for the characters (the first 127 codes are ASCII). The actual characters displayed depend on the character encoding scheme for a given font. The length of S is the number of characters. A quotation within the string is indicated by two quotes.

S = [S1 S2 ...] concatenates character arrays S1, S2, etc. into a new character array, S.

S = strcat(S1, S2, ...) concatenates S1, S2, etc., which can be character arrays or “Cell Arrays of Strings”. When the inputs are all character arrays, the output is also a character array. When any of the inputs is a cell array of strings, strcat returns a cell array of strings.

Trailing spaces in strcat character array inputs are ignored and do not appear in the output. This is not true for strcat inputs that are cell arrays of strings. Use the S = [S1 S2 ...] concatenation syntax, shown above, to preserve trailing spaces.

S = char(X) can be used to convert an array that contains positive integers representing numeric codes into a MATLAB character array.

X = double(S) converts the string to its equivalent double-precision numeric codes.

A collection of strings can be created in either of the following two ways:

- As the rows of a character array via strvcat
- As a cell array of strings via the curly braces

You can convert between character array and cell array of strings using char and cellstr. Most string functions support both types.

`ischar(S)` tells if `S` is a string variable. `iscellstr(S)` tells if `S` is a cell array of strings.

## Examples

Create a simple string that includes a single quote.

```
msg = 'You're right!'

msg =
You're right!
```

Create the string name using two methods of concatenation.

```
name = ['Thomas' ' R.' ' Lee']
name = strcat('Thomas',' R.',' Lee')
```

Create a vertical array of strings.

```
C = strvcat('Hello','Yes','No','Goodbye')

C =
Hello
Yes
No
Goodbye
```

Create a cell array of strings.

```
S = {'Hello' 'Yes' 'No' 'Goodbye'}

S =
'Hello'      'Yes'      'No'      'Goodbye'
```

## See Also

`char`, `isstrprop`, `cellstr`, `ischar`, `isletter`, `isspace`, `iscellstr`, `strvcat`, `sprintf`, `sscanf`, `text`, `input`

# strjust

---

**Purpose** Justify character array

**Syntax**  
T = strjust(S)  
T = strjust(S, 'right')  
T = strjust(S, 'left')  
T = strjust(S, 'center')

**Description** T = strjust(S) or T = strjust(S, 'right') returns a right-justified version of the character array S.

T = strjust(S, 'left') returns a left-justified version of S.

T = strjust(S, 'center') returns a center-justified version of S.

**See Also** deblank, strtrim

**Purpose** Find possible matches for string

**Syntax**  
`x = strmatch(str, strarray)`  
`x = strmatch(str, strarray, 'exact')`

**Description** `x = strmatch(str, strarray)` looks through the rows of the character array or cell array of strings `strarray` to find strings that begin with the text contained in `str`, and returns the matching row indices. Any trailing space characters in `str` or `strarray` are ignored when matching. `strmatch` is fastest when `strarray` is a character array.

`x = strmatch(str, strarray, 'exact')` compares `str` with each row of `strarray`, looking for an exact match of the entire strings. Any trailing space characters in `str` or `strarray` are ignored when matching.

**Examples** The statement

```
x = strmatch('max', strvcat('max', 'minimax', 'maximum'))
```

returns `x = [1; 3]` since rows 1 and 3 begin with 'max'. The statement

```
x = strmatch('max', strvcat('max', 'minimax', 'maximum'),'exact')
```

returns `x = 1`, since only row 1 matches 'max' exactly.

**See Also** `strcmp`, `strcmpi`, `strncmp`, `strncmpi`, `strfind`, `findstr`, `strvcat`, `regexp`, `regexpi`, `regexprep`

# strncmp, strncmpi

---

**Purpose** Compare first *n* characters of strings

**Syntax**  
TF = strncmp('str1', 'str2', n)  
TF = strncmp('str', C, n)  
TF = strncmp(C1, C2, n)

Each of these syntaxes apply to both `strncmp` and `strncmpi`. The `strncmp` function is case sensitive in matching strings, while `strncmpi` is not.

**Description** Although the following descriptions show only `strncmp`, they apply to `strncmpi` as well. The two functions are the same except that `strncmpi` compares strings without sensitivity to letter case:

TF = strncmp('str1', 'str2', n) compares the first *n* characters of strings `str1` and `str2` and returns logical 1 (true) if they are identical, and returns logical 0 (false) otherwise. `str1` and `str2` can be character arrays of any dimension, but `strncmp` does not return true unless the sizes of both arrays are equal, and the contents of the two arrays are the same.

TF = strncmp('str', C, n) compares the first *n* characters of `str` to the first *n* characters of each element of cell array `C`, where `str` is a character vector (or a 1-by-1 cell array), and `C` is a cell array of strings. The function returns TF, a logical array that is the same size as `C` and contains logical 1 (true) for those elements of `C` that are a match, and logical 0 (false) for those elements that are not. The order of the first two input arguments is not important.

TF = strncmp(C1, C2, n) compares each element of `C1` to the same element in `C2`, where `C1` and `C2` are equal-size cell arrays of strings. Input `C1` or `C2` can also be a character array with the right number of rows. The function attempts to match only the first *n* characters of each string. The function returns TF, a logical array that is the same size as `C1` and `C2`, and contains logical 1 (true) for those elements of `C1` and `C2` that are a match, and logical 0 (false) for those elements that are not.



## Remarks

These functions are intended for comparison of character data. When used to compare numeric data, they return logical 0.

Any leading and trailing blanks in either of the strings are explicitly included in the comparison.

The value returned by `strncmp` and `strncmpi` is not the same as the C language convention.

`strncmp` and `strncmpi` support international character sets.

## Examples

### Example 1

From a list of 10 MATLAB functions, find those that apply to using a camera:

```
function_list = {'calendar' 'case' 'camdolly' 'circshift' ...  
                'caxis' 'camtarget' 'cast' 'camorbit' ...  
                'callib' 'cart2sph'};
```

```
strncmp(function_list, 'cam', 3)  
ans =  
    0    0    1    0    0    1    0    1    0    0
```

```
function_list{strncmp(function_list, 'cam', 3)}  
ans =  
    camdolly  
ans =  
    camtarget  
ans =  
    camorbit
```

### Example 2

Create two 5-by-10 string arrays `str1` and `str2` that are equal except for the element at row 4, column 3. Using linear indexing, this is element 14:

```
str1 = ['AAAAAAAAA'; 'BBBBBBBBBB'; 'CCCCCCCCC'; ...  
        'DDDDDDDDD'; 'EEEEEEEEEE']
```

# strncmp, strncmpi

---

```
str1 =  
  AAAAAAAAAA  
  BBBBBBBBBB  
  CCCCCCCCCC  
  DDDDDDDDDD  
  EEEEEEEEEE  
  
str2 = str1;  
str2(4,3) = '-'  
str2 =  
  AAAAAAAAAA  
  BBBBBBBBBB  
  CCCCCCCCCC  
  DD-DDDDDDD  
  EEEEEEEEEE
```

Because MATLAB compares the arrays in linear order (that is, column by column rather than row by row), strncmp finds only the first 13 elements to be the same:

```
str1  A B C D E A B C D E A B C D E  
str2  A B C D E A B C D E A B C - E  
                                     |  
                                     element 14
```

```
strncmp(str1, str2, 13)  
ans =  
    1
```

```
strncmp(str1, str2, 14)  
ans =  
    0
```

## See Also

strcmp, strcmpi, strmatch, strfind, findstr, regexp, regexpi, regexprep, regexpttranslate

**Purpose** Read formatted data from string

---

**Note** The textscan function is intended as a replacement for both strread and textread.

---

## Syntax

```
A = strread('str')
[A, B, ...] = strread('str')
[A, B, ...] = strread('str', 'format')
[A, B, ...] = strread('str', 'format', N)
[A, B, ...] = strread('str', 'format', N, param, value, ...)
```

## Description

`A = strread('str')` reads numeric data from input string `str` into a 1-by-`N` vector `A`, where `N` equals the number of whitespace-separated numbers in `str`. Use this form only with strings containing numeric data. See “Example 1” on page 2-3135 below.

`[A, B, ...] = strread('str')` reads numeric data from the string input `str` into scalar output variables `A`, `B`, and so on. The number of output variables must equal the number of whitespace-separated numbers in `str`. Use this form only with strings containing numeric data. See “Example 2” on page 2-3135 below.

`[A, B, ...] = strread('str', 'format')` reads data from `str` into variables `A`, `B`, and so on using the specified format. The number of output variables `A`, `B`, etc. must be equal to the number of format specifiers (e.g., `%s` or `%d`) in the `format` argument. You can read all of the data in `str` to a single output variable as long as you use only one format specifier in the command. See “Example 4” on page 2-3136 and “Example 5” on page 2-3136 below.

The table [Formats for strread](#) on page 2-3132 lists the valid format specifiers. More information on using formats is available under “[Formats](#)” on page 2-3134 in the [Remarks](#) section below.

`[A, B, ...] = strread('str', 'format', N)` reads data from `str` reusing the format string `N` times, where `N` is an integer greater than zero. If `N` is -1, `strread` reads the entire string. When `str` contains

# strread

only numeric data, you can set format to the empty string ( ''). See “Example 3” on page 2-3136 below.

[A, B, ...] = strread('str', 'format', N, param, value, ...) customizes strread using param/value pairs, as listed in the table Parameters and Values for strread on page 2-3133 below. When str contains only numeric data, you can set format to the empty string ( ''). The N argument is optional and may be omitted entirely. See “Example 7” on page 2-3137 below.

## Formats for strread

| Format                            | Action                                                                                                                                                                                           | Output                |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Literals<br>(ordinary characters) | Ignore the matching characters. For example, in a string that has Dept followed by a number (for department number), to skip the Dept and read only the number, use 'Dept' in the format string. | None                  |
| %d                                | Read a signed integer value.                                                                                                                                                                     | Double array          |
| %u                                | Read an integer value.                                                                                                                                                                           | Double array          |
| %f                                | Read a floating-point value.                                                                                                                                                                     | Double array          |
| %s                                | Read a white-space separated string.                                                                                                                                                             | Cell array of strings |
| %q                                | Read a double quoted string, ignoring the quotes.                                                                                                                                                | Cell array of strings |
| %c                                | Read characters, including white space.                                                                                                                                                          | Character array       |
| %[...]                            | Read the longest string containing characters specified in the brackets.                                                                                                                         | Cell array of strings |

**Formats for strread (Continued)**

| <b>Format</b>             | <b>Action</b>                                                                                                     | <b>Output</b>         |
|---------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------|
| <code>%[ ^ . . . ]</code> | Read the longest nonempty string containing characters that are not specified in the brackets.                    | Cell array of strings |
| <code>%* . . .</code>     | Ignore the characters following *. See “Example 8” on page 2-3137 below.                                          | No output             |
| <code>%w . . .</code>     | Read field width specified by w. The %f format supports %w.pf, where w is the field width and p is the precision. |                       |

**Parameters and Values for strread**

| <b>param</b> | <b>value</b>      | <b>Action</b>                                                        |
|--------------|-------------------|----------------------------------------------------------------------|
| whitespace   | \* where * can be | Treats vector of characters, *, as white space. Default is \b\r\n\t. |
|              | b                 | Backspace                                                            |
|              | f                 | Form feed                                                            |
|              | n                 | New line                                                             |
|              | r                 | Carriage return                                                      |
|              | t                 | Horizontal tab                                                       |
|              | \\                | Backslash                                                            |
|              | \' or \'          | Single quotation mark                                                |
|              | %%                | Percent sign                                                         |

## Parameters and Values for strread (Continued)

| param        | value               | Action                                                                       |
|--------------|---------------------|------------------------------------------------------------------------------|
| delimiter    | Delimiter character | Specifies delimiter character. Default is one or more whitespace characters. |
| expchars     | Exponent characters | Default is eEdD.                                                             |
| bufsize      | Positive integer    | Specifies the maximum string length, in bytes. Default is 4095.              |
| commentstyle | matlab              | Ignores characters after %.                                                  |
| commentstyle | shell               | Ignores characters after #.                                                  |
| commentstyle | c                   | Ignores characters between /* and */.                                        |
| commentstyle | c++                 | Ignores characters after //.                                                 |

## Remarks

### Delimiters

If your data uses a character other than a space as a delimiter, you must use the `strread` parameter 'delimiter' to specify the delimiter. For example, if the string `str` used a semicolon as a delimiter, you would use this command:

```
[names, types, x, y, answer] = strread(str, '%s %s %f ...  
%d %s', 'delimiter', ';')
```

### Formats

The format string determines the number and types of return arguments. The number of return arguments must match the number of conversion specifiers in the format string.

The `strread` function continues reading `str` until the entire string is read. If there are fewer format specifiers than there are entities in `str`,

strread reapplies the format specifiers, starting over at the beginning. See “Example 5” on page 2-3136 below.

The format string supports a subset of the conversion specifiers and conventions of the C language fscanf routine. White-space characters in the format string are ignored.

**Preserving White-Space**

If you want to preserve leading and trailing spaces in a string, use the whitespace parameter as shown here:

```
str = '  An example      of preserving      spaces  ';
strread(str, '%s', 'whitespace', '')
ans =
    '  An example      of preserving      spaces  '
```

**Examples**

**Example 1**

Read numeric data into a 1-by-5 vector:

```
a = strread('0.41 8.24 3.57 6.24 9.27')
a =
    0.4100    8.2400    3.5700    6.2400    9.2700
```

**Example 2**

Read numeric data into separate scalar variables:

```
[a b c d e] = strread('0.41 8.24 3.57 6.24 9.27')
a =
    0.4100
b =
    8.2400
c =
    3.5700
d =
    6.2400
e =
    9.2700
```

## Example 3

Read the only first three numbers in the string, also formatting as floating point:

```
a = strread('0.41 8.24 3.57 6.24 9.27', '%4.2f', 3)
```

```
a =  
    0.4100  
    8.2400  
    3.5700
```

## Example 4

Truncate the data to one decimal digit by specifying format `%3.1f`. The second specifier, `.*1d`, tells `strread` not to read in the remaining decimal digit:

```
a = strread('0.41 8.24 3.57 6.24 9.27', '%3.1f .*1d')
```

```
a =  
    0.4000  
    8.2000  
    3.5000  
    6.2000  
    9.2000
```

## Example 5

Read six numbers into two variables, reusing the format specifiers:

```
[a b] = strread('0.41 8.24 3.57 6.24 9.27 3.29', '%f %f')
```

```
a =  
    0.4100  
    3.5700  
    9.2700  
b =  
    8.2400  
    6.2400
```



3.2900

### Example 6

Read string and numeric data to two output variables. Ignore commas in the input string:

```
str = 'Section 4, Page 7, Line 26';

[name value] = strread(str, '%s %d,')
name =
    'Section'
    'Page'
    'Line'
value =
     4
     7
    26
```

### Example 7

Read the string used in the last example, but this time delimiting with commas instead of spaces:

```
str = 'Section 4, Page 7, Line 26';

[a b c] = strread(str, '%s %s %s', 'delimiter', ',')
a =
    'Section 4'
b =
    'Page 7'
c =
    'Line 26'
```

### Example 8

Read selected portions of the input string:

```
str = '<table border=5 width="100%" cellspacing=0>';

[border width space] = strread(str, ...
```

# strread

---

```
        '%*s%*s %c %*s "%4s" %*s %c', 'delimiter', '= ' )
border =
    5
width =
    '100%'
space =
    0
```

## Example 9

Read the string into two vectors, restricting the Answer values to T and F. Also note that two delimiters (comma and space) are used here:

```
str = 'Answer_1: T, Answer_2: F, Answer_3: F';

[a b] = strread(str, '%s %[TF]', 'delimiter', ', ', ' ')
a =
    'Answer_1:'
    'Answer_2:'
    'Answer_3:'
b =
    'T'
    'F'
    'F'
```

## See Also

textscan, textread, sscanf

**Purpose** Find and replace substring

**Syntax** `str = strrep(str1, str2, str3)`

**Description** `str = strrep(str1, str2, str3)` replaces all occurrences of the string `str2` within string `str1` with the string `str3`.

`strrep(str1, str2, str3)`, when any of `str1`, `str2`, or `str3` is a cell array of strings, returns a cell array the same size as `str1`, `str2`, and `str3` obtained by performing a `strrep` using corresponding elements of the inputs. The inputs must all be the same size (or any can be a scalar cell). Any one of the strings can also be a character array with the right number of rows.

## Examples

```
s1 = 'This is a good example.';
str = strrep(s1, 'good', 'great')
str =
This is a great example.
A =
    'MATLAB'      'SIMULINK'
    'Toolboxes'  'The MathWorks'
B =
    'Handle Graphics'  'Real Time Workshop'
    'Toolboxes'        'The MathWorks'
C =
    'Signal Processing'  'Image Processing'
    'MATLAB'             'SIMULINK'
strrep(A, B, C)
ans =
    'MATLAB' 'SIMULINK'
    'MATLAB' 'SIMULINK'
```

**See Also** `strfind`

# strtok

---

**Purpose** Selected parts of string

**Syntax**

```
token = strtok('str')
token = strtok('str', delimiter)
[token, remain] = strtok('str', ...)
```

**Description** `token = strtok('str')` returns in `token` that part of the input string `str` that precedes the first white-space character (the default delimiter). Parsing of the string begins at the first nondelimiting (i.e., nonwhite-space) character and continues to the right until MATLAB either locates a delimiter or reaches the end of the string. If no delimiters are found in the body of the input string, then the entire string (excluding any leading delimiting characters) is returned.

White-space characters include space (ASCII 32), tab (ASCII 9), and carriage return (ASCII 13).

If `str` is a cell array of strings, `token` is a cell array of tokens.

`token = strtok('str', delimiter) [4]` is the same as the above syntax except that you can specify one or more nondefault delimiters in the character vector, `delimiter`. Ignoring any leading delimiters, MATLAB returns in `token` that part of the input string that precedes one of the characters from the given `delimiter` vector.

`[token, remain] = strtok('str', ...)` returns in `remain` a substring of the input string that begins immediately after the `token` substring and ends with the last character in `str`. If no delimiters are found in the body of the input string, then the entire string (excluding any leading delimiting characters) is returned in `token`, and `remain` is an empty string ('').

If `str` is a cell array of strings, `token` is a cell array of tokens and `remain` is a character array.

## Examples

### Example 1

This example uses the default white-space delimiter:

```
s = ' This is a simple example.';
```

```
[token, remain] = strtok(s)
token =
    This
remain =
    is a simple example.
```

## Example 2

Take a string of HTML code and break it down into segments delimited by the < and > characters. Write a while loop to parse the string and print each segment:

```
s = sprintf('%s%s%s%s', ...
    '<ul class=continued><li class=continued>', ...
    '<pre><a name="13474"></a>token = strtok', ...
    '('str'', delimiter)<a name="13475"></a>', ...
    'token = strtok('str'')');

remain = s;

while true
    [str, remain] = strtok(remain, '<>');
    if isempty(str), break; end
    disp(sprintf('%s', str))
end
```

Here is the output:

```
ul class=continued
li class=continued
pre
a name="13474"
/a
token = strtok('str', delimiter)
a name="13475"
/a
token = strtok('str')
```

## Example 3

Using `strtok` on a cell array of strings returns a cell array of strings in `token` and a character array in `remain`:

```
s = {'all in good time'; ...  
    'my dog has fleas'; ...  
    'leave no stone unturned'};  
  
remain = s;  
  
for k = 1:4  
    [token, remain] = strtok(remain);  
    token  
end
```

Here is the output:

```
token =  
    'all'  
    'my'  
    'leave'  
token =  
    'in'  
    'dog'  
    'no'  
token =  
    'good'  
    'has'  
    'stone'  
token =  
    'time'  
    'fleas'  
    'unturned'
```

## See Also

`findstr`, `strmatch`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Remove leading and trailing white space from string                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>      | <pre>S = strtrim(str) C = strtrim(cstr)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Description</b> | <p><code>S = strtrim(str)</code> returns a copy of string <code>str</code> with all leading and trailing white-space characters removed. A white-space character is one for which the <code>isspace</code> function returns logical 1 (true).</p> <p><code>C = strtrim(cstr)</code> returns a copy of the cell array of strings <code>cstr</code> with all leading and trailing white-space characters removed from each string in the cell array.</p>                                                           |
| <b>Examples</b>    | <p>Remove the leading white-space characters (spaces and tabs) from <code>str</code>:</p> <pre>str = sprintf(' \t Remove leading white-space') str =     Remove leading white-space  str = strtrim(str) str = Remove leading white-space</pre> <p>Remove leading and trailing white-space from the cell array of strings:</p> <pre>cstr = {' Trim leading white-space';         'Trim trailing white-space '};  cstr = strtrim(cstr) cstr =     'Trim leading white-space'     'Trim trailing white-space'</pre> |
| <b>See Also</b>    | <code>isspace</code> , <code>cellstr</code> , <code>deblank</code> , <code>strjust</code>                                                                                                                                                                                                                                                                                                                                                                                                                        |

# struct

---

**Purpose** Create structure array

**Syntax**

```
s = struct('field1', values1, 'field2', values2, ...)  
s = struct('field1', {}, 'field2', {}, ...)  
s = struct  
s = struct([])  
s = struct(obj)
```

**Description** `s = struct('field1', values1, 'field2', values2, ...)` creates a structure array with the specified fields and values. Each value input (`values1`, `values2`, etc.), can either be a cell array or a scalar value. Those that are cell arrays must all have the same dimensions.

The size of the resulting structure is the same size as the value cell arrays, or 1-by-1 if none of the values is a cell array. Elements of the value array inputs are placed into corresponding structure array elements.

---

**Note** If any of the values fields is an empty cell array {}, MATLAB creates an empty structure array in which all fields are also empty.

---

Structure field names must begin with a letter, and are case-sensitive. The rest of the name may contain letters, numerals, and underscore characters. Use the `namelengthmax` function to determine the maximum length of a field name.

`s = struct('field1', {}, 'field2', {}, ...)` creates an empty structure with fields `field1`, `field2`, ...

`s = struct` creates a 1-by-1 structure with no fields.

`s = struct([])` creates an empty structure with no fields.

`s = struct(obj)` creates a structure identical to the underlying structure in the object `obj`. The class information is lost.



**Remarks****Two Ways to Access Fields**

The most common way to access the data in a structure is by specifying the name of the field that you want to reference. Another means of accessing structure data is to use dynamic field names. These names express the field as a variable expression that MATLAB evaluates at run-time.

**Fields That Are Cell Arrays**

To create fields that contain cell arrays, place the cell arrays within a value cell array. For instance, to create a 1-by-1 structure, type

```
s = struct('strings',{ 'hello', 'yes'}, 'lengths', [5 3])
s =
  strings: { 'hello'  'yes' }
  lengths: [5 3]
```

**Specifying Cell Versus Noncell Values**

When using the syntax

```
s = struct('field1', values1, 'field2', values2, ...)
```

the values inputs can be cell arrays or scalar values. For those values that are specified as a cell array, MATLAB assigns each element of values{m,n,...} to the corresponding field in each element of structure s:

```
s(m,n,...).fieldN = valuesN{m,n,...}
```

For those values that are scalar, MATLAB assigns that single value to the corresponding field for all elements of structure s:

```
s(m,n,...).fieldN = valuesN
```

See Example 3, below.

**Examples****Example 1**

The command

## struct

---

```
s = struct('type', {'big','little'}, 'color', {'red'}, ...  
          'x', {3 4})
```

produces a structure array s:

```
s =  
1x2 struct array with fields:  
    type  
    color  
    x
```

The value arrays have been distributed among the fields of s:

```
s(1)  
ans =  
    type: 'big'  
    color: 'red'  
    x: 3  
  
s(2)  
ans =  
    type: 'little'  
    color: 'red'  
    x: 4
```

### Example 2

Similarly, the command

```
a.b = struct('z', {});
```

produces an empty structure a.b with field z.

```
a.b  
ans =  
    0x0 struct array with fields:  
    z
```

### Example 3

This example initializes one field `f1` using a cell array, and the other `f2` using a scalar value:

```
s = struct('f1', {1 3; 2 4}, 'f2', 25)
s =
2x2 struct array with fields:
    f1
    f2
```

Field `f1` in each element of `s` is assigned the corresponding value from the cell array `{1 3; 2 4}`:

```
s.f1
ans =
    1
ans =
    2
ans =
    3
ans =
    4
```

Field `f2` for all elements of `s` is assigned one common value because the values input for this field was specified as a scalar:

```
s.f2
ans =
    25
ans =
    25
ans =
    25
ans =
    25
```

# struct

---

## **See Also**

isstruct, fieldnames, isfield, orderfields, getfield, setfield, rmfield, substruct, deal, cell2struct, struct2cell, namelengthmax, dynamic field names

**Purpose** Convert structure to cell array

**Syntax** `c = struct2cell(s)`

**Description** `c = struct2cell(s)` converts the *m*-by-*n* structure *s* (with *p* fields) into a *p*-by-*m*-by-*n* cell array *c*.

If structure *s* is multidimensional, cell array *c* has size [*p* `size(s)`].

**Examples** The commands

```
clear s, s.category = 'tree';  
s.height = 37.4; s.name = 'birch';
```

create the structure

```
s =  
    category: 'tree'  
    height: 37.4000  
    name: 'birch'
```

Converting the structure to a cell array,

```
c = struct2cell(s)  
  
c =  
    'tree'  
    [37.4000]  
    'birch'
```

**See Also** `cell2struct`, `cell`, `iscell`, `struct`, `isstruct`, `fieldnames`, “Using Dynamic Field Names”

# structfun

---

**Purpose** Apply function to each field of scalar structure

**Syntax**

```
A = structfun(fun, S)
[A, B, ...] = structfun(fun, S)
[A, ...] = structfun(fun, S, 'param1', value1, ...)
```

**Description** `A = structfun(fun, S)` applies the function specified by `fun` to each field of scalar structure `S`, and returns the results in array `A`. `fun` is a function handle to a function that takes one input argument and returns a scalar value. Return value `A` is a column vector that has one element for each field in input structure `S`. The `N`th element of `A` is the result of applying `fun` to the `N`th field of `S`, and the order of the fields is the same as that returned by a call to `fieldnames`. (`A` is returned as one or more scalar structures when the `UniformOutput` option is set to `false`. See the table below.)

`fun` must return values of the same class each time it is called. If `fun` is a handle to an overloaded function, then `structfun` follows MATLAB dispatching rules in calling the function.

`[A, B, ...] = structfun(fun, S)` returns arrays `A, B, ...`, each array corresponding to one of the output arguments of `fun`. `structfun` calls `fun` each time with as many outputs as there are in the call to `structfun`. `fun` can return output arguments having different classes, but the class of each output must be the same each time `fun` is called.

`[A, ...] = structfun(fun, S, 'param1', value1, ...)` enables you to specify optional parameter name/parameter value pairs. Parameters are

| Parameter       | Value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'UniformOutput' | <p>Logical value indicating whether or not the outputs of fun can be returned without encapsulation in a structure. The default value is true.</p> <p>If equal to logical 1 (true), fun must return scalar values that can be concatenated into an array. The outputs can be any of the following types: numeric, logical, char, struct, or cell.</p> <p>If equal to logical 0 (false), structfun returns a scalar structure or multiple scalar structures having fields that are the same as the fields of the input structure S. The values in the output structure fields are the results of calling fun on the corresponding values in the input structure B. In this case, the outputs can be of any data type.</p>                                                                                                                                                                                                                                                                                                   |
| 'ErrorHandler'  | <p>Function handle specifying the function MATLAB is to call if the call to fun fails. MATLAB calls the error handling function with the following input arguments:</p> <ul style="list-style-type: none"> <li>• A structure, with the fields 'identifier', 'message', and 'index', respectively containing the identifier of the error that occurred, the text of the error message, and the number of the field (in the same order as returned by field names) at which the error occurred.</li> <li>• The input argument at which the call to the function failed.</li> </ul> <p>The error handling function should either rethrow an error or return the same number of outputs as fun. These outputs are then returned as the outputs of structfun. If 'UniformOutput' is true, the outputs of the error handler must also be scalars of the same type as the outputs of fun.</p> <p>For example,</p> <pre>function [A, B] = errorFunc(S, ...     varargin) warning(S.identifier, S.message); A = NaN; B = NaN;</pre> |

# structfun

---

## Examples

To create shortened weekday names from the full names, for example:  
Create a structure with strings in several fields:

```
s.f1 = 'Sunday';  
s.f2 = 'Monday';  
s.f3 = 'Tuesday';  
s.f4 = 'Wednesday';  
s.f5 = 'Thursday';  
s.f6 = 'Friday';  
s.f7 = 'Saturday';  
  
shortNames = structfun(@(x) ( x(1:3) ), s, ...  
                        'UniformOutput', false);
```

## See Also

cellfun, arrayfun, function\_handle, cell2mat, spfun



|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Concatenate strings vertically                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Syntax</b>      | <pre>S = strvcat(t1, t2, t3, ...)</pre> <pre>S = strvcat(c)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <p><code>S = strvcat(t1, t2, t3, ...)</code> forms the character array <code>S</code> containing the text strings (or string matrices) <code>t1, t2, t3, ...</code> as rows. Spaces are appended to each string as necessary to form a valid matrix. Empty arguments are ignored.</p> <p><code>S = strvcat(c)</code> when <code>c</code> is a cell array of strings, passes each element of <code>c</code> as an input to <code>strvcat</code>. Empty strings in the input are ignored.</p>                                                                                                                                                                                         |
| <b>Remarks</b>     | If each text parameter, <code>ti</code> , is itself a character array, <code>strvcat</code> appends them vertically to create arbitrarily large string matrices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Examples</b>    | <p>The command <code>strvcat('Hello', 'Yes')</code> is the same as <code>['Hello'; 'Yes']</code>, except that <code>strvcat</code> performs the padding automatically.</p> <pre>t1 = 'first'; t2 = 'string'; t3 = 'matrix'; t4 = 'second';</pre> <pre>S1 = strvcat(t1, t2, t3)           S2 = strvcat(t4, t2, t3)</pre> <pre>S1 =                               S2 =</pre> <pre>first                               second</pre> <pre>string                             string</pre> <pre>matrix                             matrix</pre> <pre>S3 = strvcat(S1, S2)</pre> <pre>S3 =</pre> <pre>first</pre> <pre>string</pre> <pre>matrix</pre> <pre>second</pre> <pre>string</pre> |

## strvcat

---

matrix

### **See Also**

strcat, cat, int2str, mat2str, num2str, strings

**Purpose** Single index from subscripts

**Syntax**  
`IND = sub2ind(siz,I,J)`  
`IND = sub2ind(siz,I1,I2,...,In)`

**Description** The `sub2ind` command determines the equivalent single index corresponding to a set of subscript values.

`IND = sub2ind(siz,I,J)` returns the linear index equivalent to the row and column subscripts `I` and `J` for a matrix of size `siz`. `siz` is a 2-element vector, where `siz(1)` is the number of rows and `siz(2)` is the number of columns.

`IND = sub2ind(siz,I1,I2,...,In)` returns the linear index equivalent to the `n` subscripts `I1,I2,...,In` for an array of size `siz`. `siz` is an `n`-element vector that specifies the size of each array dimension.

**Examples** Create a 3-by-4-by-2 array, `A`.

```
A = [17 24 1 8; 2 22 7 14; 4 6 13 20];
A(:,:,2) = A - 10
```

```
A(:,:,1) =
```

```
    17    24     1     8
     2    22     7    14
     4     6    13    20
```

```
A(:,:,2) =
```

```
     7    14    -9    -2
    -8    12    -3     4
    -6    -4     3    10
```

The value at row 2, column 1, page 2 of the array is -8.

```
A(2,1,2)
```

## sub2ind

---

```
ans =  
-8
```

To convert  $A(2, 1, 2)$  into its equivalent single subscript, use `sub2ind`.

```
sub2ind(size(A),2,1,2)  
  
ans =  
14
```

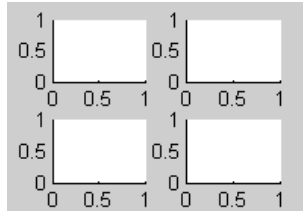
You can now access the same location in  $A$  using the single subscripting method.

```
A(14)  
  
ans =  
-8
```

### See Also

`ind2sub`, `find`, `size`

**Purpose** Create axes in tiled positions



**GUI Alternatives**

To add subplots to a figure, click one of the *New Subplot* icons in the Figure Palette, and slide right to select an arrangement of subplots. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation.

**Syntax**

```
h = subplot(m,n,p) or subplot(mnp)
subplot(m,n,p,'replace')
subplot(m,n,P)
subplot(h)
subplot('Position',[left bottom width height])
h = subplot(...)
subplot(m,n,p,'v6')
```

**Description**

subplot divides the current figure into rectangular panes that are numbered rowwise. Each pane contains an axes object. Subsequent plots are output to the current pane.

`h = subplot(m,n,p)` or `subplot(mnp)` breaks the figure window into an *m*-by-*n* matrix of small axes, selects the *p*th axes object for the current plot, and returns the axes handle. The axes are counted along the top row of the figure window, then the second row, etc. For example,

```
subplot(2,1,1), plot(income)
subplot(2,1,2), plot(outgo)
```

plots income on the top half of the window and outgo on the bottom half. If the CurrentAxes is nested in a uipanel, the panel is used as

# subplot

---

the parent for the subplot instead of the current figure. The new axes object becomes the current axes.

`subplot(m,n,p, 'replace')` If the specified axes object already exists, delete it and create a new axes.

`subplot(m,n,P)`, where `P` is a vector, specifies an axes position that covers all the subplot positions listed in `P`, including those spanned by `P`. For example, `subplot(2,3,[2 5])` creates subplots at positions 2 and 5 only (because there are no intervening locations in the grid), while `subplot(2,3,[2 6])` creates axes at positions 2, 3, 5, and 6.

`subplot(h)` makes the axes object with handle `h` current for subsequent plotting commands.

`subplot('Position',[left bottom width height])` creates an axes at the position specified by a four-element vector. `left`, `bottom`, `width`, and `height` are in normalized coordinates in the range from 0.0 to 1.0.

`h = subplot(...)` returns the handle to the new axes object.

## Backward-Compatible Version

`subplot(m,n,p, 'v6')` places the axes so that the plot boxes are aligned, but does not prevent the labels and ticks from overlapping. Saved subplots created with the `v6` option are compatible with MATLAB 6.5 and earlier versions.

Use the `subplot 'v6'` option and save the figure with the `'v6'` option when you want to be able to load a FIG-file containing subplots into MATLAB Version 6.5 or earlier.

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See Plot Objects and Backward Compatibility for more information.

**Remarks**

You can add subplots to GUIs as well as to figures. For information about creating subplots in a GUIDE-generated GUI, see “Creating Subplots” in the MATLAB Creating Graphical User Interfaces documentation.

If a subplot specification causes a new axes object to overlap any existing axes, subplot deletes the existing axes object and uicontrol objects. However, if the subplot specification exactly matches the position of an existing axes object, the matching axes object is not deleted and it becomes the current axes.

subplot(1,1,1) or clf deletes all axes objects and returns to the default subplot(1,1,1) configuration.

You can omit the parentheses and specify subplot as

```
subplot mnp
```

where m refers to the row, n refers to the column, and p specifies the pane.

Be aware when creating subplots from scripts that the Position property of subplots is not finalized until either

- A drawnow command is issued.
- MATLAB returns to await a user command.

That is, the value obtained for subplot i by the command

```
get(h(i), 'position')
```

will not be correct until the script refreshes the plot or exits.

**Special Case: subplot(111)**

The command subplot(111) is not identical in behavior to subplot(1,1,1) and exists only for compatibility with previous releases. This syntax does not immediately create an axes object, but instead sets up the figure so that the next graphics command executes a clf reset (deleting all figure children) and creates a new axes object in

# subplot

---

the default position. This syntax does not return a handle, so it is an error to specify a return argument. (MATLAB implements this behavior by setting the figure's `NextPlot` property to `replace`.)

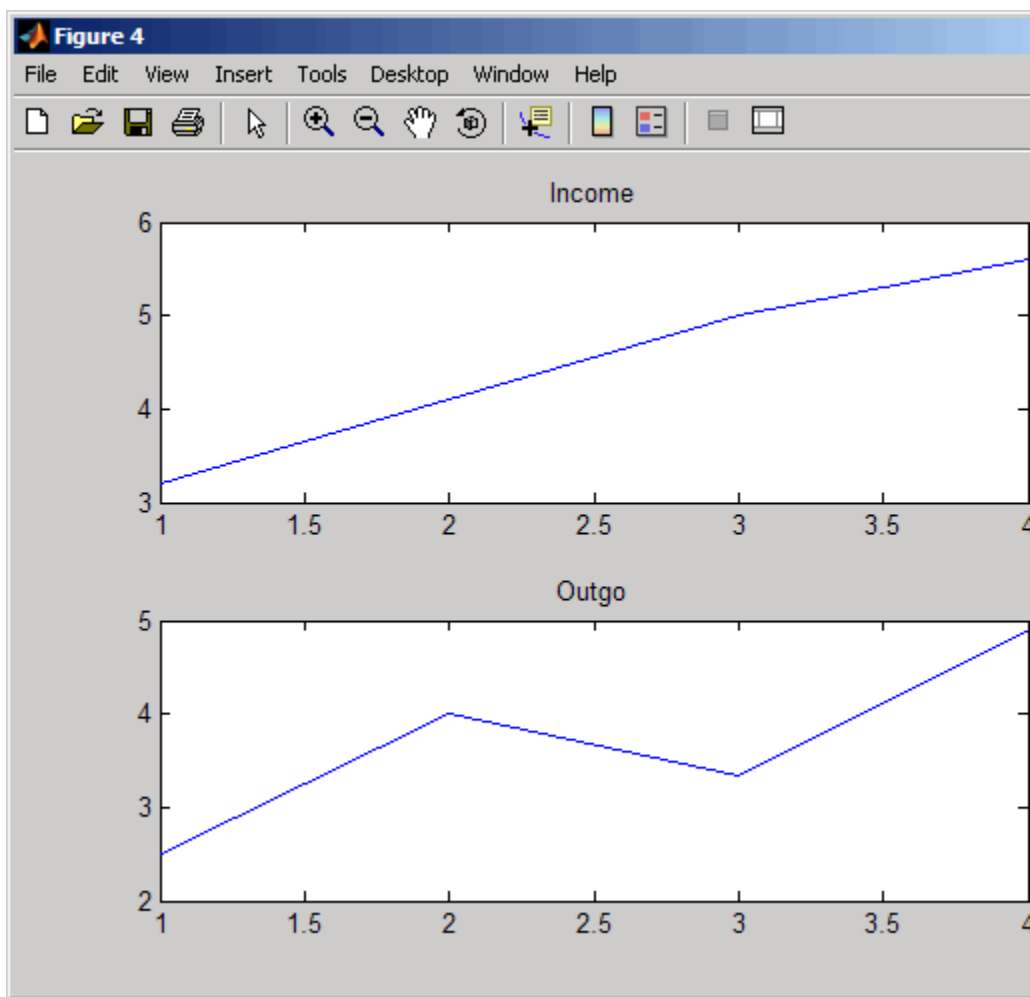
## Examples

### Upper and Lower Subplots with Titles

To plot income in the top half of a figure and outgo in the bottom half,

```
income = [3.2 4.1 5.0 5.6];  
outgo = [2.5 4.0 3.35 4.9];  
subplot(2,1,1); plot(income)  
title('Income')  
subplot(2,1,2); plot(outgo)  
title('Outgo')
```

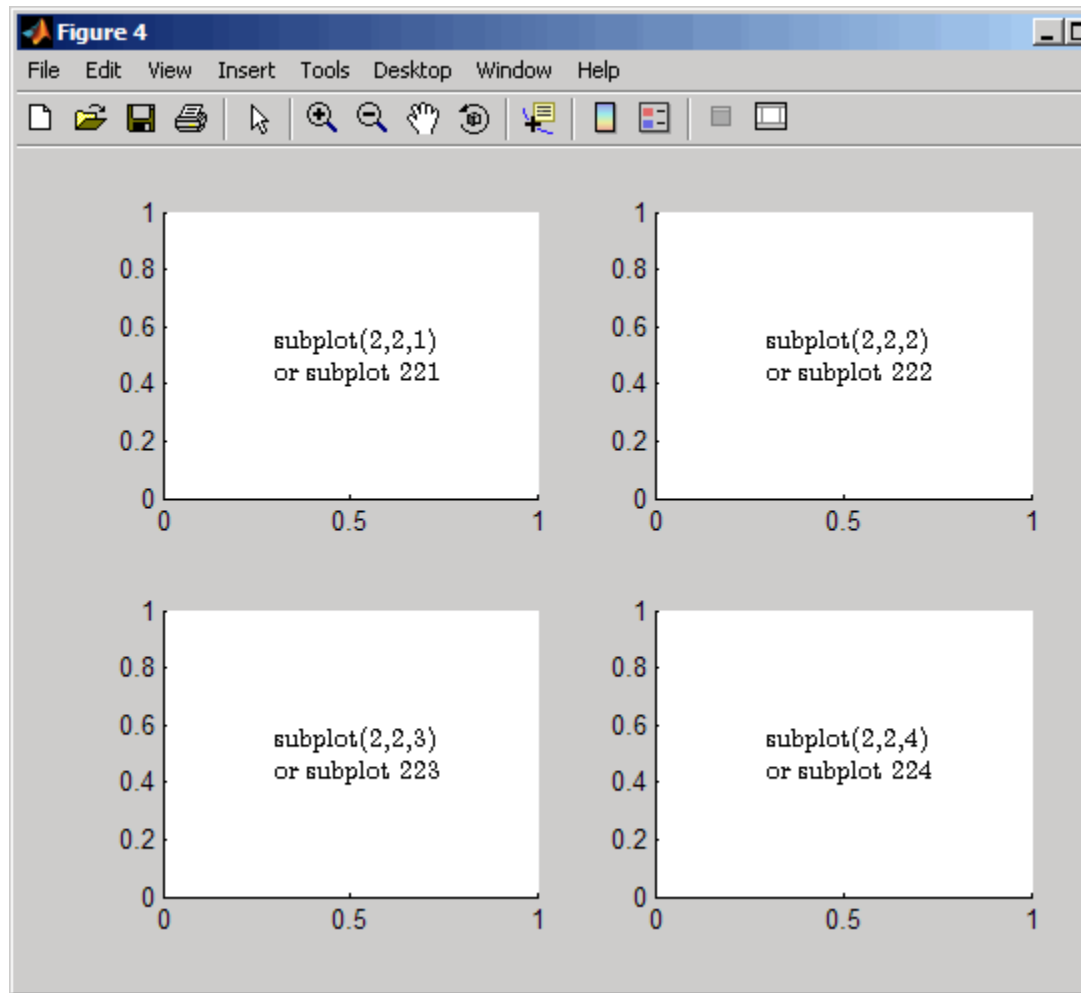




## Subplots in Quadrants

The following illustration shows four subplot regions and indicates the command used to create each.

# subplot

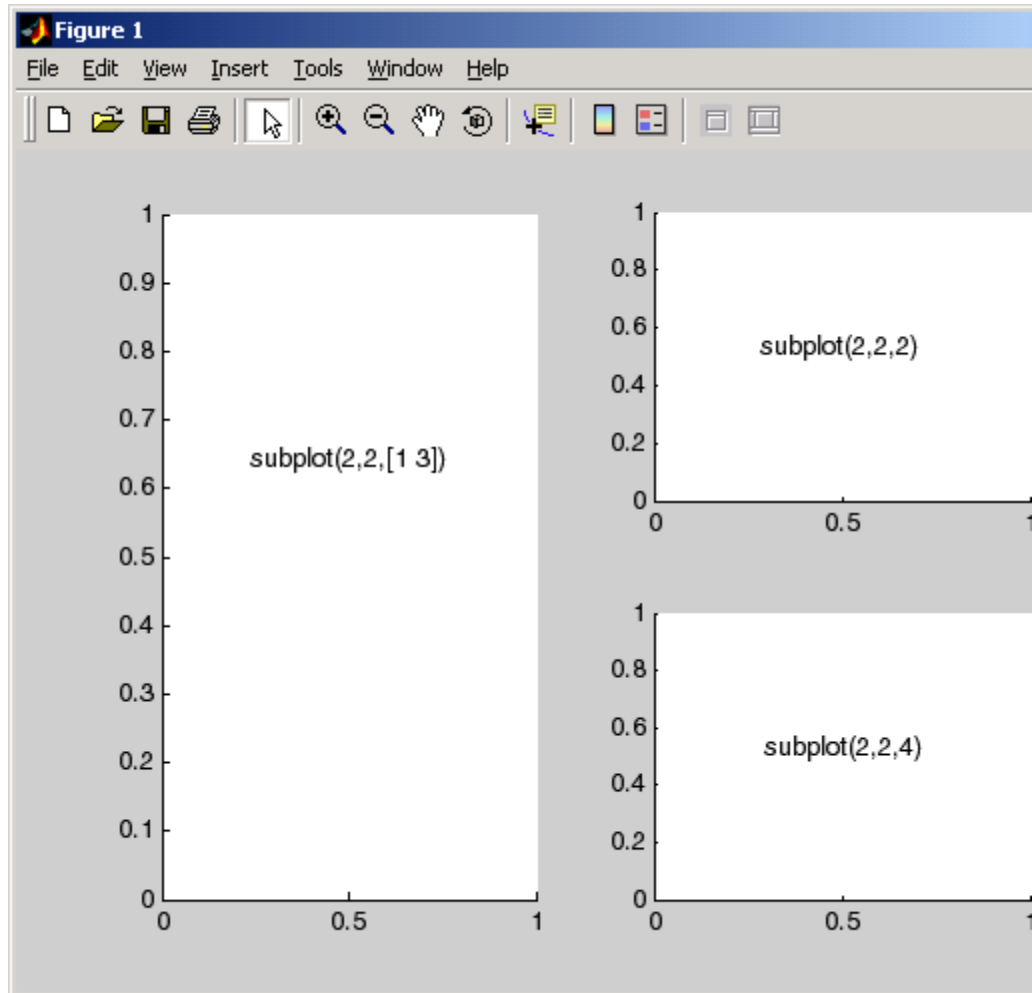


## Assymetrical Subplots

The following combinations produce asymmetrical arrangements of subplots.

```
subplot(2,2,[1 3])
```

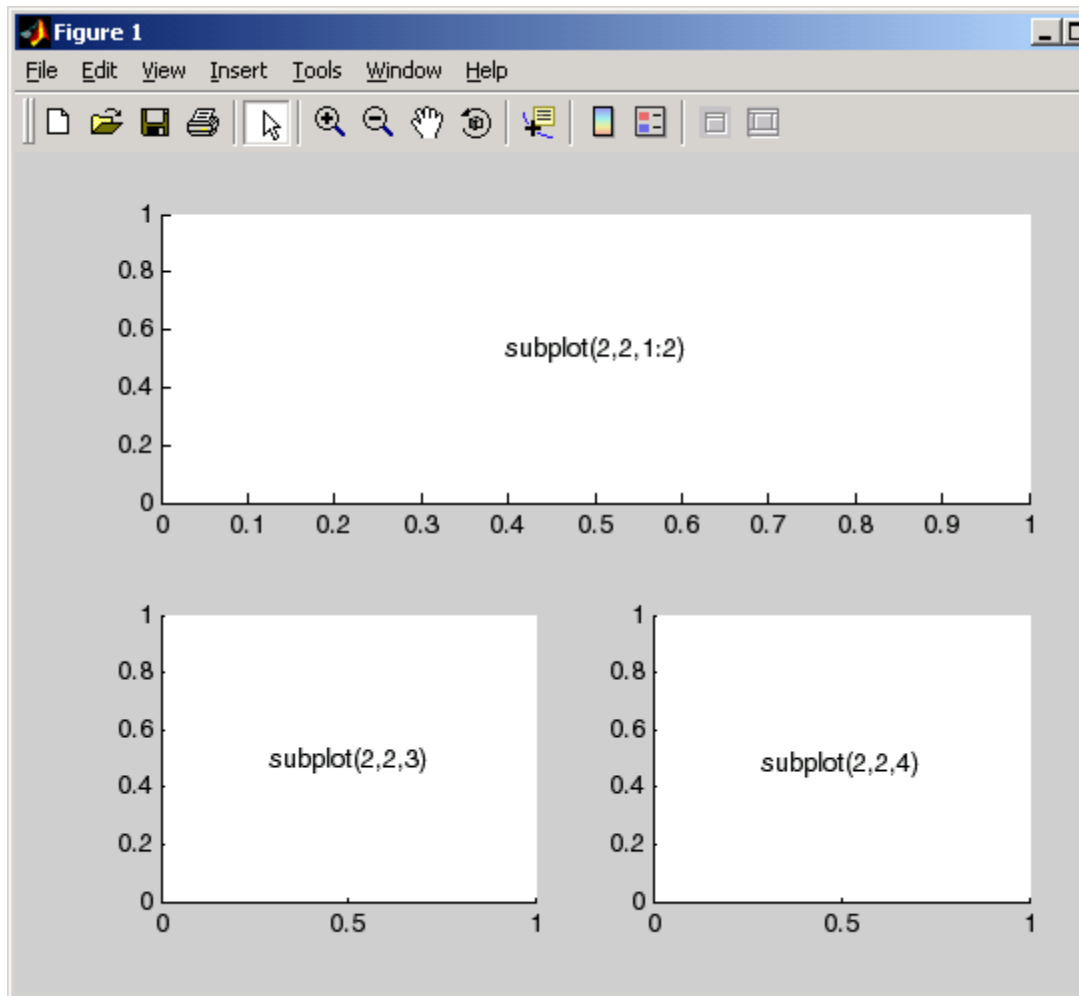
```
subplot(2,2,2)  
subplot(2,2,4)
```



You can also use the colon operator to specify multiple locations if they are in sequence.

# subplot

```
subplot(2,2,1:2)  
subplot(2,2,3)  
subplot(2,2,4)
```

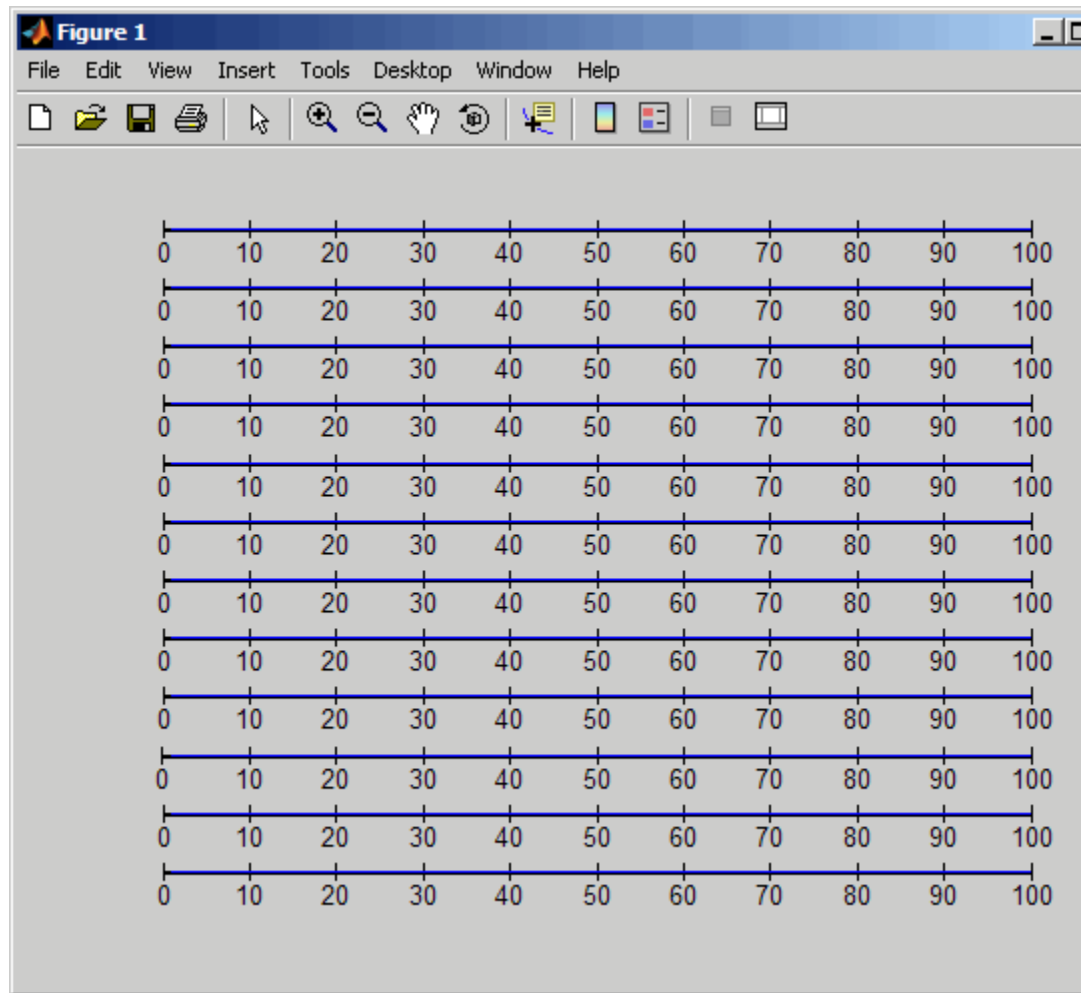


## Suppressing Axis Ticks

When you create many subplots in a figure, the axes tickmarks, which are shown by default, can either be obliterated or can cause axes to collapse, as the following code demonstrates:

```
figure
for i=1:12
    subplot(12,1,i)
    plot (sin(1:100)*10^(i-1))
end
```

# subplot

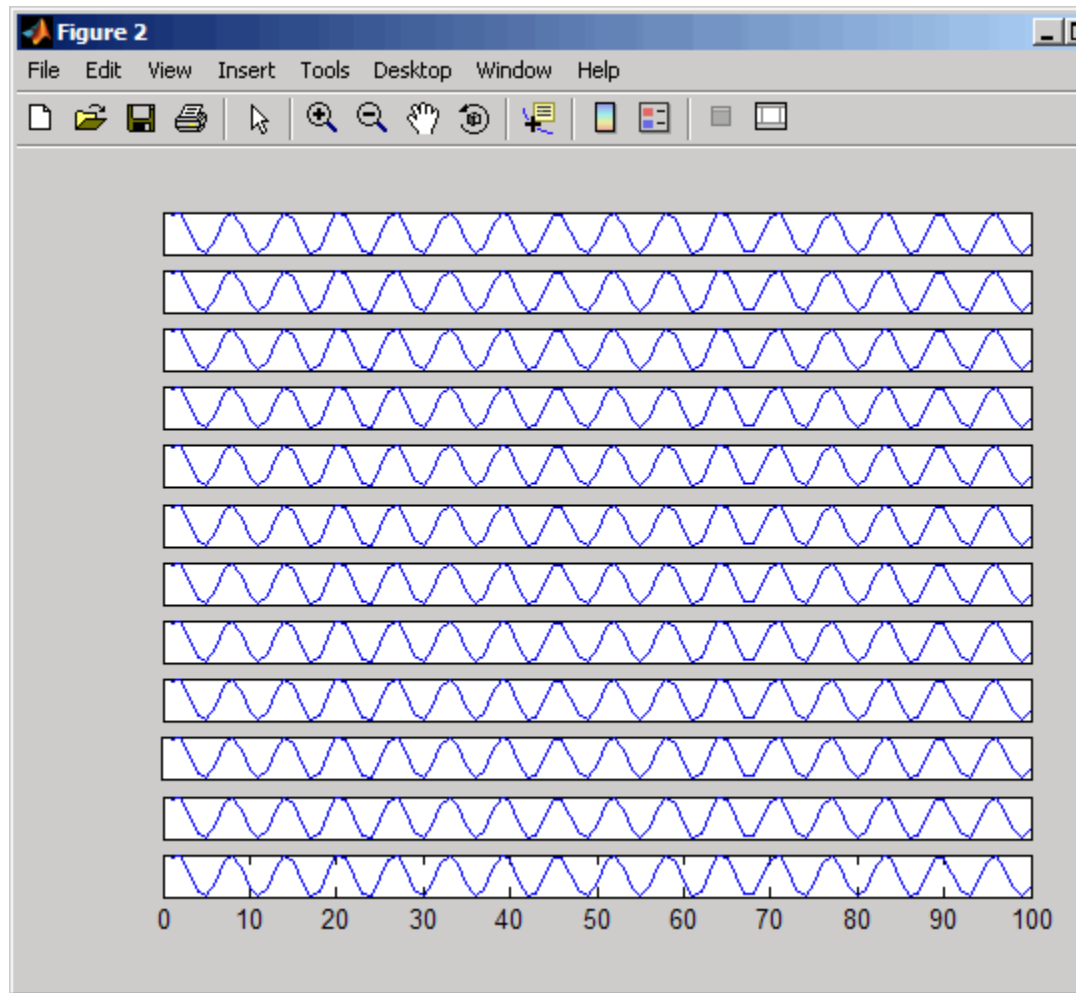


One way to get around this issue is to enlarge the figure to create enough space to properly display the tick labels.

Another approach is to eliminate the clutter by suppressing xticks and yticks for subplots as data are plotted into them. You can then label a single axes if the subplots are stacked, as follows:

```
figure
for i=1:12
    subplot(12,1,i)
    plot (sin(1:100)*10^(i-1))
    set(gca,'xtick',[],'ytick',[])
end
% Reset the bottom subplot to have xticks
set(gca,'xtickMode', 'auto')
```

# subplot



## See Also

`axes`, `cla`, `clf`, `figure`, `gca`

“Basic Plots and Graphs” on page 1-86 for more information



“Creating Subplots” in the MATLAB Creating Graphical User Interfaces documentation describes adding subplots to GUIs.

# subsasgn

---

**Purpose** Subscripted assignment for objects

**Syntax** `A = subsasgn(A, S, B)`

**Description** `A = subsasgn(A, S, B)` is called for the syntax `A(i)=B`, `A{i}=B`, or `A.i=B` when `A` is an object. `S` is a structure array with the fields

- `type`: A string containing `'()'` , `'{}'` , or `'.'`, where `'()'`  specifies integer subscripts, `'{}'`  specifies cell array subscripts, and `'.'` specifies subscripted structure fields.
- `subs`: A cell array or string containing the actual subscripts.

## Remarks

`subsasgn` is designed to be used by the MATLAB interpreter to handle indexed assignments to objects. Calling `subsasgn` directly as a function is not recommended. If you do use `subsasgn` in this way, it conforms to the formal MATLAB dispatching rules and can yield unexpected results.

In the assignment `A(J,K,...) = B(M,N,...)`, subscripts `J, K, M, N`, etc. may be scalar, vector, or array, provided that all of the following are true:

- The number of subscripts specified for `B`, excluding trailing subscripts equal to 1, does not exceed `ndims(B)`.
- The number of nonscalar subscripts specified for `A` equals the number of nonscalar subscripts specified for `B`. For example, `A(5, 1:4, 1, 2) = B(5:8)` is valid because both sides of the equation use one nonscalar subscript.
- The order and length of all nonscalar subscripts specified for `A` matches the order and length of nonscalar subscripts specified for `B`. For example, `A(1:4, 3, 3:9) = B(5:8, 1:7)` is valid because both sides of the equation (ignoring the one scalar subscript 3) use a 4-element subscript followed by a 7-element subscript.

See the Remarks section of the `numel` reference page for information concerning the use of `numel` with regards to the overloaded `subsasgn` function.

If `A` is an array of one of the fundamental MATLAB data types, then assigning a value to `A` with indexed assignment calls the builtin MATLAB `subsasgn` method. It does not call any `subsasgn` method that you may have overloaded for that data type. For example, if `A` is an array of type `double`, and there is an `@double/subsasgn` method on your MATLAB path, the statement `A(I) = B` does not call this method, but calls the MATLAB builtin `subsasgn` method instead.

## Examples

The syntax `A(1:2,:)=B` calls `A=subsasgn(A,S,B)` where `S` is a 1-by-1 structure with `S.type='()'` and `S.subs = {1:2, ':'}`. A colon used as a subscript is passed as the string `':'`.

The syntax `A{1:2}=B` calls `A=subsasgn(A,S,B)` where `S.type='{}'`.

The syntax `A.field=B` calls `subsasgn(A,S,B)` where `S.type='.'` and `S.subs='field'`.

These simple calls are combined in a straightforward way for more complicated subscripting expressions. In such cases `length(S)` is the number of subscripting levels. For instance, `A(1,2).name(3:5)=B` calls `A=subsasgn(A,S,B)` where `S` is a 3-by-1 structure array with the following values:

|                              |                               |                              |
|------------------------------|-------------------------------|------------------------------|
| <code>S(1).type='()'</code>  | <code>S(2).type='.'</code>    | <code>S(3).type='()'</code>  |
| <code>S(1).subs={1,2}</code> | <code>S(2).subs='name'</code> | <code>S(3).subs={3:5}</code> |

## See Also

`subsref`, `substruct`

See “Handling Subscripted Assignment” for more information about overloaded methods and `subsasgn`.

# subsindex

---

**Purpose** Subscripted indexing for objects

**Syntax** `ind = subsindex(A)`

**Description** `ind = subsindex(A)` is called for the syntax '`X(A)`' when `A` is an object. `subsindex` must return the value of the object as a zero-based integer index. (`ind` must contain integer values in the range 0 to `prod(size(X))-1`.) `subsindex` is called by the default `subsref` and `subsasgn` functions, and you can call it if you overload these functions.

**See Also** `subsasgn`, `subsref`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Angle between two subspaces                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Syntax</b>      | <code>theta = subspace(A,B)</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Description</b> | <code>theta = subspace(A,B)</code> finds the angle between two subspaces specified by the columns of A and B. If A and B are column vectors of unit length, this is the same as $\text{acos}(A' * B)$ .                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Remarks</b>     | If the angle between the two subspaces is small, the two spaces are nearly linearly dependent. In a physical experiment described by some observations A, and a second realization of the experiment described by B, <code>subspace(A,B)</code> gives a measure of the amount of new information afforded by the second experiment not associated with statistical errors of fluctuations.                                                                                                                                                                                                                                     |
| <b>Examples</b>    | <p>Consider two subspaces of a Hadamard matrix, whose columns are orthogonal.</p> <pre>H = hadamard(8); A = H(:,2:4); B = H(:,5:8);</pre> <p>Note that matrices A and B are different sizes — A has three columns and B four. It is not necessary that two subspaces be the same size in order to find the angle between them. Geometrically, this is the angle between two hyperplanes embedded in a higher dimensional space.</p> <pre>theta = subspace(A,B) theta =     1.5708</pre> <p>That A and B are orthogonal is shown by the fact that theta is equal to <math>\pi/2</math>.</p> <pre>theta - pi/2 ans =     0</pre> |

# subsref

---

**Purpose** Subscripted reference for objects

**Syntax** `B = subsref(A, S)`

**Description** `B = subsref(A, S)` is called for the syntax `A(i)`, `A{i}`, or `A.i` when `A` is an object. `S` is a structure array with the fields

- `type`: A string containing `'()'`, `'{}'`, or `'.'`, where `'()'` specifies integer subscripts, `'{}'` specifies cell array subscripts, and `'.'` specifies subscripted structure fields.
- `subs`: A cell array or string containing the actual subscripts.

## Remarks

`subsref` is designed to be used by the MATLAB interpreter to handle indexed references to objects. Calling `subsref` directly as a function is not recommended. If you do use `subsref` in this way, it conforms to the formal MATLAB dispatching rules and can yield unexpected results.

See the Remarks section of the `numel` reference page for information concerning the use of `numel` with regards to the overloaded `subsref` function.

If `A` is an array of one of the fundamental MATLAB data types, then referencing a value of `A` using an indexed reference calls the builtin MATLAB `subsref` method. It does not call any `subsref` method that you may have overloaded for that data type. For example, if `A` is an array of type `double`, and there is an `@double/subsref` method on your MATLAB path, the statement `B = A(I)` does not call this method, but calls the MATLAB builtin `subsref` method instead.

## Examples

The syntax `A(1:2,:)` calls `subsref(A,S)` where `S` is a 1-by-1 structure with `S.type='()'` and `S.subs={1:2, ':'}`. A colon used as a subscript is passed as the string `'.'`.

The syntax `A{1:2}` calls `subsref(A,S)` where `S.type='{}'` and `S.subs={1:2}`.

The syntax `A.field` calls `subsref(A,S)` where `S.type='.'` and `S.subs='field'`.

These simple calls are combined in a straightforward way for more complicated subscripting expressions. In such cases `length(S)` is the number of subscripting levels. For instance, `A(1,2).name(3:5)` calls `subsref(A,S)` where `S` is a 3-by-1 structure array with the following values:

```
S(1).type='()'      S(2).type='.'      S(3).type='()'
S(1).subs={1,2}    S(2).subs='name'   S(3).subs={3:5}
```

### See Also

`subsasgn`, `substruct`

See “Handling Subscripted Reference” for more information about overloaded methods and `subsref`.

# substruct

---

**Purpose** Create structure argument for subsasgn or subsref

**Syntax** `S = substruct(type1, subs1, type2, subs2, ...)`

**Description** `S = substruct(type1, subs1, type2, subs2, ...)` creates a structure with the fields required by an overloaded subsref or subsasgn method. Each type string must be one of `'.'`, `'()'`, or `'{'}`. The corresponding subs argument must be either a field name (for the `'.'` type) or a cell array containing the index vectors (for the `'()'` or `'{'}` types).

The output `S` is a structure array containing the fields

- `type`: one of `'.'`, `'()'`, or `'{'}`
- `subs`: subscript values (field name or cell array of index vectors)

## Examples

To call subsref with parameters equivalent to the syntax

```
B = A(3,5).field
```

you can use

```
S = substruct('()', {3,5}, '.', 'field');  
B = subsref(A, S);
```

The structure created by substruct in this example contains the following:

```
S(1)  
  
ans =  
  
type: '()'  
subs: {[3] [5]}  
  
S(2)
```



```
ans =  
  
    type: '.'  
    subs: 'field'
```

## See Also

subsasgn, subsref

# subvolume

---

**Purpose** Extract subset of volume data set

**Syntax**

```
[Nx,Ny,Nz,Nv] = subvolume(X,Y,Z,V,limits)
[Nx,Ny,Nz,Nv] = subvolume(V,limits)
Nv = subvolume(...)
```

**Description** `[Nx,Ny,Nz,Nv] = subvolume(X,Y,Z,V,limits)` extracts a subset of the volume data set `V` using the specified axis-aligned limits. `limits = [xmin,xmax,ymin, ymax,zmin,zmax]` (Any NaNs in the limits indicate that the volume should not be cropped along that axis.)

The arrays `X`, `Y`, and `Z` define the coordinates for the volume `V`. The subvolume is returned in `NV` and the coordinates of the subvolume are given in `NX`, `NY`, and `NZ`.

`[Nx,Ny,Nz,Nv] = subvolume(V,limits)` assumes the arrays `X`, `Y`, and `Z` are defined as

```
[X,Y,Z] = meshgrid(1:N,1:M,1:P)
```

where `[M,N,P] = size(V)`.

`Nv = subvolume(...)` returns only the subvolume.

## Examples

This example uses a data set that is a collection of MRI slices of a human skull. The data is processed in a variety of ways:

- The 4-D array is squeezed (`squeeze`) into three dimensions and then a subset of the data is extracted (`subvolume`).
- The outline of the skull is an isosurface generated as a patch (`p1`) whose vertex normals are recalculated to improve the appearance when lighting is applied (`patch`, `isosurface`, `isonormals`).
- A second patch (`p2`) with interpolated face color draws the end caps (`FaceColor`, `isocaps`).
- The view of the object is set (`view`, `axis`, `daspect`).

- A 100-element grayscale colormap provides coloring for the end caps (colormap).
- Adding lights to the right and left of the camera illuminates the object (camlight, lighting).

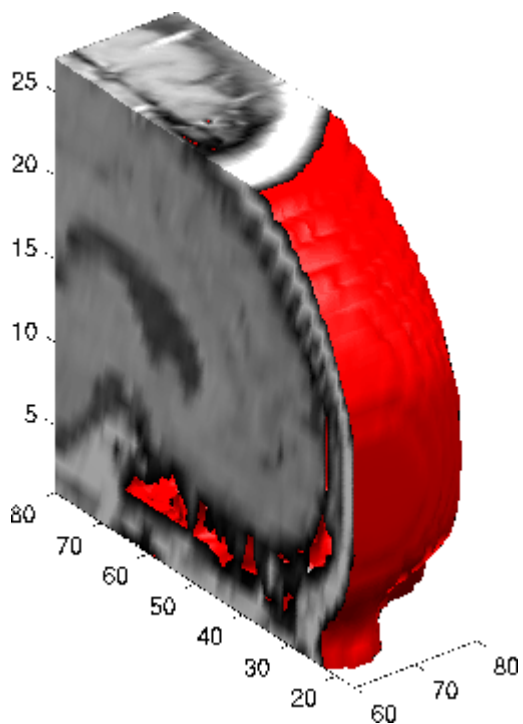
```

load mri
D = squeeze(D);
[x,y,z,D] = subvolume(D,[60,80,nan,80,nan,nan]);
p1 = patch(isosurface(x,y,z,D, 5),...
    'FaceColor','red','EdgeColor','none');
isonormals(x,y,z,D,p1);
p2 = patch(isocaps(x,y,z,D, 5),...
    'FaceColor','interp','EdgeColor','none');
view(3); axis tight; daspect([1,1,.4])
colormap(gray(100))
camlight right; camlight left; lighting gouraud

```

## subvolume

---



### See Also

`isocaps`, `isonormals`, `isosurface`, `reducepatch`, `reducevolume`, `smooth3`

“Volume Visualization” on page 1-102 for related functions

**Purpose**

Sum of array elements

**Syntax**

```
B = sum(A)
B = sum(A,dim)
B = sum(..., 'double')
B = sum(..., dim,'double')
B = sum(..., 'native')
B = sum(..., dim,'native')
```

**Description**

`B = sum(A)` returns sums along different dimensions of an array.

If `A` is a vector, `sum(A)` returns the sum of the elements.

If `A` is a matrix, `sum(A)` treats the columns of `A` as vectors, returning a row vector of the sums of each column.

If `A` is a multidimensional array, `sum(A)` treats the values along the first non-singleton dimension as vectors, returning an array of row vectors.

`B = sum(A,dim)` sums along the dimension of `A` specified by scalar `dim`. The `dim` input is an integer value from 1 to `N`, where `N` is the number of dimensions in `A`. Set `dim` to 1 to compute the sum of each column, 2 to sum rows, etc.

`B = sum(..., 'double')` and `B = sum(..., dim,'double')` performs additions in double-precision and return an answer of type `double`, even if `A` has data type `single` or an integer data type. This is the default for integer data types.

`B = sum(..., 'native')` and `B = sum(..., dim,'native')` performs additions in the native data type of `A` and return an answer of the same data type. This is the default for `single` and `double`.

**Remarks**

`sum(diag(X))` is the trace of `X`.

**Examples**

The magic square of order 3 is

```
M = magic(3)
M =
```

## sum

---

```
8   1   6
3   5   7
4   9   2
```

This is called a magic square because the sums of the elements in each column are the same.

```
sum(M) =
    15    15    15
```

as are the sums of the elements in each row, obtained either by:

- Transposing

```
sum(M') =
    15    15    15
```

- Using the `dim` argument

```
sum(M,1) =
    15
    15
    15
```

transposing:

### **Nondouble Data Type Support**

This section describes the support of `sum` for data types other than `double`.

#### **Data Type single**

You can apply `sum` to an array of type `single` and MATLAB returns an answer of type `single`. For example,

```
sum(single([2 5 8]))
```

```
ans =
```

```
15
```

```
class(ans)

ans =

single
```

### Integer Data Types

When you apply `sum` to any of the following integer data types, MATLAB returns an answer of type double:

- `int8` and `uint8`
- `int16` and `uint16`
- `int32` and `uint32`

For example,

```
sum(single([2 5 8]));
class(ans)

ans =

single
```

If you want MATLAB to perform additions on an integer data type in the same integer type as the input, use the syntax

```
sum(int8([2 5 8], 'native'));
class(ans)

ans =

int8
```

### See Also

`accumarray`, `cumsum`, `diff`, `isfloat`, `prod`

# sum (timeseries)

---

**Purpose** Sum of timeseries data

**Syntax**  
`ts_sm = sum(ts)`  
`ts_sm = sum(ts, 'PropertyName1', PropertyValue1, ...)`

**Description** `ts_sm = sum(ts)` returns the sum of the time-series data. When `ts.Data` is a vector, `ts_sm` is the sum of `ts.Data` values. When `ts.Data` is a matrix, `ts_sm` is a row vector containing the sum of each column of `ts.Data` (when `IsTimeFirst` is true and the first dimension of `ts` is aligned with time). For the N-dimensional `ts.Data` array, `sum` always operates along the first nonsingleton dimension of `ts.Data`.

`ts_sm = sum(ts, 'PropertyName1', PropertyValue1, ...)` specifies the following optional input arguments:

- 'MissingData' property has two possible values, 'remove' (default) or 'interpolate', indicating how to treat missing data during the calculation.
- 'Quality' values are specified by a vector of integers, indicating which quality codes represent missing samples (for vector data) or missing observations (for data arrays with two or more dimensions).
- 'Weighting' property has two possible values, 'none' (default) or 'time'. When you specify 'time', larger time values correspond to larger weights.

## Examples

**1** Load a 24-by-3 data array.

```
load count.dat
```

**2** Create a timeseries object with 24 time values.

```
count_ts = timeseries(count,1:24,'Name','CountPerSecond')
```

**3** Calculate the sum of each data column for this timeseries object.

```
sum(count_ts)
```



```
ans =
```

```
       768       1117       1574
```

The sum is calculated independently for each data column in the `timeseries` object.

### See Also

```
iqr (timeseries), mean (timeseries), median (timeseries), std  
(timeseries), var (timeseries), timeseries
```

# superiorto

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Establish superior class relationship                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Syntax</b>      | <code>superiorto('class1', 'class2', ...)</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Description</b> | <p>The <code>superiorto</code> function establishes a hierarchy that determines the order in which MATLAB calls object methods.</p> <p><code>superiorto('class1', 'class2', ...)</code> invoked within a class constructor method (say <code>myclass.m</code>) indicates that <code>myclass</code>'s method should be invoked if a function is called with an object of class <code>myclass</code> and one or more objects of class <code>class1</code>, <code>class2</code>, and so on.</p>                                                                                                                                                                   |
| <b>Remarks</b>     | <p>Suppose A is of class <code>'class_a'</code>, B is of class <code>'class_b'</code> and C is of class <code>'class_c'</code>. Also suppose the constructor <code>class_c.m</code> contains the statement <code>superiorto('class_a')</code>. Then <code>e = fun(a,c)</code> or <code>e = fun(c,a)</code> invokes <code>class_c/fun</code>.</p> <p>If a function is called with two objects having an unspecified relationship, the two objects are considered to have equal precedence, and the leftmost object's method is called. So <code>fun(b,c)</code> calls <code>class_b/fun</code>, while <code>fun(c,b)</code> calls <code>class_c/fun</code>.</p> |
| <b>See Also</b>    | <code>inferiorto</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

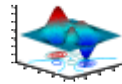
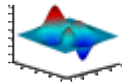
|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Open MathWorks Technical Support Web page                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Syntax</b>      | support                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Description</b> | <p>support opens the MathWorks Technical Support Web page, <a href="http://www.mathworks.com/support">http://www.mathworks.com/support</a>, in the MATLAB Web browser.</p> <p>This Web page contains resources including</p> <ul style="list-style-type: none"><li>• A search engine, including an option for solutions to common problems</li><li>• Information about installation and licensing</li><li>• A patch archive for bug fixes you can download</li><li>• Other useful resources</li></ul> |
| <b>See Also</b>    | doc, web                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

# surf, surfc


---

## Purpose

3-D shaded surface plot



## GUI Alternatives

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

## Syntax

```
surf(Z)
surf(Z,C)
surf(X,Y,Z)
surf(X,Y,Z,C)
surf(...,'PropertyName',PropertyValue)
surf(axes_handles,...)
surfc(...)
h = surf(...)
hsurface = surf('v6',...)
```

## Description

Use `surf` and `surfc` to view mathematical functions over a rectangular region. `surf` and `surfc` create colored parametric surfaces specified by  $X$ ,  $Y$ , and  $Z$ , with color specified by  $Z$  or  $C$ .

`surf(Z)` creates a three-dimensional shaded surface from the  $z$  components in matrix  $Z$ , using  $x = 1:n$  and  $y = 1:m$ , where  $[m,n] = \text{size}(Z)$ . The height,  $Z$ , is a single-valued function defined over a geometrically rectangular grid.  $Z$  specifies the color data as well as surface height, so color is proportional to surface height.

`surf(Z,C)` plots the height of  $Z$ , a single-valued function defined over a geometrically rectangular grid, and uses matrix  $C$ , assumed to be the same size as  $Z$ , to color the surface.

`surf(X,Y,Z)` creates a shaded surface using `Z` for the color data as well as surface height. `X` and `Y` are vectors or matrices defining the `x` and `y` components of a surface. If `X` and `Y` are vectors, `length(X) = n` and `length(Y) = m`, where `[m,n] = size(Z)`. In this case, the vertices of the surface faces are  $(X(j), Y(i), Z(i_x,j))$  triples.

`surf(X,Y,Z,C)` creates a shaded surface, with color defined by `C`. MATLAB performs a linear transformation on this data to obtain colors from the current colormap.

`surf(..., 'PropertyName', PropertyValue)` specifies surface properties along with the data.

`surf(axes_handles,...)` and `surfc(axes_handles,...)` plot into the axes with handle `axes_handle` instead of the current axes (`gca`).

`surfc(...)` draws a contour plot beneath the surface.

`h = surf(...)` and `h = surfc(...)` return a handle to a surfaceplot graphics object.

### Backward-Compatible Version

`hsurface = surf('v6',...)` and `hsurface = surfc('v6',...)` return the handles of surface objects instead of surfaceplot objects for compatibility with MATLAB 6.5 and earlier.

---

**Note** The `v6` option enables users of Version 7.x of MATLAB to create FIG-files that previous versions can open. It is obsolete and will be removed in a future version of MATLAB.

---

See Plot Objects and Backward Compatibility for more information.

### Remarks

`surf` and `surfc` do not accept complex inputs.

### Algorithm

Abstractly, a parametric surface is parameterized by two independent variables, `i` and `j`, which vary continuously over a rectangle; for example,  $1 \leq i \leq m$  and  $1 \leq j \leq n$ . The three functions  $x(i, j)$ ,  $y(i, j)$ ,

and  $z(i, j)$  specify the surface. When  $i$  and  $j$  are integer values, they define a rectangular grid with integer grid points. The functions  $x(i, j)$ ,  $y(i, j)$ , and  $z(i, j)$  become three  $m$ -by- $n$  matrices,  $X$ ,  $Y$ , and  $Z$ . Surface color is a fourth function,  $c(i, j)$ , denoted by matrix  $C$ .

Each point in the rectangular grid can be thought of as connected to its four nearest neighbors.

$$\begin{array}{c} i-1, j \\ | \\ i, j-1 - i, j - i, j+1 \\ | \\ i+1, j \end{array}$$

This underlying rectangular grid induces four-sided patches on the surface. To express this another way,  $[X(:) Y(:) Z(:)]$  returns a list of triples specifying points in 3-space. Each interior point is connected to the four neighbors inherited from the matrix indexing. Points on the edge of the surface have three neighbors; the four points at the corners of the grid have only two neighbors. This defines a mesh of quadrilaterals or a *quad-mesh*.

Surface color can be specified in two different ways: at the vertices or at the centers of each patch. In this general setting, the surface need not be a single-valued function of  $x$  and  $y$ . Moreover, the four-sided surface patches need not be planar. For example, you can have surfaces defined in polar, cylindrical, and spherical coordinate systems.

The shading function sets the shading. If the shading is `interp`,  $C$  must be the same size as  $X$ ,  $Y$ , and  $Z$ ; it specifies the colors at the vertices. The color within a surface patch is a bilinear function of the local coordinates. If the shading is `faceted` (the default) or `flat`,  $C(i, j)$  specifies the constant color in the surface patch:

$$\begin{array}{c} (i, j) \quad - \quad (i, j+1) \\ | \quad C(i, j) \quad | \\ (i+1, j) \quad - \quad (i+1, j+1) \end{array}$$

In this case, C can be the same size as X, Y, and Z and its last row and column are ignored. Alternatively, its row and column dimensions can be one less than those of X, Y, and Z.

The `surf` and `surfc` functions specify the viewpoint using `view(3)`.

The range of X, Y, and Z or the current setting of the axes `XLimMode`, `YLimMode`, and `ZLimMode` properties (also set by the `axis` function) determines the axis labels.

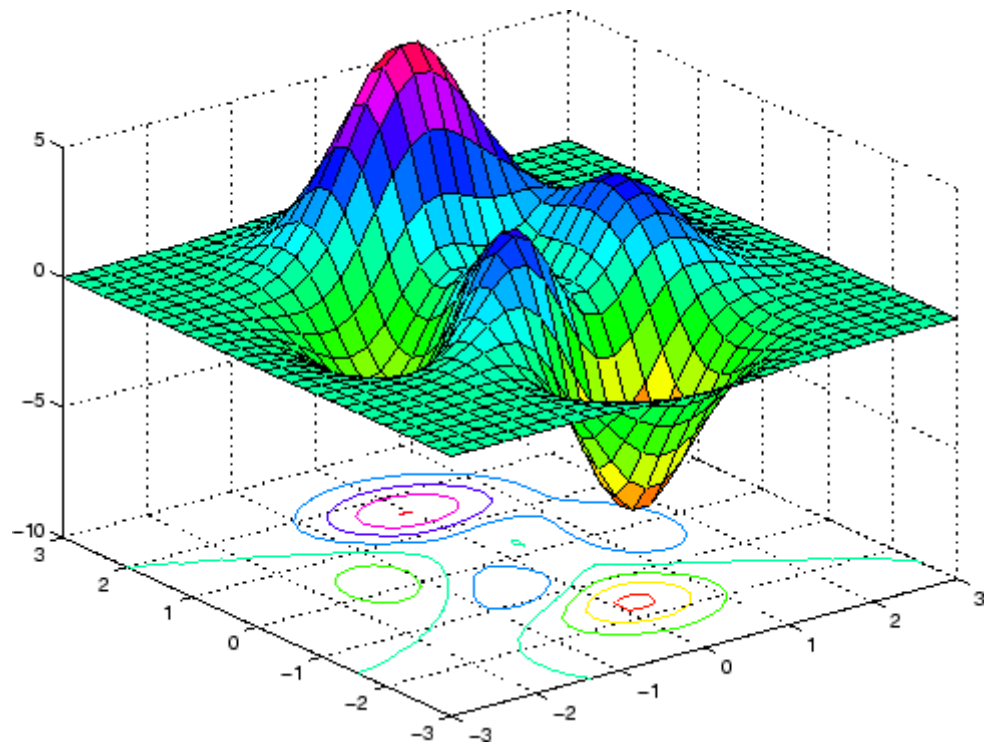
The range of C or the current setting of the axes `CLim` and `CLimMode` properties (also set by the `caxis` function) determines the color scaling. The scaled color values are used as indices into the current colormap.

## Examples

Display a surfaceplot and contour plot of the peaks surface.

```
[X,Y,Z] = peaks(30);  
surfc(X,Y,Z)  
colormap hsv  
axis([-3 3 -3 3 -10 5])
```

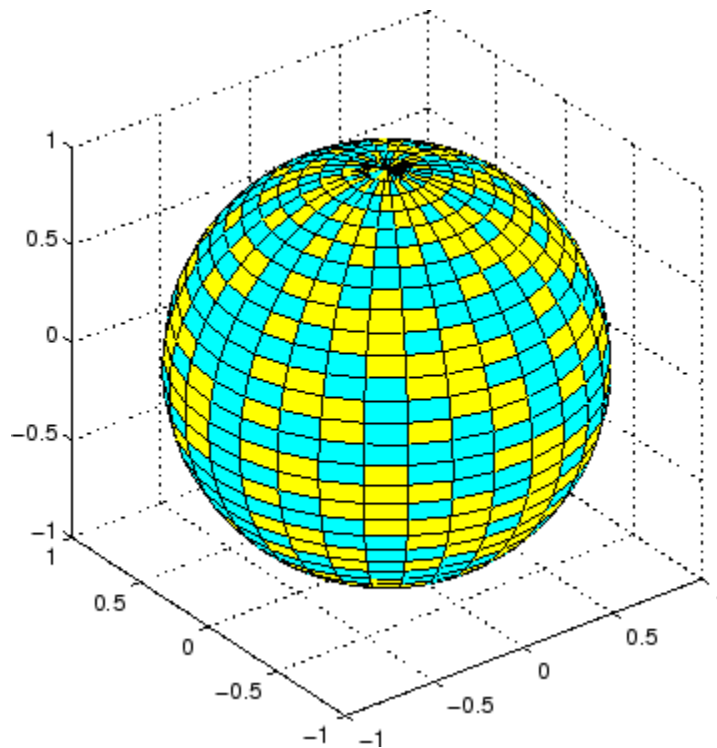
## surf, surfc



Color a sphere with the pattern of +1s and -1s in a Hadamard matrix.

```
k = 5;  
n = 2^k-1;  
[x,y,z] = sphere(n);  
c = hadamard(2^k);  
surf(x,y,z,c);  
colormap([1 1 0; 0 1 1])  
axis equal
```



**See Also**

`axis`, `caxis`, `colormap`, `contour`, `delaunay`, `imagesc`, `mesh`, `pcolor`, `shading`, `trisurf`, `view`

Properties for surfaceplot graphics objects

“Creating Surfaces and Meshes” on page 1-97 for related functions

Representing a Matrix as a Surface for more examples

Coloring Mesh and Surface Plots for information about how to control the coloring of surfaces

# surf2patch

---

**Purpose** Convert surface data to patch data

**Syntax**

```
fvc = surf2patch(Z)
fvc = surf2patch(Z,C)
fvc = surf2patch(X,Y,Z)
fvc = surf2patch(X,Y,Z,C)
fvc = surf2patch(...,'triangles')
[f,v,c] = surf2patch(...)
```

**Description** `fvc = surf2patch(h)` converts the geometry and color data from the surface object identified by the handle `h` into patch format and returns the face, vertex, and color data in the struct `fvc`. You can pass this struct directly to the `patch` command.

`fvc = surf2patch(Z)` calculates the patch data from the surface's ZData matrix `Z`.

`fvc = surf2patch(Z,C)` calculates the patch data from the surface's ZData and CData matrices `Z` and `C`.

`fvc = surf2patch(X,Y,Z)` calculates the patch data from the surface's XData, YData, and ZData matrices `X`, `Y`, and `Z`.

`fvc = surf2patch(X,Y,Z,C)` calculates the patch data from the surface's XData, YData, ZData, and CData matrices `X`, `Y`, `Z`, and `C`.

`fvc = surf2patch(...,'triangles')` creates triangular faces instead of the quadrilaterals that compose surfaces.

`[f,v,c] = surf2patch(...)` returns the face, vertex, and color data in the three arrays `f`, `v`, and `c` instead of a struct.

**Examples** The first example uses the `sphere` command to generate the XData, YData, and ZData of a surface, which is then converted to a patch. Note that the ZData (`z`) is passed to `surf2patch` as both the third and fourth arguments — the third argument is the ZData and the fourth argument is taken as the CData. This is because the `patch` command does not

automatically use the  $z$ -coordinate data for the color data, as does the `surface` command.

Also, because `patch` is a low-level command, you must set the view to 3-D and shading to faceted to produce the same results produced by the `surf` command.

```
[x y z] = sphere;  
patch(surf2patch(x,y,z,z));  
shading faceted; view(3)
```

In the second example `surf2patch` calculates face, vertex, and color data from a surface whose handle has been passed as an argument.

```
s = surf(peaks);  
pause  
patch(surf2patch(s));  
delete(s)  
shading faceted; view(3)
```

## See Also

`patch`, `reducepatch`, `shrinkfaces`, `surface`, `surf`

“Volume Visualization” on page 1-102 for related functions

# surface

---

**Purpose** Create surface object

**Syntax**

```
surface(Z)
surface(Z,C)
surface(X,Y,Z)
surface(X,Y,Z,C)
surface(x,y,Z)
surface(... 'PropertyName',PropertyValue,...)
h = surface(...)
```

**Description** `surface` is the low-level function for creating surface graphics objects. Surfaces are plots of matrix data created using the row and column indices of each element as the  $x$ - and  $y$ -coordinates and the value of each element as the  $z$ -coordinate.

`surface(Z)` plots the surface specified by the matrix  $Z$ . Here,  $Z$  is a single-valued function, defined over a geometrically rectangular grid.

`surface(Z,C)` plots the surface specified by  $Z$  and colors it according to the data in  $C$  (see "Examples").

`surface(X,Y,Z)` uses  $C = Z$ , so color is proportional to surface height above the  $x$ - $y$  plane.

`surface(X,Y,Z,C)` plots the parametric surface specified by  $X$ ,  $Y$ , and  $Z$ , with color specified by  $C$ .

`surface(x,y,Z)`, `surface(x,y,Z,C)` replaces the first two matrix arguments with vectors and must have  $\text{length}(x) = n$  and  $\text{length}(y) = m$  where  $[m,n] = \text{size}(Z)$ . In this case, the vertices of the surface facets are the triples  $(x(j), y(i), Z(i,j))$ . Note that  $x$  corresponds to the columns of  $Z$  and  $y$  corresponds to the rows of  $Z$ . For a complete discussion of parametric surfaces, see the `surf` function.

`surface(... 'PropertyName',PropertyValue,...)` follows the  $X$ ,  $Y$ ,  $Z$ , and  $C$  arguments with property name/property value pairs to specify additional surface properties.

`h = surface(...)` returns a handle to the created surface object.

## Remarks

surface does not respect the settings of the figure and axes NextPlot properties. It simply adds the surface object to the current axes.

If you do not specify separate color data (C), MATLAB uses the matrix (Z) to determine the coloring of the surface. In this case, color is proportional to values of Z. You can specify a separate matrix to color the surface independently of the data defining the area of the surface.

You can specify properties as property name/property value pairs, structure arrays, and cell arrays (see set and get for examples of how to specify these data types).

surface provides convenience forms that allow you to omit the property name for the XData, YData, ZData, and CData properties. For example,

```
surface('XData',X,'YData',Y,'ZData',Z,'CData',C)
```

is equivalent to

```
surface(X,Y,Z,C)
```

When you specify only a single matrix input argument,

```
surface(Z)
```

MATLAB assigns the data properties as if you specified

```
surface('XData',[1:size(Z,2)],...  
       'YData',[1:size(Z,1)],...  
       'ZData',Z,...  
       'CData',Z)
```

The axis, caxis, colormap, hold, shading, and view commands set graphics properties that affect surfaces. You can also set and query surface property values after creating them using the set and get commands.

## Example

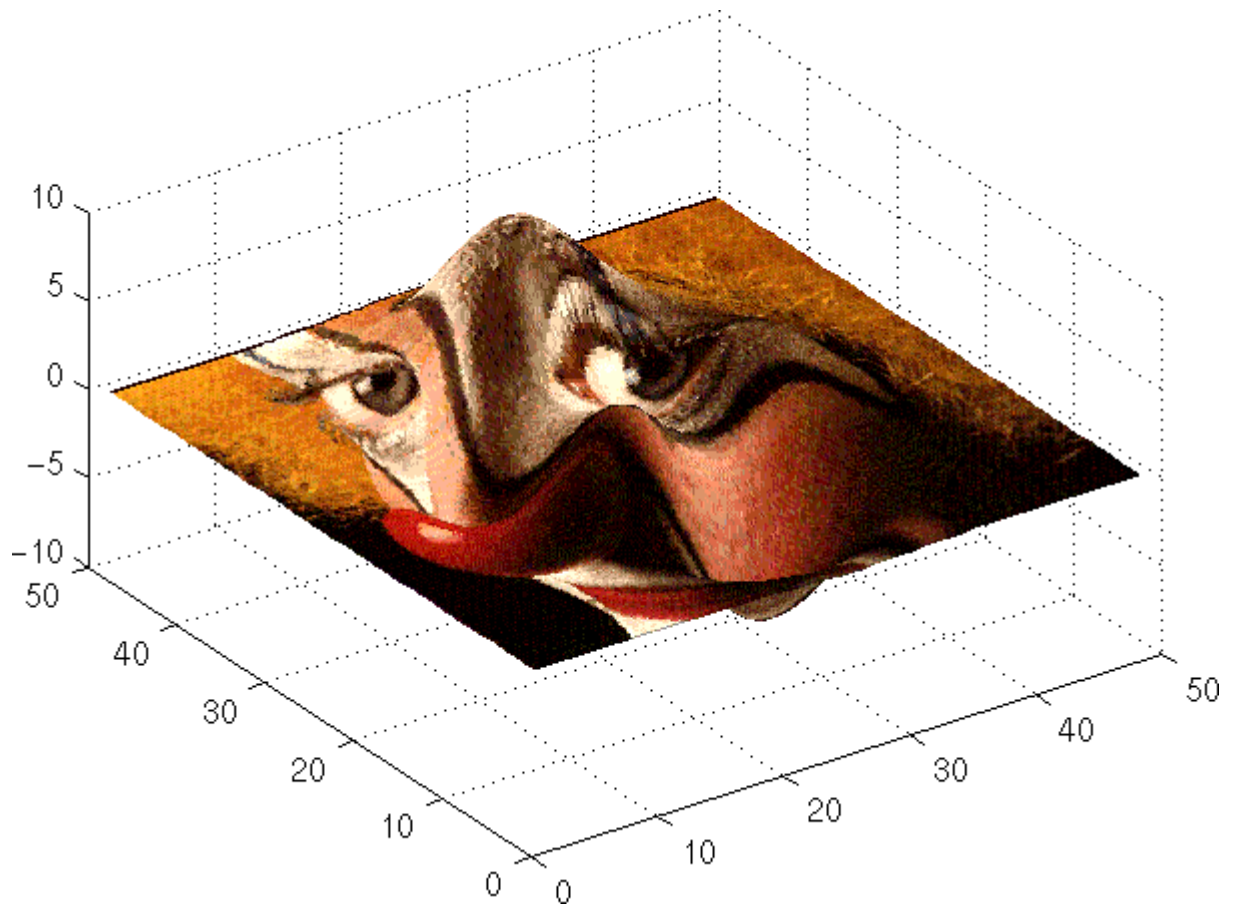
This example creates a surface using the peaks M-file to generate the data, and colors it using the clown image. The ZData is a 49-by-49

## surface

---

element matrix, while the CData is a 200-by-320 matrix. You must set the surface's FaceColor to texturemap to use ZData and CData of different dimensions.

```
load clown
surface(peaks,flipud(X),...
        'FaceColor','texturemap',...
        'EdgeColor','none',...
        'CDataMapping','direct')
colormap(map)
view(-35,45)
```



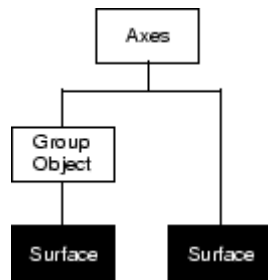
Note the use of the `surface(Z,C)` convenience form combined with property name/property value pairs.

Since the clown data (`X`) is typically viewed with the `image` command, which MATLAB normally displays with 'ij' axis numbering and `direct` `CDataMapping`, this example reverses the data in the vertical direction using `flipud` and sets the `CDataMapping` property to `direct`.

# surface

---

## Object Hierarchy



## Setting Default Properties

You can set default surface properties on the axes, figure, and root levels:

```
set(0, 'DefaultSurfaceProperty', PropertyValue...)  
set(gcf, 'DefaultSurfaceProperty', PropertyValue...)  
set(gca, 'DefaultSurfaceProperty', PropertyValue...)
```

where *Property* is the name of the surface property whose default value you want to set and *PropertyValue* is the value you are specifying. Use `set` and `get` to access the surface properties.

## See Also

`ColorSpec`, `patch`, `pcolor`, `surf`

Representing a Matrix as a Surface for examples

“Creating Surfaces and Meshes” on page 1-97 and “Object Creation Functions” on page 1-94 for related functions

Surface Properties for property descriptions



## Purpose

Surface properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Editor is an interactive tool that enables you to see and change object property values.
- The set and get commands enable you to set and query the values of properties.

To change the default values of properties, see [Setting Default Property Values](#).

See “Core Graphics Objects” for general information about this type of object.

## Surface Property Descriptions

This section lists property names along with the types of values each accepts. Curly braces { } enclose default values.

AlphaData

m-by-n matrix of double or uint8

*The transparency data.* A matrix of non-NaN values specifying the transparency of each face or vertex of the object. The AlphaData can be of class double or uint8.

MATLAB determines the transparency in one of three ways:

- Using the elements of AlphaData as transparency values (AlphaDataMapping set to none)
- Using the elements of AlphaData as indices into the current alphamap (AlphaDataMapping set to direct)
- Scaling the elements of AlphaData to range between the minimum and maximum values of the axes ALim property (AlphaDataMapping set to scaled, the default)

AlphaDataMapping

none | direct | {scaled}

# Surface Properties

---

*Transparency mapping method.* This property determines how MATLAB interprets indexed alpha data. This property can be any of the following:

- none — The transparency values of AlphaData are between 0 and 1 or are clamped to this range (the default).
- scaled — Transform the AlphaData to span the portion of the alphamap indicated by the axes ALim property, linearly mapping data values to alpha values.
- direct — use the AlphaData as indices directly into the alphamap. When not scaled, the data are usually integer values ranging from 1 to length(alphamap). MATLAB maps values less than 1 to the first alpha value in the alphamap, and values greater than length(alphamap) to the last alpha value in the alphamap. Values with a decimal portion are fixed to the nearest lower integer. If AlphaData is an array of uint8 integers, then the indexing begins at 0 (i.e., MATLAB maps a value of 0 to the first alpha value in the alphamap).

AmbientStrength  
scalar  $\geq 0$  and  $\leq 1$

*Strength of ambient light.* This property sets the strength of the ambient light, which is a nondirectional light source that illuminates the entire scene. You must have at least one visible light object in the axes for the ambient light to be visible. The axes AmbientLightColor property sets the color of the ambient light, which is therefore the same on all objects in the axes.

You can also set the strength of the diffuse and specular contribution of light objects. See the surface DiffuseStrength and SpecularStrength properties.

Annotation  
hg.Annotation object Read Only

*Control the display of surface objects in legends.* The Annotation property enables you to specify whether this surface object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the surface object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                                 |
|------------------------|---------------------------------------------------------|
| on                     | Represent this surface object in a legend (default)     |
| off                    | Do not include this surface object in a legend          |
| children               | Same as on because surface objects do not have children |

### Setting the IconDisplayStyle property

These commands set the IconDisplayStyle of a graphics object with handle hobj to off:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'off')
```

### Using the IconDisplayStyle property

See “Controlling Legends” for more information and examples.

```
BackFaceLighting  
unlit | lit | reverselit
```

# Surface Properties

---

*Face lighting control.* This property determines how faces are lit when their vertex normals point away from the camera.

- `unlit` — Face is not lit.
- `lit` — Face is lit in normal way.
- `reverselit` — Face is lit as if the vertex pointed towards the camera.

This property is useful for discriminating between the internal and external surfaces of an object. See “Back Face Lighting” for an example.

`BeingDeleted`  
on | {off} Read Only

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to on when the object’s delete function callback is called (see the `DeleteFcn` property). It remains set to on while the delete function executes, after which the object no longer exists.

For example, an object’s delete function might call other functions that act on a number of different objects. These functions may not need to perform actions on objects that are going to be deleted, and therefore, can check the object’s `BeingDeleted` property before acting.

`BusyAction`  
cancel | {queue}

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callback routines. If there is a callback routine executing, callback routines invoked subsequently always attempt to interrupt it. If the `Interruptible` property of the object whose callback is executing is set to on (the default), then

interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is off, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

## `ButtonDownFcn`

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Button press callback function.* A callback function that executes whenever you press a mouse button while the pointer is over the surface object.

See the figure's `SelectionType` property to determine if modifier keys were also pressed.

Set this property to a function handle that references the callback. The function must define at least two input arguments (handle of object associated with the button down event and an event structure, which is empty for this property). For example, the following function takes different action depending on what type of selection was made:

```
function button_down(src, evnt)
% src - the object that is the source of the event
% evnt - empty for this property
    sel_typ = get(gcf, 'SelectionType')
    switch sel_typ
        case 'normal'
            disp('User clicked left-mouse button')
            set(src, 'Selected', 'on')
        case 'extend'
            disp('User did a shift-click')
```

# Surface Properties

---

```
        set(src, 'Selected', 'on')
    case 'alt'
        disp('User did a control-click')
        set(src, 'Selected', 'on')
        set(src, 'SelectionHighlight', 'off')
    end
end
```

Suppose `h` is the handle of a surface object and that the `button_down` function is on your MATLAB path. The following statement assigns the function above to the `ButtonDownFcn`:

```
set(h, 'ButtonDownFcn', @button_down)
```

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## CData

matrix (of type double)

*Vertex colors.* A matrix containing values that specify the color at every point in `ZData`.

### Mapping CData to a Colormap

You can specify color as indexed values or true color. Indexed color data specifies a single value for each vertex. These values are either scaled to map linearly into the current colormap (see `caxis`) or interpreted directly as indices into the colormap, depending on the setting of the `CDataMapping` property.

### CData as True Color

True color defines an RGB value for each vertex. If the coordinate data (`XData`, for example) are contained in  $m$ -by- $n$  matrices, then `CData` must be an  $m$ -by- $n$ -3 array. The first page contains the red components, the second the green components, and the third the blue components of the colors.

## Texturemapping the Surface FaceColor

If you set the FaceColor property to texturemap, CData does not need to be the same size as ZData, but must be of type double or uint8. In this case, MATLAB maps CData to conform to the surface defined by ZData.

CDataMapping  
{scaled} | direct

*Direct or scaled color mapping.* This property determines how MATLAB interprets indexed color data used to color the surface. (If you use true color specification for CData, this property has no effect.)

- **scaled** — Transform the color data to span the portion of the colormap indicated by the axes CLim property, linearly mapping data values to colors. See the caxis reference page for more information on this mapping.
- **direct** — Use the color data as indices directly into the colormap. The color data should then be integer values ranging from 1 to length(colormap). MATLAB maps values less than 1 to the first color in the colormap, and values greater than length(colormap) to the last color in the colormap. Values with a decimal portion are fixed to the nearest lower integer.

Children  
matrix of handles

Always the empty matrix; surface objects have no children.

Clipping  
{on} | off

*Clipping to axes rectangle.* When Clipping is on, MATLAB does not display any portion of the surface that is outside the axes rectangle.

# Surface Properties

---

## CreateFcn

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Callback function executed during object creation.* This property defines a callback function that executes when MATLAB creates a surface object. You must define this property as a default value for surfaces or set the CreateFcn property during object creation.

For example, the following statement creates a surface (assuming  $x$ ,  $y$ ,  $z$ , and  $c$  are defined), and executes the function referenced by the function handle @myCreateFcn.

```
surface(x,y,z,c,'CreateFcn',@myCreateFcn)
```

MATLAB executes this routine after setting all surface properties. Setting this property on an existing surface object has no effect.

The handle of the object whose CreateFcn is being executed is passed by MATLAB as the first argument to the callback function and is also accessible through the root CallbackObject property, which you can query using gcbo.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## DeleteFcn

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Delete surface callback function.* A callback function that executes when you delete the surface object (e.g., when you issue a delete command or clear the axes cla or figure clf). For example, the following function displays object property data before the object is deleted.

```
function delete_fcn(src,evnt)
% src - the object that is the source of the event
```



```
% evt - empty for this property
    obj_tp = get(src, 'Type');
    disp([obj_tp, ' object deleted'])
    disp('Its user data is:')
    disp(get(src, 'UserData'))
end
```

MATLAB executes the function before deleting the object's properties so these values are available to the callback function. The function must define at least two input arguments (handle of object being deleted and an event structure, which is empty for this property)

The handle of the object whose `DeleteFcn` is being executed is passed by MATLAB as the first argument to the callback function and is also accessible through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

**DiffuseStrength**  
scalar  $\geq 0$  and  $\leq 1$

*Intensity of diffuse light.* This property sets the intensity of the diffuse component of the light falling on the surface. Diffuse light comes from light objects in the axes.

You can also set the intensity of the ambient and specular components of the light on the surface object. See the `AmbientStrength` and `SpecularStrength` properties.

**DisplayName**  
string (default is empty string)

*String used by legend for this surface object.* The legend function uses the string defined by the `DisplayName` property to label this surface object in the legend.

# Surface Properties

---

- If you specify string arguments with the legend function, `DisplayName` is set to this surface object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where  $n$  is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call legend with the `toggle` or `show` option.

See “Controlling Legends” for more examples.

## EdgeAlpha

{scalar = 1} | flat | interp

*Transparency of the surface edges.* This property can be any of the following:

- `scalar` — A single non-Nan scalar value between 0 and 1 that controls the transparency of all the edges of the object. 1 (the default) means fully opaque and 0 means completely transparent.
- `flat` — The alpha data (`AlphaData`) value for the first vertex of the face determines the transparency of the edges.
- `interp` — Linear interpolation of the alpha data (`AlphaData`) values at each vertex determines the transparency of the edge.

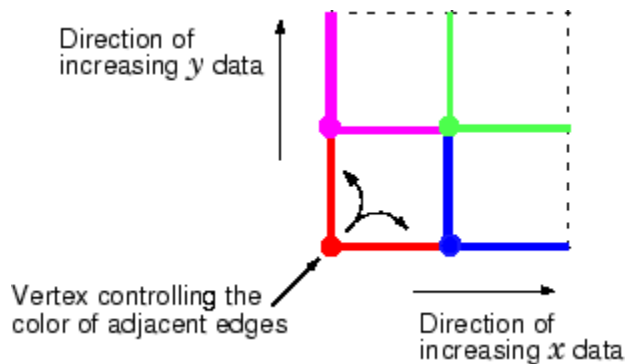
Note that you must specify `AlphaData` as a matrix equal in size to `ZData` to use `flat` or `interp` `EdgeAlpha`.

## EdgeColor

{ColorSpec} | none | flat | interp

*Color of the surface edge.* This property determines how MATLAB colors the edges of the individual faces that make up the surface:

- **ColorSpec** — A three-element RGB vector or one of the MATLAB predefined names, specifying a single color for edges. The default EdgeColor is black. See ColorSpec for more information on specifying color.
- **none** — Edges are not drawn.
- **flat** — The CData value of the first vertex for a face determines the color of each edge.



- **interp** — Linear interpolation of the CData values at the face vertices determines the edge color.

## EdgeLighting

{none} | flat | gouraud | phong

*Algorithm used for lighting calculations.* This property selects the algorithm used to calculate the effect of light objects on surface edges. Choices are

- **none** — Lights do not affect the edges of this object.

# Surface Properties

---

- flat — The effect of light objects is uniform across each edge of the surface.
- gouraud — The effect of light objects is calculated at the vertices and then linearly interpolated across the edge lines.
- phong — The effect of light objects is determined by interpolating the vertex normals across each edge line and calculating the reflectance at each pixel. Phong lighting generally produces better results than Gouraud lighting, but takes longer to render.

## EraseMode

{normal} | none | xor | background

*Erase mode.* This property controls the technique MATLAB uses to draw and erase surface objects. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- normal — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- none — Do not erase the surface when it is moved or destroyed. While the object is still visible on the screen after erasing with EraseMode none, you cannot print it because MATLAB stores no information about its former location.
- xor — Draw and erase the surface by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the surface does not damage the color of the objects behind it. However, surface color depends on the color of the screen behind it and is correctly colored only when over the axes background Color, or the figure background Color if the axes Color is set to none.

- `background` — Erase the surface by drawing it in the axes background `Color`, or the figure background `Color` if the axes `Color` is set to `none`. This damages objects that are behind the erased object, but surface objects are always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the `EraseMode` of all objects is `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look different on screen than on paper. On screen, MATLAB may mathematically combine layers of colors (e.g., performing an XOR of a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

You can use the MATLAB `getframe` command or other screen capture application to create an image of a figure containing nonnormal mode objects.

## FaceAlpha

`{scalar = 1} | flat | interp | texturemap`

*Transparency of the surface faces.* This property can be any of the following:

- `scalar` — A single non-`NaN` scalar value between 0 and 1 that controls the transparency of all the faces of the object. 1 (the default) means fully opaque and 0 means completely transparent (invisible).
- `flat` — The values of the alpha data (`AlphaData`) determine the transparency for each face. The alpha data at the first vertex determine the transparency of the entire face.
- `interp` — Bilinear interpolation of the alpha data (`AlphaData`) at each vertex determines the transparency of each face.
- `texturemap` — Use transparency for the texture map.

# Surface Properties

---

Note that you must specify AlphaData as a matrix equal in size to ZData to use flat or interp FaceAlpha.

## FaceColor

ColorSpec | none | {flat} | interp | texturemap

*Color of the surface face.* This property can be any of the following:

- ColorSpec — A three-element RGB vector or one of the MATLAB predefined names, specifying a single color for faces. See ColorSpec for more information on specifying color.
- none — Do not draw faces. Note that edges are drawn independently of faces.
- flat — The values of CData determine the color for each face of the surface. The color data at the first vertex determine the color of the entire face.
- interp — Bilinear interpolation of the values at each vertex (the CData) determines the coloring of each face.
- texturemap — Texture map the CData to the surface. MATLAB transforms the color data so that it conforms to the surface. (See the texture mapping example.)

## FaceLighting

{none} | flat | gouraud | phong

*Algorithm used for lighting calculations.* This property selects the algorithm used to calculate the effect of light objects on the surface. Choices are

- none — Lights do not affect the faces of this object.
- flat — The effect of light objects is uniform across the faces of the surface. Select this choice to view faceted objects.
- gouraud — The effect of light objects is calculated at the vertices and then linearly interpolated across the faces. Select this choice to view curved surfaces.

- phong — The effect of light objects is determined by interpolating the vertex normals across each face and calculating the reflectance at each pixel. Select this choice to view curved surfaces. Phong lighting generally produces better results than Gouraud lighting, but takes longer to render.

## HandleVisibility

{on} | callback | off

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. This property is useful for preventing command-line users from accidentally drawing into or deleting a figure that contains only user interface devices (such as a dialog box).

Handles are always visible when `HandleVisibility` is on.

Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.

Setting `HandleVisibility` to `off` makes handles invisible at all times. This might be necessary when a callback routine invokes a function that could potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

# Surface Properties

---

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties).

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

`HitTest`  
{on} | off

*Selectable by mouse click.* `HitTest` determines if the surface can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the surface. If `HitTest` is `off`, clicking on the surface selects the object below it (which may be the axes containing it).

`Interruptible`  
{on} | off

*Callback routine interruption mode.* The `Interruptible` property controls whether a surface callback routine can be interrupted by subsequently invoked callback routines. Only callback routines defined for the `ButtonDownFcn` are affected by the `Interruptible` property. MATLAB checks for events that can interrupt a callback routine only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.



## LineStyle

{-} | -- | : | -. | none

*Edge line type.* This property determines the line style used to draw surface edges. The available line styles are shown in this table.

| Symbol | Line Style           |
|--------|----------------------|
|        | Solid line (default) |
|        | Dashed line          |
| :      | Dotted line          |
| .      | Dash-dot line        |
| none   | No line              |

## LineWidth

scalar

*Edge line width.* The width of the lines in points used to draw surface edges. The default width is 0.5 points (1 point = 1/72 inch).

## Marker

marker symbol (see table)

*Marker symbol.* The Marker property specifies symbols that are displayed at vertices. You can set values for the Marker property independently from the LineStyle property.

You can specify these markers.

| Marker Specifier | Description |
|------------------|-------------|
| +                | Plus sign   |
| o                | Circle      |
| *                | Asterisk    |

# Surface Properties

---

| Marker Specifier | Description                   |
|------------------|-------------------------------|
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

## MarkerEdgeColor

none | {auto} | flat | ColorSpec

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles).

- none specifies no color, which makes nonfilled markers invisible.
- auto uses the same color as the EdgeColor property.
- flat uses the CData value of the vertex to determine the color of the maker edge.
- ColorSpec defines a single color to use for the edge (see ColorSpec for more information).

## MarkerFaceColor

{none} | auto | flat | ColorSpec

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles).

- none makes the interior of the marker transparent, allowing the background to show through.
- auto uses the axes Color for the marker face color.
- flat uses the CData value of the vertex to determine the color of the face.
- ColorSpec defines a single color to use for all markers on the surface (see ColorSpec for more information).

MarkerSize

size in points

*Marker size.* A scalar specifying the marker size, in points. The default value for MarkerSize is 6 points (1 point = 1/72 inch). Note that MATLAB draws the point marker at 1/3 the specified marker size.

MeshStyle

{both} | row | column

*Row and column lines.* This property specifies whether to draw all edge lines or just row or column edge lines.

- both draws edges for both rows and columns.
- row draws row edges only.
- column draws column edges only.

NormalMode

{auto} | manual

*MATLAB generated or user-specified normal vectors.* When this property is auto, MATLAB calculates vertex normals based on the coordinate data. If you specify your own vertex normals, MATLAB

# Surface Properties

---

sets this property to manual and does not generate its own data. See also the VertexNormals property.

## Parent

handle of axes, hggroup, or hgtransform

*Parent of surface object.* This property contains the handle of the surface object's parent. The parent of a surface object is the axes, hggroup, or hgtransform object that contains it.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

## Selected

on | {off}

*Is object selected?* When this property is on, MATLAB displays a dashed bounding box around the surface if the SelectionHighlight property is also on. You can, for example, define the ButtonDownFcn to set this property, allowing users to select the object with the mouse.

## SelectionHighlight

{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing a dashed bounding box around the surface. When SelectionHighlight is off, MATLAB does not draw the handles.

## SpecularColorReflectance

scalar in the range 0 to 1

*Color of specularly reflected light.* When this property is 0, the color of the specularly reflected light depends on both the color of the object from which it reflects and the color of the light source. When set to 1, the color of the specularly reflected light depends only on the color of the light source (i.e., the light object Color property). The proportions vary linearly for values in between.

## SpecularExponent

scalar  $\geq 1$

*Harshness of specular reflection.* This property controls the size of the specular spot. Most materials have exponents in the range of 5 to 20.

## SpecularStrength

scalar  $\geq 0$  and  $\leq 1$

*Intensity of specular light.* This property sets the intensity of the specular component of the light falling on the surface. Specular light comes from light objects in the axes.

You can also set the intensity of the ambient and diffuse components of the light on the surface object. See the AmbientStrength and DiffuseStrength properties. Also see the material function.

## Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callback routines. You can define Tag as any string.

## Type

string (read only)

*Class of the graphics object.* The class of the graphics object. For surface objects, Type is always the string 'surface'.

## UIContextMenu

handle of a uicontextmenu object

# Surface Properties

---

*Associate a context menu with the surface.* Assign this property the handle of a `uicontextmenu` object created in the same figure as the surface. Use the `uicontextmenu` function to create the context menu. MATLAB displays the context menu whenever you right-click over the surface.

`UserData`  
matrix

*User-specified data.* Any matrix you want to associate with the surface object. MATLAB does not use this data, but you can access it using the `set` and `get` commands.

`VertexNormals`  
vector or matrix

*Surface normal vectors.* This property contains the vertex normals for the surface. MATLAB generates this data to perform lighting calculations. You can supply your own vertex normal data, even if it does not match the coordinate data. This can be useful to produce interesting lighting effects.

`Visible`  
{on} | off

*Surface object visibility.* By default, all surfaces are visible. When set to `off`, the surface is not visible, but still exists, and you can query and set its properties.

`XData`  
vector or matrix

*X-coordinates.* The  $x$ -position of the surface points. If you specify a row vector, surface replicates the row internally until it has the same number of columns as `ZData`.

`YData`  
vector or matrix

*Y-coordinates.* The  $y$ -position of the surface points. If you specify a row vector, surface replicates the row internally until it has the same number of rows as ZData.

ZData  
matrix

*Z-coordinates.* The  $z$ -position of the surfaceplot data points. See the Description section for more information.

# Surfaceplot Properties

---

## Purpose

Define surfaceplot properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Editor is an interactive tool that enables you to see and change object property values.
- The set and get commands enable you to set and query the values of properties.

Note that you cannot define default properties for surfaceplot objects.

See Plot Objects for information on surfaceplot objects.

## Surfaceplot Property Descriptions

This section lists property names along with the types of values each accepts. Curly braces { } enclose default values.

AlphaData

m-by-n matrix of double or uint8

*The transparency data.* A matrix of non-NaN values specifying the transparency of each face or vertex of the object. The AlphaData can be of class double or uint8.

MATLAB determines the transparency in one of three ways:

- Using the elements of AlphaData as transparency values (AlphaDataMapping set to none)
- Using the elements of AlphaData as indices into the current alphamap (AlphaDataMapping set to direct)
- Scaling the elements of AlphaData to range between the minimum and maximum values of the axes ALim property (AlphaDataMapping set to scaled, the default)

AlphaDataMapping

{none} | direct | scaled



*Transparency mapping method.* This property determines how MATLAB interprets indexed alpha data. It can be any of the following:

- none — The transparency values of AlphaData are between 0 and 1 or are clamped to this range (the default).
- scaled — Transform the AlphaData to span the portion of the alphamap indicated by the axes ALim property, linearly mapping data values to alpha values.
- direct — Use the AlphaData as indices directly into the alphamap. When not scaled, the data are usually integer values ranging from 1 to length(alphamap). MATLAB maps values less than 1 to the first alpha value in the alphamap, and values greater than length(alphamap) to the last alpha value in the alphamap. Values with a decimal portion are fixed to the nearest, lower integer. If AlphaData is an array of uint8 integers, then the indexing begins at 0 (i.e., MATLAB maps a value of 0 to the first alpha value in the alphamap).

AmbientStrength

scalar  $\geq 0$  and  $\leq 1$

*Strength of ambient light.* This property sets the strength of the ambient light, which is a nondirectional light source that illuminates the entire scene. You must have at least one visible light object in the axes for the ambient light to be visible. The axes AmbientLightColor property sets the color of the ambient light, which is therefore the same on all objects in the axes.

You can also set the strength of the diffuse and specular contribution of light objects. See the surfaceplot DiffuseStrength and SpecularStrength properties.

Annotation

hg.Annotation object Read Only

# Surfaceplot Properties

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*Control the display of surfaceplot objects in legends.* The `Annotation` property enables you to specify whether this surfaceplot object is represented in a figure legend.

Querying the `Annotation` property returns the handle of an `hg.Annotation` object. The `hg.Annotation` object has a property called `LegendInformation`, which contains an `hg.LegendEntry` object.

Once you have obtained the `hg.LegendEntry` object, you can set its `IconDisplayStyle` property to control whether the surfaceplot object is displayed in a figure legend:

| <b>IconDisplayStyle Value</b> | <b>Purpose</b>                                              |
|-------------------------------|-------------------------------------------------------------|
| on                            | Represent this surfaceplot object in a legend (default)     |
| off                           | Do not include this surfaceplot object in a legend          |
| children                      | Same as on because surfaceplot objects do not have children |

## Setting the `IconDisplayStyle` property

These commands set the `IconDisplayStyle` of a graphics object with handle `hobj` to `off`:

```
hAnnotation = get(hobj, 'Annotation');  
hLegendEntry = get(hAnnotation, 'LegendInformation');  
set(hLegendEntry, 'IconDisplayStyle', 'off')
```

## Using the `IconDisplayStyle` property

See “Controlling Legends” for more information and examples.

## BackFaceLighting

unlit | lit | reverselit

*Face lighting control.* This property determines how faces are lit when their vertex normals point away from the camera.

- unlit — Face is not lit.
- lit — Face is lit in normal way.
- reverselit — Face is lit as if the vertex pointed towards the camera.

This property is useful for discriminating between the internal and external surfaces of an object. See Back Face Lighting for an example.

## BeingDeleted

on | {off} Read Only

*This object is being deleted.* The BeingDeleted property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the BeingDeleted property to on when the object's delete function callback is called (see the DeleteFcn property). It remains set to on while the delete function executes, after which the object no longer exists.

For example, an object's delete function might call other functions that act on a number of different objects. These functions might not need to perform actions on objects if the objects are going to be deleted, and therefore, can check the object's BeingDeleted property before acting.

## BusyAction

cancel | {queue}

*Callback routine interruption.* The BusyAction property enables you to control how MATLAB handles events that potentially interrupt executing callbacks. If there is a callback function

# Surfaceplot Properties

---

executing, callbacks invoked subsequently always attempt to interrupt it.

If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

`ButtonDownFcn`  
`cancel | {queue}`

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callbacks. If there is a callback function executing, callbacks invoked subsequently always attempt to interrupt it.

If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

## CData

matrix

*Vertex colors.* A matrix containing values that specify the color at every point in ZData. If you set the FaceColor property to texturemap, CData does not need to be the same size as ZData. In this case, MATLAB maps CData to conform to the surfaceplot defined by ZData.

You can specify color as indexed values or true color. Indexed color data specifies a single value for each vertex. These values are either scaled to map linearly into the current colormap (see caxis) or interpreted directly as indices into the colormap, depending on the setting of the CDataMapping property. Note that any non-texture data passed as an input argument must be of type double.

True color defines an RGB value for each vertex. If the coordinate data (XData, for example) are contained in  $m$ -by- $n$  matrices, then CData must be an  $m$ -by- $n$ -by-3 array. The first page contains the red components, the second the green components, and the third the blue components of the colors.

## CDataMapping

{scaled} | direct

*Direct or scaled color mapping.* This property determines how MATLAB interprets indexed color data used to color the surfaceplot. (If you use true color specification for CData, this property has no effect.)

- **scaled** — Transform the color data to span the portion of the colormap indicated by the axes CLim property, linearly mapping data values to colors. See the caxis reference page for more information on this mapping.
- **direct** — Use the color data as indices directly into the colormap. The color data should then be integer values ranging

# Surfaceplot Properties

---

from 1 to `length(colormap)`. MATLAB maps values less than 1 to the first color in the colormap, and values greater than `length(colormap)` to the last color in the colormap. Values with a decimal portion are fixed to the nearest lower integer.

## CDataMode

{auto} | manual

*Use automatic or user-specified color data values.* If you specify CData, MATLAB sets this property to manual and uses the CData values to color the surfaceplot.

If you set CDataMode to auto after having specified CData, MATLAB resets the color data of the surfaceplot to that defined by ZData, overwriting any previous values for CData.

## CDataSource

string (MATLAB variable)

*Link CData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the CData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change CData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to return data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

Children  
matrix of handles

Always the empty matrix; surfaceplot objects have no children.

Clipping  
{on} | off

*Clipping to axes rectangle.* When Clipping is on, MATLAB does not display any portion of the surfaceplot that is outside the axes rectangle.

CreateFcn  
string or function handle

*Callback routine executed during object creation.* This property defines a callback that executes when MATLAB creates an object. You must specify the callback during the creation of the object. For example,

```
area(y, 'CreateFcn', @CallbackFcn)
```

where *@CallbackFcn* is a function handle that references the callback function.

MATLAB executes this routine after setting all other object properties. Setting this property on an existing object has no effect.

# Surfaceplot Properties

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The handle of the object whose `CreateFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

`DeleteFcn`  
string or function handle

*Callback executed during object deletion.* A callback that executes when this object is deleted (e.g., this might happen when you issue a `delete` command on the object, its parent axes, or the figure containing it). MATLAB executes the callback before destroying the object’s properties so the callback routine can query these values.

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which can be queried using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

See the `BeingDeleted` property for related information.

`DiffuseStrength`  
scalar  $\geq 0$  and  $\leq 1$

*Intensity of diffuse light.* This property sets the intensity of the diffuse component of the light falling on the surface. Diffuse light comes from light objects in the axes.

You can also set the intensity of the ambient and specular components of the light on the object. See the `AmbientStrength` and `SpecularStrength` properties.



## DisplayName

string (default is empty string)

*String used by legend for this surfaceplot object.* The legend function uses the string defined by the DisplayName property to label this surfaceplot object in the legend.

- If you specify string arguments with the legend function, DisplayName is set to this surfaceplot object's corresponding string and that string is used for the legend.
- If DisplayName is empty, legend creates a string of the form, ['data' *n*], where *n* is the number assigned to the object based on its location in the list of legend entries. However, legend does not set DisplayName to this string.
- If you edit the string directly in an existing legend, DisplayName is set to the edited string.
- If you specify a string for the DisplayName property and create the legend using the figure toolbar, then MATLAB uses the string defined by DisplayName.
- To add programmatically a legend that uses the DisplayName string, call legend with the toggle or show option.

See “Controlling Legends” for more examples.

## EdgeAlpha

{scalar = 1} | flat | interp

*Transparency of the patch and surface edges.* This property can be any of the following:

- **scalar** — A single non-Nan scalar value between 0 and 1 that controls the transparency of all the edges of the object. 1 (the default) means fully opaque and 0 means completely transparent.
- **flat** — The alpha data (AlphaData) value for the first vertex of the face determines the transparency of the edges.

# Surfaceplot Properties

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- `interp` — Linear interpolation of the alpha data (AlphaData) values at each vertex determines the transparency of the edge.

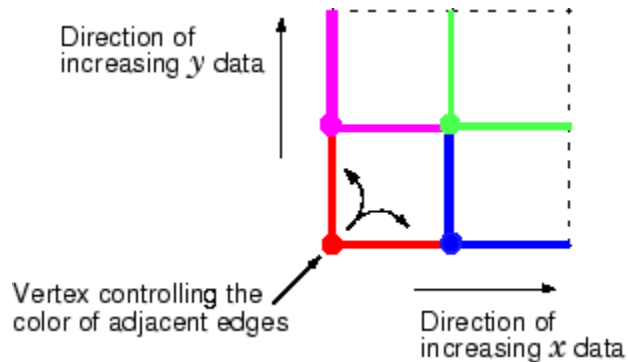
Note that you must specify AlphaData as a matrix equal in size to ZData to use `flat` or `interp` EdgeAlpha.

EdgeColor

{ColorSpec} | none | flat | interp

*Color of the surfaceplot edge.* This property determines how MATLAB colors the edges of the individual faces that make up the surface:

- `ColorSpec` — A three-element RGB vector or one of the MATLAB predefined names, specifying a single color for edges. The default EdgeColor is black. See `ColorSpec` for more information on specifying color.
- `none` — Edges are not drawn.
- `flat` — The CData value of the first vertex for a face determines the color of each edge.



- `interp` — Linear interpolation of the CData values at the face vertices determines the edge color.

## EdgeLighting

{none} | flat | gouraud | phong

*Algorithm used for lighting calculations.* This property selects the algorithm used to calculate the effect of light objects on surfaceplot edges. Choices are

- none — Lights do not affect the edges of this object.
- flat — The effect of light objects is uniform across each edge of the surface.
- gouraud — The effect of light objects is calculated at the vertices and then linearly interpolated across the edge lines.
- phong — The effect of light objects is determined by interpolating the vertex normals across each edge line and calculating the reflectance at each pixel. Phong lighting generally produces better results than Gouraud lighting, but takes longer to render.

## EraseMode

{normal} | none | xor | background

*Erase mode.* This property controls the technique MATLAB uses to draw and erase objects and their children. Alternative erase modes are useful for creating animated sequences, where control of the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

- normal — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- none — Do not erase objects when they are moved or destroyed. While the objects are still visible on the screen after erasing

# Surfaceplot Properties

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with `EraseMode` `none`, you cannot print these objects because MATLAB stores no information about their former locations.

- `xor` — Draw and erase the object by performing an exclusive OR (XOR) with each pixel index of the screen behind it. Erasing the object does not damage the color of the objects behind it. However, the color of the erased object depends on the color of the screen behind it and it is correctly colored only when it is over the axes background color (or the figure background color if the axes `Color` property is set to `none`). That is, it isn't erased correctly if there are objects behind it.
- `background` — Erase the graphics objects by redrawing them in the axes background color, (or the figure background color if the axes `Color` property is set to `none`). This damages other graphics objects that are behind the erased object, but the erased object is always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the `EraseMode` of all objects is `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look different on screen than on paper. On screen, MATLAB can mathematically combine layers of colors (e.g., performing an XOR on a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

Set the axes background color with the axes `Color` property. Set the figure background color with the figure `Color` property.

You can use the MATLAB `getframe` command or other screen capture applications to create an image of a figure containing nonnormal mode objects.

```
FaceAlpha  
{scalar = 1} | flat | interp | texturemap
```

*Transparency of the surfaceplot faces.* This property can be any of the following:

- `scalar` — A single non-NaN scalar value between 0 and 1 that controls the transparency of all the faces of the object. 1 (the default) means fully opaque and 0 means completely transparent (invisible).
- `flat` — The values of the alpha data (`AlphaData`) determine the transparency for each face. The alpha data at the first vertex determine the transparency of the entire face.
- `interp` — Bilinear interpolation of the alpha data (`AlphaData`) at each vertex determines the transparency of each face.
- `texturemap` — Use transparency for the texture map.

Note that you must specify `AlphaData` as a matrix equal in size to `ZData` to use `flat` or `interp` `FaceAlpha`.

## FaceColor

`ColorSpec` | `none` | `{flat}` | `interp`

*Color of the surfaceplot face.* This property can be any of the following:

- `ColorSpec` — A three-element RGB vector or one of the MATLAB predefined names, specifying a single color for faces. See `ColorSpec` for more information on specifying color.
- `none` — Do not draw faces. Note that edges are drawn independently of faces.
- `flat` — The values of `CData` determine the color for each face of the surface. The color data at the first vertex determine the color of the entire face.
- `interp` — Bilinear interpolation of the values at each vertex (the `CData`) determines the coloring of each face.

# Surfaceplot Properties

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- `texturemap` — Texture map the `Cdata` to the surface. MATLAB transforms the color data so that it conforms to the surface. (See the texture mapping example for `surface`.)

## `FaceLighting`

`{none} | flat | gouraud | phong`

*Algorithm used for lighting calculations.* This property selects the algorithm used to calculate the effect of light objects on the surface. Choices are

- `none` — Lights do not affect the faces of this object.
- `flat` — The effect of light objects is uniform across the faces of the surface. Select this choice to view faceted objects.
- `gouraud` — The effect of light objects is calculated at the vertices and then linearly interpolated across the faces. Select this choice to view curved surfaces.
- `phong` — The effect of light objects is determined by interpolating the vertex normals across each face and calculating the reflectance at each pixel. Select this choice to view curved surfaces. Phong lighting generally produces better results than Gouraud lighting, but takes longer to render.

## `HandleVisibility`

`{on} | callback | off`

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. `HandleVisibility` is useful for preventing command-line users from accidentally accessing objects that you need to protect for some reason.

- `on` — Handles are always visible when `HandleVisibility` is `on`.
- `callback` — Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to

protect GUIs from command-line users, while allowing callback routines to have access to object handles.

- `off` — Setting `HandleVisibility` to `off` makes handles invisible at all times. This might be necessary when a callback invokes a function that might potentially damage the GUI (such as evaluating a user-typed string) and so temporarily hides its own handles during the execution of that function.

## Functions Affected by Handle Visibility

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

## Properties Affected by Handle Visibility

When a handle's visibility is restricted using `callback` or `off`, the object's handle does not appear in its parent's `Children` property, figures do not appear in the root's `CurrentFigure` property, objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property, and axes do not appear in their parent's `CurrentAxes` property.

## Overriding Handle Visibility

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties). See also `findall`.

## Handle Validity

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties and pass it to any function that operates on handles.

# Surfaceplot Properties

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**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

HitTest  
{on} | off

*Selectable by mouse click.* HitTest determines whether this object can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the objects that compose the area graph. If HitTest is off, clicking this object selects the object below it (which is usually the axes containing it).

Interruptible  
{on} | off

*Callback routine interruption mode.* The Interruptible property controls whether an object's callback can be interrupted by callbacks invoked subsequently.

Only callbacks defined for the `ButtonDownFcn` property are affected by the Interruptible property. MATLAB checks for events that can interrupt a callback only when it encounters a `drawnow`, `figure`, `getframe`, or `pause` command in the routine. See the `BusyAction` property for related information.

Setting Interruptible to on allows any graphics object's callback to interrupt callback routines originating from a bar property. Note that MATLAB does not save the state of variables or the display (e.g., the handle returned by the `gca` or `gcf` command) when an interruption occurs.

LineStyle  
{-} | -- | : | -. | none



*Line style.* This property specifies the line style of the object. Available line styles are shown in the following table.

| Specifier String | Line Style           |
|------------------|----------------------|
| -                | Solid line (default) |
| --               | Dashed line          |
| :                | Dotted line          |
| -. .             | Dash-dot line        |
| none             | No line              |

You can use `LineStyle` none when you want to place a marker at each point but do not want the points connected with a line (see the `Marker` property).

`LineWidth`  
scalar

*The width of linear objects and edges of filled areas.* Specify this value in points (1 point =  $1/72$  inch). The default `LineWidth` is 0.5 points.

`Marker`  
character (see table)

*Marker symbol.* The `Marker` property specifies the type of markers that are displayed at plot vertices. You can set values for the `Marker` property independently from the `LineStyle` property. Supported markers include those shown in the following table.

| Marker Specifier | Description |
|------------------|-------------|
| +                | Plus sign   |
| o                | Circle      |

# Surfaceplot Properties

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| Marker Specifier | Description                   |
|------------------|-------------------------------|
| *                | Asterisk                      |
| .                | Point                         |
| x                | Cross                         |
| s                | Square                        |
| d                | Diamond                       |
| ^                | Upward-pointing triangle      |
| v                | Downward-pointing triangle    |
| >                | Right-pointing triangle       |
| <                | Left-pointing triangle        |
| p                | Five-pointed star (pentagram) |
| h                | Six-pointed star (hexagram)   |
| none             | No marker (default)           |

## MarkerEdgeColor

none | {auto} | flat | ColorSpec

*Marker edge color.* The color of the marker or the edge color for filled markers (circle, square, diamond, pentagram, hexagram, and the four triangles).

- none specifies no color, which makes nonfilled markers invisible.
- auto uses the same color as the EdgeColor property.
- flat uses the CData value of the vertex to determine the color of the maker edge.
- ColorSpec defines a single color to use for the edge (see ColorSpec for more information).

## MarkerFaceColor

{none} | auto | flat | ColorSpec

*Marker face color.* The fill color for markers that are closed shapes (circle, square, diamond, pentagram, hexagram, and the four triangles).

- none makes the interior of the marker transparent, allowing the background to show through.
- auto uses the axes Color for the marker face color.
- flat uses the CData value of the vertex to determine the color of the face.
- ColorSpec defines a single color to use for all markers on the surfaceplot (see ColorSpec for more information).

MarkerSize

size in points

*Marker size.* A scalar specifying the size of the marker in points. The default value for MarkerSize is 6 points (1 point = 1/72 inch). Note that MATLAB draws the point marker (specified by the '.' symbol) at one-third the specified size.

MeshStyle

{both} | row | column

*Row and column lines.* This property specifies whether to draw all edge lines or just row or column edge lines.

- both draws edges for both rows and columns.
- row draws row edges only.
- column draws column edges only.

NormalMode

{auto} | manual

*MATLAB generated or user-specified normal vectors.* When this property is auto, MATLAB calculates vertex normals based on the coordinate data. If you specify your own vertex normals, MATLAB

# Surfaceplot Properties

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sets this property to manual and does not generate its own data. See also the VertexNormals property.

## Parent

handle of parent axes, hggroup, or hgtransform

*Parent of this object.* This property contains the handle of the object's parent. The parent is normally the axes, hggroup, or hgtransform object that contains the object.

See “Objects That Can Contain Other Objects” for more information on parenting graphics objects.

## Selected

on | {off}

*Is object selected?* When you set this property to on, MATLAB displays selection "handles" at the corners and midpoints if the SelectionHighlight property is also on (the default). You can, for example, define the ButtonDownFcn callback to set this property to on, thereby indicating that this particular object is selected. This property is also set to on when an object is manually selected in plot edit mode.

## SelectionHighlight

{on} | off

*Objects are highlighted when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is off, MATLAB does not draw the handles except when in plot edit mode and objects are selected manually.

## SpecularColorReflectance

scalar in the range 0 to 1

*Color of specularly reflected light.* When this property is 0, the color of the specularly reflected light depends on both the color of the object from which it reflects and the color of the light source.

When set to 1, the color of the specularly reflected light depends only on the color of the light source (i.e., the light object `Color` property). The proportions vary linearly for values in between.

`SpecularExponent`  
scalar  $\geq 1$

*Harshness of specular reflection.* This property controls the size of the specular spot. Most materials have exponents in the range of 5 to 20.

`SpecularStrength`  
scalar  $\geq 0$  and  $\leq 1$

*Intensity of specular light.* This property sets the intensity of the specular component of the light falling on the surface. Specular light comes from light objects in the axes.

You can also set the intensity of the ambient and diffuse components of the light on the surfaceplot object. See the `AmbientStrength` and `DiffuseStrength` properties. Also see the material function.

`Tag`  
string

*User-specified object label.* The `Tag` property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callbacks. You can define `Tag` as any string.

For example, you might create an `areaseries` object and set the `Tag` property.

```
t = area(Y, 'Tag', 'area1')
```

# Surfaceplot Properties

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When you want to access objects of a given type, you can use `findobj` to find the object's handle. The following statement changes the `FaceColor` property of the object whose `Tag` is `area1`.

```
set(findobj('Tag','area1'),'FaceColor','red')
```

## Type

string (read only)

*Class of the graphics object.* The class of the graphics object. For surfaceplot objects, `Type` is always the string `'surface'`.

## UIContextMenu

handle of a `uicontextmenu` object

*Associate a context menu with this object.* Assign this property the handle of a `uicontextmenu` object created in the object's parent figure. Use the `uicontextmenu` function to create the context menu. MATLAB displays the context menu whenever you right-click over the object.

## UserData

array

*User-specified data.* This property can be any data you want to associate with this object (including cell arrays and structures). The object does not set values for this property, but you can access it using the `set` and `get` functions.

## VertexNormals

vector or matrix

*Surfaceplot normal vectors.* This property contains the vertex normals for the surfaceplot. MATLAB generates this data to perform lighting calculations. You can supply your own vertex normal data, even if it does not match the coordinate data. This can be useful to produce interesting lighting effects.

## Visible

{on} | off

*Visibility of this object and its children.* By default, a new object's visibility is on. This means all children of the object are visible unless the child object's `Visible` property is set to off. Setting an object's `Visible` property to off prevents the object from being displayed. However, the object still exists and you can set and query its properties.

## XData

vector or matrix

*X-coordinates.* The  $x$ -position of the surfaceplot data points. If you specify a row vector, MATLAB replicates the row internally until it has the same number of columns as `ZData`.

## XDataMode

{auto} | manual

*Use automatic or user-specified x-axis values.* If you specify `XData` (by setting the `XData` property or specifying the  $x$  input argument), MATLAB sets this property to `manual` and uses the specified values to label the  $x$ -axis.

If you set `XDataMode` to `auto` after having specified `XData`, MATLAB resets the  $x$ -axis ticks to `1:size(YData,1)` or to the column indices of the `ZData`, overwriting any previous values for `XData`.

## XDataSource

string (MATLAB variable)

*Link XData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the `XData`.

# Surfaceplot Properties

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MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change XData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

## YData

vector or matrix

*Y-coordinates.* The  $y$ -position of the surfaceplot data points. If you specify a row vector, MATLAB replicates the row internally until it has the same number of rows as ZData.

## YDataMode

{auto} | manual

*Use automatic or user-specified x-axis values.* If you specify XData, MATLAB sets this property to manual.

If you set YDataMode to auto after having specified YData, MATLAB resets the  $y$ -axis ticks and  $y$ -tick labels to the row indices of the ZData, overwriting any previous values for YData.

## YDataSource

string (MATLAB variable)



*Link YData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the YData.

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change YData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

---

**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

ZData  
matrix

*Z-coordinates.* The *z*-position of the surfaceplot data points. See the Description section for more information.

ZDataSource  
string (MATLAB variable)

*Link ZData to MATLAB variable.* Set this property to a MATLAB variable that is evaluated in the base workspace to generate the ZData.

# Surfaceplot Properties

---

MATLAB reevaluates this property only when you set it. Therefore, a change to workspace variables appearing in an expression does not change ZData.

You can use the `refreshdata` function to force an update of the object's data. `refreshdata` also enables you to specify that the data source variable be evaluated in the workspace of a function from which you call `refreshdata`.

See the `refreshdata` reference page for more information.

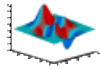
---


**Note** If you change one data source property to a variable that contains data of a different dimension, you might cause the function to generate a warning and not render the graph until you have changed all data source properties to appropriate values.

---

**Purpose**

Surface plot with colormap-based lighting

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation and Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation.

**Syntax**

```
surfl(Z)
surfl(...,'light')
surfl(...,s)
surfl(X,Y,Z,s,k)
h = surfl(...)
```

**Description**

The `surfl` function displays a shaded surface based on a combination of ambient, diffuse, and specular lighting models.

`surfl(Z)` and `surfl(X,Y,Z)` create three-dimensional shaded surfaces using the default direction for the light source and the default lighting coefficients for the shading model. `X`, `Y`, and `Z` are vectors or matrices that define the  $x$ ,  $y$ , and  $z$  components of a surface.

`surfl(...,'light')` produces a colored, lighted surface using a MATLAB light object. This produces results different from the default lighting method, `surfl(...,'cdata')`, which changes the color data for the surface to be the reflectance of the surface.

`surfl(...,s)` specifies the direction of the light source. `s` is a two- or three-element vector that specifies the direction from a surface to a light source. `s = [sx sy sz]` or `s = [azimuth elevation]`. The default `s` is 45° counterclockwise from the current view direction.

`surfl(X,Y,Z,s,k)` specifies the reflectance constant. `k` is a four-element vector defining the relative contributions of ambient light,

# surf1

---

diffuse reflection, specular reflection, and the specular shine coefficient.  $k = [k_a \ k_d \ k_s \ \text{shine}]$  and defaults to  $[.55, .6, .4, 10]$ .

`h = surf1(...)` returns a handle to a surface graphics object.

## Remarks

`surf1` does not accept complex inputs.

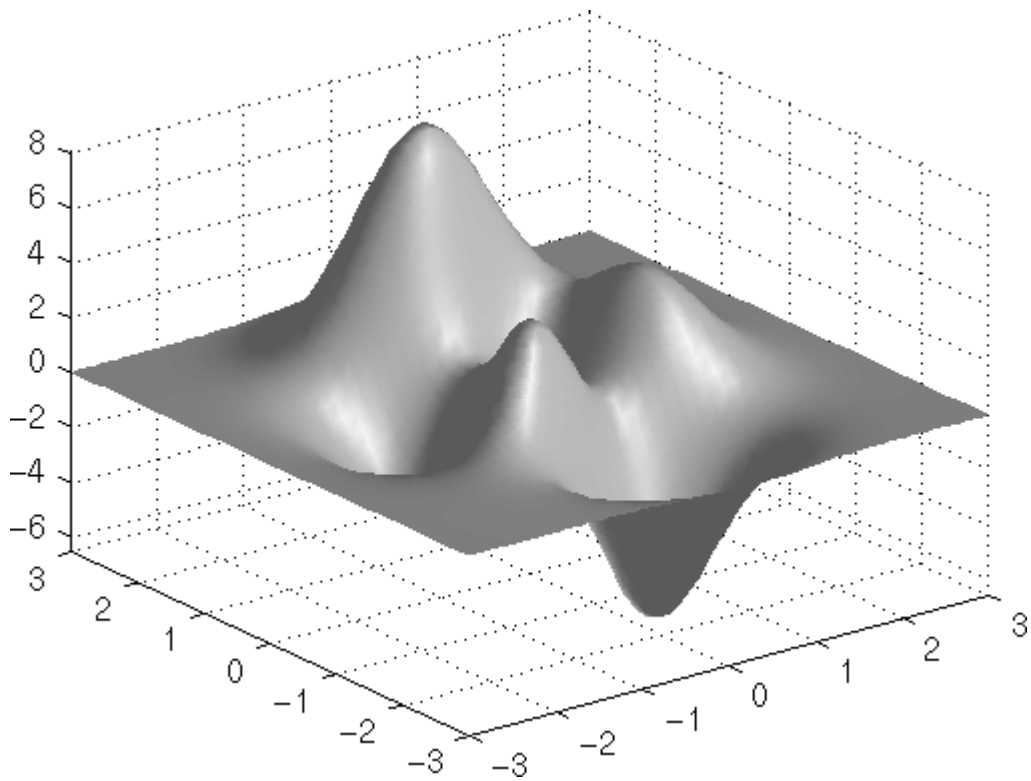
For smoother color transitions, use colormaps that have linear intensity variations (e.g., gray, copper, bone, pink).

The ordering of points in the  $X$ ,  $Y$ , and  $Z$  matrices defines the inside and outside of parametric surfaces. If you want the opposite side of the surface to reflect the light source, use `surf1(X',Y',Z')`. Because of the way surface normal vectors are computed, `surf1` requires matrices that are at least 3-by-3.

## Examples

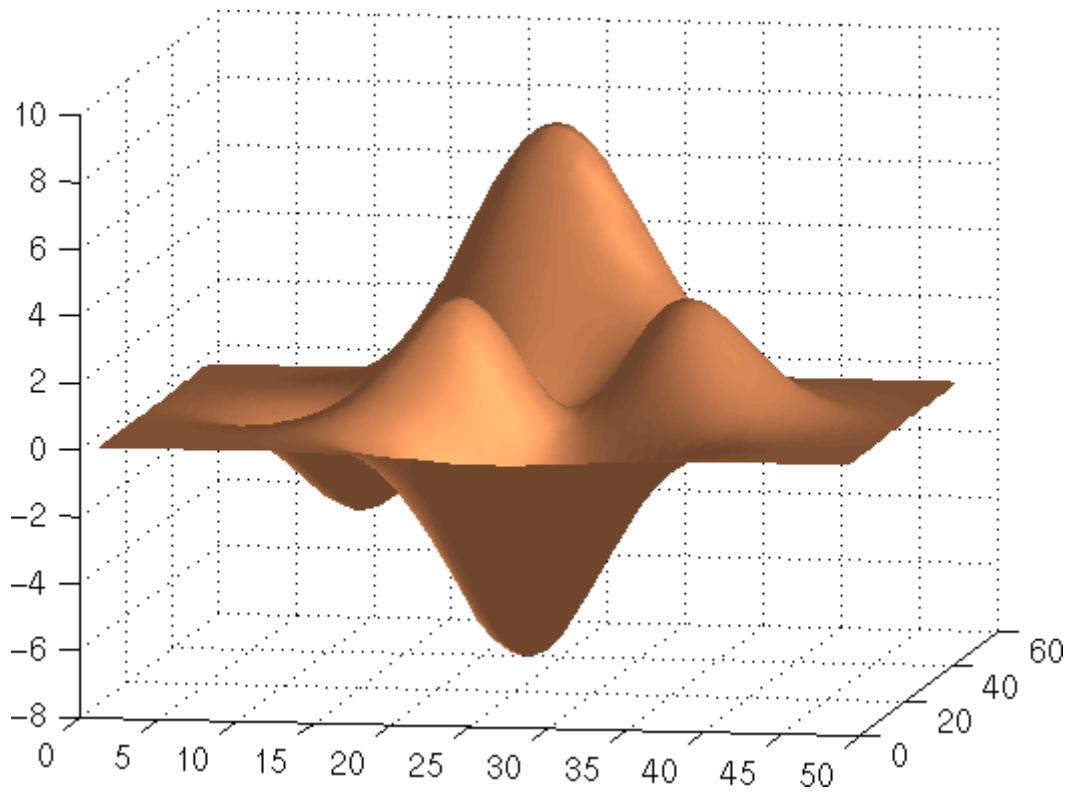
View peaks using colormap-based lighting.

```
[x,y] = meshgrid(-3:1/8:3);  
z = peaks(x,y);  
surf1(x,y,z);  
shading interp  
colormap(gray);  
axis([-3 3 -3 3 -8 8])
```



To plot a lighted surface from a view direction other than the default,

```
view([10 10])  
grid on  
hold on  
surfl(peaks)  
shading interp  
colormap copper  
hold off
```



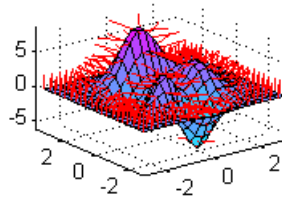
## See Also

`colormap`, `shading`, `light`

“Creating Surfaces and Meshes” on page 1-97 for functions related to surfaces

“Lighting” on page 1-101 for functions related to lighting

**Purpose** Compute and display 3-D surface normals



**Syntax**

```
surfnorm(Z)
surfnorm(X,Y,Z)
[Nx,Ny,Nz] = surfnorm(...)
```

**Description** The `surfnorm` function computes surface normals for the surface defined by  $X$ ,  $Y$ , and  $Z$ . The surface normals are unnormalized and valid at each vertex. Normals are not shown for surface elements that face away from the viewer.

`surfnorm(Z)` and `surfnorm(X,Y,Z)` plot a surface and its surface normals.  $Z$  is a matrix that defines the  $z$  component of the surface.  $X$  and  $Y$  are vectors or matrices that define the  $x$  and  $y$  components of the surface.

`[Nx,Ny,Nz] = surfnorm(...)` returns the components of the three-dimensional surface normals for the surface.

**Remarks** `surfnorm` does not accept complex inputs.

The direction of the normals is reversed by calling `surfnorm` with transposed arguments:

```
surfnorm(X',Y',Z')
```

`surf1` uses `surfnorm` to compute surface normals when calculating the reflectance of a surface.

# surfnorm

---

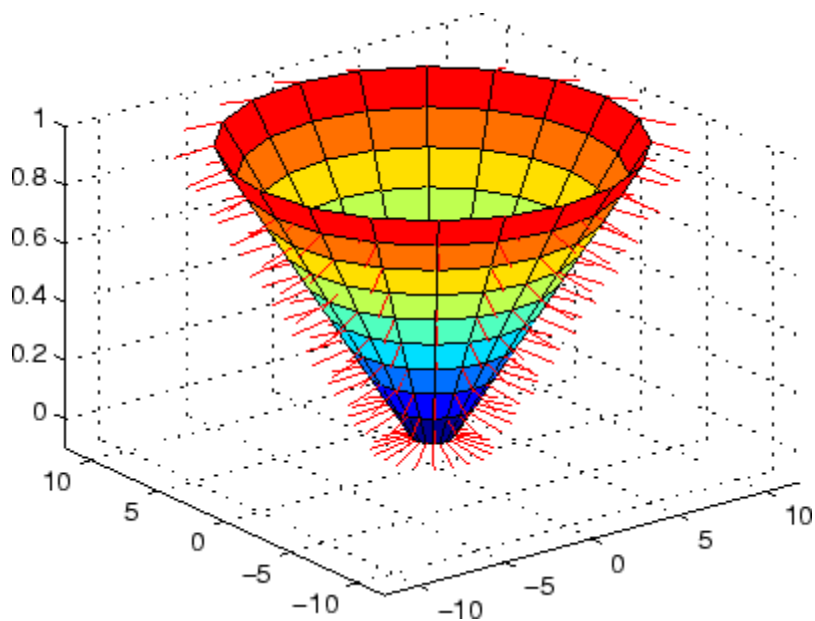
## Algorithm

The surface normals are based on a bicubic fit of the data in X, Y, and Z. For each vertex, diagonal vectors are computed and crossed to form the normal.

## Examples

Plot the normal vectors for a truncated cone.

```
[x,y,z] = cylinder(1:10);  
surfnorm(x,y,z)  
axis([-12 12 -12 12 -0.1 1])
```



## See Also

surf, quiver3

“Colormaps” on page 1-99 for related functions



**Purpose** Singular value decomposition

**Syntax**

```
s = svd(X)
[U,S,V] = svd(X)
[U,S,V] = svd(X,0)
[U,S,V] = svd(X,'econ')
```

**Description** The svd command computes the matrix singular value decomposition. `s = svd(X)` returns a vector of singular values. `[U,S,V] = svd(X)` produces a diagonal matrix `S` of the same dimension as `X`, with nonnegative diagonal elements in decreasing order, and unitary matrices `U` and `V` so that  $X = U*S*V'$ . `[U,S,V] = svd(X,0)` produces the “economy size” decomposition. If `X` is `m`-by-`n` with `m > n`, then `svd` computes only the first `n` columns of `U` and `S` is `n`-by-`n`. `[U,S,V] = svd(X,'econ')` also produces the “economy size” decomposition. If `X` is `m`-by-`n` with `m >= n`, it is equivalent to `svd(X,0)`. For `m < n`, only the first `m` columns of `V` are computed and `S` is `m`-by-`m`.

**Examples** For the matrix

```
X =
     1     2
     3     4
     5     6
     7     8
```

the statement

```
[U,S,V] = svd(X)
```

produces

```
U =
-0.1525  -0.8226  -0.3945  -0.3800
```

# svd

---

|         |         |         |         |
|---------|---------|---------|---------|
| -0.3499 | -0.4214 | 0.2428  | 0.8007  |
| -0.5474 | -0.0201 | 0.6979  | -0.4614 |
| -0.7448 | 0.3812  | -0.5462 | 0.0407  |

S =

|         |        |
|---------|--------|
| 14.2691 | 0      |
| 0       | 0.6268 |
| 0       | 0      |
| 0       | 0      |

V =

|         |         |
|---------|---------|
| -0.6414 | 0.7672  |
| -0.7672 | -0.6414 |

The economy size decomposition generated by

$$[U, S, V] = \text{svd}(X, 0)$$

produces

U =

|         |         |
|---------|---------|
| -0.1525 | -0.8226 |
| -0.3499 | -0.4214 |
| -0.5474 | -0.0201 |
| -0.7448 | 0.3812  |

S =

|         |        |
|---------|--------|
| 14.2691 | 0      |
| 0       | 0.6268 |

V =

|         |         |
|---------|---------|
| -0.6414 | 0.7672  |
| -0.7672 | -0.6414 |

## Algorithm

svd uses the LAPACK routines listed in the following table to compute the singular value decomposition.

---

|          | <b>Real</b> | <b>Complex</b> |
|----------|-------------|----------------|
| X double | DGESVD      | ZGESVD         |
| X single | SGESVD      | CGESVD         |

**Diagnostics**

If the limit of 75 QR step iterations is exhausted while seeking a singular value, this message appears:

Solution will not converge.

**References**

[1] Anderson, E., Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen, *LAPACK User's Guide* ([http://www.netlib.org/lapack/lug/lapack\\_lug.html](http://www.netlib.org/lapack/lug/lapack_lug.html)), Third Edition, SIAM, Philadelphia, 1999.

# svds

**Purpose** Find singular values and vectors

**Syntax**

```
s = svds(A)
s = svds(A,k)
s = svds(A,k,sigma)
s = svds(A,k,'L')
s = svds(A,k,sigma,options)
[U,S,V] = svds(A,...)
[U,S,V,flag] = svds(A,...)
```

**Description** `s = svds(A)` computes the six largest singular values and associated singular vectors of matrix A. If A is m-by-n, `svds(A)` manipulates eigenvalues and vectors returned by `eigs(B)`, where `B = [sparse(m,m) A; A' sparse(n,n)]`, to find a few singular values and vectors of A. The positive eigenvalues of the symmetric matrix B are the same as the singular values of A.

`s = svds(A,k)` computes the k largest singular values and associated singular vectors of matrix A.

`s = svds(A,k,sigma)` computes the k singular values closest to the scalar shift sigma. For example, `s = svds(A,k,0)` computes the k smallest singular values and associated singular vectors.

`s = svds(A,k,'L')` computes the k largest singular values (the default).

`s = svds(A,k,sigma,options)` sets some parameters (see `eigs`):

## Option Structure Fields and Descriptions

| Field name               | Parameter                                                                  | Default |
|--------------------------|----------------------------------------------------------------------------|---------|
| <code>options.tol</code> | Convergence tolerance:<br><code>norm(AV-US,1) &lt;= tol * norm(A,1)</code> | 1e-10   |

### Option Structure Fields and Descriptions (Continued)

| Field name    | Parameter                                 | Default |
|---------------|-------------------------------------------|---------|
| options.maxit | Maximum number of iterations              | 300     |
| options.disp  | Number of values displayed each iteration | 0       |

`[U,S,V] = svds(A,...)` returns three output arguments, and if A is m-by-n:

- U is m-by-k with orthonormal columns
- S is k-by-k diagonal
- V is n-by-k with orthonormal columns
- $U*S*V'$  is the closest rank k approximation to A

`[U,S,V,flag] = svds(A,...)` returns a convergence flag. If eigs converged then  $\text{norm}(A*V-U*S,1) \leq \text{tol}*\text{norm}(A,1)$  and flag is 0. If eigs did not converge, then flag is 1.

---

**Note** svds is best used to find a few singular values of a large, sparse matrix. To find all the singular values of such a matrix, `svd(full(A))` will usually perform better than `svds(A,min(size(A)))`.

---

### Algorithm

`svds(A,k)` uses eigs to find the k largest magnitude eigenvalues and corresponding eigenvectors of  $B = \begin{bmatrix} 0 & A \\ A' & 0 \end{bmatrix}$ .

`svds(A,k,0)` uses eigs to find the 2k smallest magnitude eigenvalues and corresponding eigenvectors of  $B = \begin{bmatrix} 0 & A \\ A' & 0 \end{bmatrix}$ , and then selects the k positive eigenvalues and their eigenvectors.

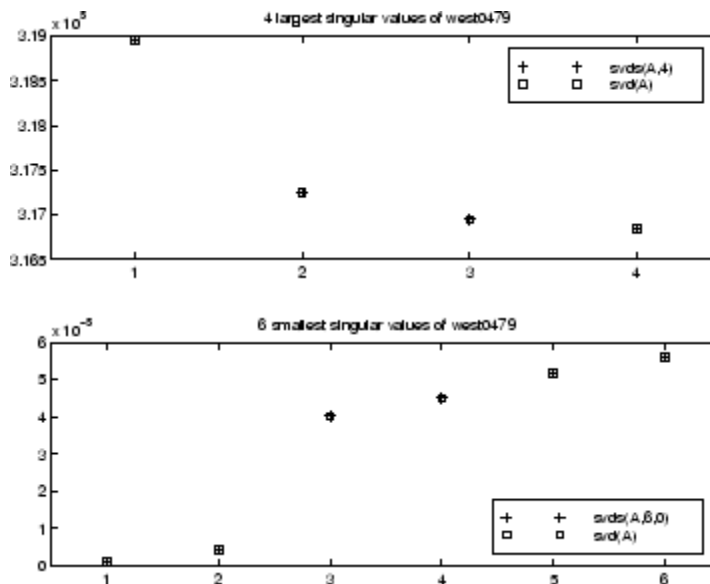
### Example

west0479 is a real 479-by-479 sparse matrix. svd calculates all 479 singular values. svds picks out the largest and smallest singular values.

# svds

```
load west0479
s = svd(full(west0479))
s1 = svds(west0479,4)
ss = svds(west0479,6,0)
```

These plots show some of the singular values of west0479 as computed by svd and svds.



The largest singular value of west0479 can be computed a few different ways:

```
svds(west0479,1) =
 3.189517598808622e+05
max(svd(full(west0479))) =
 3.18951759880862e+05
norm(full(west0479)) =
 3.189517598808623e+05
```

and estimated:

```
normest(west0479) =  
3.189385666549991e+05
```

**See Also**

svd, eigs

# swapbytes

---

**Purpose** Swap byte ordering

**Syntax** `Y = swapbytes(X)`

**Description** `Y = swapbytes(X)` reverses the byte ordering of each element in array `X`, converting little-endian values to big-endian (and vice versa). The input array must contain all full, noncomplex, numeric elements.

## Examples

### Example 1

Reverse the byte order for a scalar 32-bit value, changing hexadecimal 12345678 to 78563412:

```
A = uint32(hex2dec('12345678'));  
  
B = dec2hex(swapbytes(A))  
B =  
    78563412
```

### Example 2

Reverse the byte order for each element of a 1-by-4 matrix:

```
X = uint16([0 1 128 65535])  
X =  
     0     1    128 65535  
  
Y = swapbytes(X);  
Y =  
     0   256 32768 65535
```

Examining the output in hexadecimal notation shows the byte swapping:

```
format hex  
  
X, Y  
X =  
    0000    0001    0080    ffff
```



```
Y =
    0000    0100    8000    ffff
```

### Example 3

Create a three-dimensional array A of 16-bit integers and then swap the bytes of each element:

```
format hex

A = uint16(magic(3) * 150);
A(:,:,2) = A * 40;

A
A(:,:,1) =
    04b0    0096    0384
    01c2    02ee    041a
    0258    0546    012c
A(:,:,2) =
    bb80    1770    8ca0
    4650    7530    a410
    5dc0    d2f0    2ee0

swapbytes(A)
ans(:,:,1) =
    b004    9600    8403
    c201    ee02    1a04
    5802    4605    2c01
ans(:,:,2) =
    80bb    7017    a08c
    5046    3075    10a4
    c05d    f0d2    e02e
```

### See Also

typecast

# switch

---

**Purpose** Switch among several cases, based on expression

**Syntax**

```
switch switch_expr
  case case_expr
    statement, ..., statement
  case {case_expr1, case_expr2, case_expr3, ...}
    statement, ..., statement
  otherwise
    statement, ..., statement
end
```

**Discussion** The switch statement syntax is a means of conditionally executing code. In particular, switch executes one set of statements selected from an arbitrary number of alternatives. Each alternative is called a case, and consists of

- The case statement
- One or more case expressions
- One or more statements

In its basic syntax, switch executes the statements associated with the first case where *switch\_expr* == *case\_expr*. When the case expression is a cell array (as in the second case above), the *case\_expr* matches if any of the elements of the cell array matches the switch expression. If no case expression matches the switch expression, then control passes to the otherwise case (if it exists). After the case is executed, program execution resumes with the statement after the end.

The *switch\_expr* can be a scalar or a string. A scalar *switch\_expr* matches a *case\_expr* if *switch\_expr*==*case\_expr*. A string *switch\_expr* matches a *case\_expr* if strcmp(*switch\_expr*,*case\_expr*) returns logical 1 (true).

---

**Note for C Programmers** Unlike the C language switch construct, the MATLAB switch does not “fall through.” That is, switch executes only the first matching case; subsequent matching cases do not execute. Therefore, break statements are not used.

---

## Examples

To execute a certain block of code based on what the string, method, is set to,

```
method = 'Bilinear';

switch lower(method)
    case {'linear','bilinear'}
        disp('Method is linear')
    case 'cubic'
        disp('Method is cubic')
    case 'nearest'
        disp('Method is nearest')
    otherwise
        disp('Unknown method.')
end

Method is linear
```

## See Also

case, otherwise, end, if, else, elseif, while

# symamd

---

**Purpose** Symmetric approximate minimum degree permutation

**Syntax**

```
p = symamd(S)
p = symamd(S,knobs)
[p,stats] = symamd(...)
```

**Description** `p = symamd(S)` for a symmetric positive definite matrix `S`, returns the permutation vector `p` such that `S(p,p)` tends to have a sparser Cholesky factor than `S`. To find the ordering for `S`, `symamd` constructs a matrix `M` such that `spones(M'*M) = spones(S)`, and then computes `p = colamd(M)`. The `symamd` function may also work well for symmetric indefinite matrices.

`S` must be square; only the strictly lower triangular part is referenced.

`p = symamd(S,knobs)` where `knobs` is a scalar. If `S` is `n`-by-`n`, rows and columns with more than `knobs*n` entries are removed prior to ordering, and ordered last in the output permutation `p`. If the `knobs` parameter is not present, then `knobs = spparms('wh_frac')`.

`[p,stats] = symamd(...)` produces the optional vector `stats` that provides data about the ordering and the validity of the matrix `S`.

|                       |                                                                                                                                                                     |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>stats(1)</code> | Number of dense or empty rows ignored by <code>symamd</code>                                                                                                        |
| <code>stats(2)</code> | Number of dense or empty columns ignored by <code>symamd</code>                                                                                                     |
| <code>stats(3)</code> | Number of garbage collections performed on the internal data structure used by <code>symamd</code> (roughly of size <code>8.4*nnz(tril(S,-1)) + 9n</code> integers) |
| <code>stats(4)</code> | 0 if the matrix is valid, or 1 if invalid                                                                                                                           |
| <code>stats(5)</code> | Rightmost column index that is unsorted or contains duplicate entries, or 0 if no such column exists                                                                |
| <code>stats(6)</code> | Last seen duplicate or out-of-order row index in the column index given by <code>stats(5)</code> , or 0 if no such row index exists                                 |
| <code>stats(7)</code> | Number of duplicate and out-of-order row indices                                                                                                                    |

Although, MATLAB built-in functions generate valid sparse matrices, a user may construct an invalid sparse matrix using the MATLAB C or Fortran APIs and pass it to symamd. For this reason, symamd verifies that S is valid:

- If a row index appears two or more times in the same column, symamd ignores the duplicate entries, continues processing, and provides information about the duplicate entries in stats(4:7).
- If row indices in a column are out of order, symamd sorts each column of its internal copy of the matrix S (but does not repair the input matrix S), continues processing, and provides information about the out-of-order entries in stats(4:7).
- If S is invalid in any other way, symamd cannot continue. It prints an error message, and returns no output arguments (p or stats).

The ordering is followed by a symmetric elimination tree post-ordering.

---

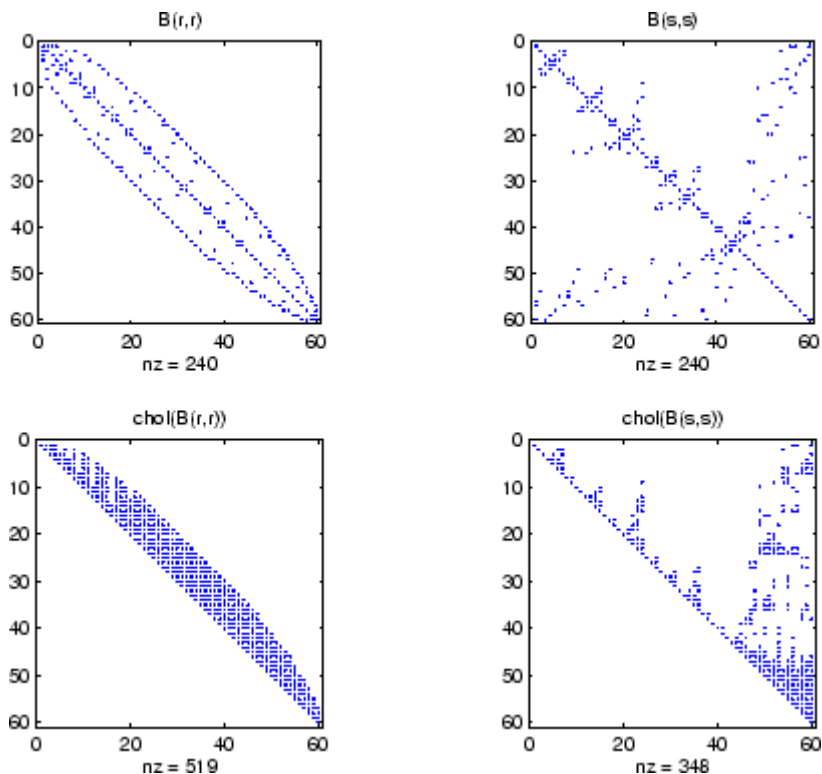
**Note** symamd tends to be faster than symmmd and tends to return a better ordering.

---

## Examples

Here is a comparison of reverse Cuthill-McKee and minimum degree on the Bucky ball example mentioned in the symrcm reference page.

```
B = bucky+4*speye(60);
r = symrcm(B);
p = symamd(B);
R = B(r,r);
S = B(p,p);
subplot(2,2,1), spy(R,4), title('B(r,r)')
subplot(2,2,2), spy(S,4), title('B(s,s)')
subplot(2,2,3), spy(chol(R),4), title('chol(B(r,r))')
subplot(2,2,4), spy(chol(S),4), title('chol(B(s,s))')
```



Even though this is a very small problem, the behavior of both orderings is typical. RCM produces a matrix with a narrow bandwidth which fills in almost completely during the Cholesky factorization. Minimum degree produces a structure with large blocks of contiguous zeros which do not fill in during the factorization. Consequently, the minimum degree ordering requires less time and storage for the factorization.

## See Also

`colamd`, `colperm`, `spparms`, `symrcm`

## References

The authors of the code for `symamd` are Stefan I. Larimore and Timothy A. Davis ([davis@cise.ufl.edu](mailto:davis@cise.ufl.edu)), University of Florida. The algorithm was developed in collaboration with John Gilbert,

Xerox PARC, and Esmond Ng, Oak Ridge National Laboratory.  
Sparse Matrix Algorithms Research at the University of Florida:  
<http://www.cise.ufl.edu/research/sparse/>

# symbfact

---

**Purpose** Symbolic factorization analysis

**Syntax**

```
count = symbfact(A)
count = symbfact(A, 'sym')
count = symbfact(A, 'col')
count = symbfact(A, 'row')
count = symbfact(A, 'lo')
[count,h,parent,post,R] = symbfact(...)
[count,h,parent,post,L] = symbfact(A,type,'lower')
```

**Description**

`count = symbfact(A)` returns the vector of row counts of  $R=\text{chol}(A'*A)$ . `symbfact` should be much faster than `chol(A)`.

`count = symbfact(A, 'sym')` is the same as `count = symbfact(A)`.

`count = symbfact(A, 'col')` returns row counts of  $R=\text{chol}(A'*A)$  (without forming it explicitly).

`count = symbfact(A, 'row')` returns row counts of  $R=\text{chol}(A*A')$ .

`count = symbfact(A, 'lo')` is the same as `count = symbfact(A)` and uses `tril(A)`.

`[count,h,parent,post,R] = symbfact(...)` has several optional return values.

The flop count for a subsequent Cholesky factorization is `sum(count.^2)`

| Return Value | Description                                                                                                                                                                |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| h            | Height of the elimination tree                                                                                                                                             |
| parent       | The elimination tree itself                                                                                                                                                |
| post         | Postordering of the elimination tree                                                                                                                                       |
| R            | 0-1 matrix having the structure of <code>chol(A)</code> for the symmetric case, <code>chol(A'*A)</code> for the 'col' case, or <code>chol(A*A')</code> for the 'row' case. |



`symbfact(A)` and `symbfact(A, 'sym')` use the upper triangular part of  $A$  (`triu(A)`) and assume the lower triangular part is the transpose of the upper triangular part. `symbfact(A, 'lo')` uses `tril(A)` instead.

`[count,h,parent,post,L] = symbfact(A,type,'lower')` where `type` is one of `'sym'`, `'col'`, `'row'`, or `'lo'` returns a lower triangular symbolic factor  $L=R'$ . This form is quicker and requires less memory.

## See Also

`chol`, `etree`, `treelayout`

# symmlq

---

**Purpose** Symmetric LQ method

**Syntax**

```
x = symmlq(A,b)
symmlq(A,b,tol)
symmlq(A,b,tol,maxit)
symmlq(A,b,tol,maxit,M)
symmlq(A,b,tol,maxit,M1,M2)
symmlq(A,b,tol,maxit,M1,M2,x0)
[x,flag] = symmlq(A,b,...)
[x,flag,relres] = symmlq(A,b,...)
[x,flag,relres,iter] = symmlq(A,b,...)
[x,flag,relres,iter,resvec] = symmlq(A,b,...)
[x,flag,relres,iter,resvec,resvecg] = symmlq(A,b,...)
```

**Description** `x = symmlq(A,b)` attempts to solve the system of linear equations  $A*x=b$  for  $x$ . The  $n$ -by- $n$  coefficient matrix  $A$  must be symmetric but need not be positive definite. It should also be large and sparse. The column vector  $b$  must have length  $n$ .  $A$  can be a function handle `afun` such that `afun(x)` returns  $A*x$ . See “Function Handles” in the MATLAB Programming documentation for more information.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `afun`, as well as the preconditioner function `mfun` described below, if necessary.

If `symmlq` converges, a message to that effect is displayed. If `symmlq` fails to converge after the maximum number of iterations or halts for any reason, a warning message is printed displaying the relative residual  $\text{norm}(b-A*x) / \text{norm}(b)$  and the iteration number at which the method stopped or failed.

`symmlq(A,b,tol)` specifies the tolerance of the method. If `tol` is `[]`, then `symmlq` uses the default,  $1e-6$ .

`symmlq(A,b,tol,maxit)` specifies the maximum number of iterations. If `maxit` is `[]`, then `symmlq` uses the default,  $\min(n,20)$ .

`symmlq(A,b,tol,maxit,M)` and `symmlq(A,b,tol,maxit,M1,M2)` use the symmetric positive definite preconditioner  $M$  or  $M = M1*M2$  and effectively solve the system  $\text{inv}(\text{sqrt}(M))*A*\text{inv}(\text{sqrt}(M))*y = \text{inv}(\text{sqrt}(M))*b$  for  $y$  and then return  $x = \text{in}(\text{sqrt}(M))*y$ . If  $M$  is `[]` then `symmlq` applies no preconditioner.  $M$  can be a function handle `mfun` such that `mfun(x)` returns  $M \backslash x$ .

`symmlq(A,b,tol,maxit,M1,M2,x0)` specifies the initial guess. If `x0` is `[]`, then `symmlq` uses the default, an all-zero vector.

`[x,flag] = symmlq(A,b,...)` also returns a convergence flag.

| Flag | Convergence                                                                                                             |
|------|-------------------------------------------------------------------------------------------------------------------------|
| 0    | <code>symmlq</code> converged to the desired tolerance <code>tol</code> within <code>maxit</code> iterations.           |
| 1    | <code>symmlq</code> iterated <code>maxit</code> times but did not converge.                                             |
| 2    | Preconditioner $M$ was ill-conditioned.                                                                                 |
| 3    | <code>symmlq</code> stagnated. (Two consecutive iterates were the same.)                                                |
| 4    | One of the scalar quantities calculated during <code>symmlq</code> became too small or too large to continue computing. |
| 5    | Preconditioner $M$ was not symmetric positive definite.                                                                 |

Whenever `flag` is not 0, the solution  $x$  returned is that with minimal norm residual computed over all the iterations. No messages are displayed if the `flag` output is specified.

`[x,flag,relres] = symmlq(A,b,...)` also returns the relative residual  $\text{norm}(b-A*x) / \text{norm}(b)$ . If `flag` is 0, `relres`  $\leq$  `tol`.

`[x,flag,relres,iter] = symmlq(A,b,...)` also returns the iteration number at which  $x$  was computed, where  $0 \leq \text{iter} \leq \text{maxit}$ .

`[x,flag,relres,iter,resvec] = symmlq(A,b,...)` also returns a vector of estimates of the `symmlq` residual norms at each iteration, including  $\text{norm}(b-A*x0)$ .

`[x,flag,relres,iter,resvec,resvecg] = symmlq(A,b,...)` also returns a vector of estimates of the conjugate gradients residual norms at each iteration.

## Examples

### Example 1

```
n = 100;
on = ones(n,1);
A = spdiags([-2*on 4*on -2*on],-1:1,n,n);
b = sum(A,2);
tol = 1e-10;
maxit = 50; M1 = spdiags(4*on,0,n,n);

x = symmlq(A,b,tol,maxit,M1);
symmlq converged at iteration 49 to a solution with relative
residual 4.3e-015
```

### Example 2

This example replaces the matrix *A* in Example 1 with a handle to a matrix-vector product function *afun*. The example is contained in an M-file `run_symmlq` that

- Calls `symmlq` with the function handle `@afun` as its first argument.
- Contains *afun* as a nested function, so that all variables in `run_symmlq` are available to *afun*.

The following shows the code for `run_symmlq`:

```
function x1 = run_symmlq
n = 100;
on = ones(n,1);
A = spdiags([-2*on 4*on -on],-1:1,n,n);
b = sum(A,2);
tol = 1e-8;
maxit = 15;
M1 = spdiags([on/(-2) on],-1:0,n,n);
M2 = spdiags([4*on -on],0:1,n,n);
```

```

x1 = symmlq(@afun,b,tol,maxit,M1);

function y = afun(x)
    y = 4 * x;
    y(2:n) = y(2:n) - 2 * x(1:n-1);
    y(1:n-1) = y(1:n-1) - 2 * x(2:n);
end
end

```

When you enter

```
x1=run_symmlq;
```

MATLAB displays the message

```

symmlq converged at iteration 49 to a solution with relative
residual 4.3e-015

```

### Example 3

Use a symmetric indefinite matrix that fails with pcg.

```

A = diag([20:-1:1,-1:-1:-20]);
b = sum(A,2);           % The true solution is the vector of all ones.
x = pcg(A,b);          % Errors out at the first iteration.
pcg stopped at iteration 1 without converging to the desired
tolerance 1e-006 because a scalar quantity became too small or
too large to continue computing.
The iterate returned (number 0) has relative residual 1

```

However, symmlq can handle the indefinite matrix A.

```

x = symmlq(A,b,1e-6,40);
symmlq converged at iteration 39 to a solution with relative
residual 1.3e-007

```

### See Also

bicg, bicgstab, cgs, lsqr, gmres, minres, pcg, qmr

function\_handle (@), mldivide (\)

## References

- [1] Barrett, R., M. Berry, T. F. Chan, et al., *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*, SIAM, Philadelphia, 1994.
- [2] Paige, C. C. and M. A. Saunders, "Solution of Sparse Indefinite Systems of Linear Equations." *SIAM J. Numer. Anal.*, Vol.12, 1975, pp. 617-629.

**Purpose** Sparse symmetric minimum degree ordering

**Syntax** `p = symmmd(S)`

---

**Note** `symmmd` is obsolete and will be removed from a future version of MATLAB. Use `symamd` instead.

---

**Description** `p = symmmd(S)` returns a symmetric minimum degree ordering of  $S$ . For a symmetric positive definite matrix  $S$ , this is a permutation  $p$  such that  $S(p, p)$  tends to have a sparser Cholesky factor than  $S$ . Sometimes `symmmd` works well for symmetric indefinite matrices too.

**Algorithm** The symmetric minimum degree algorithm is based on the column minimum degree algorithm. In fact, `symmmd(A)` just creates a nonzero structure  $K$  such that  $K' * K$  has the same nonzero structure as  $A$  and then calls the column minimum degree code for  $K$ .

**See Also** `colamd`, `colmmd`, `colperm`, `symamd`, `symrcm`

**References** [1] Gilbert, John R., Cleve Moler, and Robert Schreiber, "Sparse Matrices in MATLAB: Design and Implementation," *SIAM Journal on Matrix Analysis and Applications* 13, 1992, pp. 333-356.

**Purpose** Sparse reverse Cuthill-McKee ordering

**Syntax** `r = symrcm(S)`

**Description** `r = symrcm(S)` returns the symmetric reverse Cuthill-McKee ordering of  $S$ . This is a permutation  $r$  such that  $S(r, r)$  tends to have its nonzero elements closer to the diagonal. This is a good reordering for LU or Cholesky factorization of matrices that come from long, skinny problems. The ordering works for both symmetric and nonsymmetric  $S$ . For a real, symmetric sparse matrix,  $S$ , the eigenvalues of  $S(r, r)$  are the same as those of  $S$ , but `eig(S(r, r))` probably takes less time to compute than `eig(S)`.

**Algorithm** The algorithm first finds a pseudoperipheral vertex of the graph of the matrix. It then generates a level structure by breadth-first search and orders the vertices by decreasing distance from the pseudoperipheral vertex. The implementation is based closely on the SPARSPAK implementation described by George and Liu.

**Examples** The statement

```
B = bucky;
```

uses an M-file in the demos toolbox to generate the adjacency graph of a truncated icosahedron. This is better known as a soccer ball, a Buckminster Fuller geodesic dome (hence the name bucky), or, more recently, as a 60-atom carbon molecule. There are 60 vertices. The vertices have been ordered by numbering half of them from one hemisphere, pentagon by pentagon; then reflecting into the other hemisphere and gluing the two halves together. With this numbering, the matrix does not have a particularly narrow bandwidth, as the first spy plot shows

```
subplot(1,2,1), spy(B), title('B')
```

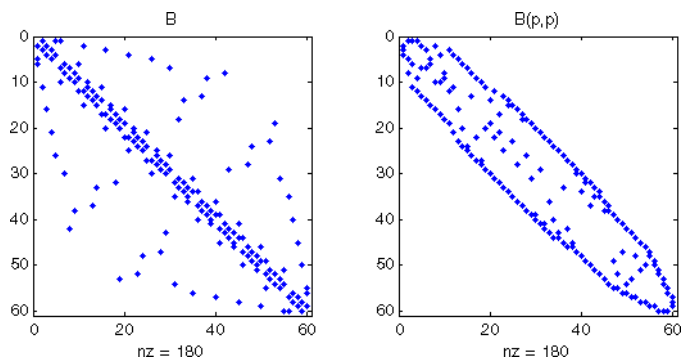
The reverse Cuthill-McKee ordering is obtained with



```
p = symrcm(B);
R = B(p,p);
```

The spy plot shows a much narrower bandwidth.

```
subplot(1,2,2), spy(R), title('B(p,p)')
```



This example is continued in the reference pages for symamd.

The bandwidth can also be computed with

```
[i,j] = find(B);
bw = max(i-j) + 1;
```

The bandwidths of B and R are 35 and 12, respectively.

## See Also

colamd, colperm, symamd

## References

[1] George, Alan and Joseph Liu, *Computer Solution of Large Sparse Positive Definite Systems*, Prentice-Hall, 1981.

[2] Gilbert, John R., Cleve Moler, and Robert Schreiber, "Sparse Matrices in MATLAB: Design and Implementation," *SIAM Journal on Matrix Analysis*, 1992. A slightly expanded version is also available as a technical report from the Xerox Palo Alto Research Center.

# symvar

---

**Purpose** Determine symbolic variables in expression

**Syntax** `symvar 'expr'`  
`s = symvar('expr')`

**Description** `symvar 'expr'` searches the expression, `expr`, for identifiers other than `i`, `j`, `pi`, `inf`, `nan`, `eps`, and common functions. `symvar` displays those variables that it finds or, if no such variable exists, displays an empty cell array, `{}`.

`s = symvar('expr')` returns the variables in a cell array of strings, `s`. If no such variable exists, `s` is an empty cell array.

**Examples** `symvar` finds variables `beta1` and `x`, but skips `pi` and the `cos` function.

```
symvar 'cos(pi*x - beta1)'
```

```
ans =
```

```
    'beta1'
```

```
    'x'
```

**See Also** `findstr`

**Purpose** Synchronize and resample two timeseries objects using common time vector

**Syntax** `[ts1 ts2] = synchronize(ts1,ts2,'SynchronizeMethod')`

**Description** `[ts1 ts2] = synchronize(ts1,ts2,'SynchronizeMethod')` creates two new timeseries objects by synchronizing `ts1` and `ts2` using a common time vector. The string `'SynchronizeMethod'` defines the method for synchronizing the timeseries and can be one of the following:

- `'Union'` — Resample timeseries objects using a time vector that is a union of the time vectors of `ts1` and `ts2` on the time range where the two time vectors overlap.
- `'Intersection'` — Resample timeseries objects on a time vector that is the intersection of the time vectors of `ts1` and `ts2`.
- `'Uniform'` — Requires an additional argument as follows:

```
[ts1 ts2] = synchronize(ts1,ts2,'Uniform','Interval',value)
```

This method resamples time series on a uniform time vector, where `value` specifies the time interval between the two samples. The uniform time vector is the overlap of the time vectors of `ts1` and `ts2`. The interval units are assumed to be the smaller units of `ts1` and `ts2`.

You can specify additional arguments by using property-value pairs:

- `'InterpMethod'`: Forces the specified interpolation method (over the default method) for this `synchronize` operation. Can be either a string, `'linear'` or `'zoh'`, or a `tsdata.interpolation` object that contains a user-defined interpolation method.
- `'QualityCode'`: Integer (between -128 and 127) used as the quality code for both time series after the synchronization.

# synchronize

---

- 'KeepOriginalTimes': Logical value (true or false) indicating whether the new time series should keep the original time values. For example,

```
ts1 = timeseries([1 2],[datestr(now); datestr(now+1)]);  
ts2 = timeseries([1 2],[datestr(now-1); datestr(now)]);
```

Note that `ts1.timeinfo.StartDate` is one day after `ts2.timeinfo.StartDate`. If you use

```
[ts1 ts2] = synchronize(ts1,ts2,'union');
```

the `ts1.timeinfo.StartDate` is changed to match `ts2.TimeInfo.StartDate` and `ts1.Time` changes to 1.

But if you use

```
[ts1 ts2] =  
synchronize(ts1,ts2,'union','KeepOriginalTimes',true);
```

`ts1.timeinfo.StartDate` is unchanged and `ts1.Time` is still 0.

- 'tolerance': Real number used as the tolerance for differentiating two time values when comparing the `ts1` and `ts2` time vectors. The default tolerance is  $1e-10$ . For example, when the sixth time value in `ts1` is  $5+(1e-12)$  and the sixth time value in `ts2` is  $5-(1e-13)$ , both values are treated as 5 by default. To differentiate those two times, you can set 'tolerance' to a smaller value such as  $1e-15$ , for example.

## See Also

`timeseries`

**Purpose**

Two ways to call MATLAB functions

**Description**

You can call MATLAB functions using either *command syntax* or *function syntax*, as described below.

**Command Syntax**

A function call in this syntax consists of the function name followed by one or more arguments separated by spaces:

```
functionname arg1 arg2 ... argn
```

Command syntax does not allow you to obtain any values that might be returned by the function. Attempting to assign output from the function to a variable using command syntax generates an error. Use function syntax instead.

Examples of command syntax:

```
save mydata.mat x y z
import java.awt.Button java.lang.String
```

Arguments are treated as string literals. See the examples below, under “Argument Passing” on page 2-3286.

**Function Syntax**

A function call in this syntax consists of the function name followed by one or more arguments separated by commas and enclosed in parentheses:

```
functionname(arg1, arg2, ..., argn)
```

You can assign the output of the function to one or more output values. When assigning to more than one output variable, separate the variables by commas or spaces and enclose them in square brackets ([ ]):

```
[out1,out2,...,outn] = functionname(arg1, arg2, ..., argn)
```

Examples of function syntax:

```
copyfile('srcfile', '..\mytests', 'writable')
[x1,x2,x3,x4] = deal(A{:})
```

Arguments are passed to the function by value. See the examples below, under “Argument Passing” on page 2-3286.

## Argument Passing

When calling a function using command syntax, MATLAB passes the arguments as string literals. When using function syntax, arguments are passed by value.

In the following example, assign a value to A and then call `disp` on the variable to display the value passed. Calling `disp` with command syntax passes the variable name, 'A':

```
A = pi;
disp A
A
```

while function syntax passes the value assigned to A:

```
A = pi;
disp(A)
3.1416
```

The next example passes two strings to `strcmp` for comparison. Calling the function with command syntax compares the variable names, 'str1' and 'str2':

```
str1 = 'one';    str2 = 'one';
strcmp str1 str2
ans =
    0           (unequal)
```

while function syntax compares the values assigned to the variables, 'one' and 'one':

```
str1 = 'one';    str2 = 'one';
strcmp(str1, str2)
```

```
ans =  
    1      (equal)
```

### Passing Strings

When using the function `syntax` to pass a string literal to a function, you must enclose the string in single quotes, ('string'). For example, to create a new directory called `myapptests`, use

```
mkdir('myapptests')
```

On the other hand, variables that contain strings do not need to be enclosed in quotes:

```
dirname = 'myapptests';  
mkdir(dirname)
```

### See Also

`mlint`

# system

---

**Purpose** Execute operating system command and return result

**Syntax** `system('command')`  
`[status, result] = system('command')`

**Description** `system('command')` calls upon the operating system to run `command`, for example `dir` or `ls` or a UNIX shell script, and directs the output to MATLAB. If `command` runs successfully, `ans` is 0. If `command` fails or does not exist on your operating system, `ans` is a nonzero value and an explanatory message appears.

`[status, result] = system('command')` calls upon the operating system to run `command`, and directs the output to MATLAB. If `command` runs successfully, `status` is 0 and `result` contains the output from `command`. If `command` fails or does not exist on your operating system, `status` is a nonzero value and `result` contains an explanatory message.

---

**Note** Running `system` on Windows with a command that relies on the current directory fails when the current directory is specified using a UNC pathname because DOS does not support UNC pathnames. When this happens, MATLAB returns the error:

```
??? Error using ==> system DOS commands may not be  
executed when the current directory is a UNC pathname.
```

To work around this limitation, change the directory to a mapped drive prior to running `system` or a function that calls `system`.

---

**Examples** On a Windows system, display the current directory by accessing the operating system.

```
[status currdir] = system('cd')  
status =  
    0  
currdir =
```



D:\work\matlab\test

**See Also**

! (bang), computer, dos, perl, unix, winopen

“Running External Programs” in the MATLAB Desktop Tools and Development Environment documentation

# tan

**Purpose** Tangent of argument in radians

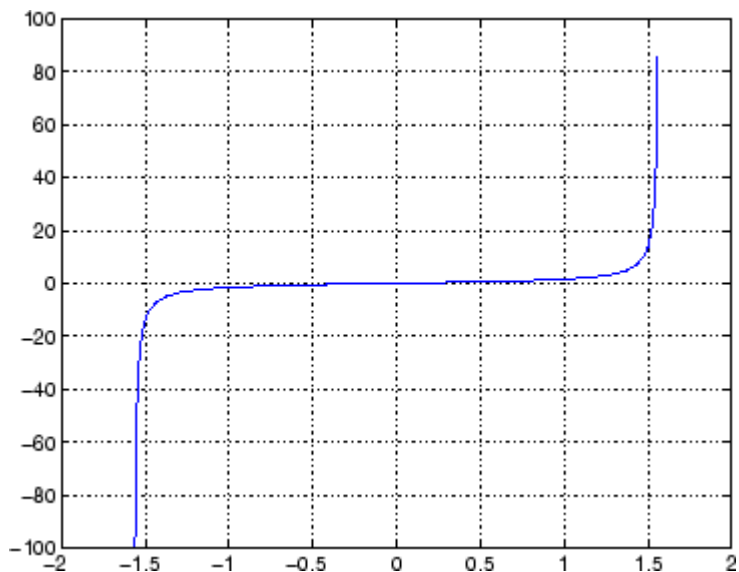
**Syntax**  $Y = \tan(X)$

**Description** The tan function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.

$Y = \tan(X)$  returns the circular tangent of each element of  $X$ .

**Examples** Graph the tangent function over the domain  $-\pi/2 < x < \pi/2$ .

```
x = (-pi/2)+0.01:0.01:(pi/2)-0.01;  
plot(x,tan(x)), grid on
```



The expression  $\tan(\pi/2)$  does not evaluate as infinite but as the reciprocal of the floating point accuracy  $\text{eps}$  since  $\pi$  is only a floating-point approximation to the exact value of  $\pi$ .

**Definition** The tangent can be defined as

---

$$\tan(z) = \frac{\sin(z)}{\cos(z)}$$

**Algorithm**

tan uses FDLIBM, which was developed at SunSoft, a Sun Microsystems, Inc. business, by Kwok C. Ng, and others. For information about FDLIBM, see <http://www.netlib.org>.

**See Also**

tand, tanh, atan, atan2, atand, atanh

# tand

---

**Purpose** Tangent of argument in degrees

**Syntax**  $Y = \text{tand}(X)$

**Description**  $Y = \text{tand}(X)$  is the tangent of the elements of  $X$ , expressed in degrees. For odd integers  $n$ ,  $\text{tand}(n*90)$  is infinite, whereas  $\tan(n*\pi/2)$  is large but finite, reflecting the accuracy of the floating point value of  $\pi$ .

**See Also** `tan`, `tanh`, `atan`, `atan2`, `atand`, `atanh`

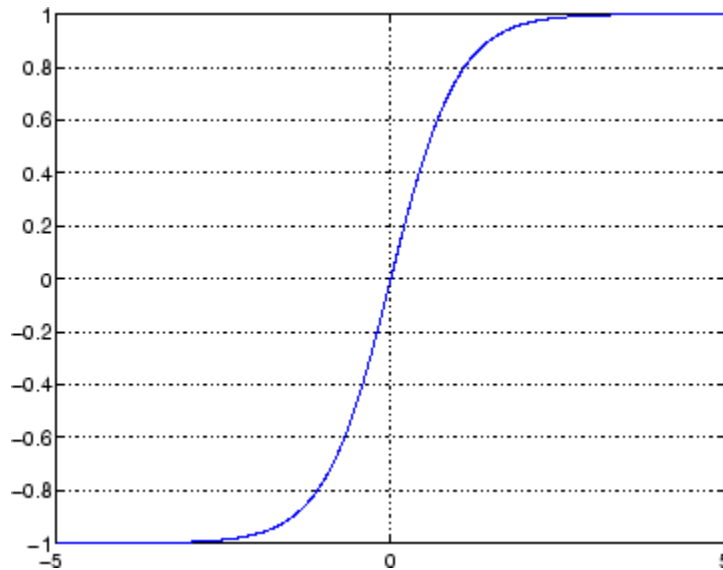
**Purpose** Hyperbolic tangent

**Syntax**  $Y = \tanh(X)$

**Description** The tanh function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.  $Y = \tanh(X)$  returns the hyperbolic tangent of each element of  $X$ .

**Examples** Graph the hyperbolic tangent function over the domain  $-5 \leq x \leq 5$ .

```
x = -5:0.01:5;  
plot(x,tanh(x)), grid on
```



**Definition** The hyperbolic tangent can be defined as

$$\tanh(z) = \frac{\sinh(z)}{\cosh(z)}$$

# tanh

---

## **Algorithm**

tanh uses FDLIBM, which was developed at SunSoft, a Sun Microsystems, Inc. business, by Kwok C. Ng, and others. For information about FDLIBM, see <http://www.netlib.org>.

## **See Also**

atan, atan2, tan

**Purpose** Compress files into tar file

**Syntax**

```
tar(tarfilename,files)
tar(tarfilename,files,rootdir)
entrynames = tar(...)
```

**Description** `tar(tarfilename,files)` creates a tar file with the name `tarfilename` from the list of files and directories specified in `files`. Relative paths are stored in the tar file, but absolute paths are not. Directories recursively include all of their content.

`tarfilename` is a string specifying the name of the tar file. The `.tar` extension is appended to `tarfilename` if omitted. The `tarfilename` extension can end in `.tgz` or `.gz`. In this case, `tarfilename` is gzipped.

`files` is a string or cell array of strings containing the list of files or directories included in `tarfilename`. Individual files that are on the MATLAB path can be specified as partial pathnames. Otherwise an individual file can be specified relative to the current directory or with an absolute path. Directories must be specified relative to the current directory or with absolute paths. On UNIX systems, directories can also start with `~/` or `~username/`, which expands to the current user's home directory or the specified user's home directory, respectively. The wildcard character `*` can be used when specifying files or directories, except when relying on the MATLAB path to resolve a filename or partial pathname.

`tar(tarfilename,files,rootdir)` allows the path for `files` to be specified relative to `rootdir` rather than the current directory.

`entrynames = tar(...)` returns a string cell array of the relative path entry names contained in `tarfilename`.

**Example** Tar all files in the current directory to the file `backup.tgz`:

```
tar('backup.tgz','.');
```

**See Also** `gzip`, `gunzip`, `untar`, `unzip`, `zip`

# tempdir

---

|                    |                                                                                                                                                                                                                        |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Name of system's temporary directory                                                                                                                                                                                   |
| <b>Syntax</b>      | <code>tmp_dir = tempdir</code>                                                                                                                                                                                         |
| <b>Description</b> | <code>tmp_dir = tempdir</code> returns the name of the system's temporary directory, if one exists. This function does not create a new directory. See "Opening Temporary Files and Directories" for more information. |
| <b>See Also</b>    | <code>tempname</code>                                                                                                                                                                                                  |



**Purpose** Unique name for temporary file

**Syntax** `tmp_nam = tempname`

**Description** `tmp_nam = tempname` returns a unique string, `tmp_nam`, suitable for use as a temporary filename.

---

**Note** The filename that `tempname` generates is not guaranteed to be unique; however, it is likely to be so.

---

See “Opening Temporary Files and Directories” for more information.

**See Also** `tempdir`

# tetramesh

---

**Purpose** Tetrahedron mesh plot

**Syntax**

```
tetramesh(T,X,c)
tetramesh(T,X)
h = tetramesh(...)
tetramesh(...,'param','value','param','value'...)
```

**Description** `tetramesh(T,X,c)` displays the tetrahedrons defined in the  $m$ -by-4 matrix  $T$  as mesh.  $T$  is usually the output of `delaunayn`. A row of  $T$  contains indices into  $X$  of the vertices of a tetrahedron.  $X$  is an  $n$ -by-3 matrix, representing  $n$  points in 3 dimension. The tetrahedron colors are defined by the vector  $C$ , which is used as indices into the current colormap.

---

**Note** If  $T$  is the output of `delaunay3`, then  $X$  is the concatenation of the `delaunay3` input arguments  $x$ ,  $y$ ,  $z$  interpreted as column vectors, i.e.,  $X = [x(:) \ y(:) \ z(:)]$ .

---

`tetramesh(T,X)` uses  $C = 1:m$  as the color for the  $m$  tetrahedrons. Each tetrahedron has a different color (modulo the number of colors available in the current colormap).

`h = tetramesh(...)` returns a vector of tetrahedron handles. Each element of  $h$  is a handle to the set of patches forming one tetrahedron. You can use these handles to view a particular tetrahedron by turning the patch 'Visible' property 'on' or 'off'.

`tetramesh(...,'param','value','param','value'...)` allows additional patch property name/property value pairs to be used when displaying the tetrahedrons. For example, the default transparency parameter is set to 0.9. You can overwrite this value by using the property name/property value pair ('FaceAlpha',value) where value is a number between 0 and 1. See Patch Properties for information about the available properties.

**Examples**

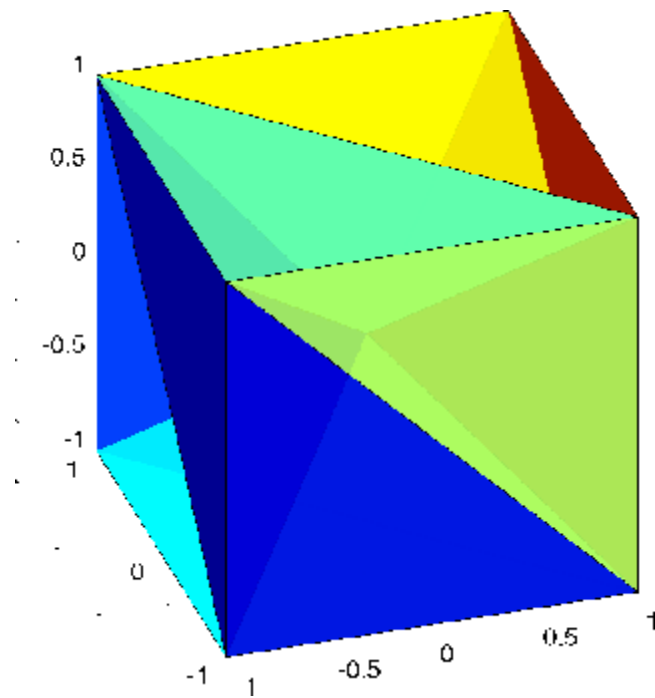
Generate a 3-dimensional Delaunay tessellation, then use tetramesh to visualize the tetrahedrons that form the corresponding simplex.

```
d = [-1 1];  
[x,y,z] = meshgrid(d,d,d); % A cube  
x = [x(:);0];  
y = [y(:);0];  
z = [z(:);0];  
% [x,y,z] are corners of a cube plus the center.  
X = [x(:) y(:) z(:)];  
Tes = delaunayn(X)
```

```
Tes =  
  9  1  5  6  
  3  9  1  5  
  2  9  1  6  
  2  3  9  4  
  2  3  9  1  
  7  9  5  6  
  7  3  9  5  
  8  7  9  6  
  8  2  9  6  
  8  2  9  4  
  8  3  9  4  
  8  7  3  9  
tetramesh(Tes,X);camorbit(20,0)
```

# tetramesh

---



## See Also

`delaunay`, `patch`, `Patch Properties`, `trimesh`, `trisurf`

**Purpose** Produce TeX format from character string

**Syntax** `texlabel(f)`  
`texlabel(f, 'literal')`

**Description** `texlabel(f)` converts the MATLAB expression `f` into the TeX equivalent for use in text strings. It processes Greek variable names (e.g., `lambda`, `delta`, etc.) into a string that is displayed as actual Greek letters.

`texlabel(f, 'literal')` prints Greek variable names as literals.

If the string is too long to fit into a figure window, then the center of the expression is replaced with a tilde ellipsis (`~~~`).

**Examples** You can use `texlabel` as an argument to the `title`, `xlabel`, `ylabel`, `zlabel`, and `text` commands. For example,

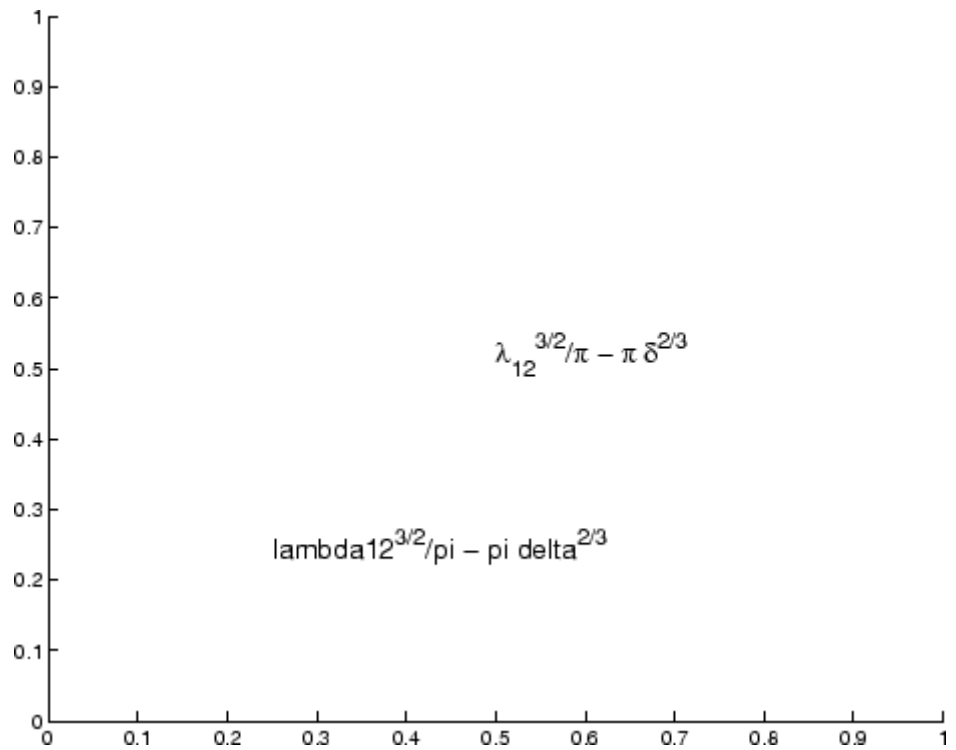
```
title(texlabel('sin(sqrt(x^2 + y^2))/sqrt(x^2 + y^2)'))
```

By default, `texlabel` translates Greek variable names to the equivalent Greek letter. You can select literal interpretation by including the `literal` argument. For example, compare these two commands.

```
text(.5,.5,...
      texlabel('lambda12^(3/2)/pi - pi*delta^(2/3)'))
text(.25,.25,...
      texlabel('lambda12^(3/2)/pi - pi*delta^(2/3)', 'literal'))
```

# textlabel

---



## See Also

text, title, xlabel, ylabel, zlabel, the text String property  
“Annotating Plots” on page 1-87 for related functions

**Purpose**

Create text object in current axes

**Syntax**

```
text(x,y,'string')
text(x,y,z,'string')
text(x,y,z,'string','PropertyName',PropertyValue....)
text('PropertyName',PropertyValue....)
h = text(...)
```

**Description**

`text` is the low-level function for creating text graphics objects. Use `text` to place character strings at specified locations.

`text(x,y,'string')` adds the string in quotes to the location specified by the point  $(x,y)$ .

`text(x,y,z,'string')` adds the string in 3-D coordinates.

`text(x,y,z,'string','PropertyName',PropertyValue....)` adds the string in quotes to the location defined by the coordinates and uses the values for the specified text properties. See the text property list section at the end of this page for a list of text properties.

`text('PropertyName',PropertyValue....)` omits the coordinates entirely and specifies all properties using property name/property value pairs.

`h = text(...)` returns a column vector of handles to text objects, one handle per object. All forms of the `text` function optionally return this output argument.

See the String property for a list of symbols, including Greek letters.

**Remarks****Position Text Within the Axes**

The default text units are the units used to plot data in the graph. Specify the text location coordinates (the  $x$ ,  $y$ , and  $z$  arguments) in the data units of the current graph (see “Example”). You can use other units to position the text by set the text `Units` property to `normalized` or one of the nonrelative units (pixels, inches, centimeters, points).

Note that the Axes Units property controls the positioning of the Axes within the figure and is not related to the axes data units used for graphing.

The Extent, VerticalAlignment, and HorizontalAlignment properties control the positioning of the character string with regard to the text location point.

If the coordinates are vectors, text writes the string at all locations defined by the list of points. If the character string is an array the same length as x, y, and z, text writes the corresponding row of the string array at each point specified.

## Multiline Text

When specifying strings for multiple text objects, the string can be

- A cell array of strings
- A padded string matrix

Each element of the specified string array creates a different text object.

When specifying the string for a single text object, cell arrays of strings and padded string matrices result in a text object with a multiline string, while vertical slash characters are not interpreted as separators and result in a single line string containing vertical slashes.

## Behavior of the Text Function

text is a low-level function that accepts property name/property value pairs as input arguments. However, the convenience form,

```
text(x,y,z,'string')
```

is equivalent to

```
text('Position',[x,y,z],'String','string')
```

You can specify other properties only as property name/property value pairs. See the text property list at the end of this page for a description



---

of each property. You can specify properties as property name/property value pairs, structure arrays, and cell arrays (see the `set` and `get` reference pages for examples of how to specify these data types).

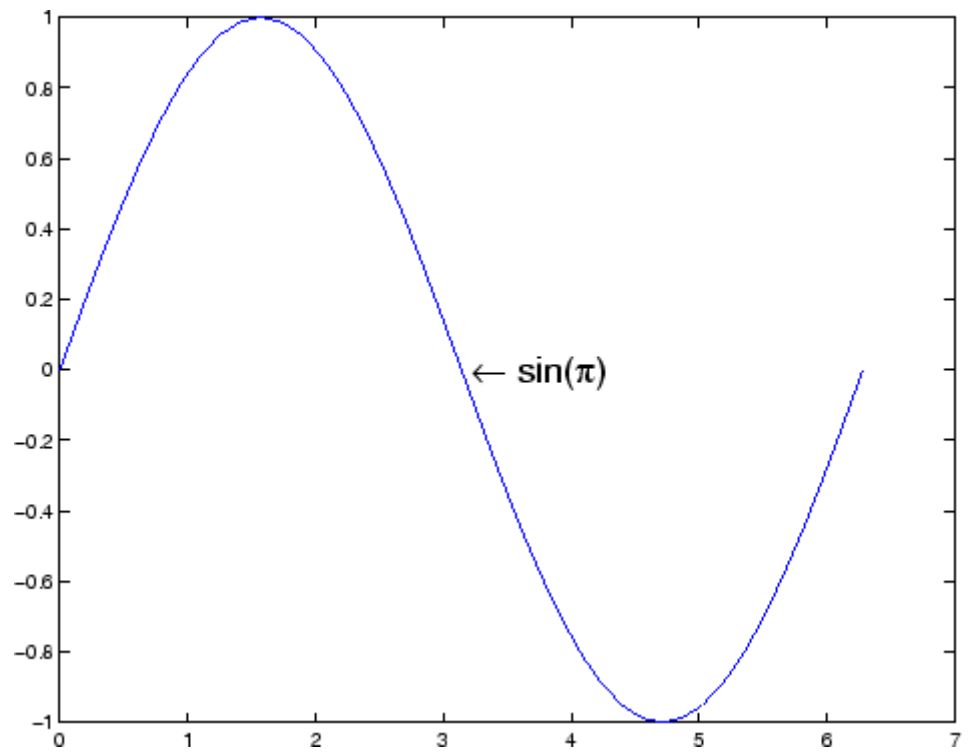
`text` does not respect the setting of the figure or axes `NextPlot` property. This allows you to add text objects to an existing axes without setting `hold` to on.

## Examples

The statements

```
plot(0:pi/20:2*pi,sin(0:pi/20:2*pi))
text(pi,0,' \leftarrow sin(\pi)', 'FontSize',18)
```

annotate the point at  $(\pi,0)$  with the string  $\sin(\pi)$



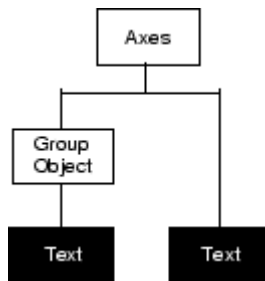
The statement

```
text(x,y,'\ite^{i\omega\tau} = cos(\omega\tau) + i sin(\omega\tau)')
```

uses embedded TeX sequences to produce

$$e^{i\omega\tau} = \cos(\omega\tau) + i \sin(\omega\tau)$$

## Object Hierarchy



### Setting Default Properties

You can set default text properties on the axes, figure, and root levels:

```
set(0, 'DefaulttextProperty', PropertyValue...)  
set(gcf, 'DefaulttextProperty', PropertyValue...)  
set(gca, 'DefaulttextProperty', PropertyValue...)
```

Where *Property* is the name of the text property and *PropertyValue* is the value you are specifying. Use `set` and `get` to access text properties.

### See Also

`annotation`, `gtext`, `int2str`, `num2str`, `title`, `xlabel`, `ylabel`, `zlabel`, `strings`

“Object Creation Functions” on page 1-94 for related functions

Text Properties for property descriptions

# Text Properties

---

## Purpose

Text properties

## Modifying Properties

You can set and query graphics object properties using the property editor or the set and get commands.

- The Property Editor is an interactive tool that enables you to see and change object property values.
- The set and get commands enable you to set and query the values of properties.

To change the default values of properties, see [Setting Default Property Values](#).

See [Core Objects](#) for general information about this type of object.

## Text Property Descriptions

This section lists property names along with the types of values each accepts. Curly braces { } enclose default values.

Annotation

hg.Annotation object Read Only

*Control the display of text objects in legends.* The Annotation property enables you to specify whether this text object is represented in a figure legend.

Querying the Annotation property returns the handle of an hg.Annotation object. The hg.Annotation object has a property called LegendInformation, which contains an hg.LegendEntry object.

Once you have obtained the hg.LegendEntry object, you can set its IconDisplayStyle property to control whether the text object is displayed in a figure legend:

| IconDisplayStyle Value | Purpose                                              |
|------------------------|------------------------------------------------------|
| on                     | Represent this text object in a legend (default)     |
| off                    | Do not include this text object in a legend          |
| children               | Same as on because text objects do not have children |

## Setting the IconDisplayStyle property

These commands set the `IconDisplayStyle` of a graphics object with handle `hobj` to `off`:

```
hAnnotation = get(hobj,'Annotation');  
hLegendEntry = get(hAnnotation,'LegendInformation');  
set(hLegendEntry,'IconDisplayStyle','off')
```

## Using the IconDisplayStyle property

See “Controlling Legends” for more information and examples.

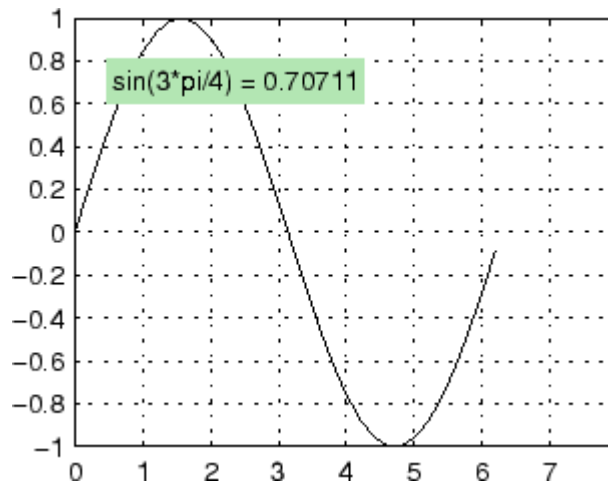
`BackgroundColor`  
`ColorSpec | {none}`

*Color of text extent rectangle.* This property enables you to define a color for the rectangle that encloses the text `Extent` plus the text `Margin`. For example, the following code creates a text object that labels a plot and sets the background color to light green.

```
text(3*pi/4,sin(3*pi/4),...  
 ['sin(3*pi/4) = ',num2str(sin(3*pi/4))],...  
 'HorizontalAlignment','center',...  
 'BackgroundColor',[.7 .9 .7]);
```

# Text Properties

---



For additional features, see the following properties:

- `EdgeColor` — Color of the rectangle's edge (none by default).
- `LineStyle` — Style of the rectangle's edge line (first set `EdgeColor`)
- `LineWidth` — Width of the rectangle's edge line (first set `EdgeColor`)
- `Margin` — Increase the size of the rectangle by adding a margin to the existing text extent rectangle. This margin is added to the text extent rectangle to define the text background area that is enclosed by the `EdgeColor` rectangle. Note that the text extent does not change when you change the margin; only the rectangle displayed when you set the `EdgeColor` property and the area defined by the `BackgroundColor` change.

See also [Drawing Text in a Box](#) in the MATLAB Graphics documentation for an example using background color with contour labels.

`BeingDeleted`  
on | {off} read only

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to `on` when the object's delete function callback is called (see the `DeleteFcn` property). It remains set to `on` while the delete function executes, after which the object no longer exists.

For example, an object's delete function might call other functions that act on a number of different objects. These functions may not need to perform actions on objects that are going to be deleted, and therefore can check the object's `BeingDeleted` property before acting.

`BusyAction`  
`cancel | {queue}`

*Callback routine interruption.* The `BusyAction` property enables you to control how MATLAB handles events that potentially interrupt executing callback routines. If there is a callback routine executing, callback routines invoked subsequently always attempt to interrupt it. If the `Interruptible` property of the object whose callback is executing is set to `on` (the default), then interruption occurs at the next point where the event queue is processed. If the `Interruptible` property is set to `off`, the `BusyAction` property (of the object owning the executing callback) determines how MATLAB handles the event. The choices are

- `cancel` — Discard the event that attempted to execute a second callback routine.
- `queue` — Queue the event that attempted to execute a second callback routine until the current callback finishes.

`ButtonDownFcn`  
functional handle, cell array containing function handle and additional arguments, or string (not recommended)

## Text Properties

---

*Button press callback function.* A callback function that executes whenever you press a mouse button while the pointer is over the text object.

See the figure's `SelectionType` property to determine if modifier keys were also pressed.

Set this property to a function handle that references the callback. The function must define at least two input arguments (handle of object associated with the button down event and an event structure, which is empty for this property). For example, the following function takes different action depending on what type of selection was made:

```
function button_down(src, evnt)
% src - the object that is the source of the event
% evnt - empty for this property
    sel_typ = get(gcf, 'SelectionType')
    switch sel_typ
        case 'normal'
            disp('User clicked left-mouse button')
            set(src, 'Selected', 'on')
        case 'extend'
            disp('User did a shift-click')
            set(src, 'Selected', 'on')
        case 'alt'
            disp('User did a control-click')
            set(src, 'Selected', 'on')
            set(src, 'SelectionHighlight', 'off')
    end
end
```

Suppose `h` is the handle of a text object and that the `button_down` function is on your MATLAB path. The following statement assigns the function above to the `ButtonDownFcn`:

```
set(h, 'ButtonDownFcn', @button_down)
```



See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## Children

matrix (read only)

The empty matrix; text objects have no children.

## Clipping

on | {off}

*Clipping mode.* When Clipping is on, MATLAB does not display any portion of the text that is outside the axes.

## Color

ColorSpec

*Text color.* A three-element RGB vector or one of the predefined names, specifying the text color. The default value for Color is white. See ColorSpec for more information on specifying color.

## CreateFcn

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Callback function executed during object creation.* A callback function that executes when MATLAB creates a text object. You must define this property as a default value for text or in a call to the text function that creates a new text object. For example, the statement

```
set(0, 'DefaultTextCreateFcn', @text_create)
```

defines a default value on the root level that sets the figure Pointer property to crosshairs whenever you create a text object. The callback function must be on your MATLAB path when you execute the above statement.

```
function text_create(src, evnt)
```

# Text Properties

---

```
% src - the object that is the source of the event
% evnt - empty for this property
set(gcf,'Pointer','crosshair')
end
```

MATLAB executes this function after setting all text properties. Setting this property on an existing text object has no effect. The function must define at least two input arguments (handle of object created and an event structure, which is empty for this property).

The handle of the object whose `CreateFcn` is being executed is passed by MATLAB as the first argument to the callback function and is also accessible through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## DeleteFcn

functional handle, cell array containing function handle and additional arguments, or string (not recommended)

*Delete text callback function.* A callback function that executes when you delete the text object (e.g., when you issue a `delete` command or clear the axes `cla` or figure `clf`). For example, the following function displays object property data before the object is deleted.

```
function delete_fcn(src,evnt)
% src - the object that is the source of the event
% evnt - empty for this property
    obj_tp = get(src,'Type');
    disp([obj_tp, ' object deleted'])
    disp('Its user data is:')
    disp(get(src,'UserData'))
end
```

MATLAB executes the function before deleting the object's properties so these values are available to the callback function. The function must define at least two input arguments (handle of object being deleted and an event structure, which is empty for this property)

The handle of the object whose `DeleteFcn` is being executed is passed by MATLAB as the first argument to the callback function and is also accessible through the root `CallbackObject` property, which you can query using `gcbo`.

See [Function Handle Callbacks](#) for information on how to use function handles to define the callback function.

### `DisplayName`

string (default is empty string)

*String used by legend for this text object.* The legend function uses the string defined by the `DisplayName` property to label this text object in the legend.

- If you specify string arguments with the legend function, `DisplayName` is set to this text object's corresponding string and that string is used for the legend.
- If `DisplayName` is empty, legend creates a string of the form, `['data' n]`, where `n` is the number assigned to the object based on its location in the list of legend entries. However, legend does not set `DisplayName` to this string.
- If you edit the string directly in an existing legend, `DisplayName` is set to the edited string.
- If you specify a string for the `DisplayName` property and create the legend using the figure toolbar, then MATLAB uses the string defined by `DisplayName`.
- To add programmatically a legend that uses the `DisplayName` string, call `legend` with the `toggle` or `show` option.

# Text Properties

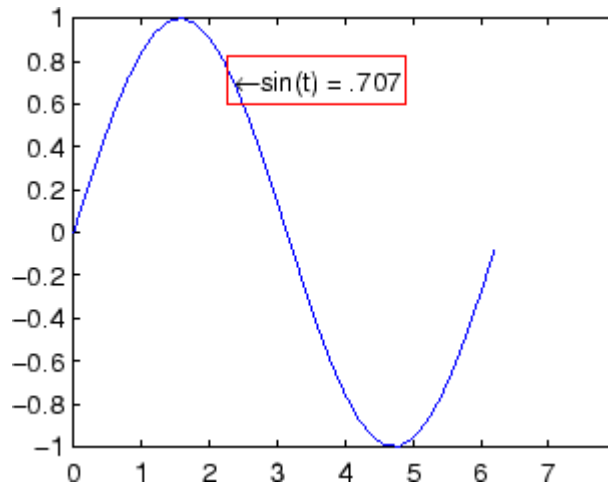
---

See “Controlling Legends” for more examples.

EdgeColor  
ColorSpec | {none}

*Color of edge drawn around text extent rectangle plus margin.* This property enables you to specify the color of a box drawn around the text Extent plus the text Margin. For example, the following code draws a red rectangle around text that labels a plot.

```
text(3*pi/4,sin(3*pi/4),...  
'\leftarrow sin(t) = .707',...  
'EdgeColor','red');
```



For additional features, see the following properties:

- BackgroundColor — Color of the rectangle’s interior (none by default)
- LineStyle — Style of the rectangle’s edge line (first set EdgeColor)
- LineWidth — Width of the rectangle’s edge line (first set EdgeColor)

- **Margin** — Increases the size of the rectangle by adding a margin to the area defined by the text extent rectangle. This margin is added to the text extent rectangle to define the text background area that is enclosed by the `EdgeColor` rectangle. Note that the text extent does not change when you change the margin; only the rectangle displayed when you set the `EdgeColor` property and the area defined by the `BackgroundColor` change.

## Editing

on | {off}

*Enable or disable editing mode.* When this property is set to the default off, you cannot edit the text string interactively (i.e., you must change the `String` property to change the text). When this property is set to on, MATLAB places an insert cursor at the end of the text string and enables editing. To apply the new text string,

- 1 Press the **Esc** key.
- 2 Click in any figure window (including the current figure).
- 3 Reset the `Editing` property to off.

MATLAB then updates the `String` property to contain the new text and resets the `Editing` property to off. You must reset the `Editing` property to on to resume editing.

## EraseMode

{normal} | none | xor | background

*Erase mode.* This property controls the technique MATLAB uses to draw and erase text objects. Alternative erase modes are useful for creating animated sequences where controlling the way individual objects are redrawn is necessary to improve performance and obtain the desired effect.

# Text Properties

---

- `normal` — Redraw the affected region of the display, performing the three-dimensional analysis necessary to ensure that all objects are rendered correctly. This mode produces the most accurate picture, but is the slowest. The other modes are faster, but do not perform a complete redraw and are therefore less accurate.
- `none` — Do not erase the text when it is moved or destroyed. While the object is still visible on the screen after erasing with `EraseMode none`, you cannot print it because MATLAB stores no information about its former location.
- `xor` — Draw and erase the text by performing an exclusive OR (XOR) with each pixel index of the screen beneath it. When the text is erased, it does not damage the objects beneath it. However, when text is drawn in `xor` mode, its color depends on the color of the screen beneath it. It is correctly colored only when it is over axes background `Color`, or the figure background `Color` if the axes `Color` is set to `none`.
- `background` — Erase the text by drawing it in the axes background `Color`, or the figure background `Color` if the axes `Color` is set to `none`. This damages objects that are behind the erased text, but text is always properly colored.

## Printing with Nonnormal Erase Modes

MATLAB always prints figures as if the `EraseMode` of all objects is set to `normal`. This means graphics objects created with `EraseMode` set to `none`, `xor`, or `background` can look differently on screen than on paper. On screen, MATLAB may mathematically combine layers of colors (e.g., performing an XOR of a pixel color with that of the pixel behind it) and ignore three-dimensional sorting to obtain greater rendering speed. However, these techniques are not applied to the printed output.

You can use the MATLAB `getframe` command or other screen capture application to create an image of a figure containing nonnormal mode objects.

## Extent

position rectangle (read only)

*Position and size of text.* A four-element read-only vector that defines the size and position of the text string

```
[left,bottom,width,height]
```

If the Units property is set to data (the default), left and bottom are the  $x$ - and  $y$ -coordinates of the lower left corner of the text Extent.

For all other values of Units, left and bottom are the distance from the lower left corner of the axes position rectangle to the lower left corner of the text Extent. width and height are the dimensions of the Extent rectangle. All measurements are in units specified by the Units property.

FontAngle

```
{normal} | italic | oblique
```

*Character slant.* MATLAB uses this property to select a font from those available on your particular system. Generally, setting this property to italic or oblique selects a slanted font.

FontName

A name, such as Courier, or the string FixedWidth

*Font family.* A string specifying the name of the font to use for the text object. To display and print properly, this must be a font that your system supports. The default font is Helvetica.

## Specifying a Fixed-Width Font

If you want text to use a fixed-width font that looks good in any locale, you should set FontName to the string FixedWidth:

```
set(text_handle,'FontName','FixedWidth')
```

This eliminates the need to hard-code the name of a fixed-width font, which may not display text properly on systems that do not use ASCII character encoding (such as in Japan where multibyte character sets

# Text Properties

---

are used). A properly written MATLAB application that needs to use a fixed-width font should set `FontName` to `FixedWidth` (note that this string is case sensitive) and rely on `FixedWidthFontName` to be set correctly in the end user's environment.

End users can adapt a MATLAB application to different locales or personal environments by setting the root `FixedWidthFontName` property to the appropriate value for that locale from `startup.m`.

Note that setting the root `FixedWidthFontName` property causes an immediate update of the display to use the new font.

## FontSize

size in `FontUnits`

*Font size.* A value specifying the font size to use for text in units determined by the `FontUnits` property. The default point size is 10 (1 point = 1/72 inch).

## FontWeight

light | {normal} | demi | bold

*Weight of text characters.* MATLAB uses this property to select a font from those available on your particular system. Generally, setting this property to bold or demi causes MATLAB to use a bold font.

## FontUnits

{points} | normalized | inches |  
centimeters | pixels

*Font size units.* MATLAB uses this property to determine the units used by the `FontSize` property. Normalized units interpret `FontSize` as a fraction of the height of the parent axes. When you resize the axes, MATLAB modifies the screen `FontSize` accordingly. pixels, inches, centimeters, and points are absolute units (1 point = 1/72 inch).



Note that if you are setting both the `FontSize` and the `FontUnits` in one function call, you must set the `FontUnits` property first so that MATLAB can correctly interpret the specified `FontSize`.

## `HandleVisibility`

`{on} | callback | off`

*Control access to object's handle by command-line users and GUIs.* This property determines when an object's handle is visible in its parent's list of children. `HandleVisibility` is useful for preventing command-line users from accidentally drawing into or deleting a figure that contains only user interface devices (such as a dialog box).

Handles are always visible when `HandleVisibility` is set to `on`.

Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.

Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

When a handle is not visible in its parent's list of children, it cannot be returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`.

When a handle's visibility is restricted using `callback` or `off`,

- The object's handle does not appear in its parent's `Children` property.

# Text Properties

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- Figures do not appear in the root's `CurrentFigure` property.
- Objects do not appear in the root's `CallbackObject` property or in the figure's `CurrentObject` property.
- Axes do not appear in their parent's `CurrentAxes` property.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible regardless of their `HandleVisibility` settings (this does not affect the values of the `HandleVisibility` properties).

Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

`HitTest`  
`{on} | off`

*Selectable by mouse click.* `HitTest` determines if the text can become the current object (as returned by the `gco` command and the figure `CurrentObject` property) as a result of a mouse click on the text. If `HitTest` is set to `off`, clicking the text selects the object below it (which is usually the axes containing it).

For example, suppose you define the button down function of an image (see the `ButtonDownFcn` property) to display text at the location you click with the mouse.

First define the callback routine.

```
function bd_function
pt = get(gca,'CurrentPoint');
text(pt(1,1),pt(1,2),pt(1,3),...
    '{\fontsize{20}\oplus} The spot to label',...
    'HitTest','off')
```

Now display an image, setting its `ButtonDownFcn` property to the callback routine.

```
load earth
image(X, 'ButtonDownFcn', 'bd_function'); colormap(map)
```

When you click the image, MATLAB displays the text string at that location. With `HitTest` set to `off`, existing text cannot intercept any subsequent button down events that occur over the text. This enables the image's button down function to execute.

`HorizontalAlignment`  
{left} | center | right

*Horizontal alignment of text.* This property specifies the horizontal justification of the text string. It determines where MATLAB places the string with regard to the point specified by the `Position` property. The following picture illustrates the alignment options.

`HorizontalAlignment` viewed with the `VerticalAlignment` set to `middle` (the default).



See the `Extent` property for related information.

`Interpreter`  
latex | {tex} | none

*Interpret  $T_E X$  instructions.* This property controls whether MATLAB interprets certain characters in the `String` property as  $T_E X$  instructions (default) or displays all characters literally. The options are:

- `latex` — Supports the full  $L_A T_E X$  markup language.
- `tex` — Supports a subset of plain  $T_E X$  markup language. See the `String` property for a list of supported  $T_E X$  instructions.

# Text Properties

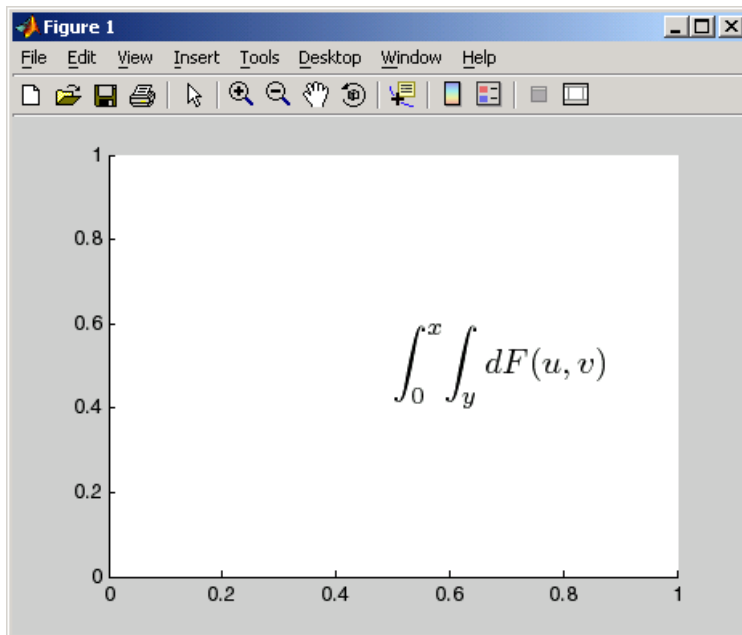
---

- none — Displays literal characters.

## Latex Interpreter

To enable the LaTeX interpreter for text objects, set the Interpreter property to `latex`. For example, the following statement displays an equation in a figure at the point `[.5 .5]`, and enlarges the font to 16 points.

```
text('Interpreter','latex',...  
    'String','$$\int_0^x \int_y dF(u,v)$$',...  
    'Position',[.5 .5],...  
    'FontSize',16)
```



## Information About Using TEX

The following references may be useful to people who are not familiar with T<sub>E</sub>X.

- Donald E. Knuth, *The T<sub>E</sub>Xbook*, Addison Wesley, 1986.
- The T<sub>E</sub>X Users Group home page: <http://www.tug.org>

## Interruptible

{on} | off

*Callback routine interruption mode.* The Interruptible property controls whether a text callback routine can be interrupted by subsequently invoked callback routines. Text objects have three properties that define callback routines: ButtonDownFcn, CreateFcn, and DeleteFcn. See the BusyAction property for information on how MATLAB executes callback routines.

## LineStyle

{-} | -- | : | -. | none

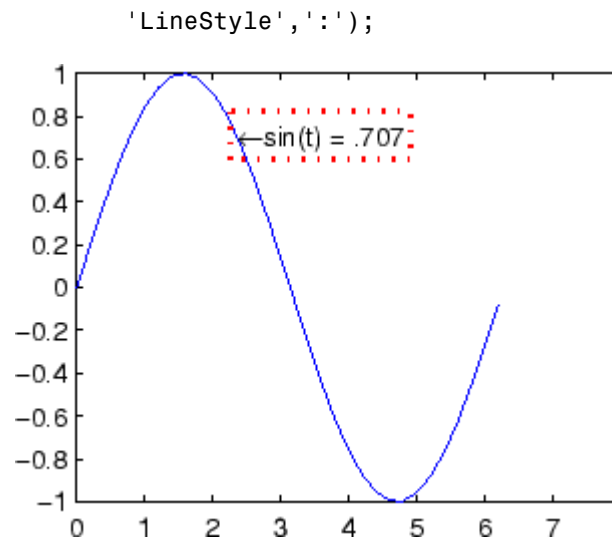
*Edge line type.* This property determines the line style used to draw the edges of the text Extent. The available line styles are shown in the following table.

| Symbol | Line Style           |
|--------|----------------------|
| -      | Solid line (default) |
| --     | Dashed line          |
| :      | Dotted line          |
| -.     | Dash-dot line        |
| none   | No line              |

For example, the following code draws a red rectangle with a dotted line style around text that labels a plot.

```
text(3*pi/4,sin(3*pi/4),...  
    '\leftarrow sin(t) = .707',...  
    'EdgeColor','red',...  
    'LineWidth',2,...
```

# Text Properties



For additional features, see the following properties:

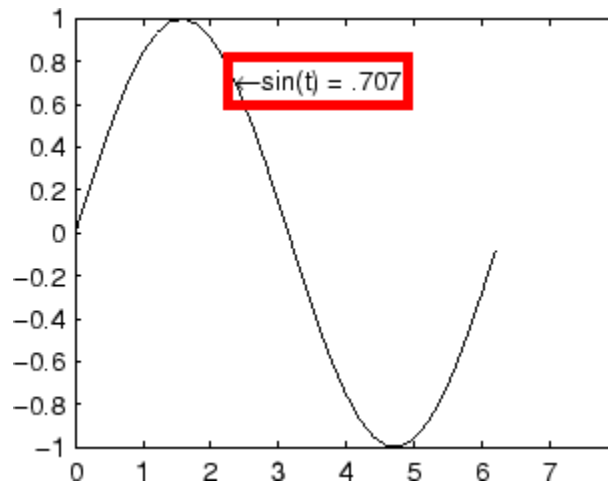
- `BackgroundColor` — Color of the rectangle's interior (none by default)
- `EdgeColor` — Color of the rectangle's edge (none by default)
- `LineWidth` — Width of the rectangle's edge line (first set `EdgeColor`)
- `Margin` — Increases the size of the rectangle by adding a margin to the existing text extent rectangle. This margin is added to the text extent rectangle to define the text background area that is enclosed by the `EdgeColor` rectangle. Note that the text extent does not change when you change the margin; only the rectangle displayed when you set the `EdgeColor` property and the area defined by the `BackgroundColor` change.

`LineWidth`  
scalar (points)

*Width of line used to draw text extent rectangle. When you set the text `EdgeColor` property to a color (the default is none), MATLAB*

displays a rectangle around the text Extent. Use the LineWidth property to specify the width of the rectangle edge. For example, the following code draws a red rectangle around text that labels a plot and specifies a line width of 3 points:

```
text(3*pi/4,sin(3*pi/4),...  
'\leftarrow sin(t) = .707',...  
'EdgeColor','red',...  
'LineWidth',3);
```



For additional features, see the following properties:

- BackgroundColor — Color of the rectangle's interior (none by default)
- EdgeColor — Color of the rectangle's edge (none by default)
- LineStyle — Style of the rectangle's edge line (first set EdgeColor)
- Margin — Increases the size of the rectangle by adding a margin to the existing text extent rectangle. This margin is added to the text extent rectangle to define the text background area that is enclosed by the EdgeColor rectangle. Note that the text extent does not change when you change the margin; only the rectangle displayed

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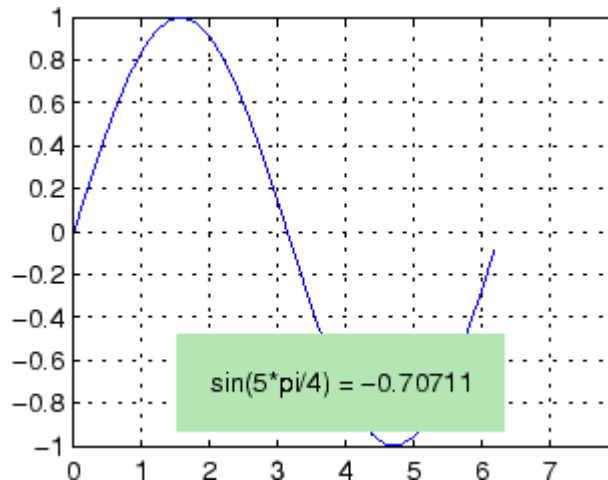
when you set the `EdgeColor` property and the area defined by the `BackgroundColor` change.

Margin

scalar (pixels)

*Distance between the text extent and the rectangle edge.* When you specify a color for the `BackgroundColor` or `EdgeColor` text properties, MATLAB draws a rectangle around the area defined by the text `Extent` plus the value specified by the `Margin`. For example, the following code displays a light green rectangle with a 10-pixel margin.

```
text(5*pi/4,sin(5*pi/4),...  
    ['sin(5*pi/4) = ',num2str(sin(5*pi/4))],...  
    'HorizontalAlignment','center',...  
    'BackgroundColor',[.7 .9 .7],...  
    'Margin',10);
```



For additional features, see the following properties:



- `BackgroundColor` — Color of the rectangle's interior (none by default)
- `EdgeColor` — Color of the rectangle's edge (none by default)
- `LineStyle` — Style of the rectangle's edge line (first set `EdgeColor`)
- `LineWidth` — Width of the rectangle's edge line (first set `EdgeColor`)

## See how margin affects text extent properties

This example enables you to change the values of the `Margin` property and observe the effects on the `BackgroundColor` area and the `EdgeColor` rectangle.

[Click to view in editor](#) — This link opens the MATLAB editor with the following example.

[Click to run example](#) — Use your scroll wheel to vary the `Margin`.

### Parent

handle of axes, `hggroup`, or `hgtransform`

*Parent of text object.* This property contains the handle of the text object's parent. The parent of a text object is the axes, `hggroup`, or `hgtransform` object that contains it.

See [Objects That Can Contain Other Objects](#) for more information on parenting graphics objects.

### Position

`[x,y,[z]]`

*Location of text.* A two- or three-element vector, `[x y [z]]`, that specifies the location of the text in three dimensions. If you omit the `z` value, it defaults to 0. All measurements are in units specified by the `Units` property. Initial value is `[0 0 0]`.

### Rotation

scalar (default = 0)

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*Text orientation.* This property determines the orientation of the text string. Specify values of rotation in degrees (positive angles cause counterclockwise rotation).

Selected  
on | {off}

*Is object selected?* When this property is set to on, MATLAB displays selection handles if the SelectionHighlight property is also set to on. You can, for example, define the ButtonDownFcn to set this property, allowing users to select the object with the mouse.

SelectionHighlight  
{on} | off

*Objects are highlighted when selected.* When the Selected property is set to on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is set to off, MATLAB does not draw the handles.

String  
string

*The text string.* Specify this property as a quoted string for single-line strings, or as a cell array of strings, or a padded string matrix for multiline strings. MATLAB displays this string at the specified location. Vertical slash characters are not interpreted as line breaks in text strings, and are drawn as part of the text string. See Mathematical Symbols, Greek Letters, and TeX Characters for an example.

When the text Interpreter property is set to TeX (the default), you can use a subset of TeX commands embedded in the string to produce special characters such as Greek letters and mathematical symbols. The following table lists these characters and the character sequences used to define them.

| Character Sequence     | Symbol      | Character Sequence    | Symbol     | Character Sequence            | Symbol            |
|------------------------|-------------|-----------------------|------------|-------------------------------|-------------------|
| <code>\alpha</code>    | $\alpha$    | <code>\upsilon</code> | $\upsilon$ | <code>\sim</code>             | $\sim$            |
| <code>\beta</code>     | $\beta$     | <code>\phi</code>     | $\Phi$     | <code>\leq</code>             | $\leq$            |
| <code>\gamma</code>    | $\gamma$    | <code>\chi</code>     | $\chi$     | <code>\infty</code>           | $\infty$          |
| <code>\delta</code>    | $\delta$    | <code>\psi</code>     | $\Psi$     | <code>\clubsuit</code>        | $\clubsuit$       |
| <code>\epsilon</code>  | $\epsilon$  | <code>\omega</code>   | $\omega$   | <code>\diamondsuit</code>     | $\diamondsuit$    |
| <code>\zeta</code>     | $\zeta$     | <code>\Gamma</code>   | $\Gamma$   | <code>\heartsuit</code>       | $\heartsuit$      |
| <code>\eta</code>      | $\eta$      | <code>\Delta</code>   | $\Delta$   | <code>\spadesuit</code>       | $\spadesuit$      |
| <code>\theta</code>    | $\Theta$    | <code>\Theta</code>   | $\Theta$   | <code>\leftrightharrow</code> | $\leftrightarrow$ |
| <code>\vartheta</code> | $\vartheta$ | <code>\Lambda</code>  | $\Lambda$  | <code>\leftarrow</code>       | $\leftarrow$      |
| <code>\iota</code>     | $\iota$     | <code>\Xi</code>      | $\Xi$      | <code>\uparrow</code>         | $\uparrow$        |
| <code>\kappa</code>    | $\kappa$    | <code>\Pi</code>      | $\Pi$      | <code>\rightarrow</code>      | $\rightarrow$     |
| <code>\lambda</code>   | $\lambda$   | <code>\Sigma</code>   | $\Sigma$   | <code>\downarrow</code>       | $\downarrow$      |
| <code>\mu</code>       | $\mu$       | <code>\Upsilon</code> | $\Upsilon$ | <code>\circ</code>            | $\circ$           |
| <code>\nu</code>       | $\nu$       | <code>\Phi</code>     | $\Phi$     | <code>\pm</code>              | $\pm$             |
| <code>\xi</code>       | $\xi$       | <code>\Psi</code>     | $\Psi$     | <code>\geq</code>             | $\geq$            |
| <code>\pi</code>       | $\pi$       | <code>\Omega</code>   | $\Omega$   | <code>\propto</code>          | $\propto$         |
| <code>\rho</code>      | $\rho$      | <code>\forall</code>  | $\forall$  | <code>\partial</code>         | $\partial$        |
| <code>\sigma</code>    | $\sigma$    | <code>\exists</code>  | $\exists$  | <code>\bullet</code>          | $\bullet$         |
| <code>\varsigma</code> | $\varsigma$ | <code>\ni</code>      | $\ni$      | <code>\div</code>             | $\div$            |
| <code>\tau</code>      | $\tau$      | <code>\cong</code>    | $\cong$    | <code>\neq</code>             | $\neq$            |
| <code>\equiv</code>    | $\equiv$    | <code>\approx</code>  | $\approx$  | <code>\aleph</code>           | $\aleph$          |
| <code>\Im</code>       | $\Im$       | <code>\Re</code>      | $\Re$      | <code>\wp</code>              | $\wp$             |

# Text Properties

| Character Sequence   | Symbol    | Character Sequence     | Symbol      | Character Sequence      | Symbol       |
|----------------------|-----------|------------------------|-------------|-------------------------|--------------|
| <code>\otimes</code> | $\otimes$ | <code>\oplus</code>    | $\oplus$    | <code>\oslash</code>    | $\oslash$    |
| <code>\cap</code>    | $\cap$    | <code>\cup</code>      | $\cup$      | <code>\supseteq</code>  | $\supseteq$  |
| <code>\supset</code> | $\supset$ | <code>\subseteq</code> | $\subseteq$ | <code>\subset</code>    | $\subset$    |
| <code>\int</code>    | $\int$    | <code>\in</code>       |             | <code>\o</code>         | $\circ$      |
| <code>\rfloor</code> | $\rfloor$ | <code>\lceil</code>    | $\lceil$    | <code>\nabla</code>     | $\nabla$     |
| <code>\lfloor</code> | $\lfloor$ | <code>\cdot</code>     | $\cdot$     | <code>\ldots</code>     | $\dots$      |
| <code>\perp</code>   | $\perp$   | <code>\neg</code>      | $\neg$      | <code>\prime</code>     | $'$          |
| <code>\wedge</code>  | $\wedge$  | <code>\times</code>    | $\times$    | <code>\O</code>         | $\oslash$    |
| <code>\rceil</code>  | $\rceil$  | <code>\surd</code>     | $\surd$     | <code>\mid</code>       | $ $          |
| <code>\vee</code>    | $\vee$    | <code>\varpi</code>    | $\varpi$    | <code>\copyright</code> | $\copyright$ |
| <code>\langle</code> | $\langle$ | <code>\rangle</code>   | $\rangle$   |                         |              |

You can also specify stream modifiers that control font type and color. The first four modifiers are mutually exclusive. However, you can use `\fontname` in combination with one of the other modifiers:

- `\bf` — Bold font
- `\it` — Italic font
- `\sl` — Oblique font (rarely available)
- `\rm` — Normal font
- `\fontname{fontname}` — Specify the name of the font family to use.
- `\fontsize{fontsize}` — Specify the font size in FontUnits.
- `\color{colorSpec}` — Specify color for succeeding characters

Stream modifiers remain in effect until the end of the string or only within the context defined by braces { }.

## Specifying Text Color in TeX Strings

Use the `\color` modifier to change the color of characters following it from the previous color (which is black by default). Syntax is:

- `\color{colorname}` for the eight basic named colors (red, green, yellow, magenta, blue, black, white), and plus the four Simulink colors (gray, darkGreen, orange, and lightBlue)

Note that short names (one-letter abbreviations) for colors are not supported by the `\color` modifier.

- `\color[rgb]{r g b}` to specify an RGB triplet with values between 0 and 1 as a cell array

For example,

```
text(.1,.5,['\fontsize{16}black {\color{magenta}magenta '...  
'\color[rgb]{0 .5 .5}teal \color{red}red} black again'])
```

# Text Properties

---



## Specifying Subscript and Superscript Characters

The subscript character “`_`” and the superscript character “`^`” modify the character or substring defined in braces immediately following.

To print the special characters used to define the TeX strings when Interpreter is `TeX`, prefix them with the backslash “`\`” character: `\{, \}, \_, \^`.

See the “Examples” on page 2-3305 in the text reference page for more information.

When Interpreter is set to `none`, no characters in the String are interpreted, and all are displayed when the text is drawn.

When Interpreter is set to `latex`, MATLAB provides a complete  $\text{La}_T\text{E}_X$  interpreter for text objects. See the Interpreter property for more information.

## Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when you are constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callback routines. You can define Tag as any string.

## Type

string (read only)

*Class of graphics object.* For text objects, Type is always the string 'text'.

## Units

pixels | normalized | inches |  
centimeters | points | {data}

*Units of measurement.* This property specifies the units MATLAB uses to interpret the Extent and Position properties. All units are measured from the lower left corner of the axes plot box.

- Normalized units map the lower left corner of the rectangle defined by the axes to (0,0) and the upper right corner to (1.0,1.0).
- pixels, inches, centimeters, and points are absolute units (1 point =  $1/72$  inch).
- data refers to the data units of the parent axes as determined by the data graphed (not the axes Units property, which controls the positioning of the within the figure window).

If you change the value of Units, it is good practice to return it to its default value after completing your computation so as not to affect other functions that assume Units is set to the default value.

# Text Properties

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UserData  
matrix

*User-specified data.* Any data you want to associate with the text object. MATLAB does not use this data, but you can access it using `set` and `get`.

UIContextMenu  
handle of a `uicontextmenu` object

*Associate a context menu with the text.* Assign this property the handle of a `uicontextmenu` object created in the same figure as the text. Use the `uicontextmenu` function to create the context menu. MATLAB displays the context menu whenever you right-click over the text.

VerticalAlignment  
top | cap | {middle} | baseline |  
bottom

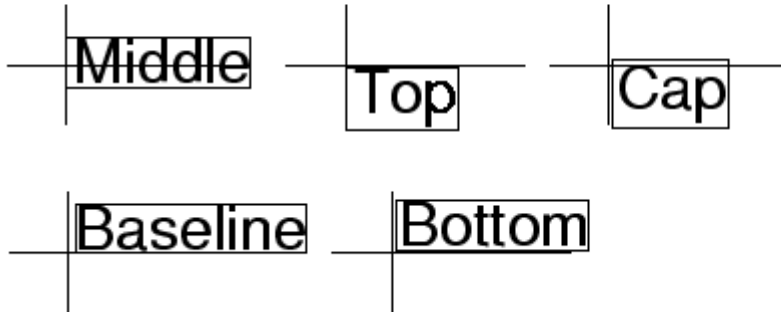
*Vertical alignment of text.* This property specifies the vertical justification of the text string. It determines where MATLAB places the string with regard to the value of the `Position` property. The possible values mean

- `top` — Place the top of the string's Extent rectangle at the specified *y*-position.
- `cap` — Place the string so that the top of a capital letter is at the specified *y*-position.
- `middle` — Place the middle of the string at the specified *y*-position.
- `baseline` — Place font baseline at the specified *y*-position.
- `bottom` — Place the bottom of the string's Extent rectangle at the specified *y*-position.

The following picture illustrates the alignment options.



**Text VerticalAlignment** property viewed with the **HorizontalAlignment** property set to left (the default).



Visible  
{on} | off

*Text visibility.* By default, all text is visible. When set to off, the text is not visible, but still exists, and you can query and set its properties.

# textread

---

## Purpose

Read data from text file; write to multiple outputs

---

**Note** The textscan function is intended as a replacement for both textread and streadd.

---

## Graphical Interface

As an alternative to textread, use the Import Wizard. To activate the Import Wizard, select **Import Data** from the **File** menu.

## Syntax

```
[A,B,C,...] = textread('filename','format')
[A,B,C,...] = textread('filename','format',N)
[...] = textread(...,'param','value',...)
```

## Description

[A,B,C,...] = textread('filename','format') reads data from the file 'filename' into the variables A,B,C, and so on, using the specified format, until the entire file is read. The filename and format inputs are strings, each enclosed in single quotes. textread is useful for reading text files with a known format. textread handles both fixed and free format files.

---

**Note** When reading large text files, reading from a specific point in a file, or reading file data into a cell array rather than multiple outputs, you might prefer to use the textscan function.

---

textread matches and converts groups of characters from the input. Each input field is defined as a string of non-white-space characters that extends to the next white-space or delimiter character, or to the maximum field width. Repeated delimiter characters are significant, while repeated white-space characters are treated as one.

The format string determines the number and types of return arguments. The number of return arguments is the number of items in the format string. The format string supports a subset of the conversion specifiers and conventions of the C language fscanf routine.

Values for the format string are listed in the table below. White-space characters in the format string are ignored.

| <b>format</b>                     | <b>Action</b>                                                                                                                                                                                  | <b>Output</b>         |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Literals<br>(ordinary characters) | Ignore the matching characters. For example, in a file that has Dept followed by a number (for department number), to skip the Dept and read only the number, use 'Dept' in the format string. | None                  |
| %d                                | Read a signed integer value.                                                                                                                                                                   | Double array          |
| %u                                | Read an integer value.                                                                                                                                                                         | Double array          |
| %f                                | Read a floating-point value.                                                                                                                                                                   | Double array          |
| %s                                | Read a white-space or delimiter-separated string.                                                                                                                                              | Cell array of strings |
| %q                                | Read a double quoted string, ignoring the quotes.                                                                                                                                              | Cell array of strings |
| %c                                | Read characters, including white space.                                                                                                                                                        | Character array       |
| %[...]                            | Read the longest string containing characters specified in the brackets.                                                                                                                       | Cell array of strings |
| %[^...]                           | Read the longest nonempty string containing characters that are not specified in the brackets.                                                                                                 | Cell array of strings |
| %*...<br>instead of<br>%          | Ignore the matching characters specified by *.                                                                                                                                                 | No output             |
| %w...<br>instead of<br>%          | Read field width specified by w. The %f format supports %w.pf, where w is the field width and p is the precision.                                                                              |                       |

[A,B,C,...] = textread('filename','format',N) reads the data, reusing the format string N times, where N is an integer greater than zero. If N is smaller than zero, textread reads the entire file.

# textread

[...] = textread(..., 'param', 'value', ...) customizes textread using param/value pairs, as listed in the table below.

| param        | value                      | Action                                                                    |
|--------------|----------------------------|---------------------------------------------------------------------------|
|              | ' '\b<br>\n<br>\r<br>\t    | Space<br>Backspace<br>Newline<br>Carriage return<br>Horizontal tab        |
| bufsize      | Positive integer           | Specifies the maximum string length, in bytes. Default is 4095.           |
| commentstyle | matlab                     | Ignores characters after %.                                               |
| commentstyle | shell                      | Ignores characters after #.                                               |
| commentstyle | c                          | Ignores characters between /* and */.                                     |
| commentstyle | c++                        | Ignores characters after //.                                              |
| delimiter    | One or more characters     | Act as delimiters between elements. Default is none.                      |
| emptyvalue   | Scalar double              | Value given to empty cells when reading delimited files. Default is 0.    |
| endofline    | Single character or '\r\n' | Character that denotes the end of a line. Default is determined from file |
| expchars     | Exponent characters        | Default is eEdD.                                                          |
| headerlines  | Positive integer           | Ignores the specified number of lines at the beginning of the file.       |
| whitespace   | Any from the list below:   | Treats vector of characters as white space. Default is ' \b\t'.           |

---

**Note** When textread reads a consecutive series of whitespace values, it treats them as one white space. When it reads a consecutive series of delimiter values, it treats each as a separate delimiter.

---

## Remarks

If you want to preserve leading and trailing spaces in a string, use the whitespace parameter as shown here:

```
textread('myfile.txt', '%s', 'whitespace', '')
ans =
    '  An  example      of preserving  spaces  '
```

## Examples

### Example 1 – Read All Fields in Free Format File Using %

The first line of mydata.dat is

```
Sally    Level1 12.34 45 Yes
```

Read the first line of the file as a free format file using the % format.

```
[names, types, x, y, answer] = textread('mydata.dat', ...
    '%s %s %f %d %s', 1)
```

returns

```
names =
    'Sally'
types =
    'Level1'
x =
    12.340000000000000
y =
    45
answer =
    'Yes'
```

## Example 2 – Read as Fixed Format File, Ignoring the Floating Point Value

The first line of mydata.dat is

```
Sally    Level1 12.34 45 Yes
```

Read the first line of the file as a fixed format file, ignoring the floating-point value.

```
[names, types, y, answer] = textread('mydata.dat', ...  
    '%9c %5s %*f %2d %3s', 1)
```

returns

```
names =  
Sally  
types =  
    'Level1'  
y =  
    45  
answer =  
    'Yes'
```

`%*f` in the format string causes `textread` to ignore the floating point value, in this case, 12.34.

## Example 3 – Read Using Literal to Ignore Matching Characters

The first line of mydata.dat is

```
Sally    Type1 12.34 45 Yes
```

Read the first line of the file, ignoring the characters Type in the second field.

```
[names, typenum, x, y, answer] = textread('mydata.dat', ...  
    '%s Type%d %f %d %s', 1)
```

returns

```
names =
    'Sally'
typenum =
    1
x =
    12.340000000000000
y =
    45
answer =
    'Yes'
```

Type%d in the format string causes the characters Type in the second field to be ignored, while the rest of the second field is read as a signed integer, in this case, 1.

#### Example 4 – Specify Value to Fill Empty Cells

For files with empty cells, use the emptyvalue parameter. Suppose the file data.csv contains:

```
1,2,3,4,,6
7,8,9,,11,12
```

Read the file using NaN to fill any empty cells:

```
data = textread('data.csv', '', 'delimiter', ',', ...
    'emptyvalue', NaN);
```

#### Example 5 – Read M-File into a Cell Array of Strings

Read the file fft.m into cell array of strings.

```
file = textread('fft.m', '%s', 'delimiter', '\n', ...
    'whitespace', '');
```

### See Also

textscan, dlmread, csvread, strread, fscanf

# textscan

---

**Purpose** Read formatted data from text file or string

**Syntax**

```
C = textscan(fid, 'format')
C = textscan(fid, 'format', N)
C = textscan(fid, 'format', param, value, ...)
C = textscan(fid, 'format', N, param, value, ...)
C = textscan(str, ...)
[C, position] = textscan(...)
```

## Description

---

**Note** Before reading a file with `textscan`, you must open the file with the `fopen` function. `fopen` supplies the `fid` input required by `textscan`. When you are finished reading from the file, you should close the file by calling `fclose(fid)`.

---

`C = textscan(fid, 'format')` reads data from an open text file identified by file identifier `fid` into cell array `C`. MATLAB parses the data into fields and converts it according to the conversion specifiers in `format`. The `format` input is a string enclosed in single quotes. These conversion specifiers determine the type of each cell in the output cell array. The number of specifiers determines the number of cells in the cell array.

`C = textscan(fid, 'format', N)` reads data from the file, reusing the `format` conversion specifier `N` times, where `N` is a positive integer. You can resume reading from the file after `N` cycles by calling `textscan` again using the original `fid`.

`C = textscan(fid, 'format', param, value, ...)` reads data from the file using nondefault parameter settings specified by one or more pairs of `param` and `value` arguments. The section “User Configurable Options” on page 2-3353 lists all valid parameter strings, value descriptions, and defaults.

`C = textscan(fid, 'format', N, param, value, ...)` reads data from the file, reusing the `format` conversion specifier `N` times, and using



nondefault parameter settings specified by pairs of param and value arguments.

`C = textscan(str, ...)` reads data from string `str` in exactly the same way as it does when reading from a file. You can use the format, `N`, and parameter/value arguments described above with this syntax. Unlike when reading from a file, if you call `textscan` more than once on the same string, it does not resume reading where the last call left off but instead reads from the beginning of the string each time.

`[C, position] = textscan(...)` returns the location of the file or string position as the second output argument. For a file, this is exactly equivalent to calling `ftell(fid)` after making the call to `textscan`. For a string, it indicates how many characters were read.

### **The Difference Between the `textscan` and `textread` Functions**

The `textscan` function differs from `textread` in the following ways:

- The `textscan` function offers better performance than `textread`, making it a better choice when reading large files.
- With `textscan`, you can start reading at any point in the file. Once the file is open, (`textscan` requires that you open the file first), you can `fseek` to any position in the file and begin the scan at that point. The `textread` function requires that you start reading from the beginning of the file.
- Subsequent `textscan` operations start reading the file at the point where the last scan left off. The `textread` function always begins at the start of the file, regardless of any prior `textread` operations.
- `textscan` returns a single cell array regardless of how many fields you read. With `textscan`, you don't need to match the number of output arguments to the number of fields being read as you would with `textread`.
- `textscan` offers more choices in how the data being read is converted.
- `textscan` offers more user-configurable options.

## Field Delimiters

The `textscan` function sees a text file as a collection of blocks. Each block consists of a number of internally consistent fields. Each field consists of a group of characters delimited by a field delimiter character. Fields can span a number of rows. Each row is delimited by an end-of-line (EOL) character sequence.

The default field delimiter is the white-space character, (i.e., any character that returns `true` from a call to the `isspace` function). You can set the delimiter to a different character by specifying a `'delimiter'` parameter in the `textscan` command (see “User Configurable Options” on page 2-3353). If a nondefault delimiter is specified, repeated delimiter characters are treated as separate delimiters. When using the default delimiter, repeated white-space characters are treated as a single delimiter.

The default end-of-line character sequence depends on which operating system you are using. You can change the end-of-line setting to a different character sequence by specifying an `'endofline'` parameter in the `textscan` command (see “User Configurable Options” on page 2-3353).

## Conversion Specifiers

This table shows the conversion type specifiers supported by `textscan`.

| Specifier         | Description                                        |
|-------------------|----------------------------------------------------|
| <code>%n</code>   | Read a number and convert to double.               |
| <code>%d</code>   | Read a number and convert to <code>int32</code> .  |
| <code>%d8</code>  | Read a number and convert to <code>int8</code> .   |
| <code>%d16</code> | Read a number and convert to <code>int16</code> .  |
| <code>%d32</code> | Read a number and convert to <code>int32</code> .  |
| <code>%d64</code> | Read a number and convert to <code>int64</code> .  |
| <code>%u</code>   | Read a number and convert to <code>uint32</code> . |

| Specifier | Description                                                                                                                                             |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| %u8       | Read a number and convert to uint8.                                                                                                                     |
| %u16      | Read a number and convert to uint16.                                                                                                                    |
| %u32      | Read a number and convert to uint32.                                                                                                                    |
| %u64      | Read a number and convert to uint64.                                                                                                                    |
| %f        | Read a number and convert to double.                                                                                                                    |
| %f32      | Read a number and convert to single.                                                                                                                    |
| %f64      | Read a number and convert to double.                                                                                                                    |
| %s        | Read a string.                                                                                                                                          |
| %q        | Read a (possibly double-quoted) string.                                                                                                                 |
| %c        | Read one character, including white space.                                                                                                              |
| %[...]    | Read characters that match characters between the brackets. Stop reading at the first nonmatching character. Use %[...] to include ] in the set.        |
| %[^...]   | Read characters that do not match characters between the brackets. Stop reading at the first matching character. Use %[^...] to exclude ] from the set. |
| %*n...    | Ignore n characters of the field, where n is an integer less than or equal to the number of characters in the field (e.g., %*4s).                       |

### Specifying Field Length

To read a certain number of characters or digits from a field, specify that number directly following the percent sign. For example, if the file you are reading contains the string

```
'Blackbird singing in the dead of night'
```

then the following command returns only five characters of the first field:

```
C = textscan(fid, '%5s', 1);  
C{:}  
ans =  
    'Black'
```

If you continue reading from the file, `textscan` resumes the operation at the point in the string where you left off. It applies the next format specifier to that portion of the field. For example, execute this command on the same file:

```
C = textscan(fid, '%s %s', 1);
```

---

**Note** Spaces between the conversion specifiers are shown only to make the example easier to read. They are not required.

---

`textscan` reads starting from where it left off and continues to the next whitespace, returning 'bird'. The second `%s` reads the word 'singing'.

The results are

```
C{:}  
ans =  
    'bird'  
ans =  
    'singing'
```

### Skipping Fields

To skip any field, put an asterisk directly after the percent sign. MATLAB does not create an output cell for any fields that are skipped.

Refer to the example from the last section, where the file you are reading contains the string

```
'Blackbird singing in the dead of night'
```

Seek to the beginning of the file and reread the line, this time skipping the second, fifth, and sixth fields:

```
fseek(fid, 0, -1);
C = textscan(fid, '%s %*s %s %s %*s %*s %s', 1);
```

C is a cell array of cell arrays, each containing a string. Piece together the string and display it:

```
str = '';
for k = 1:length(C)
    str = [str char(C{k}) ' '];
    if k == 4, disp(str), end
end
```

Blackbird in the night

### Skipping Literal Strings

In addition to skipping entire fields, you can have `textscan` skip leading literal characters in a string. Reading a file containing the following data,

```
Sally   Level1  12.34
Joe     Level2  23.54
Bill    Level3  34.90
```

this command removes the substring 'Level' from the output and converts the level number to a `uint8`:

```
C = textscan(fid, '%s Level%u8 %f');
```

This returns a cell array C with the second cell containing only the unsigned integers:

```
C{1} = {'Sally'; 'Joe'; 'Bill'}           class cell
C{2} = [1; 2; 3]                          class uint8
C{3} = [12.34; 23.54; 34.90]              class double
```

## Specifying Numeric Field Length and Decimal Digits

With numeric fields, you can specify the number of digits to read in the same manner described for strings in the section “Specifying Field Length” on page 2-3347. The next example uses a file containing the line

```
'405.36801 551.94387 298.00752 141.90663'
```

This command returns the starting 7 digits of each number in the line. Note that the decimal point counts as a digit.

```
C = textscan(fid, '%7f32 %*n');  
C{:} =  
    [405.368; 551.943; 298.007; 141.906]
```

You can also control the number of digits that are read to the right of the decimal point for any numeric field of type %f, %f32, or %f64. The format specifier in this command uses a %9.1 prefix to cause textscan to read the first 9 digits of each number, but only include 1 digit of the decimal value in the number it returns:

```
C = textscan(fid, '%9.1f32 %*n');  
C{:} =  
    [405.3; 551.9; 298.0; 141.9]
```

## Conversion of Numeric Fields

This table shows how textscan interprets the numeric field specifiers.

| Format Specifier                     | Action Taken                                                             |
|--------------------------------------|--------------------------------------------------------------------------|
| %n, %d, %u, %f, and variants thereof | Read to the first delimiter.<br>Example: %n reads '473.238 ' as 473.238. |

| Format Specifier                         | Action Taken                                                                                                                                                                                   |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| %Nn, %Nd, %Nu, %Nf, and variants thereof | Read N digits (counting a decimal point as a digit), or up to the first delimiter, whichever comes first.<br>Example: %5f32 reads '473.238 ' as 473.2.                                         |
| Specifiers that start with %N.Df         | Read N digits (counting a decimal point as a digit), or up to the first delimiter, whichever comes first. Return D decimal digits in the output.<br>Example: %7.2f reads '473.238 ' as 473.23. |

Conversion specifiers %n, %d, %u, %f, or any variant thereof (e.g., %d16) return a K-by-1 MATLAB numeric vector of the type indicated by the conversion specifier, where K is the number of times that specifier was found in the file. `textscan` converts the numeric fields from the field content to the output type according to the conversion specifier and MATLAB rules regarding overflow and truncation. NaN, Inf, and -Inf are converted according to applicable MATLAB rules.

`textscan` imports any complex number as a whole into a complex numeric field, converting the real and imaginary parts to the specified numeric type. Valid forms for a complex number are

| Form                | Example  |
|---------------------|----------|
| -<real>-<imag>i   j | 5.7-3.1i |
| -<imag>i   j        | -7j      |

Embedded white-space in a complex number is invalid and is regarded as a field delimiter.

### Conversion of Strings

This table shows how `textscan` interprets the string field specifiers.

| <b>Format Specifier</b>              | <b>Action Taken</b>                                                                                                                                                                                             |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>%s</code> or <code>%q</code>   | Read to the first delimiter.<br>Example: <code>%s</code> reads 'summer' as 'summer'.                                                                                                                            |
| <code>%Ns</code> or <code>%Nq</code> | Read N characters, or to the first delimiter, whichever comes first.<br>Example: <code>%3s</code> reads 'summer' as 'sum'.                                                                                      |
| <code>%[abc]</code>                  | Read those characters that match any character specified within the brackets, stopping just before the first character that does not match.<br>Example: <code>%[mus]</code> reads 'summer' as 'summ'.           |
| <code>%N[abc]</code>                 | Read as many as N characters that match any character specified within the brackets, stopping just before the first character that does not match.<br>Example: <code>%2[mus]</code> reads 'summer' as 'su'.     |
| <code>%[^abc]</code>                 | Read those characters that do not match any character specified within the brackets, stopping just before the first character that does match.<br>Example: <code>%[^xrg]</code> reads 'summer' as 'summe'.      |
| <code>%N[^abc]</code>                | Read as many as N characters that do not match any character specified within the brackets, stopping just before the first character that does match.<br>Example: <code>%2[^xrg]</code> reads 'summer' as 'su'. |

Conversion specifiers `%s`, `%q`, `%[...]`, and `%[^...]` return a K-by-1 MATLAB cell vector of strings, where K is the number of times that specifier was found in the file. If you set the delimiter parameter to a non-white-space character, or set the whitespace parameter to `'`, `textscan` returns all characters in the string field, including white-space. Otherwise each string terminates at the beginning of white-space.



## Conversion of Characters

This table shows how `textscan` interprets the character field specifiers.

| Format Specifier | Action Taken                                                                                                      |
|------------------|-------------------------------------------------------------------------------------------------------------------|
| <code>%c</code>  | Read one character.<br>Example: <code>%c</code> reads 'Let's go!' as 'L'.                                         |
| <code>%Nc</code> | Read N characters, including delimiter characters.<br>Example: <code>%9c</code> reads 'Let's go!' as 'Let's go!'. |

Conversion specifier `%Nc` returns a K-by-N MATLAB character array, where K is the number of times that specifier was found in the file. `textscan` returns all characters, including white-space, but excluding the delimiter.

## Conversion of Empty Fields

An empty field in the text file is defined by two adjacent delimiters indicating an empty set of characters, or, in all cases except `%c`, white-space. The empty field is returned as NaN by default, but is user definable. In addition, you may specify custom strings to be used as empty values, in *numeric fields only*. `textscan` does not examine nonnumeric fields for custom empty values. See “User Configurable Options” on page 2-3353.

---

**Note** MATLAB represents integer NaN as zero. If `textscan` reads an empty field that is assigned an integer format specifier (one that starts with `%d` or `%u`), it returns the empty value as zero rather than as NaN. (See the value returned in `C{5}` in Example 6 — Using a Nondefault Empty Value.

---

## User Configurable Options

This table shows the valid `param-value` options and their default values. Parameter names are not case-sensitive.

| <b>Parameter</b>    | <b>Value</b>                                                                                                                                                                          | <b>Default</b>           |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| BufSize             | Maximum string length in bytes                                                                                                                                                        | 4095                     |
| CollectOutput       | If true, MATLAB concatenates consecutive cells of the output that have the same data type into a single array.                                                                        | 0 (false)                |
| CommentStyle        | Symbol(s) designating text to be ignored (see “Values for commentStyle” on page 2-3355, below)                                                                                        | None                     |
| Delimiter           | Delimiter characters                                                                                                                                                                  | Whitespace               |
| EmptyValue          | Empty cell value in delimited files                                                                                                                                                   | NaN                      |
| endOfLine           | End-of-line character                                                                                                                                                                 | Determined from the file |
| expChars            | Exponent characters                                                                                                                                                                   | 'eEdD'                   |
| HeaderLines         | Number of lines to skip. (This includes the remainder of the current line, unless you are positioned at the beginning of the file.)                                                   | 0                        |
| MultipleDelimsAsOne | If set to 1, textread treats consecutive delimiters as a single delimiter. If set to 0, textread treats them as separate delimiters. Only valid if the delimiter option is specified. | 0                        |

| Parameter     | Value                                                                                            | Default |
|---------------|--------------------------------------------------------------------------------------------------|---------|
| ReturnOnError | Behavior on failing to read or convert (1=true, or 0)                                            | 1       |
| TreatAsEmpty  | String(s) to be treated as an empty value. A single string or cell array of strings can be used. | None    |
| Whitespace    | White-space characters                                                                           | ' \b\t' |

### White-Space Characters

Leading white-space characters are not included in the processing of any of the data fields. When processing numeric data, trailing whitespace is also assumed to have no significance.

### Values for commentStyle

Possible values for the `commentStyle` parameter are

| Value                        | Description                                                                  | Example                       |
|------------------------------|------------------------------------------------------------------------------|-------------------------------|
| Single string, S             | Ignore any characters that follow string S and are on the same line.         | '%', '//'                     |
| Cell array of two strings, C | Ignore any characters that lie between the opening and closing strings in C. | {'/*', '*/'},<br>{'/%', '%/'} |

### Resuming a Text Scan

If `textscan` fails to convert a data field, it stops reading and returns all fields read before the failure. When reading from a file, you can resume reading from the same file by calling `textscan` again using the same file identifier, `fid`. When reading from a string, the two-output argument syntax enables you to resume reading from the string at the

point where the last read terminated. The following command is an example of how you can do this:

```
textscan(str(position+1:end), ...)
```

## Remarks

For information on how to use `textscan` to import large data sets, see “Reading Files with Large Data Sets” in the MATLAB Programming documentation.

## Examples

### Example 1 – Reading Different Types of Data

Text file `scan1.dat` contains data in the following form:

```
Sally Level1 12.34 45 1.23e10 inf NaN Yes
Joe Level2 23.54 60 9e19 -inf 0.001 No
Bill Level3 34.90 12 2e5 10 100 No
```

Read each column into a variable:

```
fid = fopen('scan1.dat');
C = textscan(fid, '%s %s %f32 %d8 %u %f %f %s');
fclose(fid);
```

---

**Note** Spaces between the conversion specifiers are shown only to make the example easier to read. They are not required.

---

`textscan` returns a 1-by-8 cell array `C` with the following cells:

```
C{1} = {'Sally'; 'Joe'; 'Bill'}           class cell
C{2} = {'Level1'; 'Level2'; 'Level3'}     class cell
C{3} = [12.34; 23.54; 34.9]               class single
C{4} = [45; 60; 12]                       class int8
C{5} = [4294967295; 4294967295; 200000]   class uint32
C{6} = [Inf; -Inf; 10]                    class double
C{7} = [NaN; 0.001; 100]                  class double
C{8} = {'Yes'; 'No'; 'No'}               class cell
```

The first two elements of `C{5}` are the maximum values for a 32-bit unsigned integer, or `intmax('uint32')`.

### Example 2 – Reading All But One Field

Read the file as a fixed-format file, skipping the third field:

```
fid = fopen('scan1.dat');
C = textscan(fid, '%7c %6s %*f %d8 %u %f %f %s');
fclose(fid);
```

`textscan` returns a 1-by-8 cell array `C` with the following cells:

```
C{1} = ['Sally  '; 'Joe   '; 'Bill  ']    class char
C{2} = {'Level1'; 'Level2'; 'Level3'}    class cell
C{3} = [45; 60; 12]                        class int8
C{4} = [4294967295; 4294967295; 200000]    class uint32
C{5} = [Inf; -Inf; 10]                     class double
C{6} = [NaN; 0.001; 100]                   class double
C{7} = {'Yes'; 'No'; 'No'}                 class cell
```

### Example 3 – Reading Only the First Field

Read the first column into a cell array, skipping the rest of the line:

```
fid = fopen('scan1.dat');
names = textscan(fid, '%s%*[^\\n]');
fclose(fid);
```

`textscan` returns a 1-by-1 cell array `names`:

```
size(names)
ans =
     1     1
```

The one cell contains

```
names{1} = {'Sally'; 'Joe'; 'Bill'}    class cell
```

## Example 4 – Removing a Literal String in the Output

The second format specifier in this example, %sLevel, tells textscan to read the second field from a line in the file, but to ignore the initial string 'Level' within that field. All that is left of the field is a numeric digit. textscan assigns the next specifier, %f, to that digit, converting it to a double.

See C{2} in the results:

```
fid = fopen('scan1.dat');
C = textscan(fid, '%s Level%u8 %f32 %d8 %u %f %f %s');
fclose(fid);
```

textscan returns a 1-by-8 cell array, C, with cells

```
C{1} = {'Sally'; 'Joe'; 'Bill'}           class cell
C{2} = [1; 2; 3]                          class uint8
C{3} = [12.34; 23.54; 34.90]              class single
C{4} = [45; 60; 12]                       class int8
C{5} = [4294967295; 4294967295; 200000]   class uint32
C{6} = [Inf; -Inf; 10]                    class double
C{7} = [NaN; 0.001; 100]                  class double
C{8} = {'Yes'; 'No'; 'No'}               class cell
```

## Example 5 – Using a Nondefault Delimiter and White-Space

Read the M-file into a cell array of strings:

```
fid = fopen('fft.m');
file = textscan(fid, '%s', 'delimiter', '\n', ...
               'whitespace', '');
fclose(fid);
```

textscan returns a 1-by-1 cell array, file, that contains a 37-by-1 cell array:

```
file =
    {37x1 cell}
```

Show some of the text from the first three lines of the file:

```
lines = file{1};
lines{1:3, :}
ans =
%FFT Discrete Fourier transform.
ans =
% FFT(X) is the discrete Fourier transform (DFT) of vector X. For
ans =
% matrices, the FFT operation is applied to each column. For N-D
```

### Example 6 – Using a Nondefault Empty Value

Read files with empty cells, setting the emptyvalue parameter. The file data.csv contains

```
1, 2, 3, 4, , 6
7, 8, 9, , 11, 12
```

Read the file as shown here, using -Inf in empty cells:

```
fid = fopen('data.csv');
C = textscan(fid, '%f%f%f%f%u32%f', 'delimiter', ',', ...
            'emptyValue', -Inf);
fclose(fid);
```

textscan returns a 1-by-6 cell array C with the following cells:

```
C{1} = [1; 7]           class double
C{2} = [2; 8]           class double
C{3} = [3; 9]           class double
C{4} = [4; NaN]         class double
C{5} = [-Inf; 11]       class uint32 (-Inf converted to 0)
C{6} = [6; 12]          class double
```

### Example 7 – Using Custom Empty Values and Comments

You have a file data.csv that contains the lines

```
abc, 2, NA, 3, 4
// Comment Here
def, na, 5, 6, 7
```

Designate what should be treated as empty values and as comments. Read in all other values from the file:

```
fid = fopen('data5.csv');
C = textscan(fid, '%s%n%n%n%n', 'delimiter', ',', ...
             'treatAsEmpty', {'NA', 'na'}, ...
             'commentStyle', '//');
fclose(fid);
```

This returns the following data in cell array C:

```
C{:}
ans =
    'abc'
    'def'
ans =
     2
    NaN
ans =
    NaN
     5
ans =
     3
     6
ans =
     4
     7
```

## Example 8 – Reading From a String

Read in a string (quoted from Albert Einstein) using textscan:

```
str = ...
    ['Do not worry about your difficulties in Mathematics.' ...
    'I can assure you mine are still greater.'];
```



```
s = textscan(str, '%s', 'delimiter', '.');

s{:}
ans =
    'Do not worry about your difficulties in Mathematics'
    'I can assure you mine are still greater'
```

### Example 9 – Handling Multiple Delimiters

This example takes a comma-separated list of names, the test pilots known as the Mercury Seven, and uses `textscan` to return a list of their names in a cell array. When some names are removed from the input list, leaving multiple sequential delimiters, `textscan`, by default, accounts for this. If you override that default by calling `textscan` with the `multipleDelimsAsOne` option, `textscan` ignores the missing names.

Here is the full list of the astronauts:

```
Mercury7 = ...
    'Shepard,Grissom,Glenn,Carpenter,Schirra,Cooper,Slayton';
```

Remove the names Grissom and Cooper from the input string, and `textscan`, by default, does not treat the multiple delimiters as one, and returns an empty string for each missing name:

```
Mercury7 = 'Shepard,,Glenn,Carpenter,Schirra,,Slayton';
names = textscan(Mercury7, '%s', 'delimiter', ',');
names{:}'
ans =
    'Shepard' '' 'Glenn' 'Carpenter' 'Schirra' '' 'Slayton'
```

Using the same input string, but this time setting the `multipleDelimsAsOne` switch, `textscan` ignores the multiple delimiters:

```
names = textscan(Mercury7, '%s', 'delimiter', ',', ...
    'multipleDelimsAsOne', 1);
names{:}'
```

```
ans =  
    'Shepard'  'Glenn'  'Carpenter'  'Schirra'  'Slayton'
```

## Example 10 – Using the CollectOutput Switch

Shown below are the contents of a file `wire_gage.txt`. The first line contains four column headers in text. The lines that follow that are numeric data:

| AWG  | Area   | Resistance | Diameter |
|------|--------|------------|----------|
| 0000 | 211600 | 0.049      | 0.46     |
| 000  | 167810 | 0.0618     | 0.40965  |
| 00   | 133080 | 0.078      | 0.3648   |
| 0    | 105530 | 0.0983     | 0.32485  |
| 1    | 83694  | 0.124      | 0.2893   |
| 2    | 66373  | 0.1563     | 0.25763  |
| 3    | 52634  | 0.197      | 0.22942  |
| 4    | 41742  | 0.2485     | 0.20431  |
| 5    | 33102  | 0.3133     | 0.18194  |
| 6    | 26250  | 0.3951     | 0.16202  |
| 7    | 20816  | 0.4982     | 0.14428  |
| 8    | 16509  | 0.6282     | 0.12849  |
| 9    | 13094  | 0.7921     | 0.11443  |
| 10   | 10381  | 0.9989     | 0.10189  |

When you read the file with `textscan` having the `CollectOutput` switch set to zero, MATLAB returns each column of the numeric data in a separate 44-by-1 cell array:

```
format long g  
fid = fopen('wire_gage.txt', 'r');  
  
C_text = textscan(fid, '%s', 4, 'delimiter', '|');  
  
C_data0 = textscan(fid, '%d %f %f %f', 'CollectOutput', 0)  
C_data0 =  
    [44x1 int32] [44x1 double] [44x1 double] [44x1 double]
```

Reading the file with `CollectOutput` set to one collects all data of a common type, double in this case, into a single 44-by-3 cell array:

```
frewind(fid)

C_text = textscan(fid, '%s', 4, 'delimiter', '|');

C_data1 = textscan(fid, '%d %f %f %f', 'CollectOutput', 1)
C_data1 =
    [44x1 int32]    [44x3 double]
```

**See Also**

`dlmread`, `dlmwrite`, `xlswrite`, `fopen`, `fseek`, `importdata`

# textwrap

---

**Purpose** Wrapped string matrix for given uicontrol

**Syntax** `outstring = textwrap(h,instring)`  
`[outstring,position]=textwrap(h,instring)`

**Description** `outstring = textwrap(h,instring)` returns a wrapped string cell array, `outstring`, that fits inside the uicontrol with handle `h`. `instring` is a cell array, with each cell containing a single line of text. `outstring` is the wrapped string matrix in cell array format. Each cell of the input string is considered a paragraph.

`[outstring,position]=textwrap(h,instring)` returns the recommended position of the uicontrol in the units of the uicontrol. `position` considers the extent of the multiline text in the  $x$  and  $y$  directions.

**Example** Place a text-wrapped string in a uicontrol:

```
pos = [10 10 100 10];
h = uicontrol('Style','Text','Position',pos);
string = {'This is a string for the uicontrol.',
         'It should be correctly wrapped inside.'};
[outstring,newpos] = textwrap(h,string);
pos(4) = newpos(4);
set(h,'String',outstring,'Position',[pos(1),pos(2),pos(3)+10,po
s(4)])
```

**See Also** `uicontrol`

**Purpose** Terminate function and issue exception

**Syntax** throw(ME)

**Description** throw(ME) terminates the currently running function, issues an exception based on MException object ME, and returns control to the keyboard or to any enclosing catch block. A thrown MException displays a message in the Command Window unless it is caught by try-catch. throw also sets the MException stack field to the location from which the throw method was called.

## Examples **Example 1**

This example tests the output of M-file evaluate\_plots and throws an exception if it is not acceptable:

```
[minval, maxval] = evaluate_plots(p24, p28, p41);
if minval < lower_bound || maxval > upper_bound
    ME = MException('VerifyOutput:OutOfBounds', ...
        'Results are outside the allowable limits');
    throw(ME);
end
```

## **Example 2**

This example attempts to open a file in a directory that is not on the MATLAB path. It uses a nested try-catch block to give the user the opportunity to extend the path. If the still cannot be found, the program issues an exception with the first error appended to the second:

```
function data = read_it(filename);
try
    fid = fopen(filename, 'r');
    data = fread(fid);
catch eObj1
    if strcmp(eObj1.identifier, 'MATLAB:FileIO:InvalidFid')
        msg = sprintf('\n%s%s%s', 'Cannot open file ', ...
            filename, '. Try another location? ');
```

## throw (MException)

---

```
    reply = input(msg, 's')
    if reply(1) == 'y'
        newdir = input('Enter directory name: ', 's');
    else
        throw(eObj1);
    end
    addpath(newdir);
    try
        fid = fopen(filename, 'r');
        data = fread(fid);
    catch eObj2
        eObj3 = addCause(eObj2, eObj1)
        throw(eObj3);
    end
    rmpath(newdir);
end
end
fclose(fid);
```

If you run this function in a try-catch block at the command line, you can look at the MException object by assigning it to a variable (e) with the catch command.

```
try
    d = read_it('anytextfile.txt');
catch e
end

e
e =
    MException object with properties:

        identifier: 'MATLAB:FileIO:InvalidFid'
        message: 'Invalid file identifier. Use fopen to
generate a valid file identifier.'
        stack: [1x1 struct]
        cause: {[1x1 MException]}
```

```
Cannot open file anytextfile.txt. Try another location?y
Enter directory name: xxxxxxx
Warning: Name is nonexistent or not a directory: xxxxxxx.
> In path at 110
   In addpath at 89
```

### See Also

error, try, catch, assert, MException, rethrow(MException),  
throwAsCaller(MException), addCause(MException),  
getReport(MException), disp(MException), isequal(MException),  
eq(MException), ne(MException), last(MException),

# throwAsCaller (MException)

---

**Purpose** Throw exception, as if from calling function

**Syntax** throwAsCaller(ME)

**Description** throwAsCaller(ME) throws an exception from the currently running M-file based on MException object ME. MATLAB exits the currently running function and returns control to either the keyboard or an enclosing catch block in a calling function. Unlike the throw function, MATLAB omits the current stack frame from the stack field of the MException, thus making the exception look as if it is being thrown by the caller of the function.

In some cases, it is not relevant to show the person running your program the true location that generated an exception, but is better to point to the calling function where the problem really lies. You might also find throwAsCaller useful when you want to simplify the error display, or when you have code that you do not want made public.

## Examples

The function klein\_bottle, in this example, generates a Klein Bottle figure by revolving the figure-eight curve defined by XYKLEIN. It defines a few variables and calls the function draw\_klein, which executes three functions in a try-catch block. If there is an error, the catch block issues an exception using either throw or throwAsCaller:

```
function klein_bottle(ab, pq)
    rtr = [2 0.5 1];
    box = [-3 3 -3 3 -2 2];
    vue = [55 60];
    draw_klein(ab, rtr, pq, box, vue)

function draw_klein(ab, rtr, pq, box, vue)
    clf
    try
        tube('xyklein',ab, rtr, pq, box, vue);
        shading interp
        colormap(pink);
```



```
catch ME
    throw(ME)
%   throwAsCaller(ME)
end
```

Call the `klein_bottle` function, passing an incorrect value for the second argument. (The correct value would be a vector, such as `[40 40]`.) Because the catch block issues the exception using `throw`, MATLAB displays error messages for line 15 of function `draw_klein`, and for line 5 of function `klein_bottle`:

```
klein_bottle(ab, pi)
??? Attempted to access pq(2); index out of bounds because
    numel(pq)=1.

Error in ==> klein_bottle>draw_klein at 15
    throw(ME);

Error in ==> klein_bottle at 5
    draw_figure(ab, rtr, pq, box, vue)
```

Run the function again, this time changing the `klein_bottle.m` file so that the catch block uses `throwAsCaller` instead of `throw`. This time, MATLAB only displays the error at line 5 of the main program:

```
klein_bottle(ab, pi)
??? Attempted to access pq(2); index out of bounds because
    numel(pq)=1.

Error in ==> klein_bottle at 5
    draw_figure(ab, rtr, pq, box, vue)
```

### See Also

`error`, `try`, `catch`, `assert`, `MException`, `throw(MException)`, `rethrow(MException)`, `addCause(MException)`, `getReport(MException)`, `disp(MException)`, `isequal(MException)`, `eq(MException)`, `ne(MException)`, `last(MException)`

# tic, toc

---

**Purpose** Measure performance using stopwatch timer

**Syntax**

```
tic
    any statements
toc
t = toc
```

**Description**

tic starts a stopwatch timer.

toc prints the elapsed time since tic was used.

t = toc returns the elapsed time in t.

**Remarks**

The tic and toc functions work together to measure elapsed time. tic saves the current time that toc uses later to measure the elapsed time. The sequence of commands

```
tic
operations
toc
```

measures the amount of time MATLAB takes to complete one or more operations, and displays the time in seconds.

**Examples**

This example measures how the time required to solve a linear system varies with the order of a matrix.

```
for n = 1:100
    A = rand(n,n);
    b = rand(n,1);
    tic
    x = A\b;
    t(n) = toc;
end
plot(t)
```

**See Also** clock, cputime, etime, profile

---

|                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>                 | Construct timer object                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Syntax</b>                  | <pre>T = timer T = timer('PropertyName1', PropertyValue1, 'PropertyName2',           PropertyValue2,...)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Description</b>             | <p>T = timer constructs a timer object with default attributes.</p> <p>T = timer('PropertyName1', PropertyValue1, 'PropertyName2', PropertyValue2,...) constructs a timer object in which the given property name/value pairs are set on the object. See “Timer Object Properties” on page 2-3371 for a list of all the properties supported by the timer object.</p> <p>Note that the property name/property value pairs can be in any format supported by the set function, i.e., property/value string pairs, structures, and property/value cell array pairs.</p> |
| <b>Examples</b>                | <p>This example constructs a timer object with a timer callback function handle, mycallback, and a 10 second interval.</p> <pre>t = timer('TimerFcn',@mycallback, 'Period', 10.0);</pre>                                                                                                                                                                                                                                                                                                                                                                              |
| <b>See Also</b>                | <code>delete(timer)</code> , <code>disp(timer)</code> , <code>get(timer)</code> , <code>isvalid(timer)</code> , <code>set(timer)</code> , <code>start</code> , <code>startat</code> , <code>stop</code> , <code>timerfind</code> , <code>timerfindall</code> , <code>wait</code>                                                                                                                                                                                                                                                                                      |
| <b>Timer Object Properties</b> | <p>The timer object supports the following properties that control its attributes. The table includes information about the data type of each property and its default value.</p> <p>To view the value of the properties of a particular timer object, use the <code>get(timer)</code> function. To set the value of the properties of a timer object, use the <code>set(timer)</code> function.</p>                                                                                                                                                                  |

# timer

| Property Name | Property Description                                                                                                                                                                                                                 | Data Types, Values, Defaults, Access |                                             |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------|
| AveragePeriod | Average time between TimerFcn executions since the timer started.<br><br>Note: Value is NaN until timer executes two timer callbacks.                                                                                                | Data type                            | double                                      |
|               |                                                                                                                                                                                                                                      | Default                              | NaN                                         |
|               |                                                                                                                                                                                                                                      | Read only                            | Always                                      |
| BusyMode      | Action taken when a timer has to execute TimerFcn before the completion of previous execution of TimerFcn.<br>'drop' — Do not execute the function<br>'error' — Generate an error<br>'queue' — Execute function at next opportunity. | Data type                            | Enumerated string                           |
|               |                                                                                                                                                                                                                                      | Values                               | 'drop'<br>'error'<br>'queue'                |
|               |                                                                                                                                                                                                                                      | Default                              | 'drop'                                      |
|               |                                                                                                                                                                                                                                      | Read only                            | While Running = 'on'                        |
| ErrorFcn      | Function that the timer executes when an error occurs. This function executes before the StopFcn. See “Creating Callback Functions” for more information.                                                                            | Data type                            | Text string, function handle, or cell array |
|               |                                                                                                                                                                                                                                      | Default                              | None                                        |
|               |                                                                                                                                                                                                                                      | Read only                            | Never                                       |

| Property Name | Property Description                                                                                             | Data Types, Values, Defaults, Access |                                                                                                                                                                                      |
|---------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ExecutionMode | Determines how the timer object schedules timer events. See “Timer Object Execution Modes” for more information. | Data type                            | Enumerated string                                                                                                                                                                    |
|               |                                                                                                                  | Values                               | 'singleShot'<br>'fixedDelay'<br>'fixedRate'<br>'fixedSpacing'                                                                                                                        |
|               |                                                                                                                  | Default                              | 'singleShot'                                                                                                                                                                         |
|               |                                                                                                                  | Read only                            | While Running = 'on'                                                                                                                                                                 |
| InstantPeriod | The time between the last two executions of TimerFcn.                                                            | Data type                            | double                                                                                                                                                                               |
|               |                                                                                                                  | Default                              | NaN                                                                                                                                                                                  |
|               |                                                                                                                  | Read only                            | Always                                                                                                                                                                               |
| Name          | User-supplied name.                                                                                              | Data type                            | Text string                                                                                                                                                                          |
|               |                                                                                                                  | Default                              | 'timer- <i>i</i> ', where <i>i</i> is a number indicating the <i>i</i> th timer object created this session. To reset <i>i</i> to 1, execute the <code>clear classes</code> command. |
|               |                                                                                                                  | Read only                            | Never                                                                                                                                                                                |

# timer

| Property Name    | Property Description                                                                                                                                                                                                                                                                                                                                                                        | Data Types, Values, Defaults, Access |                         |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-------------------------|
| ObjectVisibility | Provides a way for application developers to prevent end-user access to the timer objects created by their application. The timerfind function does not return an object whose ObjectVisibility property is set to 'off'. Objects that are not visible are still valid. If you have access to the object (for example, from within the M-file that created it), you can set its properties. | Data type                            | Enumerated string       |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Values                               | 'off'<br>'on'           |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Default                              | 'on'                    |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Read only                            | Never                   |
| Period           | Specifies the delay, in seconds, between executions of TimerFcn.                                                                                                                                                                                                                                                                                                                            | Data type                            | double                  |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Value                                | Any number $\geq 0.001$ |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Default                              | 1.0                     |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Read only                            | While Running = 'on'    |
| Running          | Indicates whether the timer is currently executing.                                                                                                                                                                                                                                                                                                                                         | Data type                            | Enumerated string       |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Values                               | 'off'<br>'on'           |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Default                              | 'off'                   |
|                  |                                                                                                                                                                                                                                                                                                                                                                                             | Read only                            | Always                  |

| Property Name | Property Description                                                                                                           | Data Types, Values, Defaults, Access |                                             |
|---------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------|
| StartDelay    | Specifies the delay, in seconds, between the start of the timer and the first execution of the function specified in TimerFcn. | Data type                            | double                                      |
|               |                                                                                                                                | Values                               | Any number $\geq 0$                         |
|               |                                                                                                                                | Default                              | 0                                           |
|               |                                                                                                                                | Read only                            | While Running = 'on'                        |
| StartFcn      | Function the timer calls when it starts. See “Creating Callback Functions” for more information.                               | Data type                            | Text string, function handle, or cell array |
|               |                                                                                                                                | Default                              | None                                        |
|               |                                                                                                                                | Read only                            | Never                                       |

# timer

| Property Name | Property Description                                                                                                                                                                                                                                                                                                                                                                                                      | Data Types, Values, Defaults, Access |                                             |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------|
| StopFcn       | Function the timer calls when it stops. The timer stops when <ul style="list-style-type: none"> <li>• You call the timer stop function</li> <li>• The timer finishes executing TimerFcn, i.e., the value of TasksExecuted reaches the limit set by TasksToExecute.</li> <li>• An error occurs (The ErrorFcn is called first, followed by the StopFcn.)</li> </ul> See “Creating Callback Functions” for more information. | Data type                            | Text string, function handle, or cell array |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                           | Default                              | None                                        |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                           | Read only                            | Never                                       |
| Tag           | User supplied label.                                                                                                                                                                                                                                                                                                                                                                                                      | Data type                            | Text string                                 |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                           | Default                              | Empty string ( ' ' )                        |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                           | Read only                            | Never                                       |



| Property Name  | Property Description                                                                                    | Data Types, Values, Defaults, Access |                                             |
|----------------|---------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------|
| TasksToExecute | Specifies the number of times the timer should execute the function specified in the TimerFcn property. | Data type                            | double                                      |
|                |                                                                                                         | Values                               | Any number > 0                              |
|                |                                                                                                         | Default                              | 1                                           |
|                |                                                                                                         | Read only                            | Never                                       |
| TasksExecuted  | The number of times the timer has called TimerFcn since the timer was started.                          | Data type                            | double                                      |
|                |                                                                                                         | Values                               | Any number >= 0                             |
|                |                                                                                                         | Default                              | 0                                           |
|                |                                                                                                         | Read only                            | Always                                      |
| TimerFcn       | Timer callback function. See “Creating Callback Functions” for more information.                        | Data type                            | Text string, function handle, or cell array |
|                |                                                                                                         | Default                              | None                                        |
|                |                                                                                                         | Read only                            | Never                                       |
| Type           | Identifies the object type.                                                                             | Data type                            | Text string                                 |
|                |                                                                                                         | Values                               | 'timer'                                     |
|                |                                                                                                         | Read only                            | Always                                      |
| UserData       | User-supplied data.                                                                                     | Data type                            | User-defined                                |
|                |                                                                                                         | Default                              | []                                          |
|                |                                                                                                         | Read only                            | Never                                       |

# timerfind

---

**Purpose** Find timer objects

**Syntax**

```
out = timerfind
out = timerfind('P1', V1, 'P2', V2,...)
out = timerfind(S)
out = timerfind(obj, 'P1', V1, 'P2', V2,...)
```

**Description** out = timerfind returns an array, out, of all the timer objects that exist in memory.

out = timerfind('P1', V1, 'P2', V2,...) returns an array, out, of timer objects whose property values match those passed as parameter/value pairs, P1, V1, P2, V2. Parameter/value pairs may be specified as a cell array.

out = timerfind(S) returns an array, out, of timer objects whose property values match those defined in the structure, S. The field names of S are timer object property names and the field values are the corresponding property values.

out = timerfind(obj, 'P1', V1, 'P2', V2,...) restricts the search for matching parameter/value pairs to the timer objects listed in obj. obj can be an array of timer objects.

---

**Note** When specifying parameter/value pairs, you can use any mixture of strings, structures, and cell arrays in the same call to timerfind.

---

Note that, for most properties, timerfind performs case-sensitive searches of property values. For example, if the value of an object's Name property is 'MyObject', timerfind will not find a match if you specify 'myobject'. Use the get function to determine the exact format of a property value. However, properties that have an enumerated list of possible values are not case sensitive. For example, timerfind will find an object with an ExecutionMode property value of 'singleShot' or 'singleshot'.

## Examples

These examples use `timerfind` to find timer objects with the specified property values.

```
t1 = timer('Tag', 'broadcastProgress', 'Period', 5);
t2 = timer('Tag', 'displayProgress');
out1 = timerfind('Tag', 'displayProgress')
out2 = timerfind({'Period', 'Tag'}, {5, 'broadcastProgress'})
```

## See Also

`get(timer)`, `timer`, `timerfindall`

# timerfindall

---

**Purpose** Find timer objects, including invisible objects

**Syntax**

```
out = timerfindall
out = timerfindall('P1', V1, 'P2', V2,...)
out = timerfindall(S)
out = timerfindall(obj, 'P1', V1, 'P2', V2,...)
```

**Description** `out = timerfindall` returns an array, `out`, containing all the timer objects that exist in memory, regardless of the value of the object's `ObjectVisibility` property.

`out = timerfindall('P1', V1, 'P2', V2,...)` returns an array, `out`, of timer objects whose property values match those passed as parameter/value pairs, `P1`, `V1`, `P2`, `V2`. Parameter/value pairs may be specified as a cell array.

`out = timerfindall(S)` returns an array, `out`, of timer objects whose property values match those defined in the structure, `S`. The field names of `S` are timer object property names and the field values are the corresponding property values.

`out = timerfindall(obj, 'P1', V1, 'P2', V2,...)` restricts the search for matching parameter/value pairs to the timer objects listed in `obj`. `obj` can be an array of timer objects.

---

**Note** When specifying parameter/value pairs, you can use any mixture of strings, structures, and cell arrays in the same call to `timerfindall`.

---

Note that, for most properties, `timerfindall` performs case-sensitive searches of property values. For example, if the value of an object's `Name` property is `'MyObject'`, `timerfindall` will not find a match if you specify `'myobject'`. Use the `get` function to determine the exact format of a property value. However, properties that have an enumerated list of possible values are not case sensitive. For example, `timerfindall` will find an object with an `ExecutionMode` property value of `'singleShot'` or `'singleShot'`.

**Examples**

Create several timer objects.

```
t1 = timer;
t2 = timer;
t3 = timer;
```

Set the `ObjectVisibility` property of one of the objects to 'off'.

```
t2.ObjectVisibility = 'off';
```

Use `timerfind` to get a listing of all the timer objects in memory. Note that the listing does not include the timer object (timer-2) whose `ObjectVisibility` property is set to 'off'.

```
timerfind
```

Timer Object Array

| Index: | ExecutionMode: | Period: | TimerFcn: | Name:   |
|--------|----------------|---------|-----------|---------|
| 1      | singleShot     | 1       | ''        | timer-1 |
| 2      | singleShot     | 1       | ''        | timer-3 |

Use `timerfindall` to get a listing of all the timer objects in memory. This listing includes the timer object whose `ObjectVisibility` property is set to 'off'.

```
timerfindall
```

Timer Object Array

| Index: | ExecutionMode: | Period: | TimerFcn: | Name:   |
|--------|----------------|---------|-----------|---------|
| 1      | singleShot     | 1       | ''        | timer-1 |
| 2      | singleShot     | 1       | ''        | timer-2 |
| 3      | singleShot     | 1       | ''        | timer-3 |

**See Also**

`get(timer)`, `timer`, `timerfind`

# timeseries

---

**Purpose** Create timeseries object

**Syntax**

```
ts = timeseries
ts = timeseries(Data)
ts = timeseries(Name)
ts = timeseries(Data,Time)
ts = timeseries(Data,Time,Quality)
ts = timeseries(Data,...,'Parameter',Value,...)
```

**Description** `ts = timeseries` creates an empty time-series object.

`ts = timeseries(Data)` creates a time series with the specified `Data`. `ts` has a default time vector that ranges from 0 to `N-1` with a 1-second interval, where `N` is the number of samples. The default name of the timeseries object is 'unnamed'.

`ts = timeseries(Name)` creates an empty time series with the name specified by a string `Name`. This name can differ from the time-series variable name.

`ts = timeseries(Data,Time)` creates a time series with the specified `Data` array and `Time`. When time values are date strings, you must specify `Time` as a cell array of date strings.

`ts = timeseries(Data,Time,Quality)` creates a timeseries object. The `Quality` attribute is an integer vector with values -128 to 127 that specifies the quality in terms of codes defined by `QualityInfo.Code`.

`ts = timeseries(Data,...,'Parameter',Value,...)` creates a timeseries object with optional parameter-value pairs after the `Data`, `Time`, and `Quality` arguments. You can specify the following parameters:

- `Name` — Time-series name entered as a string
- `IsTimeFirst` — Logical value (`true` or `false`) specifying whether the first or last dimension of the data array is aligned with the time vector. You can set this property when the data array is square and, therefore, the dimension that is aligned with time is ambiguous.

- `IsDatetimeum` — Logical value (true or false) that when set to true specifies that `Time` values are dates in the format of MATLAB serial dates.

## Remarks

### Definition: timeseries

The time-series object, called `timeseries`, is a MATLAB variable that contains time-indexed data and properties in a single, coherent structure. For example, in addition to data and time values, you can also use the time-series object to store events, descriptive information about data and time, data quality, and the interpolation method.

### Definition: Data Sample

A time-series *data sample* consists of one or more values recorded at a specific time. The number of data samples in a time series is the same as the length of the time vector.

For example, suppose that `ts.data` has the size 5-by-4-by-3 and the time vector has the length 5. Then, the number of samples is 5 and the total number of data values is  $5 \times 4 \times 3 = 60$ .

### Notes About Quality

When `Quality` is a vector, it must have the same length as the time vector. In this case, each `Quality` value applies to the corresponding data sample. When `Quality` is an array, it must have the same size as the data array. In this case, each `Quality` value applies to the corresponding data value of the `ts.data` array.

## Examples

### Example 1 — Using Default Time Vector

Create a `timeseries` object called `'LaunchData'` that contains four data sets, each stored as a column of length 5 and using the default time vector:

```
b = timeseries(rand(5, 4), 'Name', 'LaunchData')
```

## Example 2 – Using Uniform Time Vector

Create a `timeseries` object containing a single data set of length 5 and a time vector starting at 1 and ending at 5:

```
b = timeseries(rand(5,1),[1 2 3 4 5])
```

## Example 3

Create a `timeseries` object called 'FinancialData' containing five data points at a single time point:

```
b = timeseries(rand(1,5),1,'Name','FinancialData')
```

## See Also


`addsample`, `tscollection`, `tsdata.event`, `tsprops`



**Purpose**

Add title to current axes

**GUI  
Alternative**

To create or modify a plot's title from a GUI, use **Insert Title** from the figure menu. Use the Property Editor, one of the plotting tools , to modify the position, font, and other properties of a legend. For details, see The Property Editor in the MATLAB Graphics documentation.

**Syntax**

```
title('string')
title(fname)
title(...,'PropertyName',PropertyValue,...)
title(axes_handle,...)
h = title(...)
```

**Description**

Each axes graphics object can have one title. The title is located at the top and in the center of the axes.

`title('string')` outputs the string at the top and in the center of the current axes.

`title(fname)` evaluates the function that returns a string and displays the string at the top and in the center of the current axes.

`title(...,'PropertyName',PropertyValue,...)` specifies property name and property value pairs for the text graphics object that `title` creates. Do not use the 'String' text property to set the title string; the content of the title should be given by the first argument.

`title(axes_handle,...)` adds the title to the specified axes.

`h = title(...)` returns the handle to the text object used as the title.

**Examples**

Display today's date in the current axes:

```
title(date)
```

Include a variable's value in a title:

```
f = 70;
c = (f-32)/1.8;
```

# title

---

```
title(['Temperature is ', num2str(c), 'C'])
```

Include a variable's value in a title and set the color of the title to yellow:

```
n = 3;
title(['Case number #', int2str(n)], 'Color', 'y')
```

Include Greek symbols in a title:

```
title('\ite^{\omega\tau} = cos(\omega\tau) + isin(\omega\tau)')
```

Include a superscript character in a title:

```
title('\alpha^2')
```

Include a subscript character in a title:

```
title('X_1')
```

The text object `String` property lists the available symbols.

Create a multiline title using a multiline cell array.

```
title({'First line'; 'Second line'})
```

## Remarks

`title` sets the `Title` property of the current axes graphics object to a new text graphics object. See the text `String` property for more information.

## See Also

`gtext`, `int2str`, `num2str`, `text`, `xlabel`, `ylabel`, `zlabel`

“Annotating Plots” on page 1-87 for related functions

Text Properties for information on setting parameter/value pairs in titles

Adding Titles to Graphs for more information on ways to add titles

**Purpose** Convert CDF epoch object to MATLAB datenum

**Syntax** `n = todatenum(obj)`

**Description** `n = todatenum(obj)` converts the CDF epoch object `ep_obj` into a MATLAB serial date number. Note that a CDF epoch is the number of milliseconds since 01-Jan-0000 whereas a MATLAB datenum is the number of days since 00-Jan-0000.

**Examples** Construct a CDF epoch object from a date string, and then convert the object back into a MATLAB date string:

```
dstr = datestr(today)
dstr =
    08-Oct-2003

obj = cdfepoch(dstr)
obj =
    cdfepoch object:
    08-Oct-2003 00:00:00

dstr2 = datestr(todatenum(obj))
dstr2 =
    08-Oct-2003
```

**See Also** `cdfepoch`, `cdfinfo`, `cdfread`, `cdfwrite`, `datenum`

# toeplitz

---

**Purpose** Toeplitz matrix

**Syntax** `T = toeplitz(c,r)`  
`T = toeplitz(r)`

**Description** A *Toeplitz* matrix is defined by one row and one column. A *symmetric Toeplitz* matrix is defined by just one row. `toeplitz` generates Toeplitz matrices given just the row or row and column description.

`T = toeplitz(c,r)` returns a nonsymmetric Toeplitz matrix `T` having `c` as its first column and `r` as its first row. If the first elements of `c` and `r` are different, a message is printed and the column element is used.

`T = toeplitz(r)` returns the symmetric or Hermitian Toeplitz matrix formed from vector `r`, where `r` defines the first row of the matrix.

**Examples** A Toeplitz matrix with diagonal disagreement is

```
c = [1 2 3 4 5];
r = [1.5 2.5 3.5 4.5 5.5];
toeplitz(c,r)
Column wins diagonal conflict:
ans =
    1.000    2.500    3.500    4.500    5.500
    2.000    1.000    2.500    3.500    4.500
    3.000    2.000    1.000    2.500    3.500
    4.000    3.000    2.000    1.000    2.500
    5.000    4.000    3.000    2.000    1.000
```

**See Also** `hankel`, `kron`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Root directory for specified toolbox                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Syntax</b>      | <pre>toolboxdir('tbxdirname') s = toolboxdir('tbxdirname') s = toolboxdir tbxdirname</pre>                                                                                                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <p><code>toolboxdir('tbxdirname')</code> returns a string that is the absolute path to the specified toolbox, <code>tbxdirname</code>, where <code>tbxdirname</code> is the directory name for the toolbox.</p> <p><code>s = toolboxdir('tbxdirname')</code> returns the absolute path to the specified toolbox to the output argument, <code>s</code>.</p> <p><code>s = toolboxdir tbxdirname</code> is the command form of the syntax.</p> |
| <b>Remarks</b>     | <p><code>toolboxdir</code> is particularly useful for MATLAB Compiler. The base directory of all toolboxes installed with MATLAB is</p> <pre>matlabroot/toolbox/tbxdirname</pre> <p>However, in deployed mode, the base directories of the toolboxes are different. <code>toolboxdir</code> returns the correct root directory, whether running from MATLAB or from an application deployed with MATLAB Compiler.</p>                        |
| <b>Example</b>     | <p>To obtain the pathname for Control System Toolbox, run</p> <pre>s = toolboxdir('control')</pre> <p>MATLAB returns</p> <pre>s = \\myhome\r2007b\matlab\toolbox\control</pre>                                                                                                                                                                                                                                                               |
| <b>See Also</b>    | <p><code>matlabroot</code></p> <p><code>ctfroot</code> in MATLAB Compiler</p>                                                                                                                                                                                                                                                                                                                                                                |

# trace

---

|                    |                                                                                    |
|--------------------|------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Sum of diagonal elements                                                           |
| <b>Syntax</b>      | <code>b = trace(A)</code>                                                          |
| <b>Description</b> | <code>b = trace(A)</code> is the sum of the diagonal elements of the matrix A.     |
| <b>Algorithm</b>   | <code>trace</code> is a single-statement M-file.<br><code>t = sum(diag(A));</code> |
| <b>See Also</b>    | <code>det</code> , <code>eig</code>                                                |

**Purpose** Transpose timeseries object

**Syntax** `ts1 = transpose(ts)`

**Description** `ts1 = transpose(ts)` returns a new timeseries object `ts1` with `IsTimeFirst` value set to the opposite of what it is for `ts`. For example, if `ts` has the first data dimension aligned with the time vector, `ts1` has the last data dimension aligned with the time vector.

**Remarks** The `transpose` function that is overloaded for the timeseries objects does not transpose the data. Instead, this function changes whether the first or the last dimension of the data is aligned with the time vector.

---

**Note** To transpose the data, you must transpose the `Data` property of the time series. For example, you can use the syntax `transpose(ts.Data)` or `(ts.Data)'`. `Data` must be a 2-D array.

---

Consider a time series with 10 samples with the property `IsTimeFirst = True`. When you transpose this time series, the data size is changed from 10-by-1 to 1-by-1-by-10. Note that the first dimension of the `Data` property is shown explicitly.

The following table summarizes how MATLAB displays the size for time-series data (up to three dimensions) before and after transposing.

### Data Size Before and After Transposing

| Size of Original Data | Size of Transposed Data |
|-----------------------|-------------------------|
| N-by-1                | 1-by-1-by-N             |

# transpose (timeseries)

---

## Data Size Before and After Transposing (Continued)

| Size of Original Data | Size of Transposed Data |
|-----------------------|-------------------------|
| N-by-M                | M-by-1-by-N             |
| N-by-M-by-L           | M-by-L-by-N             |

### Examples

Suppose that a `timeseries` object `ts` has `ts.Data` size 10-by-3-by-2 and its time vector has a length of 10. The `IsTimeFirst` property of `ts` is set to `true`, which means that the first dimension of the data is aligned with the time vector. `transpose(ts)` modifies the `timeseries` object such that the last dimension of the data is now aligned with the time vector. This permutes the data such that the size of `ts.Data` becomes 3-by-2-by-10.

### See Also

`ctranspose (timeseries)`, `tsprops`



**Purpose**

Trapezoidal numerical integration

**Syntax**

```
Z = trapz(Y)
Z = trapz(X,Y)
Z = trapz(...,dim)
```

**Description**

`Z = trapz(Y)` computes an approximation of the integral of `Y` via the trapezoidal method (with unit spacing). To compute the integral for spacing other than one, multiply `Z` by the spacing increment. Input `Y` can be complex.

If `Y` is a vector, `trapz(Y)` is the integral of `Y`.

If `Y` is a matrix, `trapz(Y)` is a row vector with the integral over each column.

If `Y` is a multidimensional array, `trapz(Y)` works across the first nonsingleton dimension.

`Z = trapz(X,Y)` computes the integral of `Y` with respect to `X` using trapezoidal integration. Inputs `X` and `Y` can be complex.

If `X` is a column vector and `Y` an array whose first nonsingleton dimension is `length(X)`, `trapz(X,Y)` operates across this dimension.

`Z = trapz(...,dim)` integrates across the dimension of `Y` specified by scalar `dim`. The length of `X`, if given, must be the same as `size(Y,dim)`.

**Examples****Example 1**

The exact value of  $\int_0^{\pi} \sin(x) dx$  is 2.

To approximate this numerically on a uniformly spaced grid, use

```
X = 0:pi/100:pi;
Y = sin(X);
```

Then both

```
Z = trapz(X,Y)
```

and

```
Z = pi/100*trapz(Y)
```

produce

```
Z =  
    1.9998
```

## Example 2

A nonuniformly spaced example is generated by

```
X = sort(rand(1,101)*pi);  
Y = sin(X);  
Z = trapz(X,Y);
```

The result is not as accurate as the uniformly spaced grid. One random sample produced

```
Z =  
    1.9984
```

## Example 3

This example uses two complex inputs:

```
z = exp(1i*pi*(0:100)/100);  
  
trapz(z, 1./z)  
ans =  
    0.0000 + 3.1411i
```

## See Also

`cumsum`, `cumtrapz`

**Purpose** Lay out tree or forest

**Syntax** `[x,y] = treelayout(parent,post)`  
`[x,y,h,s] = treelayout(parent,post)`

**Description** `[x,y] = treelayout(parent,post)` lays out a tree or a forest. `parent` is the vector of parent pointers, with 0 for a root. `post` is an optional postorder permutation on the tree nodes. If you omit `post`, `treelayout` computes it. `x` and `y` are vectors of coordinates in the unit square at which to lay out the nodes of the tree to make a nice picture.

`[x,y,h,s] = treelayout(parent,post)` also returns the height of the tree `h` and the number of vertices `s` in the top-level separator.

**See Also** `etree`, `treepplot`, `etreeplot`, `sympfact`

# treeplot

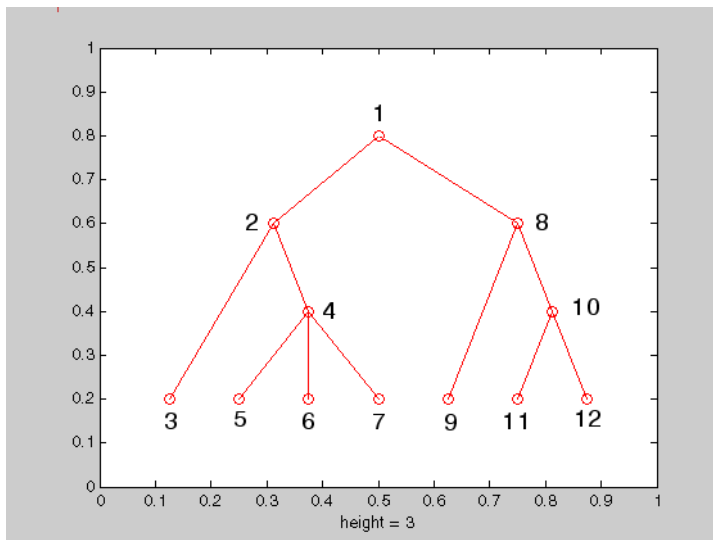
**Purpose** Plot picture of tree

**Syntax**  
`treeplot(p)`  
`treeplot(p,nodeSpec,edgeSpec)`

**Description** `treeplot(p)` plots a picture of a tree given a vector of parent pointers, with  $p(i) = 0$  for a root.

`treeplot(p,nodeSpec,edgeSpec)` allows optional parameters `nodeSpec` and `edgeSpec` to set the node or edge color, marker, and linestyle. Use `' '` to omit one or both.

**Examples** To plot a tree with 12 nodes, call `treeplot` with a 12-element input vector. The index of each element in the vector is shown adjacent to each node in the figure below. (These indices are shown only for the point of illustrating the example; they are not part of the `treeplot` output.)



To generate this plot, set the value of each element in the nodes vector to the index of its parent, (setting the parent of the root node to zero).

The node marked 1 in the figure is represented by nodes(1) in the input vector, and because this is the root node which has a parent of zero, you set its value to zero:

```
nodes(1) = 0;    % Root node
```

nodes(2) and nodes(8) are children of nodes(1), so set these elements of the input vector to 1:

```
nodes(2) = 1;    nodes(8) = 1;
```

nodes(5:7) are children of nodes(4), so set these elements to 4:

```
nodes(5) = 4;    nodes(6) = 4;    nodes(7) = 4;
```

Continue in this manner until each element of the vector identifies its parent. For the plot shown above, the nodes vector now looks like this:

```
nodes = [0 1 2 2 4 4 4 1 8 8 10 10];
```

Now call treeplot to generate the plot:

```
treeplot(nodes)
```

## See Also

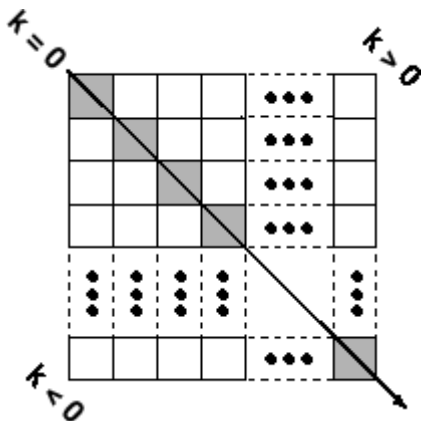
etree, etreeplot, treelayout

# tril

**Purpose** Lower triangular part of matrix

**Syntax**  
`L = tril(X)`  
`L = tril(X,k)`

**Description** `L = tril(X)` returns the lower triangular part of `X`.  
`L = tril(X,k)` returns the elements on and below the `k`th diagonal of `X`. `k = 0` is the main diagonal, `k > 0` is above the main diagonal, and `k < 0` is below the main diagonal.



**Examples** `tril(ones(4,4), -1)`

```
ans =  
  
0 0 0 0  
1 0 0 0  
1 1 0 0  
1 1 1 0
```

**See Also** `diag`, `triu`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Triangular mesh plot                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>      | <pre>trimesh(Tri,X,Y,Z) trimesh(Tri,X,Y,Z,C) trimesh(...'PropertyName',PropertyValue...) h = trimesh(...)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <p><code>trimesh(Tri,X,Y,Z)</code> displays triangles defined in the <math>m</math>-by-3 face matrix <code>Tri</code> as a mesh. Each row of <code>Tri</code> defines a single triangular face by indexing into the vectors or matrices that contain the <math>X</math>, <math>Y</math>, and <math>Z</math> vertices.</p> <p><code>trimesh(Tri,X,Y,Z,C)</code> specifies color defined by <code>C</code> in the same manner as the <code>surf</code> function. MATLAB performs a linear transformation on this data to obtain colors from the current colormap.</p> <p><code>trimesh(...'PropertyName',PropertyValue...)</code> specifies additional patch property names and values for the patch graphics object created by the function.</p> <p><code>h = trimesh(...)</code> returns a handle to a patch graphics object.</p> |
| <b>Example</b>     | <p>Create vertex vectors and a face matrix, then create a triangular mesh plot.</p> <pre>x = rand(1,50); y = rand(1,50); z = peaks(6*x-3,6*x-3); tri = delaunay(x,y); trimesh(tri,x,y,z)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>See Also</b>    | <p><code>patch</code>, <code>tetramesh</code>, <code>triplot</code>, <code>trisurf</code>, <code>delaunay</code></p> <p>“Creating Surfaces and Meshes” on page 1-97 for related functions</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

# triplequad

---

**Purpose** Numerically evaluate triple integral

**Syntax**  
`triplequad(fun,xmin,xmax,ymin,ymax,zmin,zmax)`  
`triplequad(fun,xmin,xmax,ymin,ymax,zmin,zmax,tol)`  
`triplequad(fun,xmin,xmax,ymin,ymax,zmin,zmax,tol,method)`

**Description** `triplequad(fun,xmin,xmax,ymin,ymax,zmin,zmax)` evaluates the triple integral  $\int_{xmin}^{xmax} \int_{ymin}^{ymax} \int_{zmin}^{zmax} fun(x,y,z)$  over the three dimensional rectangular region  $xmin \leq x \leq xmax$ ,  $ymin \leq y \leq ymax$ ,  $zmin \leq z \leq zmax$ . `fun` is a function handle. See “Function Handles” in the MATLAB Programming documentation for more information. `fun(x,y,z)` must accept a vector `x` and scalars `y` and `z`, and return a vector of values of the integrand.

“Parameterizing Functions Called by Function Functions”, in the MATLAB Mathematics documentation, explains how to provide additional parameters to the function `fun`, if necessary.

`triplequad(fun,xmin,xmax,ymin,ymax,zmin,zmax,tol)` uses a tolerance `tol` instead of the default, which is  $1.0e-6$ .

`triplequad(fun,xmin,xmax,ymin,ymax,zmin,zmax,tol,method)` uses the quadrature function specified as `method`, instead of the default `quad`. Valid values for `method` are `@quad1` or the function handle of a user-defined quadrature method that has the same calling sequence as `quad` and `quad1`.

**Examples** Pass M-file function handle `@integrnd` to `triplequad`:P

```
Q = triplequad(@integrnd,0,pi,0,1,-1,1);
```

where the M-file `integrnd.m` is

```
function f = integrnd(x,y,z)  
f = y*sin(x)+z*cos(x);
```

Pass anonymous function handle `F` to `triplequad`:

```
F = @(x,y,z)y*sin(x)+z*cos(x);
```



```
Q = triplequad(F,0,pi,0,1,-1,1);
```

This example integrates  $y*\sin(x)+z*\cos(x)$  over the region  $0 \leq x \leq \pi, 0 \leq y \leq 1, -1 \leq z \leq 1$ . Note that the integrand can be evaluated with a vector  $x$  and scalars  $y$  and  $z$ .

## See Also

`dblquad`, `quad`, `quadgk`, `quadl`, `function handle (@)`, “Anonymous Functions”

# triplot

---

**Purpose** 2-D triangular plot

**Syntax**

```
triplot(TRI,x,y)
triplot(TRI,x,y,color)
h = triplot(...)
triplot(...,'param','value','param','value'...)
```

**Description** `triplot(TRI,x,y)` displays the triangles defined in the  $m$ -by-3 matrix `TRI`. A row of `TRI` contains indices into the vectors `x` and `y` that define a single triangle. The default line color is blue.

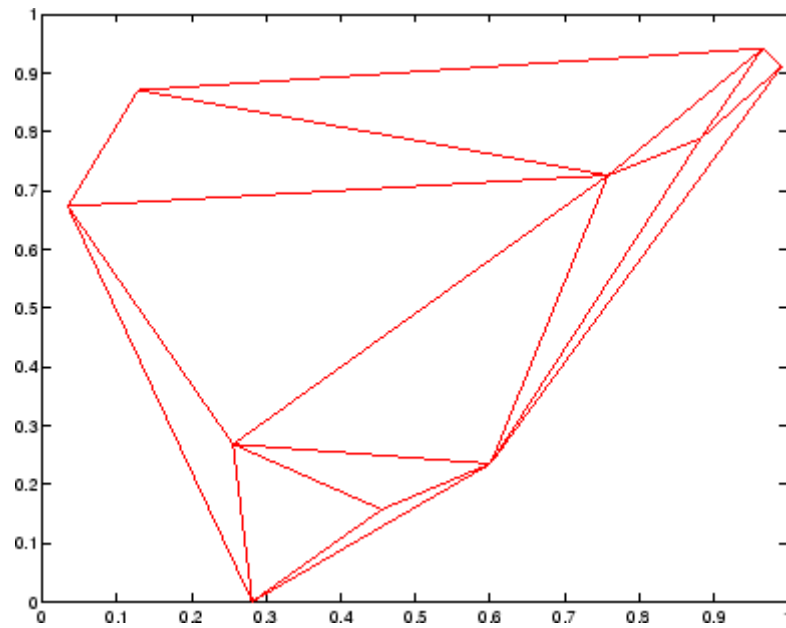
`triplot(TRI,x,y,color)` uses the string `color` as the line color. `color` can also be a line specification. See `ColorSpec` for a list of valid color strings. See `LineStyle` for information about line specifications.

`h = triplot(...)` returns a vector of handles to the displayed triangles.

`triplot(...,'param','value','param','value'...)` allows additional line property name/property value pairs to be used when creating the plot. See `Line Properties` for information about the available properties.

**Examples** This code plots the Delaunay triangulation for 10 randomly generated points.

```
rand('state',7);
x = rand(1,10);
y = rand(1,10);
TRI = delaunay(x,y);
triplot(TRI,x,y,'red')
```



**See Also**

ColorSpec, delaunay, line, Line Properties, LineSpec, plot, trimesh, trisurf

# trisurf

---

**Purpose** Triangular surface plot

**Syntax**

```
trisurf(Tri,X,Y,Z)
trisurf(Tri,X,Y,Z,C)
trisurf(...'PropertyName',PropertyValue...)
h = trisurf(...)
```

**Description**

`trisurf(Tri,X,Y,Z)` displays triangles defined in the  $m$ -by-3 face matrix `Tri` as a surface. Each row of `Tri` defines a single triangular face by indexing into the vectors or matrices that contain the  $X$ ,  $Y$ , and  $Z$  vertices.

`trisurf(Tri,X,Y,Z,C)` specifies color defined by `C` in the same manner as the `surf` function. MATLAB performs a linear transformation on this data to obtain colors from the current colormap.

`trisurf(...'PropertyName',PropertyValue...)` specifies additional patch property names and values for the patch graphics object created by the function.

`h = trisurf(...)` returns a patch handle.

**Example** Create vertex vectors and a face matrix, then create a triangular surface plot.

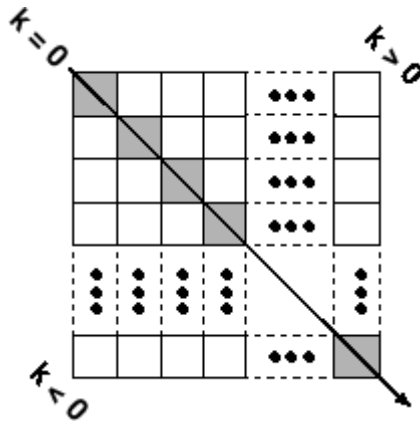
```
x = rand(1,50);
y = rand(1,50);
z = peaks(6*x-3,6*x-3);
tri = delaunay(x,y);
trisurf(tri,x,y,z)
```

**See Also** `patch`, `surf`, `tetramesh`, `trimesh`, `triplot`, `delaunay`  
“Creating Surfaces and Meshes” on page 1-97 for related functions

**Purpose** Upper triangular part of matrix

**Syntax**  $U = \text{triu}(X)$   
 $U = \text{triu}(X,k)$

**Description**  $U = \text{triu}(X)$  returns the upper triangular part of  $X$ .  
 $U = \text{triu}(X,k)$  returns the element on and above the  $k$ th diagonal of  $X$ .  
 $k = 0$  is the main diagonal,  $k > 0$  is above the main diagonal, and  $k < 0$  is below the main diagonal.



**Examples** `triu(ones(4,4), -1)`

ans =

```

1  1  1  1
1  1  1  1
0  1  1  1
0  0  1  1

```

**See Also** `diag`, `tril`

# true

---

**Purpose** Logical 1 (true)

**Syntax**  
true  
true(n)  
true(m, n)  
true(m, n, p, ...)  
true(size(A))

**Description** true is shorthand for logical 1.  
true(n) is an n-by-n matrix of logical ones.  
true(m, n) or true([m, n]) is an m-by-n matrix of logical ones.  
true(m, n, p, ...) or true([m n p ...]) is an m-by-n-by-p-by-... array of logical ones.

---

**Note** The size inputs m, n, p, ... should be nonnegative integers. Negative integers are treated as 0.

---

true(size(A)) is an array of logical ones that is the same size as array A.

**Remarks** true(n) is much faster and more memory efficient than logical(ones(n)).

**See Also** false, logical

**Purpose**

Attempt to execute block of code, and catch errors

**Syntax**

try

**Description**

try marks the start of a *try block* in a try-catch statement. If MATLAB detects an error while executing code in the try block, it immediately jumps to the start of the respective *catch block* and executes the error handling code in that block.

A try-catch statement is a programming device that enables you to define how certain errors are to be handled in your program. This bypasses the default MATLAB error-handling mechanism when these errors are detected. The try-catch statement consists of two blocks of MATLAB code, a *try block* and a *catch block*, delimited by the keywords try, catch, and end:

```
try
    MATLAB commands      % Try block
catch ME
    MATLAB commands      % Catch block
end
```

Each of these blocks consists of one or more MATLAB commands. The try block is just another piece of your program code; the commands in this block execute just like any other part of your program. Any errors MATLAB encounters in the try block are dealt with by the respective catch block. This is where you write your error-handling code. If the try block executes without error, MATLAB skips the catch block entirely. If an error occurs while executing the catch block, the program terminates unless this error is caught by another try-catch block.

Specifying the try, catch, and end commands, as well as the commands that make up the try and catch blocks, on separate lines is recommended. If you combine any of these components on the same line, separate them with commas:

```
try, surf, catch ME, ME.stack, end
ans =
```

```
file: 'matlabroot\toolbox\matlab\graph3d\surf.m'  
name: 'surf'  
line: 54
```

## Examples

The catch block in this example checks to see if the specified file could not be found. If this is the case, the program allows for the possibility that a common variation of the filename extension (e.g., jpeg instead of jpg) was used by retrying the operation with a modified extension. This is done using a try-catch statement that is nested within the original try-catch.

```
function d_in = read_image(filename)  
file_format = regexp(filename, '(?<=\.)\w+$', 'match');  
  
try  
    fid = fopen(filename, 'r');  
    d_in = fread(fid);  
catch ME1  
    % Get last segment of the error message identifier.  
    idSegLast = regexp(ME1.identifier, '(?<=:)\w+$', 'match');  
  
    % Did the read fail because the file could not be found?  
    if strcmp(idSegLast, 'InvalidFid') && ~exist(filename, 'file')  
  
        % Yes. Try modifying the filename extension.  
        switch file_format  
        case 'jpg' % Change jpg to jpeg  
            filename = regexp(filename, '(?<=\.)\w+$', 'jpeg');  
        case 'jpeg' % Change jpeg to jpg  
            filename = regexp(filename, '(?<=\.)\w+$', 'jpg');  
        case 'tif' % Change tif to tiff  
            filename = regexp(filename, '(?<=\.)\w+$', 'tiff');  
        case 'tiff' % Change tiff to tif  
            filename = regexp(filename, '(?<=\.)\w+$', 'tif');  
        otherwise  
            disp(sprintf('File %s not found', filename));  
            rethrow(ME1);  
        end  
    end  
end
```



```
end

% Try again, with modified filenames.
try
    fid = fopen(filename, 'r');
    d_in = fread(fid);
catch ME2
    disp(sprintf('Unable to access file %s', filename));
    ME2 = addCause(ME2, ME1);
    rethrow(ME2)
end
end
end
```

**See Also**

catch, rethrow, end, lasterror, eval, evalin

# tscollection

---

**Purpose** Create tscollection object

**Syntax**

```
tsc = tscollection(TimeSeries)
tsc = tscollection(Time)
tsc = tscollection(Time,TimeSeries,'Parameter',Value,...)
```

**Description** `tsc = tscollection(TimeSeries)` creates a `tscollection` object `tsc` with one or more `timeseries` objects already in the MATLAB workspace. The argument `TimeSeries` can be a

- Single `timeseries` object
- Cell array of `timeseries` objects

`tsc = tscollection(Time)` creates an empty `tscollection` object with the time vector `Time`. When time values are date strings, you must specify `Time` as a cell array of date strings.

`tsc = tscollection(Time,TimeSeries,'Parameter',Value,...)` creates a `tscollection` object with optional parameter-value pairs you enter after the `Time` and `TimeSeries` arguments. You can specify the following parameters:

- **Name** — String that specifies the name of this `tscollection` object
- **IsDatetimeum** — Logical value (`true` or `false`) that when set to `true` specifies that the `Time` values are dates in the format of MATLAB serial dates.

**Remarks** **Definition: Time Series Collection**

A time series collection object is a MATLAB variable that groups several time series with a common time vector. The time series that you include in the collection are called members of this collection.

### Properties of Time Series Collection Objects

This table lists the properties of the `tscollection` object. You can specify the `Time`, `TimeSeries`, and `Name` properties as input arguments in the constructor.

| Property | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Name     | <code>tscollection</code> name as a string. This can differ from the <code>tscollection</code> name in the MATLAB workspace.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Time     | <p>When <code>TimeInfo.StartDate</code> is empty, values are measured relative to 0. When <code>TimeInfo.StartDate</code> is defined, values represent date strings measured relative to the <code>StartDate</code>.</p> <p>The length of <code>Time</code> must be the same as the first or the last dimension of <code>Data</code> for each collection.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| TimeInfo | <p>Contains fields for contextual information about <code>Time</code>:</p> <ul style="list-style-type: none"> <li>• <b>Units</b> — Time units with any of the following values: 'weeks', 'days', 'hours', 'minutes', 'seconds', 'milliseconds', 'microseconds', 'nanoseconds'</li> <li>• <b>Start</b> — Start time</li> <li>• <b>End</b> — End time (read only)</li> <li>• <b>Increment</b> — Interval between subsequent time values. NaN when times are not uniformly sampled.</li> <li>• <b>Length</b> — Length of the time vector (read only)</li> <li>• <b>Format</b> — String defining the date string display format. See <code>datestr</code>.</li> <li>• <b>StartDate</b> — Date string defining the reference date. See <code>setabstime (tscollection)</code>.</li> <li>• <b>UserData</b> — Any additional user-defined information</li> </ul> |

# tscollection

---

## Examples

The following example shows how to create a `tscollection` object.

- 1 Import the sample data.

```
load count.dat
```

- 2 Create three `timeseries` objects to store each set of data:

```
count1 = timeseries(count(:,1),1:24,'name', 'ts1');  
count2 = timeseries(count(:,2),1:24,'name', 'ts2');
```

- 3 Create a `tscollection` object named `tsc` and add to it two out of three time series already in the MATLAB workspace, by using the following syntax:

```
tsc = tscollection({count1 count2},'name','tsc')
```

## See Also

`addts`, `datestr`, `setabstime (tscollection)`, `timeseries`, `tsprops`

**Purpose** Construct event object for timeseries object

**Syntax**  
`e = tsdata.event(Name,Time)`  
`e = tsdata.event(Name,Time,'Datenum')`

**Description** `e = tsdata.event(Name,Time)` creates an event object with the specified `Name` that occurs at the time `Time`. `Time` can either be a real value or a date string.

`e = tsdata.event(Name,Time,'Datenum')` uses `'Datenum'` to indicate that the `Time` value is a serial date number generated by the `datenum` function. The `Time` value is converted to a date string after the event is created.

**Remarks** You add events by using the `addevent` method.

Fields of the `tsdata.event` object include the following:

- `EventData` — MATLAB array that stores any user-defined information about the event
- `Name` — String that specifies the name of the event
- `Time` — Time value when this event occurs, specified as a real number
- `Units` — Time units
- `StartDate` — A reference date, specified in MATLAB `datestr` format. `StartDate` is empty when you have a numerical (non-date-string) time vector.

# tsearch

---

**Purpose** Search for enclosing Delaunay triangle

**Syntax** `T = tsearch(x,y,TRI,xi,yi)`

**Description** `T = tsearch(x,y,TRI,xi,yi)` returns an index into the rows of TRI for each point in xi, yi. The tsearch command returns NaN for all points outside the convex hull. Requires a triangulation TRI of the points x,y obtained from delaunay.

**See Also** delaunay, delaunayn, dsearch, tsearchn

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | N-D closest simplex search                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Syntax</b>      | $t = \text{tsearchn}(X, \text{TES}, XI)$<br>$[t, P] = \text{tsearchn}(X, \text{TES}, XI)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Description</b> | <p><math>t = \text{tsearchn}(X, \text{TES}, XI)</math> returns the indices <math>t</math> of the enclosing simplex of the Delaunay tessellation <math>\text{TES}</math> for each point in <math>XI</math>. <math>X</math> is an <math>m</math>-by-<math>n</math> matrix, representing <math>m</math> points in <math>N</math>-dimensional space. <math>XI</math> is a <math>p</math>-by-<math>n</math> matrix, representing <math>p</math> points in <math>N</math>-dimensional space. <math>\text{tsearchn}</math> returns NaN for all points outside the convex hull of <math>X</math>. <math>\text{tsearchn}</math> requires a tessellation <math>\text{TES}</math> of the points <math>X</math> obtained from <code>delaunayn</code>.</p> <p><math>[t, P] = \text{tsearchn}(X, \text{TES}, XI)</math> also returns the barycentric coordinate <math>P</math> of <math>XI</math> in the simplex <math>\text{TES}</math>. <math>P</math> is a <math>p</math>-by-<math>n+1</math> matrix. Each row of <math>P</math> is the Barycentric coordinate of the corresponding point in <math>XI</math>. It is useful for interpolation.</p> |
| <b>Algorithm</b>   | $\text{tsearchn}$ is based on Qhull [1]. For information about Qhull, see <a href="http://www.qhull.org/">http://www.qhull.org/</a> . For copyright information, see <a href="http://www.qhull.org/COPYING.txt">http://www.qhull.org/COPYING.txt</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>See Also</b>    | <code>delaunayn</code> , <code>griddatan</code> , <code>tsearch</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Reference</b>   | [1] Barber, C. B., D.P. Dobkin, and H.T. Huhdanpaa, "The Quickhull Algorithm for Convex Hulls," <i>ACM Transactions on Mathematical Software</i> , Vol. 22, No. 4, Dec. 1996, p. 469-483.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

**Purpose** Help on timeseries object properties

**Syntax** help timeseries/tsprops

**Description** help timeseries/tsprops lists the properties of the timeseries object and briefly describes each property.

## Time Series Object Properties

| Property | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Data     | <p>Time-series data, where each data sample corresponds to a specific time.</p> <p>The data can be a scalar, a vector, or a multidimensional array. Either the first or last dimension of the data must be aligned with Time.</p> <p>By default, NaNs are used to represent missing or unspecified data. Set the <code>TreatNaNasMissing</code> property to determine how missing data is treated in calculations.</p>                                                                                                                                                                                                                                                                                                                                                                                   |
| DataInfo | <p>Contains fields for storing contextual information about Data:</p> <ul style="list-style-type: none"><li>• <code>Unit</code> — String that specifies data units</li><li>• <code>Interpolation</code> — A <code>tsdata.interpolation</code> object that specifies the interpolation method for this time series.<br/>Fields of the <code>tsdata.interpolation</code> object include:<ul style="list-style-type: none"><li>▪ <code>Fhandle</code> — Function handle to a user-defined interpolation function</li><li>▪ <code>Name</code> — String that specifies the name of the interpolation method. Predefined methods include 'linear' and 'zoh' (zero-order hold). 'linear' is the default.</li></ul></li><li>• <code>UserData</code> — Any user-defined information entered as a string</li></ul> |



## Time Series Object Properties (Continued)

| Property | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Events   | <p>An array of <code>tsdata.event</code> objects that stores event information for this time series. You add events by using the <code>addevent</code> method.</p> <p>Fields of the <code>tsdata.event</code> object include the following:</p> <ul style="list-style-type: none"><li>• <code>EventData</code> — Any user-defined information about the event</li><li>• <code>Name</code> — String that specifies the name of the event</li><li>• <code>Time</code> — Time value when this event occurs, specified as a real number or a date string</li><li>• <code>Units</code> — Time units</li><li>• <code>StartDate</code> — A reference date specified in MATLAB date-string format. <code>StartDate</code> is empty when you have a numerical (non-date-string) time vector.</li></ul> |

## Time Series Object Properties (Continued)

| Property    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IsTimeFirst | <p>Logical value (true or false) specifies whether the first or last dimension of the Data array is aligned with the time vector.</p> <p>You can set this property when the Data array is square and it is ambiguous which dimension is aligned with time. By default, the first Data dimension that matches the length of the time vector is aligned with the time vector.</p> <p>When you set this property to:</p> <ul style="list-style-type: none"> <li>• true — The first dimension of the data array is aligned with the time vector. For example:<br/> <code>ts=timeseries(rand(3,3),1:3, 'IsTimeFirst',true);</code></li> <li>• false — The last dimension of the data array is aligned with the time vector. For example:<br/> <code>ts=timeseries(rand(3,3),1:3, 'IsTimeFirst',false);</code></li> </ul> <p>After a time series is created, this property is read only.</p> |
| Name        | <p>Time-series name entered as a string. This name can differ from the name of the time-series variable in the MATLAB workspace.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Quality     | <p>An integer vector or array containing values -128 to 127 that specifies the quality in terms of codes defined by <code>QualityInfo.Code</code>.</p> <p>When <code>Quality</code> is a vector, it must have the same length as the time vector. In this case, each <code>Quality</code> value applies to a corresponding data sample.</p> <p>When <code>Quality</code> is an array, it must have the same size as the data array. In this case, each <code>Quality</code> value applies to the corresponding value of the data array.</p>                                                                                                                                                                                                                                                                                                                                            |

## Time Series Object Properties (Continued)

| Property    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QualityInfo | <p>Provides a lookup table that converts numerical Quality codes to readable descriptions. QualityInfo fields include the following:</p> <ul style="list-style-type: none"><li>• Code — Integer vector containing values -128 to 127 that define the “dictionary” of quality codes, which you can assign to each Data value by using the Quality property</li><li>• Description — Cell vector of strings, where each element provides a readable description of the associated quality Code</li><li>• UserData — Stores any additional user-defined information</li></ul> <p>Lengths of Code and Description must match.</p> |
| Time        | <p>Array of time values.</p> <p>When TimeInfo.StartDate is empty, the numerical Time values are measured relative to 0 in specified units. When TimeInfo.StartDate is defined, the time values are date strings measured relative to the StartDate in specified units.</p> <p>The length of Time must be the same as either the first or the last dimension of Data.</p>                                                                                                                                                                                                                                                     |

## Time Series Object Properties (Continued)

| Property          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TimeInfo          | <p>Uses the following fields for storing contextual information about Time:</p> <ul style="list-style-type: none"><li>• <b>Units</b> — Time units can have any of following values: 'weeks', 'days', 'hours', 'minutes', 'seconds', 'milliseconds', 'microseconds', or 'nanoseconds'</li><li>• <b>Start</b> — Start time</li><li>• <b>End</b> — End time (read only)</li><li>• <b>Increment</b> — Interval between two subsequent time values</li><li>• <b>Length</b> — Length of the time vector (read only)</li><li>• <b>Format</b> — String defining the date string display format. See the MATLAB <code>datestr</code> function reference page for more information.</li><li>• <b>StartDate</b> — Date string defining the reference date. See the MATLAB <code>setabstime (timeseries)</code> function reference page for more information.</li><li>• <b>UserData</b> — Stores any additional user-defined information</li></ul> |
| TreatNaNasMissing | <p>Logical value that specifies how to treat NaN values in Data:</p> <ul style="list-style-type: none"><li>• <b>true</b> — (Default) Treat all NaN values as missing data except during statistical calculations.</li><li>• <b>false</b> — Include NaN values in statistical calculations, in which case NaN values are propagated to the result.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

**See Also**

`datestr`, `get (timeseries)`, `set (timeseries)`, `setabstime (timeseries)`

# tstool

---

**Purpose** Open Time Series Tools GUI

**Syntax**

```
tstool
tstool(ts)
tstool(tsc)
tstool(sldata)
tstool(ModelDataLogs, 'replace')
```

**Description**

`tstool` starts the Time Series Tools GUI without loading any data.

`tstool(ts)` starts the Time Series Tools GUI and loads the time-series object `ts` from the MATLAB workspace.

`tstool(tsc)` starts the Time Series Tools GUI and loads the time-series collection object `tsc` from the MATLAB workspace.

`tstool(sldata)` starts the Time Series Tools GUI and loads the logged-signal data `sldata` from a Simulink model. If a Simulink logged signal `Name` property contains a `/`, the entire logged signal, including all levels of the signal hierarchy, is not imported into Time Series Tools.

`tstool(ModelDataLogs, 'replace')` replaces the logged-signal data object `ModelDataLogs` in the Time Series Tools GUI with an updated logged signal after you rerun the Simulink model. Use this command to update the `ModelDataLogs` object in the Time Series Tools GUI if you change the model or the logged-signal data settings.

**See Also** `timeseries`, `tscollection`

**Purpose**

Display contents of file

**Syntax**

```
type('filename')  
type filename
```

**Description**

`type('filename')` displays the contents of the specified file in the MATLAB Command Window. Use the full path for `filename`, or use a MATLAB relative partial pathname.

If you do not specify a filename extension and there is no filename file without an extension, the `type` function adds the `.m` extension by default. The `type` function checks the directories specified in the MATLAB search path, which makes it convenient for listing the contents of M-files on the screen. Use `type` with `more` on to see the listing one screen at a time.

`type filename` is the command form of the syntax.

**Examples**

`type('foo.bar')` lists the contents of the file `foo.bar`.

`type foo` lists the contents of the file `foo`. If `foo` does not exist, `type foo` lists the contents of the file `foo.m`.

**See Also**

`cd`, `dbtype`, `delete`, `dir`, `more`, `partialpath`, `path`, `what`, `who`

# typecast

---

**Purpose** Convert data types without changing underlying data

**Syntax** `Y = typecast(X, type)`

**Description** `Y = typecast(X, type)` converts a numeric value in `X` to the data type specified by `type`. Input `X` must be a full, noncomplex, numeric scalar or vector. The `type` input is a string set to one of the following: 'uint8', 'int8', 'uint16', 'int16', 'uint32', 'int32', 'uint64', 'int64', 'single', or 'double'.

`typecast` is different from the MATLAB `cast` function in that it does not alter the input data. `typecast` always returns the same number of bytes in the output `Y` as were in the input `X`. For example, casting the 16-bit integer 1000 to `uint8` with `typecast` returns the full 16 bits in two 8-bit segments (3 and 232) thus keeping its original value ( $3 \times 256 + 232 = 1000$ ). The `cast` function, on the other hand, truncates the input value to 255.

The output of `typecast` can be formatted differently depending on what system you use it on. Some computer systems store data starting with its most significant byte (an ordering called *big-endian*), while others start with the least significant byte (called *little-endian*).

---

**Note** MATLAB issues an error if `X` contains fewer values than are needed to make an output value.

---

## Examples

### Example 1

This example converts between data types of the same size:

```
typecast(uint8(255), 'int8')
ans =
    -1
```

```
typecast(int16(-1), 'uint16')
ans =
```



65535

### Example 2

Set X to a 1-by-3 vector of 32-bit integers, then cast it to an 8-bit integer type:

```
X = uint32([1 255 256])
X =
         1         255         256
```

Running this on a little-endian system produces the following results. Each 32-bit value is divided up into four 8-bit segments:

```
Y = typecast(X, 'uint8')
Y =
     1     0     0     0 255     0     0     0     0     1     0     0
```

The third element of X, 256, exceeds the 8 bits that it is being converted to in Y(9) and thus overflows to Y(10):

```
Y(9:12)
ans =
     0     1     0     0
```

Note that `length(Y)` is equal to `4.*length(X)`. Also note the difference between the output of `typecast` versus that of `cast`:

```
Z = cast(X, 'uint8')
Z =
     1 255 255
```

### Example 3

This example casts a smaller data type (`uint8`) into a larger one (`uint16`). Displaying the numbers in hexadecimal format makes it easier to see just how the data is being rearranged:

```
format hex
X = uint8([44 55 66 77])
X =
```

# typecast

---

```
2c 37 42 4d
```

The first typecast is done on a big-endian system. The four 8-bit segments of the input data are combined to produce two 16-bit segments:

```
Y = typecast(X, 'uint16')
Y =
    2c37    424d
```

The second is done on a little-endian system. Note the difference in byte ordering:

```
Y = typecast(X, 'uint16')
Y =
    372c    4d42
```

You can format the little-endian output into big-endian (and vice versa) using the `swapbytes` function:

```
Y = swapbytes(typecast(X, 'uint16'))
Y =
    2c37    424d
```

## Example 4

This example attempts to make a 32-bit value from a vector of three 8-bit values. MATLAB issues an error because there are an insufficient number of bytes in the input:

```
format hex

typecast(uint8([120 86 52]), 'uint32')
??? Too few input values to make output type.

Error in ==> typecast at 29
out = typecastc(in, datatype);
```

Repeat the example, but with a vector of four 8-bit values, and it returns the expected answer:

```
typecast(uint8([120 86 52 18]), 'uint32')
ans =
    12345678
```

**See Also**      [cast](#), [class](#), [swapbytes](#)

# uibbuttongroup

---

**Purpose** Create container object to exclusively manage radio buttons and toggle buttons

**Syntax** `uibbuttongroup('PropertyName1',Value1,'PropertyName2',Value2, ...)`  
`handle = uibbuttongroup(...)`

**Description** A `uibbuttongroup` groups components and manages exclusive selection behavior for radio buttons and toggle buttons that it contains. It can also contain other user interface controls, axes, `uipanel`s, and `uibbuttongroup`s. It cannot contain ActiveX controls.

`uibbuttongroup('PropertyName1',Value1,'PropertyName2',Value2,...)` creates a visible container component in the current figure window. This component manages exclusive selection behavior for `uicontrol`s of style `radiobutton` and `togglebutton`.

Use the `Parent` property to specify the parent as a figure, `uipanel`, or `uibbuttongroup`. If you do not specify a parent, `uibbuttongroup` adds the button group to the current figure. If no figure exists, one is created.

See the `Uibbuttongroup` Properties reference page for more information.

A `uibbuttongroup` object can have axes, `uicontrol`, `uipanel`, and `uibbuttongroup` objects as children. However, only `uicontrol`s of style `radiobutton` and `togglebutton` are managed by the component.

For the children of a `uibbuttongroup` object, the `Position` property is interpreted relative to the button group. If you move the button group, the children automatically move with it and maintain their positions in the button group.

If you have a button group that contains a set of radio buttons and toggle buttons and you want:

- An immediate action to occur when a radio button or toggle button is selected, you must include the code to control the radio and toggle buttons in the button group's `SelectionChangeFcn` callback function, not in the individual toggle button `Callback` functions. See the

SelectionChangeFcn property and the example on this reference page for more information.

- Another component such as a push button to base its action on the selection, then that component's Callback callback can get the handle of the selected radio button or toggle button from the button group's SelectedObject property.

`handle = uibuttongroup(...)` creates a uibuttongroup object and returns a handle to it in `handle`.

After creating a uibuttongroup, you can set and query its property values using `set` and `get`. Run `get(handle)` to see a list of properties and their current values. Run `set(handle)` to see a list of object properties you can set and their legal values.

## Examples

This example creates a uibuttongroup with three radiobuttons. It manages the radiobuttons with the SelectionChangeFcn callback, `selcbk`.

When you select a new radio button, `selcbk` displays the uibuttongroup handle on one line, the EventName, OldValue, and NewValue fields of the event data structure on a second line, and the value of the SelectedObject property on a third line.

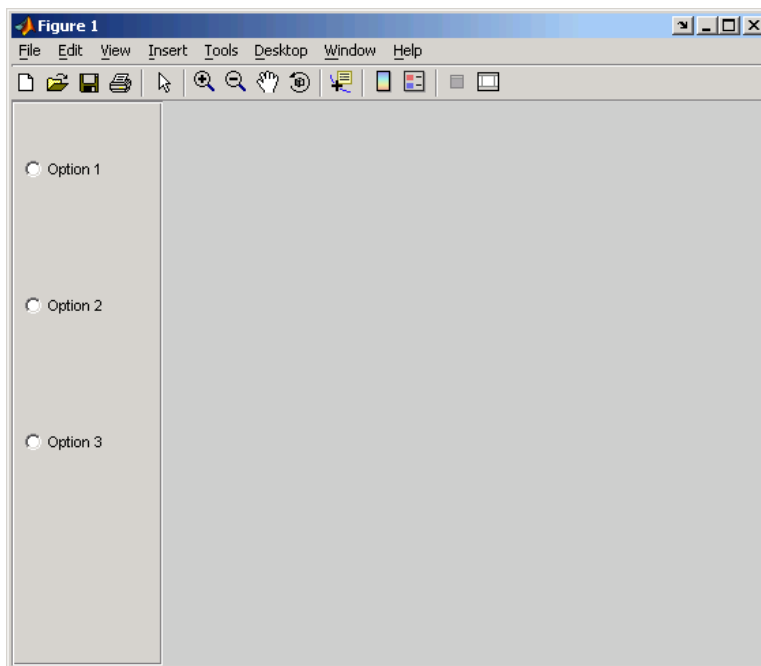
```
% Create the button group.
h = uibuttongroup('visible','off','Position',[0 0 .2 1]);
% Create three radio buttons in the button group.
u0 = uicontrol('Style','Radio','String','Option 1',...
    'pos',[10 350 100 30],'parent',h,'HandleVisibility','off');
u1 = uicontrol('Style','Radio','String','Option 2',...
    'pos',[10 250 100 30],'parent',h,'HandleVisibility','off');
u2 = uicontrol('Style','Radio','String','Option 3',...
    'pos',[10 150 100 30],'parent',h,'HandleVisibility','off');
% Initialize some button group properties.
set(h,'SelectionChangeFcn',@selcbk);
set(h,'SelectedObject',[]); % No selection
set(h,'Visible','on');
```

# uibbuttongroup

---

For the `SelectionChangeFcn` callback, `selcbk`, the source and event data structure arguments are available only if `selcbk` is called using a function handle. See `SelectionChangeFcn` for more information.

```
function selcbk(source,eventdata)
disp(source);
disp([eventdata.EventName,' ',...
      get(eventdata.OldValue,'String'),' ', ...
      get(eventdata.NewValue,'String')]);
disp(get(get(source,'SelectedObject'),'String'));
```



If you click Option 2 with no option selected, the `SelectionChangeFcn` callback, `selcbk`, displays:

```
3.0011
```

```
SelectionChanged Option 2  
Option 2
```

If you then click Option 1, the SelectionChangeFcn callback, selcbk, displays:

```
3.0011
```

```
SelectionChanged Option 2 Option 1  
Option 1
```

## See Also

uicontrol, uipanel

# Uibuttongroup Properties

---

**Purpose** Describe button group properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` functions enable you to set and query the values of properties.

Uibuttongroup takes its default property values from `uipanel`. To set a `uibuttongroup` default property value, set the default for the corresponding `uipanel` property. Note that you can set no default values for the `uibuttongroup` `SelectedObject` and `SelectionChangeFcn` properties.

For more information about changing the default value of a property see “Setting Default Property Values”. For an example, see the `CreateFcn` property.

**Uibuttongroup Properties** This section describes all properties useful to `uibuttongroup` objects and lists valid values. Curly braces { } enclose default values.

| Property Name                | Description                                |
|------------------------------|--------------------------------------------|
| <code>BackgroundColor</code> | Color of the button group background       |
| <code>BorderType</code>      | Type of border around the button group     |
| <code>BorderWidth</code>     | Width of the button group border in pixels |
| <code>BusyAction</code>      | Interruption of other callback routines    |
| <code>ButtonDownFcn</code>   | Button-press callback routine              |
| <code>Children</code>        | All children of the button group           |



## Uibuttongroup Properties

| Property Name      | Description                                                                                                                      |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Clipping           | Clipping of child axes, panels, and button groups to the button group. Does not affect child user interface controls (uicontrol) |
| CreateFcn          | Callback routine executed during object creation                                                                                 |
| DeleteFcn          | Callback routine executed during object deletion                                                                                 |
| FontAngle          | Title font angle                                                                                                                 |
| FontName           | Title font name                                                                                                                  |
| FontSize           | Title font size                                                                                                                  |
| FontUnits          | Title font units                                                                                                                 |
| FontWeight         | Title font weight                                                                                                                |
| ForegroundColor    | Title font color and color of 2-D border line                                                                                    |
| HandleVisibility   | Handle accessibility from command line and GUIs                                                                                  |
| HighlightColor     | 3-D frame highlight color                                                                                                        |
| Interruptible      | Callback routine interruption mode                                                                                               |
| Parent             | uibuttongroup object's parent                                                                                                    |
| Position           | Button group position relative to parent figure, panel, or button group                                                          |
| ResizeFcn          | User-specified resize routine                                                                                                    |
| Selected           | Whether object is selected                                                                                                       |
| SelectedObject     | Currently selected uicontrol of style radiobutton or togglebutton                                                                |
| SelectionChangeFcn | Callback routine executed when the selected radio button or toggle button changes                                                |
| SelectionHighlight | Object highlighted when selected                                                                                                 |

# Uibuttongroup Properties

---

| Property Name | Description                                                                                                                                                |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ShadowColor   | 3-D frame shadow color                                                                                                                                     |
| Tag           | User-specified object identifier                                                                                                                           |
| Title         | Title string                                                                                                                                               |
| TitlePosition | Location of title string in relation to the button group                                                                                                   |
| Type          | Object class                                                                                                                                               |
| UIContextMenu | Associate context menu with the button group                                                                                                               |
| Units         | Units used to interpret the position vector                                                                                                                |
| UserData      | User-specified data                                                                                                                                        |
| Visible       | Button group visibility                                                                                                                                    |
|               | <hr/> <b>Note</b> Controls the Visible property of child axes, panels, and button groups. Does not affect child user interface controls (uicontrol). <hr/> |

BackgroundColor  
ColorSpec

*Color of the uibuttongroup background.* A three-element RGB vector or one of the MATLAB predefined names, specifying the background color. See the ColorSpec reference page for more information on specifying color.

BorderType  
none | {etchedin} | etchedout |  
beveledin | beveledout | line

*Border of the uibuttongroup area.* Used to define the button group area graphically. Etched and beveled borders provide a 3-D look. Use the HighlightColor and ShadowColor properties to specify

the border color of etched and beveled borders. A line border is 2-D. Use the `ForegroundColor` property to specify its color.

`BorderWidth`  
integer

*Width of the button group border.* The width of the button group borders in pixels. The default border width is 1 pixel. 3-D borders wider than 3 may not appear correctly at the corners.

`BusyAction`  
cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new event uses the value of `BusyAction` to decide whether or not to attempt to interrupt the executing callback.

- If the value is `cancel`, the event is discarded and the second callback does not execute.
- If the value is `queue`, and the `Interruptible` property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

---

`ButtonDownFcn`  
string or function handle

# Uibuttongroup Properties

---

*Button-press callback routine.* A callback routine that executes when you press a mouse button while the pointer is in a 5-pixel wide border around the uibuttongroup. This is useful for implementing actions to interactively modify object properties, such as size and position, when they are clicked on (using the selectmoveresize function, for example).

If you define this routine as a string, the string can be a valid MATLAB expression or the name of an M-file. The expression executes in the MATLAB workspace.

## Children

vector of handles

*Children of the uibuttongroup.* A vector containing the handles of all children of the uibuttongroup. Although a uibuttongroup manages only uicontrols of style radiobutton and togglebutton, its children can be axes, uipanel, uibuttongroups, and other uicontrols. You can use this property to reorder the children.

## Clipping

{on} | off

*Clipping mode.* By default, MATLAB clips a uibuttongroup's child axes, uipanel, and uibuttongroups to the uibuttongroup rectangle. If you set Clipping to off, the axis, uipanel, or uibuttongroup is displayed outside the button group rectangle. This property does not affect child uicontrols which, by default, can display outside the button group rectangle.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a uibuttongroup object. MATLAB sets all property values for the uibuttongroup before executing the CreateFcn callback so these values are available to

the callback. Within the function, use `gcbo` to get the handle of the `uibuttongroup` being created.

Setting this property on an existing `uibuttongroup` object has no effect.

To define a default `CreateFcn` callback for all new `uibuttongroups` you must define the same default for all `uipanel`s. This default applies unless you override it by specifying a different `CreateFcn` callback when you call `uibuttongroup`. For example, the code

```
set(0,'DefaultUipanelCreateFcn','set(gcbo,...  
    'FontName','arial','FontSize',12)')
```

creates a default `CreateFcn` callback that runs whenever you create a new panel or button group. It sets the default font name and font size of the `uipanel` or `uibuttongroup` title.

To override this default and create a button group whose `FontName` and `FontSize` properties are set to different values, call `uibuttongroup` with code similar to

```
hpt = uibuttongroup(...,'CreateFcn','set(gcbo,...  
    'FontName','times','FontSize',14)')
```

---

**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uibuttongroup` call. In the example above, if instead of redefining the `CreateFcn` property for this `uibuttongroup`, you had explicitly set `FontSize` to 14, the default `CreateFcn` callback would have set `FontSize` back to the system dependent default.

---

# Uibuttongroup Properties

---

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

DeleteFcn  
string or function handle

*Callback routine executed during object deletion.* A callback routine that executes when you delete the uibuttongroup object (e.g., when you issue a delete command or clear the figure containing the uibuttongroup). MATLAB executes the routine before destroying the object’s properties so these values are available to the callback routine. The handle of the object whose DeleteFcn is being executed is accessible only through the root CallbackObject property, which you can query using gcbo.

FontAngle  
{normal} | italic | oblique

*Character slant used in the Title.* MATLAB uses this property to select a font from those available on your particular system. Setting this property to italic or oblique selects a slanted version of the font, when it is available on your system.

FontName  
string

*Font family used in the Title.* The name of the font in which to display the Title. To display and print properly, this must be a font that your system supports. The default font is system dependent. To eliminate the need to hard code the name of a fixed-width font, which may not display text properly on systems that do not use ASCII character encoding (such as in Japan), set FontName to the string FixedWidth. This string value is case insensitive.

```
set(uicontrol_handle, 'FontName', 'FixedWidth')
```

This then uses the value of the root FixedWidthFontName property, which can be set to the appropriate value for a locale

from `startup.m` in the end user's environment. Setting the root `FixedWidthFontName` property causes an immediate update of the display to use the new font.

`FontSize`  
integer

*Title font size.* A number specifying the size of the font in which to display the `Title`, in units determined by the `FontUnits` property. The default size is system dependent.

`FontUnits`  
inches | centimeters | normalized |  
{points} | pixels

*Title font size units.* Normalized units interpret `FontSize` as a fraction of the height of the `uibuttongroup`. When you resize the `uibuttongroup`, MATLAB modifies the screen `FontSize` accordingly. `pixels`, `inches`, `centimeters`, and `points` are absolute units (1 point = 1/72 inch).

`FontWeight`  
light | {normal} | demi | bold

*Weight of characters in the title.* MATLAB uses this property to select a font from those available on your particular system. Setting this property to `bold` causes MATLAB to use a bold version of the font, when it is available on your system.

`ForegroundColor`  
`ColorSpec`

*Color used for title font and 2-D border line.* A three-element RGB vector or one of the MATLAB predefined names, specifying the font or line color. See the `ColorSpec` reference page for more information on specifying color.

`HandleVisibility`  
{on} | callback | off

## Uibuttongroup Properties

---

*Control access to object's handle.* This property determines when an object's handle is visible in its parent's list of children. When a handle is not visible in its parent's list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`. Neither is the handle visible in the parent figure's `CurrentObject` property. Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when `HandleVisibility` is on.
- Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

---

**Note** `Uicontrols` of style `radiobutton` and `togglebutton` that are managed by a `uibuttongroup` should not be accessed outside the button group. Set the `HandleVisibility` of such radio buttons and toggle buttons to `off` or `callback` to prevent inadvertent access.

---

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.



HighlightColor  
ColorSpec

*3-D frame highlight color.* A three-element RGB vector or one of the MATLAB predefined names, specifying the highlight color. See the ColorSpec reference page for more information on specifying color.

Interruptible  
{on} | off

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The Interruptible property of the object whose callback is executing
- Whether the executing callback contains drawnow, figure, getframe, pause, or waitfor statements
- The BusyAction property of the object whose callback is waiting to execute

If the Interruptible property of the object whose callback is executing is on (the default), the callback can be interrupted. Whenever the callback calls one of the drawnow, figure, getframe, pause, or waitfor functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the Interruptible property of the object whose callback is executing is off, the callback cannot be interrupted (except by certain callbacks; see the note below). The BusyAction property of the object whose callback is waiting to execute determines what happens to the waiting callback.

# Uibuttongroup Properties

---

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. The interrupting callback starts execution at the next `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statement. A figure's `WindowButtonDownFcn` callback routine, or an object's `ButtonDownFcn` or `Callback` routine is processed according to the rules described above.

---

Parent  
handle

*Uibuttongroup parent.* The handle of the `uibuttongroup`'s parent figure, `uipanel`, or `uibuttongroup`. You can move a `uibuttongroup` object to another figure, `uipanel`, or `uibuttongroup` by setting this property to the handle of the new parent.

Position  
position rectangle

*Size and location of uibuttongroup relative to parent.* The rectangle defined by this property specifies the size and location of the button group within the parent figure window, `uipanel`, or `uibuttongroup`. Specify `Position` as

[left bottom width height]

`left` and `bottom` are the distance from the lower-left corner of the parent object to the lower-left corner of the `uibuttongroup` object. `width` and `height` are the dimensions of the `uibuttongroup` rectangle, including the title. All measurements are in units specified by the `Units` property.

`ResizeFcn`  
string or function handle

*Resize callback routine.* MATLAB executes this callback routine whenever a user resizes the uibuttongroup and the figure `Resize` property is set to on, or in GUIDE, the **Resize behavior** option is set to Other. You can query the uibuttongroup `Position` property to determine its new size and position. During execution of the callback routine, the handle to the figure being resized is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

You can use `ResizeFcn` to maintain a GUI layout that is not directly supported by the MATLAB `Position/Units` paradigm.

For example, consider a GUI layout that maintains an object at a constant height in pixels and attached to the top of the figure, but always matches the width of the figure. The following `ResizeFcn` accomplishes this; it keeps the uicontrol whose `Tag` is 'StatusBar' 20 pixels high, as wide as the figure, and attached to the top of the figure. Note the use of the `Tag` property to retrieve the uicontrol handle, and the `gcbo` function to retrieve the figure handle. Also note the defensive programming regarding figure `Units`, which the callback requires to be in pixels in order to work correctly, but which the callback also restores to their previous value afterwards.

```
u = findobj('Tag','StatusBar');
fig = gcbo;
old_units = get(fig,'Units');
set(fig,'Units','pixels');
figpos = get(fig,'Position');
upos = [0, figpos(4) - 20, figpos(3), 20];
set(u,'Position',upos);
set(fig,'Units',old_units);
```

You can change the figure `Position` from within the `ResizeFcn` callback; however, the `ResizeFcn` is not called again as a result.

# Uibuttongroup Properties

---

Note that the `print` command can cause the `ResizeFcn` to be called if the `PaperPositionMode` property is set to `manual` and you have defined a resize function. If you do not want your resize function called by `print`, set the `PaperPositionMode` to `auto`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

## Selected

on | off (read only)

*Is object selected?* This property indicates whether the button group is selected. When this property is on, MATLAB displays selection handles if the `SelectionHighlight` property is also on. You can, for example, define the `ButtonDownFcn` function to set this property, allowing users to select the object with the mouse.

## SelectedObject

scalar handle

*Currently selected radio button or toggle button uicontrol* in the managed group of components. Use this property to determine the currently selected component or to initialize selection of one of the radio buttons or toggle buttons. By default, `SelectedObject` is set to the first `uicontrol` radio button or toggle button that is added. Set it to `[]` if you want no selection. Note that `SelectionChangeFcn` does not execute when this property is set by the user.

## SelectionChangeFcn

string or function handle

Callback routine executed when the selected radio button or toggle button changes. If this routine is called as a function handle, `uibuttongroup` passes it two arguments. The first argument, `source`, is the handle of the `uibuttongroup`. The second argument, `eventdata`, is an event data structure that contains the fields shown in the following table.

# Uibuttongroup Properties

| Event Data Structure Field | Description                                                               |
|----------------------------|---------------------------------------------------------------------------|
| EventName                  | 'SelectionChanged'                                                        |
| OldValue                   | Handle of the object selected before this event. [] if none was selected. |
| NewValue                   | Handle of the currently selected object.                                  |

If you have a button group that contains a set of radio buttons and/or toggle buttons and you want an immediate action to occur when a radio button or toggle button is selected, you must include the code to control the radio and toggle buttons in the button group's `SelectionChangeFcn` callback function, not in the individual toggle button `Callback` functions.

If you want another component such as a push button to base its action on the selection, then that component's `Callback` callback can get the handle of the selected radio button or toggle button from the button group's `SelectedObject` property.

---

**Note** For GUIDE GUIs, `hObject` contains the handle of the selected radio button or toggle button. See “Examples: Programming GUIDE GUI Components” for more information.

---

`SelectionHighlight`  
{on} | off

*Object highlighted when selected.* When the `Selected` property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When `SelectionHighlight` is off, MATLAB does not draw the handles.

`ShadowColor`  
ColorSpec

# Uibuttongroup Properties

---

*3-D frame shadow color.* ShadowColor is a three-element RGB vector or one of the MATLAB predefined names, specifying the shadow color. See the ColorSpec reference page for more information on specifying color.

Tag

string

*User-specified object identifier.* The Tag property provides a means to identify graphics objects with a user-specified label. You can define Tag as any string.

With the findobj function, you can locate an object with a given Tag property value. This saves you from defining object handles as global variables. For example, this function call returns the handles of all children (of the specified figures) that have the Tag value 'FormatTb'.

```
h = findobj(figurehandles,'Tag','FormatTb')
```

Title

string

*Title string.* The text displayed in the button group title. You can position the title using the TitlePosition property.

If the string value is specified as a cell array of strings or padded string matrix, only the first string in the cell array or padded string matrix is displayed; the rest are ignored. Vertical slash ('|') characters are not interpreted as line breaks and instead show up in the text displayed in the uibuttongroup title.

Setting a property value to default, remove, or factory produces the effect described in “Defining Default Values”. To set Title to one of these words, you must precede the word with the backslash character. For example,

```
hp = uibuttongroup(...,'Title','\Default');
```

## TitlePosition

{lefttop} | centertop | righttop |  
leftbottom | centerbottom | rightbottom

*Location of the title.* This property determines the location of the title string, in relation to the uibuttongroup.

## Type

string (read-only)

*Object class.* This property identifies the kind of graphics object. For uibuttongroup objects, Type is always the string 'uibuttongroup'.

## UIContextMenu

handle

*Associate a context menu with a uibuttongroup.* Assign this property the handle of a Uicontextmenu object. MATLAB displays the context menu whenever you right-click the uibuttongroup. Use the uicontextmenu function to create the context menu.

## Units

inches | centimeters | {normalized} |  
points | pixels | characters

*Units of measurement.* MATLAB uses these units to interpret the Position property. For the button group itself, units are measured from the lower-left corner of its parent figure window, panel, or button group. For children of the button group, they are measured from the lower-left corner of the button group.

- Normalized units map the lower-left corner of the button group or figure window to (0,0) and the upper-right corner to (1.0,1.0).
- pixels, inches, centimeters, and points are absolute units (1 point = 1/72 inch).
- Character units are characters using the default system font; the width of one character is the width of the letter x, the

# Uibuttongroup Properties

---

height of one character is the distance between the baselines of two lines of text.

If you change the value of `Units`, it is good practice to return it to its default value after completing your computation so as not to affect other functions that assume `Units` is set to the default value.

`UserData`  
matrix

*User-specified data.* Any data you want to associate with the `uibuttongroup` object. MATLAB does not use this data, but you can access it using `set` and `get`.

`Visible`  
{on} | off

*Uibuttongroup visibility.* By default, a `uibuttongroup` object is visible. When set to `off`, the `uibuttongroup` is not visible, but still exists and you can query and set its properties.

---

**Note** The value of a `uibuttongroup`'s `Visible` property also controls the `Visible` property of child axes, `uipanel`s, and `uibuttongroup`s. This property does not affect the `Visible` property of child `uicontrol`s.

---



**Purpose**

Create context menu

**Syntax**

```
handle = uicontextmenu('PropertyName',PropertyValue,...)
```

**Description**

`handle = uicontextmenu('PropertyName',PropertyValue,...)` creates a context menu, which is a menu that appears when the user right-clicks on a graphics object. See the [Uicontextmenu Properties](#) reference page for more information.

You create context menu items using the `uimenu` function. Menu items appear in the order the `uimenu` statements appear. You associate a context menu with an object using the `UIContextMenu` property for the object and specifying the context menu's handle as the property value.

**Example**

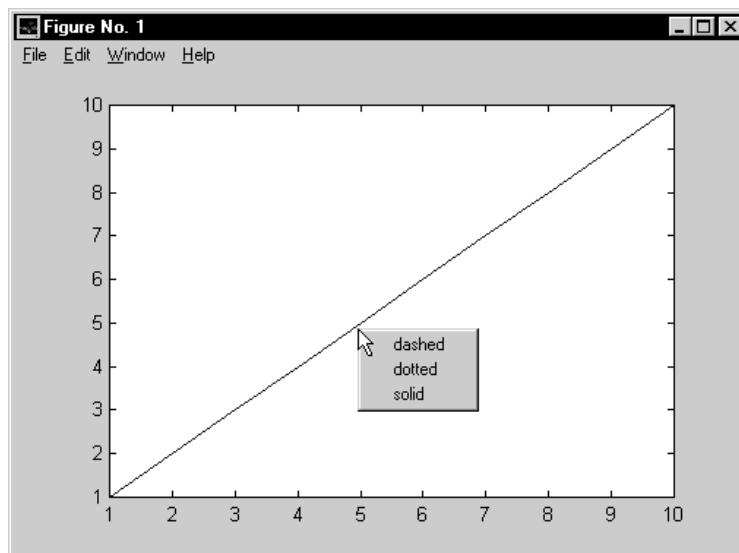
These statements define a context menu associated with a line. When the user right clicks or presses **Alt+click** anywhere on the line, the menu appears. Menu items enable the user to change the line style.

```
% Define the context menu
cmenu = uicontextmenu;
% Define the line and associate it with the context menu
hline = plot(1:10, 'UIContextMenu', cmenu);
% Define callbacks for context menu items
cb1 = ['set(hline, 'LineStyle', '--)'];
cb2 = ['set(hline, 'LineStyle', ':)'];
cb3 = ['set(hline, 'LineStyle', '-')'];
% Define the context menu items
item1 = uimenu(cmenu, 'Label', 'dashed', 'Callback', cb1);
item2 = uimenu(cmenu, 'Label', 'dotted', 'Callback', cb2);
item3 = uimenu(cmenu, 'Label', 'solid', 'Callback', cb3);
```

When the user right clicks or presses **Alt+click** on the line, the context menu appears, as shown in this figure:

# uicontextmenu

---



**See Also** [uibuttongroup](#), [uicontrol](#), [uimenu](#), [uipanel](#)

## Purpose

Describe context menu properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` functions enable you to set and query the values of properties.

For more information about changing the default value of a property see “Setting Default Property Values”. For an example, see the `CreateFcn` property.

## Uicontextmenu Properties

This section lists all properties useful to `uicontextmenu` objects along with valid values and descriptions of their use. Curly braces `{}` enclose default values.

| Property                      | Purpose                                                              |
|-------------------------------|----------------------------------------------------------------------|
| <code>BusyAction</code>       | Callback routine interruption                                        |
| <code>Callback</code>         | Control action                                                       |
| <code>Children</code>         | The <code>uimenu</code> s defined for the <code>uicontextmenu</code> |
| <code>CreateFcn</code>        | Callback routine executed during object creation                     |
| <code>DeleteFcn</code>        | Callback routine executed during object deletion                     |
| <code>HandleVisibility</code> | Whether handle is accessible from command line and GUIs              |
| <code>Interruptible</code>    | Callback routine interruption mode                                   |
| <code>Parent</code>           | <code>Uicontextmenu</code> object's parent                           |

# Uicontextmenu Properties

---

| Property | Purpose                                             |
|----------|-----------------------------------------------------|
| Position | Location of uicontextmenu when Visible is set to on |
| Tag      | User-specified object identifier                    |
| Type     | Class of graphics object                            |
| UserData | User-specified data                                 |
| Visible  | Uicontextmenu visibility                            |

## BusyAction

cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new event uses the value of BusyAction to decide whether or not to attempt to interrupt the executing callback.

- If the value is cancel, the event is discarded and the second callback does not execute.
- If the value is queue, and the Interruptible property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a DeleteFcn or CreateFcn callback or a figure's CloseRequest or ResizeFcn callback, it interrupts an executing callback regardless of the value of that object's Interruptible property. See the Interruptible property for information about controlling a callback's interruptibility.

---

## Callback

string

*Control action.* A routine that executes whenever you right-click an object for which a context menu is defined. The routine executes immediately before the context menu is posted. Define this routine as a string that is a valid MATLAB expression or the name of an M-file. The expression executes in the MATLAB workspace.

## Children

matrix

The uimenu items defined for the uicontextmenu.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a uicontextmenu object. MATLAB sets all property values for the uicontextmenu before executing the CreateFcn callback so these values are available to the callback. Within the function, use `gcb0` to get the handle of the uicontextmenu being created.

Setting this property on an existing uicontextmenu object has no effect.

You can define a default CreateFcn callback for all new uicontextmenus. This default applies unless you override it by specifying a different CreateFcn callback when you call `uicontextmenu`. For example, the code

```
set(0, 'DefaultUicontextmenuCreateFcn', 'set(gcb0, ...  
    'Visible', 'on')')
```

# Uicontextmenu Properties

---

creates a default `CreateFcn` callback that runs whenever you create a new context menu. It sets the default `Visible` property of a context menu.

To override this default and create a context menu whose `Visible` property is set to a different value, call `uicontextmenu` with code similar to

```
hpt = uicontextmenu(...,'CreateFcn','set(gcbo,...  
    'Visible','off')')
```

---

**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uicontextmenu` call. In the example above, if instead of redefining the `CreateFcn` property for this `uicontextmenu`, you had explicitly set `Visible` to `off`, the default `CreateFcn` callback would have set `Visible` back to the default, i.e., `on`.

---

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

`DeleteFcn`  
string or function handle

*Delete uicontextmenu callback routine.* A callback routine that executes when you delete the `uicontextmenu` object (e.g., when you issue a `delete` command or clear the figure containing the `uicontextmenu`). MATLAB executes the routine before destroying the object’s properties so these values are available to the callback routine.

The handle of the object whose DeleteFcn is being executed is accessible only through the root CallbackObject property, which you can query using gcbo.

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

## HandleVisibility

{on} | callback | off

*Control access to object’s handle.* This property determines when an object’s handle is visible in its parent’s list of children. When a handle is not visible in its parent’s list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes get, findobj, gca, gcf, gco, newplot, cla, clf, and close. Neither is the handle visible in the parent figure’s CurrentObject property. Handles that are hidden are still valid. If you know an object’s handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when HandleVisibility is on.
- Setting HandleVisibility to callback causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting HandleVisibility to off makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

You can set the root ShowHiddenHandles property to on to make all handles visible, regardless of their HandleVisibility

# Uicontextmenu Properties

---

settings. This does not affect the values of the `HandleVisibility` properties.

`Interruptible`  
{on} | off

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The `Interruptible` property of the object whose callback is executing
- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the `Interruptible` property of the object whose callback is executing is `on` (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the `Interruptible` property of the object whose callback is executing is `off`, the callback cannot be interrupted (except by certain callbacks; see the note below). The `BusyAction` property of the object whose callback is waiting to execute determines what happens to the callback.



---

**Note** If the interrupting callback is a DeleteFcn or CreateFcn callback or a figure's CloseRequest or ResizeFcn callback, it interrupts an executing callback regardless of the value of that object's Interruptible property. The interrupting callback starts execution at the next drawnow, figure, getframe, pause, or waitfor statement. A figure's WindowButtonDownFcn callback routine, or an object's ButtonDownFcn or Callback routine are processed according to the rules described above.

---

Parent

handle

*Uicontextmenu's parent.* The handle of the uicontextmenu's parent object. You can move a uicontextmenu object to another figure, uipanel, or uibuttongroup by setting this property to the handle of the new parent.

Position

vector

*Uicontextmenu's position.* A two-element vector that defines the location of a context menu posted by setting the Visible property value to on. Specify Position as

[x y]

where vector elements represent the horizontal and vertical distances in pixels from the bottom left corner of the figure window, panel, or button group to the top left corner of the context menu.

Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This

# Uicontextmenu Properties

---

is particularly useful when constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callback routines. You can define Tag as any string.

## Type

string

*Class of graphics object.* For uicontextmenu objects, Type is always the string 'uicontextmenu'.

## UserData

matrix

*User-specified data.* Any data you want to associate with the uicontextmenu object. MATLAB does not use this data, but you can access it using set and get.

## Visible

on | {off}

*Uicontextmenu visibility.* The Visible property can be used in two ways:

- Its value indicates whether the context menu is currently posted. While the context menu is posted, the property value is on; when the context menu is not posted, its value is off.
- Its value can be set to on to force the posting of the context menu. Similarly, setting the value to off forces the context menu to be removed. When used in this way, the Position property determines the location of the posted context menu.

**Purpose**

Create user interface control object

**Syntax**

```
handle = uicontrol('PropertyName',PropertyValue,...)
handle = uicontrol(parent,'PropertyName',PropertyValue,...)
handle = uicontrol
uicontrol(uich)
```

**Description**

`uicontrol` creates a `uicontrol` graphics objects (user interface controls), which you use to implement graphical user interfaces.

`handle = uicontrol('PropertyName',PropertyValue,...)` creates a `uicontrol` and assigns the specified properties and values to it. It assigns the default values to any properties you do not specify. The default `uicontrol` style is a `pushbutton`. The default parent is the current figure. See the `Uicontrol Properties` reference page for more information.

`handle = uicontrol(parent,'PropertyName',PropertyValue,...)` creates a `uicontrol` in the object specified by the `handle`, `parent`. If you also specify a different value for the `Parent` property, the value of the `Parent` property takes precedence. `parent` can be the handle of a figure, `uipanel`, or `uibuttongroup`.

`handle = uicontrol` creates a `pushbutton` in the current figure. The `uicontrol` function assigns all properties their default values.

`uicontrol(uich)` gives focus to the `uicontrol` specified by the `handle`, `uich`.

When selected, most `uicontrol` objects perform a predefined action. MATLAB supports numerous styles of `uicontrols`, each suited for a different purpose:

- Check boxes
- Editable text fields
- Frames
- List boxes

- Pop-up menus
- Push buttons
- Radio buttons
- Sliders
- Static text labels
- Toggle buttons

For information on using these uicontrols within GUIDE, the MATLAB GUI development environment, see [Examples: Programming GUI Components in the MATLAB Creating GUIs documentation](#)

## Specifying the Uicontrol Style

To create a specific type of uicontrol, set the `Style` property as one of the following strings:

- `'checkbox'` – Check boxes generate an action when selected. These devices are useful when providing the user with a number of independent choices. To activate a check box, click the mouse button on the object. The state of the device is indicated on the display.
- `'edit'` – Editable text fields enable users to enter or modify text values. Use editable text when you want text as input. If `Max-Min>1`, then multiple lines are allowed. For multi-line edit boxes, a vertical scrollbar enables scrolling, as do the arrow keys.
- `'frame'` – Frames are rectangles that provide a visual enclosure for regions of a figure window. Frames can make a user interface easier to understand by grouping related controls. Frames have no callback routines associated with them. Only other uicontrols can appear within frames.

Frames are opaque, not transparent, so the order in which you define uicontrols is important in determining whether uicontrols within a frame are covered by the frame or are visible. *Stacking order* determines the order objects are drawn: objects defined first are drawn first; objects defined later are drawn over existing objects. If

you use a frame to enclose objects, you must define the frame before you define the objects.

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**Note** Most frames in existing GUIs can now be replaced with panels (`uipanel`) or button groups (`uibuttongroup`). GUIDE continues to support frames in those GUIs that contain them, but the frame component does not appear in the GUIDE Layout Editor component palette.

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- 'listbox' – List boxes display a list of items and enable users to select one or more items. The `Min` and `Max` properties control the selection mode:

If  $\text{Max} - \text{Min} > 1$ , then multiple selection is allowed.

If  $\text{Max} - \text{Min} \leq 1$ , then only single selection is allowed.

The `Value` property indicates selected entries and contains the indices into the list of strings; a vector value indicates multiple selections. MATLAB evaluates the list box's callback routine after any mouse button up event that changes the `Value` property. Therefore, you may need to add a "Done" button to delay action caused by multiple clicks on list items. List boxes differentiate between single and double clicks and set the figure `SelectionType` property to `normal` or `open` accordingly before evaluating the list box's `Callback` property.

- 'popupmenu' – Pop-up menus (also known as drop-down menus or combo boxes) open to display a list of choices when pressed. When not open, a pop-up menu indicates the current choice. Pop-up menus are useful when you want to provide users with a number of mutually exclusive choices, but do not want to take up the amount of space that a series of radio buttons requires.
- 'pushbutton' – Push buttons generate an action when pressed. To activate a push button, click the mouse button on the push button.
- 'radiobutton' – Radio buttons are similar to check boxes, but are intended to be mutually exclusive within a group of related radio

buttons (i.e., only one is in a pressed state at any given time). To activate a radio button, click the mouse button on the object. The state of the device is indicated on the display. Note that your code can implement mutually exclusive behavior for radio buttons.

- 'slider' – Sliders accept numeric input within a specific range by enabling the user to move a sliding bar. Users move the bar by pressing the mouse button and dragging the pointer over the bar, or by clicking in the trough or on an arrow. The location of the bar indicates a numeric value, which is selected by releasing the mouse button. You can set the minimum, maximum, and current values of the slider.
- 'text' – Static text boxes display lines of text. Static text is typically used to label other controls, provide directions to the user, or indicate values associated with a slider. Users cannot change static text interactively and there is no way to invoke the callback routine associated with it.
- 'togglebutton' – Toggle buttons are controls that execute callbacks when clicked on and indicate their state, either on or off. Toggle buttons are useful for building toolbars.

## Remarks

- The `uicontrol` function accepts property name/property value pairs, structures, and cell arrays as input arguments and optionally returns the handle of the created object. You can also set and query property values after creating the object using the `set` and `get` functions.
- A `uicontrol` object is a child of a `figure`, `uipanel`, or `uibuttongroup` and therefore does not require an axes to exist when placed in a figure window, `uipanel`, or `uibuttongroup`.
- When MATLAB is paused and a `uicontrol` has focus, pressing a keyboard key does not cause MATLAB to resume. Click anywhere outside a `uicontrol` and then press any key. See the `pause` function for more information.

## Examples

### Example 1

The following statement creates a push button that clears the current axes when pressed.

```
h = uicontrol('Style', 'pushbutton', 'String', 'Clear',...
             'Position', [20 150 100 70], 'Callback', 'cla');
```

This statement gives focus to the pushbutton.

```
uicontrol(h)
```

### Example 2

You can create a `uicontrol` object that changes figure colormaps by specifying a pop-up menu and supplying an M-file name as the object's `Callback`:

```
hpop = uicontrol('Style', 'popup',...
                'String', 'hsv|hot|cool|gray',...
                'Position', [20 320 100 50],...
                'Callback', 'setmap');
```

The above call to `uicontrol` defines four individual choices in the menu: `hsv`, `hot`, `cool`, and `gray`. You specify these choices with the `String` property, separating the choices with the `"|"` character.

The `Callback`, in this case `setmap`, is the name of an M-file that defines a more complicated set of instructions than a single MATLAB command. `setmap` contains these statements:

```
val = get(hpop, 'Value');
if val == 1
    colormap(hsv)
elseif val == 2
    colormap(hot)
elseif val == 3
    colormap(cool)
elseif val == 4
    colormap(gray)
```

# uicontrol

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end

The Value property contains a number that indicates the selected choice. The choices are numbered sequentially from one to four. The setmap M-file can get and then test the contents of the Value property to determine what action to take.

## See Also

textwrap, uibuttongroup, uimenu, uipanel



## Purpose

Describe user interface control (`uicontrol`) properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` commands enable you to set and query the values of properties

To change the default value of properties see “Setting Default Property Values”. You can also set default `uicontrol` properties on the root and figure levels:

```
set(0, 'DefaultUicontrolProperty', PropertyValue...)  
set(gcf, 'DefaultUicontrolProperty', PropertyValue...)
```

where *Property* is the name of the `uicontrol` property whose default value you want to set and *PropertyValue* is the value you are specifying as the default. Use `set` and `get` to access `uicontrol` properties.

For information on using these `uicontrols` within GUIDE, the MATLAB GUI development environment, see Programming GUI Components in the MATLAB Creating GUIs documentation.

## Uicontrol Properties

This section lists all properties useful to `uicontrol` objects along with valid values and descriptions of their use. Curly braces `{}` enclose default values.

| Property                     | Purpose                       |
|------------------------------|-------------------------------|
| <code>BackgroundColor</code> | Object background color       |
| <code>BusyAction</code>      | Callback routine interruption |
| <code>ButtonDownFcn</code>   | Button-press callback routine |
| <code>Callback</code>        | Control action                |

# Uicontrol Properties

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| <b>Property</b>     | <b>Purpose</b>                                          |
|---------------------|---------------------------------------------------------|
| CData               | Truecolor image displayed on the control                |
| Children            | Uicontrol objects have no children                      |
| CreateFcn           | Callback routine executed during object creation        |
| DeleteFcn           | Callback routine executed during object deletion        |
| Enable              | Enable or disable the uicontrol                         |
| FontAngle           | Character slant                                         |
| FontName            | Font family                                             |
| FontSize            | Font size                                               |
| FontUnits           | Font size units                                         |
| FontWeight          | Weight of text characters                               |
| ForegroundColor     | Color of text                                           |
| HandleVisibility    | Whether handle is accessible from command line and GUIs |
| HitTest             | Whether selectable by mouse click                       |
| HorizontalAlignment | Alignment of label string                               |
| Interruptible       | Callback routine interruption mode                      |
| KeyPressFcn         | Key press callback routine                              |
| ListboxTop          | Index of top-most string displayed in list box          |
| Max                 | Maximum value (depends on uicontrol object)             |
| Min                 | Minimum value (depends on uicontrol object)             |
| Parent              | Uicontrol object's parent                               |
| Position            | Size and location of uicontrol object                   |

| Property           | Purpose                                                     |
|--------------------|-------------------------------------------------------------|
| Selected           | Whether object is selected                                  |
| SelectionHighlight | Object highlighted when selected                            |
| SliderStep         | Slider step size                                            |
| String             | Uicontrol object label, also list box and pop-up menu items |
| Style              | Type of uicontrol object                                    |
| Tag                | User-specified object identifier                            |
| TooltipString      | Content of object's tooltip                                 |
| Type               | Class of graphics object                                    |
| UIContextMenu      | Uicontextmenu object associated with the uicontrol          |
| Units              | Units to interpret position vector                          |
| UserData           | User-specified data                                         |
| Value              | Current value of uicontrol object                           |
| Visible            | Uicontrol visibility                                        |

BackgroundColor  
ColorSpec

*Object background color.* The color used to fill the uicontrol rectangle. Specify a color using a three-element RGB vector or one of the MATLAB predefined names. The default color is determined by system settings. See ColorSpec for more information on specifying color.

BusyAction  
cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for

# Uicontrol Properties

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which a callback is defined, the callback associated with the new event uses the value of `BusyAction` to decide whether or not to attempt to interrupt the executing callback.

- If the value is `cancel`, the event is discarded and the second callback does not execute.
- If the value is `queue`, and the `Interruptible` property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

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**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

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## `ButtonDownFcn`

string or function handle (GUIDE sets this property)

*Button-press callback routine.* A callback routine that can execute when you press a mouse button while the pointer is on or near a uicontrol. Specifically:

- If the uicontrol's `Enable` property is set to on, the `ButtonDownFcn` callback executes when you click the right or left mouse button in a 5-pixel border around the uicontrol or when you click the right mouse button on the control itself.
- If the uicontrol's `Enable` property is set to `inactive` or `off`, the `ButtonDownFcn` executes when you click the right or left mouse button in the 5-pixel border or on the control itself.

This is useful for implementing actions to interactively modify control object properties, such as size and position, when they are clicked on (using `selectmoveresize`, for example).

Define this routine as a string that is a valid MATLAB expression or the name of an M-file. The expression executes in the MATLAB workspace.

To add a `ButtonDownFcn` callback in GUIDE, select **View Callbacks** from the Layout Editor **View** menu, then select `ButtonDownFcn`. GUIDE sets this property to the appropriate string and adds the callback to the M-file the next time you save the GUI. Alternatively, you can set this property to the string `%automatic`. The next time you save the GUI, GUIDE sets this property to the appropriate string and adds the callback to the M-file.

Use the `Callback` property to specify the callback routine that executes when you activate the enabled uicontrol (e.g., click a push button).

## Callback

string or function handle (GUIDE sets this property)

*Control action.* A routine that executes whenever you activate the uicontrol object (e.g., when you click on a push button or move a slider). Define this routine as a string that is a valid MATLAB expression or the name of an M-file. The expression executes in the MATLAB workspace.

For examples of `Callback` callbacks for each style of component:

- For GUIDE GUIs, see “Examples: Programming GUIDE GUI Components”.
- For programmatically created GUIs, see “Examples: Programming GUI Components”.

Callback routines defined for static text do not execute because no action is associated with these objects.

# Uicontrol Properties

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To execute the callback routine for an edit text control, type in the desired text and then do one of the following:

- Click another component, the menu bar, or the background of the GUI.
- For a single line editable text box, press **Enter**.
- For a multiline editable text box, press **Ctrl+Enter**.

## CData

matrix

*Tricolor image displayed on control.* A three-dimensional matrix of RGB values that defines a tricolor image displayed on a control, which must be a **push button** or **toggle button**. Each value must be between 0.0 and 1.0. Setting CData on a **radio button** or **checkbox** will replace the default CData on these controls. The control will continue to work as expected, but its state is not reflected by its appearance when clicked.

For **push buttons** and **toggle buttons**, CData overlaps the String. In the case of **radio buttons** and **checkboxes**, CData takes precedence over String and, depending on its size, it can displace the text.

Setting CData to [ ] restores the default CData for **radio buttons** and **checkboxes**.

## Children

matrix

The empty matrix; uicontrol objects have no children.

## Clipping

{on} | off

This property has no effect on uicontrol objects.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a uicontrol object. MATLAB sets all property values for the uicontrol before executing the CreateFcn callback so these values are available to the callback. Within the function, use `gcbo` to get the handle of the uicontrol being created.

Setting this property on an existing uicontrol object has no effect.

You can define a default CreateFcn callback for all new uicontrols. This default applies unless you override it by specifying a different CreateFcn callback when you call `uicontrol`. For example, the code

```
set(0, 'DefaultUicontrolCreateFcn', 'set(gcbo,...  
    'BackgroundColor','white')')
```

creates a default CreateFcn callback that runs whenever you create a new uicontrol. It sets the default background color of all new uicontrols.

To override this default and create a uicontrol whose `BackgroundColor` is set to a different value, call `uicontrol` with code similar to

```
hpt = uicontrol(..., 'CreateFcn', 'set(gcbo,...  
    'BackgroundColor','blue')')
```

# Uicontrol Properties

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**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uicontrol` call. In the example above, if instead of redefining the `CreateFcn` property for this `uicontrol`, you had explicitly set `BackgroundColor` to blue, the default `CreateFcn` callback would have set `BackgroundColor` back to the default, i.e., white.

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See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

`DeleteFcn`  
string or function handle

*Delete uicontrol callback routine.* A callback routine that executes when you delete the `uicontrol` object (e.g., when you issue a `delete` command or clear the figure containing the `uicontrol`). MATLAB executes the routine before destroying the object’s properties so these values are available to the callback routine.

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

`Enable`  
{on} | inactive | off

*Enable or disable the uicontrol.* This property controls how `uicontrols` respond to mouse button clicks, including which callback routines execute.



- `on` – The uicontrol is operational (the default).
- `inactive` – The uicontrol is not operational, but looks the same as when `Enable` is `on`.
- `off` – The uicontrol is not operational and its image (set by the `Cdata` property) is grayed out.

When you left-click on a uicontrol whose `Enable` property is `on`, MATLAB performs these actions in this order:

- 1** Sets the figure's `SelectionType` property.
- 2** Executes the uicontrol's `ClickedCallback` routine.
- 3** Does not set the figure's `CurrentPoint` property and does not execute either the control's `ButtonDownFcn` or the figure's `WindowButtonDownFcn` callback.

When you left-click on a uicontrol whose `Enable` property is `off`, or when you right-click a uicontrol whose `Enable` property has any value, MATLAB performs these actions in this order:

- 4** Sets the figure's `SelectionType` property.
- 5** Sets the figure's `CurrentPoint` property.
- 6** Executes the figure's `WindowButtonDownFcn` callback.

## Extent

position rectangle (read only)

*Size of uicontrol character string.* A four-element vector that defines the size and position of the character string used to label the uicontrol. It has the form:

`[0,0,width,height]`

The first two elements are always zero. `width` and `height` are the dimensions of the rectangle. All measurements are in units specified by the `Units` property.

# Uicontrol Properties

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Since the Extent property is defined in the same units as the uicontrol itself, you can use this property to determine proper sizing for the uicontrol with regard to its label. Do this by

- Defining the String property and selecting the font using the relevant properties.
- Getting the value of the Extent property.
- Defining the width and height of the Position property to be somewhat larger than the width and height of the Extent.

For multiline strings, the Extent rectangle encompasses all the lines of text. For single line strings, the Extent is returned as a single line, even if the string wraps when displayed on the control.

## FontAngle

{normal} | italic | oblique

*Character slant.* MATLAB uses this property to select a font from those available on your particular system. Setting this property to italic or oblique selects a slanted version of the font, when it is available on your system.

## FontName

string

*Font family.* The name of the font in which to display the String. To display and print properly, this must be a font that your system supports. The default font is system dependent.

To use a fixed-width font that looks good in any locale (and displays properly in Japan, where multibyte character sets are used), set FontName to the string FixedWidth (this string value is case sensitive):

```
set(uicontrol_handle, 'FontName', 'FixedWidth')
```

This parameter value eliminates the need to hard code the name of a fixed-width font, which may not display text properly on

systems that do not use ASCII character encoding (such as in Japan). A properly written MATLAB application that needs to use a fixed-width font should set `FontName` to `FixedWidth` and rely on the root `FixedWidthFontName` property to be set correctly in the end user's environment.

End users can adapt a MATLAB application to different locales or personal environments by setting the root `FixedWidthFontName` property to the appropriate value for that locale from `startup.m`. Setting the root `FixedWidthFontName` property causes an immediate update of the display to use the new font.

## FontSize

size in `FontUnits`

*Font size.* A number specifying the size of the font in which to display the String, in units determined by the `FontUnits` property. The default point size is system dependent.

## FontUnits

{points} | normalized | inches |  
centimeters | pixels

*Font size units.* This property determines the units used by the `FontSize` property. Normalized units interpret `FontSize` as a fraction of the height of the uicontrol. When you resize the uicontrol, MATLAB modifies the screen `FontSize` accordingly. pixels, inches, centimeters, and points are absolute units (1 point =  $\frac{1}{72}$  inch).

## FontWeight

light | {normal} | demi | bold

*Weight of text characters.* MATLAB uses this property to select a font from those available on your particular system. Setting this property to bold causes MATLAB to use a bold version of the font, when it is available on your system.

# Uicontrol Properties

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ForegroundColor  
ColorSpec

*Color of text.* This property determines the color of the text defined for the String property (the uicontrol label). Specify a color using a three-element RGB vector or one of the MATLAB predefined names. The default text color is black. See ColorSpec for more information on specifying color.

HandleVisibility  
{on} | callback | off

*Control access to object's handle.* This property determines when an object's handle is visible in its parent's list of children. When a handle is not visible in its parent's list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes get, findobj, gca, gcf, gco, newplot, cla, clf, and close. Neither is the handle visible in the parent figure's CurrentObject property. Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when HandleVisibility is on.
- Setting HandleVisibility to callback causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting HandleVisibility to off makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.

---

**Note** Radio buttons and toggle buttons that are managed by a `uibuttongroup` should not be accessed outside the button group. Set the `HandleVisibility` of such radio buttons and toggle buttons to `off` to prevent inadvertent access.

---

## HitTest

`{on}` | `off`

*Selectable by mouse click.* This property has no effect on uicontrol objects.

## HorizontalAlignment

`left` | `{center}` | `right`

*Horizontal alignment of label string.* This property determines the justification of the text defined for the `String` property (the uicontrol label):

- `left` — Text is left justified with respect to the uicontrol.
- `center` — Text is centered with respect to the uicontrol.
- `right` — Text is right justified with respect to the uicontrol.

On Microsoft Windows systems, this property affects only edit and text uicontrols.

## Interruptible

`{on}` | `off`

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for

# Uicontrol Properties

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which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The `Interruptible` property of the object whose callback is executing
- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the `Interruptible` property of the object whose callback is executing is `on` (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the `Interruptible` property of the object whose callback is executing is `off`, the callback cannot be interrupted (except by certain callbacks; see the note below). The `BusyAction` property of the object whose callback is waiting to execute determines what happens to the callback.

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**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. The interrupting callback starts execution at the next `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statement. A figure's `WindowButtonDownFcn` callback routine, or an object's `ButtonDownFcn` or `Callback` routine are processed according to the rules described above.

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**KeyPressFcn**  
string or function handle

*Key press callback function.* A callback routine invoked by a key press when the callback's uicontrol object has focus. Focus is denoted by a border or a dotted border, respectively, in UNIX and Microsoft Windows. If no uicontrol has focus, the figure's key press callback function, if any, is invoked. KeyPressFcn can be a function handle, the name of an M-file, or any legal MATLAB expression.

If the specified value is the name of an M-file, the callback routine can query the figure's CurrentCharacter property to determine what particular key was pressed and thereby limit the callback execution to specific keys.

If the specified value is a function handle, the callback routine can retrieve information about the key that was pressed from its event data structure argument.

| Event Data Structure Field | Description                                                                         | Examples:  |            |           |           |
|----------------------------|-------------------------------------------------------------------------------------|------------|------------|-----------|-----------|
|                            |                                                                                     | a          | =          | Shift     | Shift/a   |
| Character                  | Character interpretation of the key that was pressed.                               | 'a'        | '='        | ' '       | 'A'       |
| Modifier                   | Current modifier, such as 'control', or an empty cell array if there is no modifier | {1x0 cell} | {1x0 cell} | {'shift'} | {'shift'} |
| Key                        | Name of the key that was pressed.                                                   | 'a'        | 'equal'    | 'shift'   | 'a'       |

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

**ListboxTop**  
scalar

# Uicontrol Properties

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*Index of top-most string displayed in list box.* This property applies only to the `listbox` style of uicontrol. It specifies which string appears in the top-most position in a list box that is not large enough to display all list entries. `ListboxTop` is an index into the array of strings defined by the `String` property and must have a value between 1 and the number of strings. Noninteger values are fixed to the next lowest integer.

Max

scalar

*Maximum value.* This property specifies the largest value allowed for the `Value` property. Different styles of uicontrols interpret `Max` differently:

- Check boxes – `Max` is the setting of the `Value` property while the check box is selected.
- Editable text – If  $\text{Max} - \text{Min} > 1$ , then editable text boxes accept multiline input. If  $\text{Max} - \text{Min} \leq 1$ , then editable text boxes accept only single line input.
- List boxes – If  $\text{Max} - \text{Min} > 1$ , then list boxes allow multiple item selection. If  $\text{Max} - \text{Min} \leq 1$ , then list boxes do not allow multiple item selection.
- Radio buttons – `Max` is the setting of the `Value` property when the radio button is selected.
- Sliders – `Max` is the maximum slider value and must be greater than the `Min` property. The default is 1.
- Toggle buttons – `Max` is the value of the `Value` property when the toggle button is selected. The default is 1.
- Pop-up menus, push buttons, and static text do not use the `Max` property.

Min

scalar



*Minimum value.* This property specifies the smallest value allowed for the Value property. Different styles of uicontrols interpret Min differently:

- Check boxes – Min is the setting of the Value property while the check box is not selected.
- Editable text – If  $\text{Max} - \text{Min} > 1$ , then editable text boxes accept multiline input. If  $\text{Max} - \text{Min} \leq 1$ , then editable text boxes accept only single line input.
- List boxes – If  $\text{Max} - \text{Min} > 1$ , then list boxes allow multiple item selection. If  $\text{Max} - \text{Min} \leq 1$ , then list boxes allow only single item selection.
- Radio buttons – Min is the setting of the Value property when the radio button is not selected.
- Sliders – Min is the minimum slider value and must be less than Max. The default is 0.
- Toggle buttons – Min is the value of the Value property when the toggle button is not selected. The default is 0.
- Pop-up menus, push buttons, and static text do not use the Min property.

Parent

handle

*Uicontrol parent.* The handle of the uicontrol's parent object. You can move a uicontrol object to another figure, uipanel, or uibuttongroup by setting this property to the handle of the new parent.

Position

position rectangle

*Size and location of uicontrol.* The rectangle defined by this property specifies the size and location of the control within

# Uicontrol Properties

---

the parent figure window, uipanel, or uibuttongroup. Specify Position as

```
[left bottom width height]
```

left and bottom are the distance from the lower-left corner of the parent object to the lower-left corner of the uicontrol object. width and height are the dimensions of the uicontrol rectangle. All measurements are in units specified by the Units property.

On Microsoft Windows systems, the height of pop-up menus is automatically determined by the size of the font. The value you specify for the height of the Position property has no effect.

The width and height values determine the orientation of sliders. If width is greater than height, then the slider is oriented horizontally. If height is greater than width, then the slider is oriented vertically.

---

**Note** The height of a pop-up menu is determined by the font size. The height you set in the position vector is ignored. The height element of the position vector is not changed.

On Mac platforms, the height of a horizontal slider is constrained. If the height you set in the position vector exceeds this constraint, the displayed height of the slider is the maximum allowed. The height element of the position vector is not changed.

---

Selected

on | {off} (read only)

*Is object selected.* When this property is on, MATLAB displays selection handles if the SelectionHighlight property is also on. You can, for example, define the ButtonDownFcn to set this property, allowing users to select the object with the mouse.

SelectionHighlight  
{on} | off

*Object highlight when selected.* When the Selected property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When SelectionHighlight is off, MATLAB does not draw the handles.

SliderStep  
[min\_step max\_step]

*Slider step size.* This property controls the amount the slider Value changes when you click the mouse on the arrow button (min\_step) or on the slider trough (max\_step). Specify SliderStep as a two-element vector; each value must be in the range [0, 1]. The actual step size is a function of the specified SliderStep and the total slider range (Max - Min). The default, [0.01 0.10], provides a 1 percent change for clicks on the arrow button and a 10 percent change for clicks in the trough.

For example, if you create the following slider,

```
uicontrol('Style','slider','Min',1,'Max',7,...  
         'Value',2,'SliderStep',[0.1 0.6])
```

clicking on the arrow button moves the indicator by,

```
0.1*(7-1)  
ans =  
    0.6000
```

and clicking in the trough moves the indicator by,

```
0.6*(7-1)  
ans =  
    3.6000
```

Note that if the specified step size moves the slider to a value outside the range, the indicator moves only to the Max or Min value.

# Uicontrol Properties

---

See also the Max, Min, and Value properties.

String  
string

*Uicontrol label, list box items, pop-up menu choices.*

**For check boxes, editable text, push buttons, radio buttons, static text, and toggle buttons**, the text displayed on the object. For list boxes and pop-up menus, the set of entries or items displayed in the object.

---

**Note** If you specify a numerical value for String, MATLAB converts it to char but the result may not be what you expect. If you have numerical data, you should first convert it to a string, e.g., using num2str, before assigning it to the String property.

---

**For uicontrol objects that display only one line of text** (check box, push button, radio button, toggle button), if the string value is specified as a cell array of strings or padded string matrix, only the first string of a cell array or of a padded string matrix is displayed; the rest are ignored. Vertical slash ('|') characters are not interpreted as line breaks and instead show up in the text displayed in the uicontrol.

**For multiple line editable text or static text controls**, line breaks occur between each row of the string matrix, and each cell of a cell array of strings. Vertical slash ('|') characters and \n characters are not interpreted as line breaks, and instead show up in the text displayed in the uicontrol.

**For multiple items on a list box or pop-up menu**, you can specify the items in any of the formats shown in the following table.

| String Property Format                                   | Example                    |
|----------------------------------------------------------|----------------------------|
| Cell array of strings                                    | {'one' 'two' 'three'}      |
| Padded string matrix                                     | ['one '; 'two '; 'three '] |
| String vector separated by vertical slash ( ) characters | ['one two three']          |

If you specify a component width that is too small to accommodate one or more of the specified strings, MATLAB truncates those strings with an ellipsis. Use the Value property to set the index of the initial item selected.

For **check boxes**, **push buttons**, **radio buttons**, **toggle buttons**, and the selected item in **popup menus**, when the specified text is clipped because it is too long for the uicontrol, an ellipsis (...) is appended to the text in the active GUI to indicate that it has been clipped.

For **push buttons** and **toggle buttons**, CData overlaps the String. In the case of **radio buttons** and **checkboxes**, CData takes precedence over String and, depending on its size, can displace the text.

For **editable text**, the String property value is set to the string entered by the user.

# Uicontrol Properties

---

---

**Reserved Words** There are three reserved words: default, remove, factory (case sensitive). If you want to use one of these reserved words in the String property, you must precede it with a backslash ('\') character. For example,

```
h = uicontrol('Style','edit','String','\default');
```

---

## Style

{pushbutton} | togglebutton | radiobutton | checkbox | edit | text | slider | frame | listbox | popupmenu

*Style of uicontrol object to create.* The Style property specifies the kind of uicontrol to create. See the uicontrol Description section for information on each type.

## Tag

string (GUIDE sets this property)

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callback routines. You can define Tag as any string.

## TooltipString

string

*Content of tooltip for object.* The TooltipString property specifies the text of the tooltip associated with the uicontrol. When the user moves the mouse pointer over the control and leaves it there, the tooltip is displayed.

## Type

string (read only)

*Class of graphics object.* For uicontrol objects, Type is always the string 'uicontrol'.

UIContextMenu  
handle

*Associate a context menu with uicontrol.* Assign this property the handle of a uicontextmenu object. MATLAB displays the context menu whenever you right-click over the uicontrol. Use the uicontextmenu function to create the context menu.

Units

{pixels} | normalized | inches | centimeters | points | characters (GUIDE default: normalized)

*Units of measurement.* MATLAB uses these units to interpret the Extent and Position properties. All units are measured from the lower-left corner of the parent object.

- Normalized units map the lower-left corner of the parent object to (0,0) and the upper-right corner to (1.0,1.0).
- pixels, inches, centimeters, and points are absolute units (1 point = 1/72 inch).
- Character units are characters using the default system font; the width of one character is the width of the letter x, the height of one character is the distance between the baselines of two lines of text.

If you change the value of Units, it is good practice to return it to its default value after completing your computation so as not to affect other functions that assume Units is set to the default value.

UserData  
matrix

# Uicontrol Properties

---

*User-specified data.* Any data you want to associate with the uicontrol object. MATLAB does not use this data, but you can access it using `set` and `get`.

## Value

scalar or vector

*Current value of uicontrol.* The uicontrol style determines the possible values this property can have:

- Check boxes set `Value` to `Max` when they are on (when selected) and `Min` when off (not selected).
- List boxes set `Value` to a vector of indices corresponding to the selected list entries, where 1 corresponds to the first item in the list.
- Pop-up menus set `Value` to the index of the item selected, where 1 corresponds to the first item in the menu. The `Examples` section shows how to use the `Value` property to determine which item has been selected.
- Radio buttons set `Value` to `Max` when they are on (when selected) and `Min` when off (not selected).
- Sliders set `Value` to the number indicated by the slider bar.
- Toggle buttons set `Value` to `Max` when they are down (selected) and `Min` when up (not selected).
- Editable text, push buttons, and static text do not set this property.

Set the `Value` property either interactively with the mouse or through a call to the `set` function. The display reflects changes made to `Value`.

## Visible

{on} | off



*Uicontrol visibility.* By default, all uicontrols are visible. When set to off, the uicontrol is not visible, but still exists and you can query and set its properties.

---

**Note** Setting `Visible` to off for uicontrols that are not displayed initially in the GUI, can result in faster startup time for the GUI.

---

# uigetdir

---

**Purpose** Open standard dialog box for selecting a directory

**Syntax**

```
uigetdir
directory_name = uigetdir
directory_name = uigetdir(start_path)
directory_name = uigetdir(start_path,dialog_title)
```

**Description** `uigetdir` displays a modal dialog box enabling the user to browse through the directory structure and select a directory or type the name of a directory. If the directory exists, `uigetdir` returns the selected path when the user clicks **OK**. For Windows platforms, `uigetdir` opens a dialog box in the base directory (the Windows desktop) with the current directory selected. See “Remarks” on page 2-3491 for information about UNIX and Mac platforms.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. To block MATLAB program execution as well, use the `uiwait` function. For more information about modal dialog boxes, see `WindowState` in the MATLAB Figure Properties.

---

`directory_name = uigetdir` returns the path to the selected directory when the user clicks **OK**. If the user clicks **Cancel** or closes the dialog window, `directory_name` is set to 0.

`directory_name = uigetdir(start_path)` opens a dialog box with the directory specified by `start_path` selected. If `start_path` is a valid directory path, the dialog box opens in the specified directory.

If `start_path` is an empty string ( `''` ), the dialog box opens in the current directory. If `start_path` is not a valid directory path, the dialog box opens in the base directory. For Windows, this is the Windows desktop. See “Remarks” on page 2-3491 for information about UNIX and Mac platforms.

`directory_name = uigetdir(start_path,dialog_title)` opens a dialog box with the specified title. On Windows platforms, the

string replaces the default caption inside the dialog box for specifying instructions to the user. The default `dialog_title` is `Select Directory to Open`. See “Remarks” on page 2-3491 for information about UNIX and Mac platforms.

---

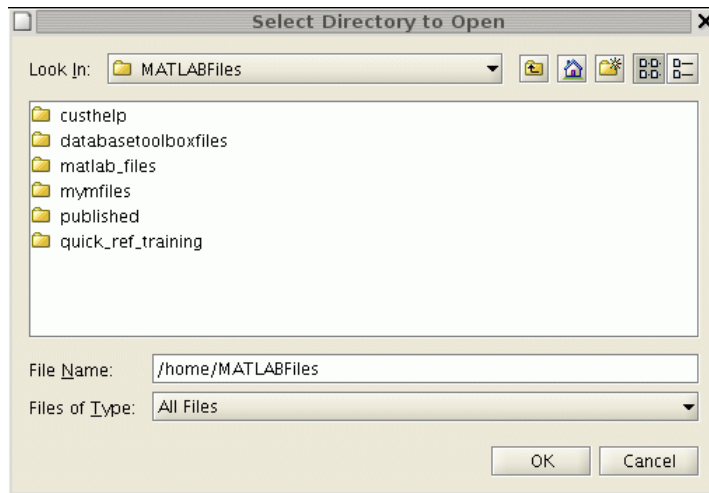
**Note** On Windows platforms, users can click the **New Folder** button to add a new directory to the directory structure displayed. Users can also drag and drop existing directories.

---

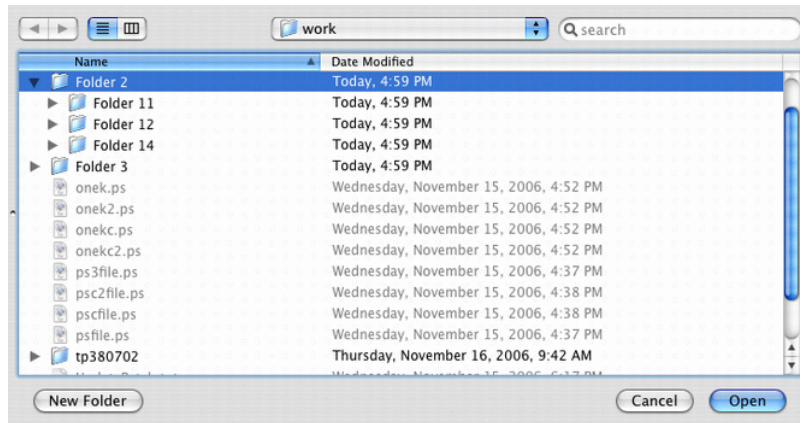
## Remarks

For Windows platforms, the dialog box is similar to those shown in the “Examples” on page 2-3492 below.

For UNIX platforms, `uigetdir` opens a dialog box in the base directory (the directory from which MATLAB is started) with the current directory selected. The `dialog_title` string replaces the default title of the dialog box. The dialog box is similar to the one shown in the following figure.



For Mac platforms, `uigetdir` opens a dialog box in the base directory (the current directory) with the current directory open. The `dialog_title` string, if any, is ignored. The dialog box is similar to the one shown in the following figure.



## Examples

### Example 1

The following statement displays directories on the C: drive.

```
dname = uigetdir('C:\');
```

The dialog box is shown in the following figure.



If the user selects the directory Desktop, as shown in the figure, and clicks **OK**, `uigetdir` returns

```
dname =  
C:\WINNT\Profiles\All Users\Desktop
```

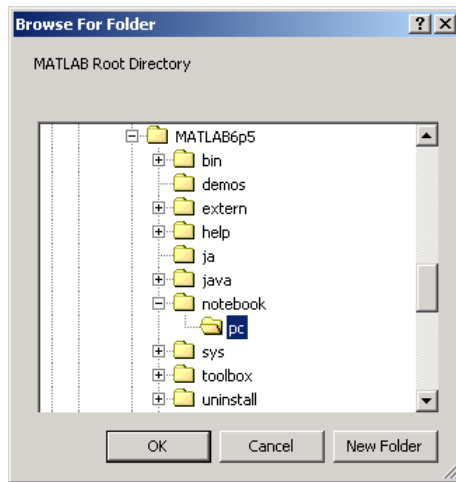
## Example 2

The following statement uses the `matlabroot` command to display the MATLAB root directory in the dialog box:

```
uigetdir(matlabroot, 'MATLAB Root Directory')
```

# uigetdir

---



If the user selects the directory MATLAB6.5/notebook/pc, as shown in the figure, `uigetdir` returns a string like

```
C:\MATLAB6.5\notebook\pc
```

assuming that MATLAB is installed on drive C:\.

## See Also

`uigetfile`, `uiputfile`

**Purpose** Open standard dialog box for retrieving files

**Syntax**

```
uigetfile  
[FileName,PathName,FilterIndex] = uigetfile(FilterSpec)  
[FileName,PathName,FilterIndex] = uigetfile(FilterSpec,  
    DialogTitle)  
[FileName,PathName,FilterIndex] = uigetfile(FilterSpec,  
    DialogTitle,DefaultName)  
[FileName,PathName,FilterIndex] = uigetfile(...,'MultiSelect',  
    selectmode)
```

**Description** `uigetfile` displays a modal dialog box that lists files in the current directory and enables the user to select or type the name of a file to be opened. If the filename is valid and if the file exists, `uigetfile` returns the filename when the user clicks **Open**. Otherwise `uigetfile` displays an appropriate error message from which control returns to the dialog box. The user can then enter another filename or click **Cancel**. If the user clicks **Cancel** or closes the dialog window, `uigetdir` returns 0.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. To block MATLAB program execution, use the `uiwait` function. For more information about modal dialog boxes, see `WindowState` in the MATLAB Figure Properties.

---

`[FileName,PathName,FilterIndex] = uigetfile(FilterSpec)` displays only those files with extensions that match `FilterSpec`. `FilterSpec` can be a string or a cell array of strings, and can include the \* wildcard. For example, '\*.m' lists all the MATLAB M-files. A `FilterSpec` string can also be a filename. In this case the filename becomes the default filename and the file's extension is used as the default filter. If `FilterSpec` is a string, `uigetfile` appends 'All Files' to the list of file types.

If `FilterSpec` is a cell array, the first column contains a list of file extensions. The optional second column contains a corresponding list of

descriptions. These descriptions replace standard descriptions in the **Files of type** field. A description cannot be an empty string. “Example 2” on page 2-3499 and “Example 3” on page 2-3500 illustrate use of a cell array as FilterSpec.

If FilterSpec is not specified, uigetfile uses the default list of file types (i.e., all MATLAB files).

After the user clicks **Open** and if the filename exists, uigetfile returns the name of the file in FileName and its path in PathName. If the user clicks **Cancel** or closes the dialog window, FileName and PathName are set to 0.

FilterIndex is the index of the filter selected in the dialog box. Indexing starts at 1. If the user clicks **Cancel** or closes the dialog window, FilterIndex is set to 0.

[FileName,PathName,FilterIndex] =  
uigetfile(FilterSpec,DialogTitle) displays a dialog box that has the title DialogTitle. To use the default file types and specify a dialog title, enter

```
uigetfile('',DialogTitle)
```

---

**Note** For Mac platforms, DialogTitle is ignored.

---

[FileName,PathName,FilterIndex] =  
uigetfile(FilterSpec,DialogTitle,DefaultName) displays a dialog box in which the filename specified by DefaultName appears in the **File name** field. DefaultName can also be a path or a path/filename. In this case, uigetfile opens the dialog box in the directory specified by the path. See “Example 6” on page 2-3503 . If the path does not include a filename, it must end with a slash (/) or backslash (\) separator. For example, 'C:\Work\'. Note that uigetfile recognizes both './' and './.' as valid values. If the specified path does not exist, uigetfile opens the dialog box in the current directory.

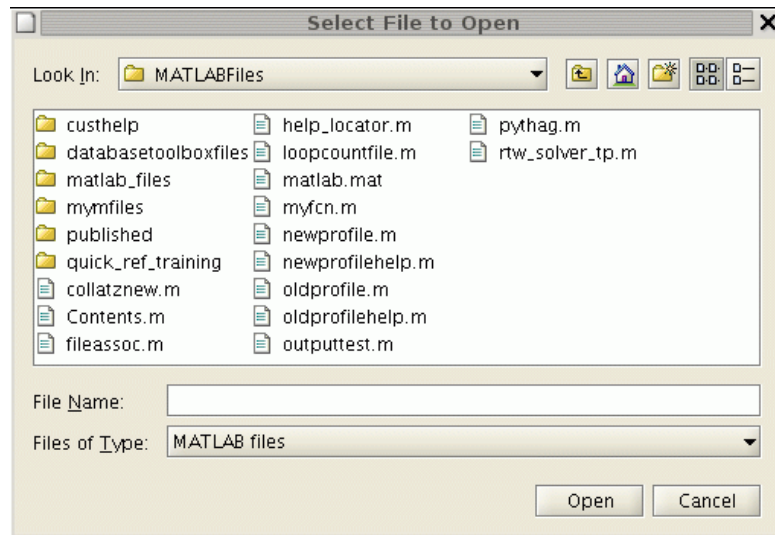


[FileName,PathName,FilterIndex] =  
uigetfile(...,'MultiSelect',*selectmode*) sets the multiselect mode to specify if multiple file selection is enabled for the uigetfile dialog. Valid values for *selectmode* are 'on' and 'off' (default). If 'MultiSelect' is 'on' and the user selects more than one file in the dialog box, then FileName is a cell array of strings, each of which represents the name of a selected file. Filenames in the cell array are in the sort order native to your platform. Because multiple selections are always in the same directory, PathName is always a string that represents a single directory.

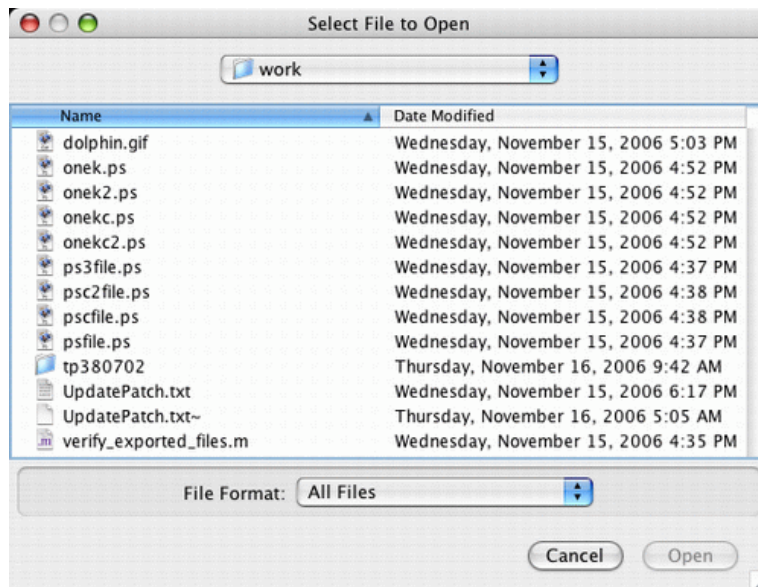
## Remarks

For Windows platforms, the dialog box is the Windows dialog box native to your platform. Because of this, it may differ from those shown in “Examples” on page 2-3498 below.

For UNIX platforms, the dialog box is similar to the one shown in the following figure.



For Mac platforms, the dialog box is similar to the one shown in the following figure.



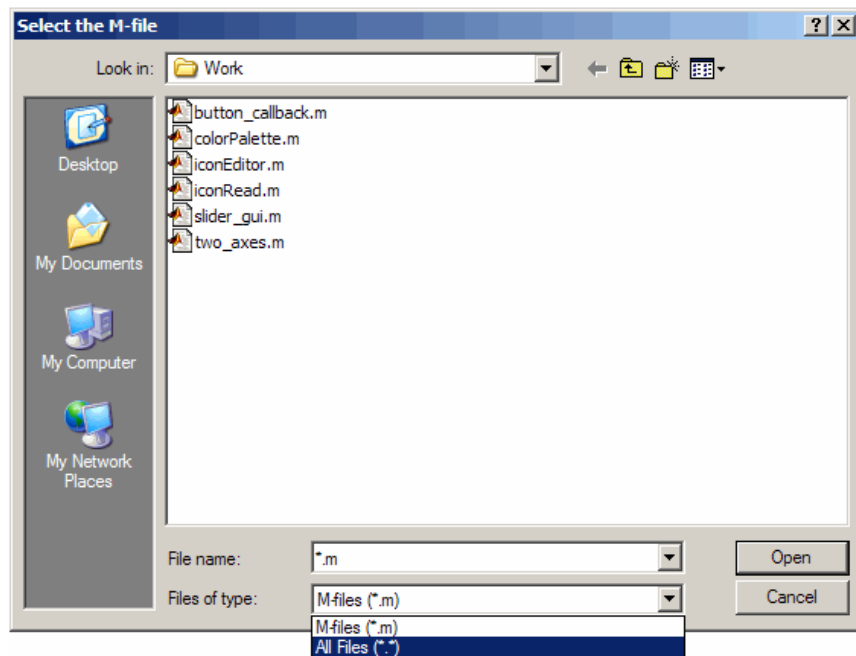
## Examples

### Example 1

The following statement displays a dialog box that enables the user to retrieve a file. The statement lists all MATLAB M-files within a selected directory. The name and path of the selected file are returned in `FileName` and `PathName`. Note that `uigetfile` appends All Files (\*.\*) to the file types when `FilterSpec` is a string.

```
[FileName,PathName] = uigetfile('*.*','Select the M-file');
```

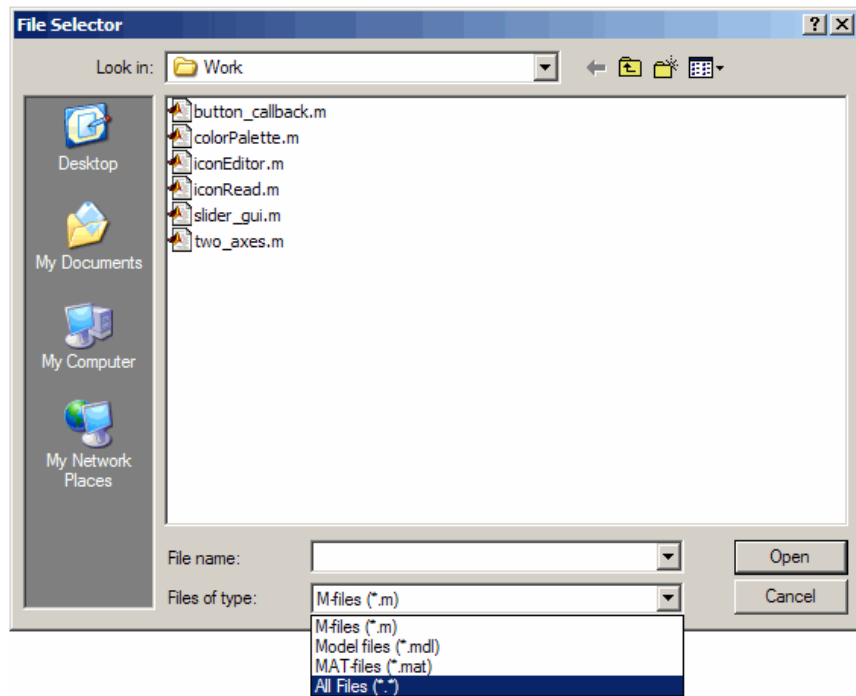
The dialog box is shown in the following figure.



## Example 2

To create a list of file types that appears in the **Files of type** list box, separate the file extensions with semicolons, as in the following code. Note that `uigetfile` displays a default description for each known file type, such as "Simulink Models" for `.mdl` files.

```
[filename, pathname] = ...
    uigetfile({'*.m'; '*.mdl'; '*.mat'; '*.*'}, 'File Selector');
```

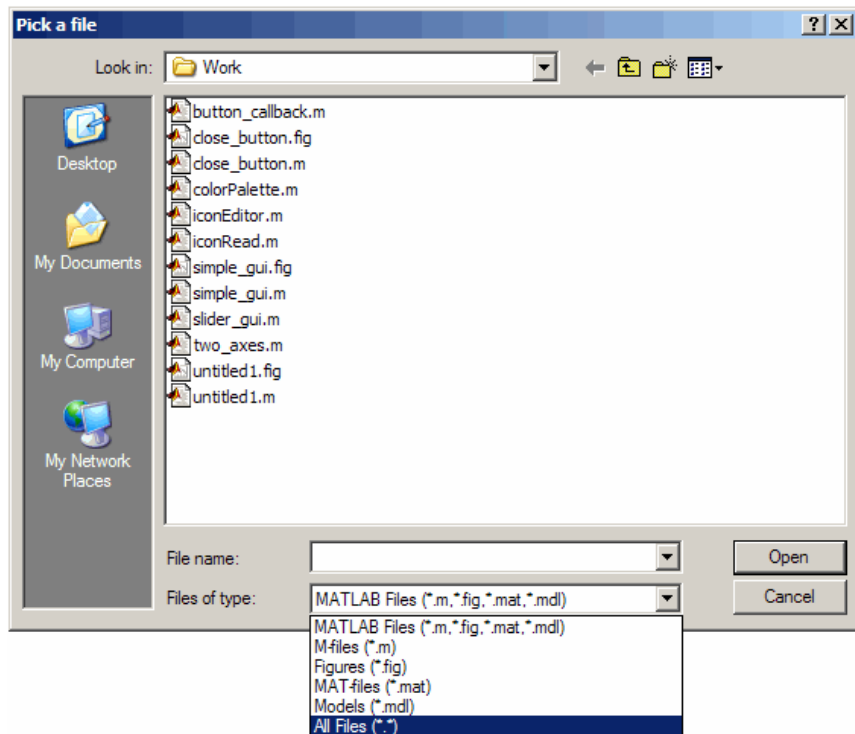


### Example 3

If you want to create a list of file types and give them descriptions that are different from the defaults, use a cell array, as in the following code. This example also associates multiple file types with the 'MATLAB Files' description.

```
[filename, pathname] = uigetfile( ...  
{ '*.m;*.fig;*.mat;*.mdl', 'MATLAB Files (*.m;*.fig;*.mat;*.mdl)';  
  '*.m', 'M-files (*.m)'; ...  
  '*.fig', 'Figures (*.fig)'; ...  
  '*.mat', 'MAT-files (*.mat)'; ...  
  '*.mdl', 'Models (*.mdl)'; ...  
  '*.*', 'All Files (*.*)' }, ...  
  'Pick a file');
```

The first column of the cell array contains the file extensions, while the second contains the descriptions you want to provide for the file types. Note that the first entry of column one contains several extensions, separated by semicolons, all of which are associated with the description 'MATLAB Files (\*.m;\*.fig;\*.mat;\*.mdl)'. The code produces the dialog box shown in the following figure.



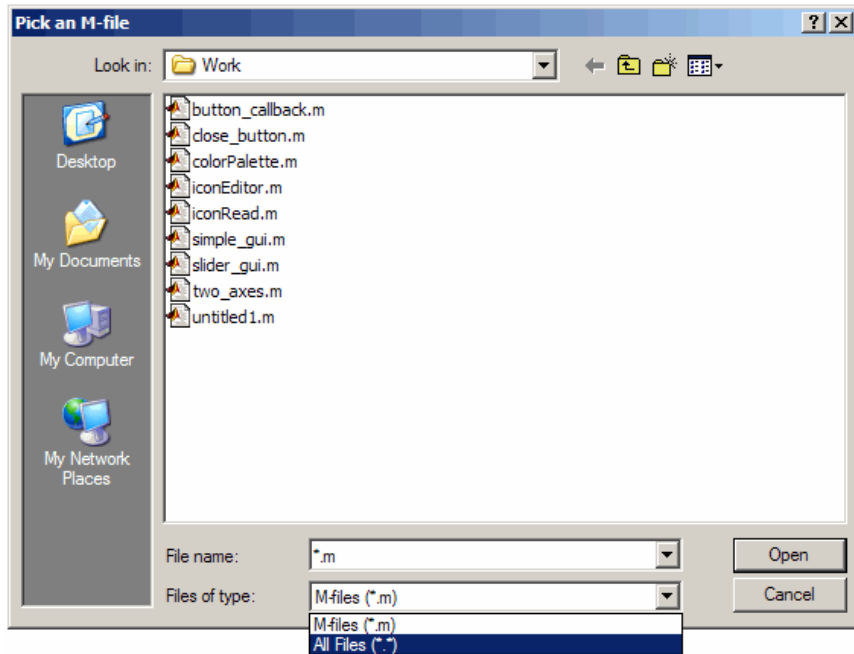
#### Example 4

The following code checks for the existence of the file and displays a message about the result of the open operation.

```
[filename, pathname] = uigetfile('*.m', 'Pick an M-file');
```

# uigetfile

```
if isequal(filename,0)
    disp('User selected Cancel')
else
    disp(['User selected', fullfile(pathname, filename)])
end
```

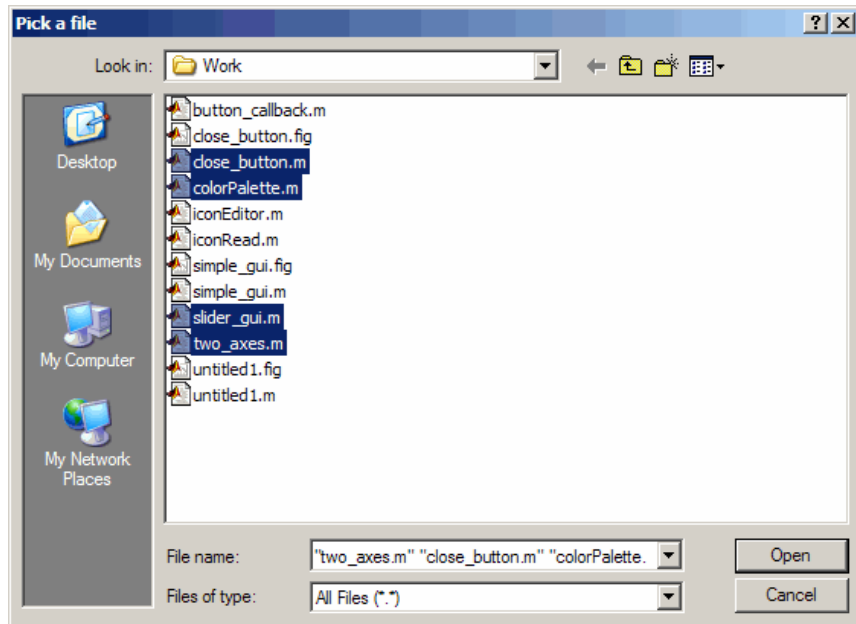


## Example 5

This example creates a list of file types and gives them descriptions that are different from the defaults, then enables multiple file selection. The user can select multiple files by holding down the **Shift** or **Ctrl** key and clicking on a file.

```
[filename, pathname, filterindex] = uigetfile( ...
{ '*.mat', 'MAT-files (*.mat)'; ...
  '*.mdl', 'Models (*.mdl)'; ...
  '*.*', 'All Files (*.*)'}, ...
```

```
'Pick a file', ...
'MultiSelect', 'on');
```

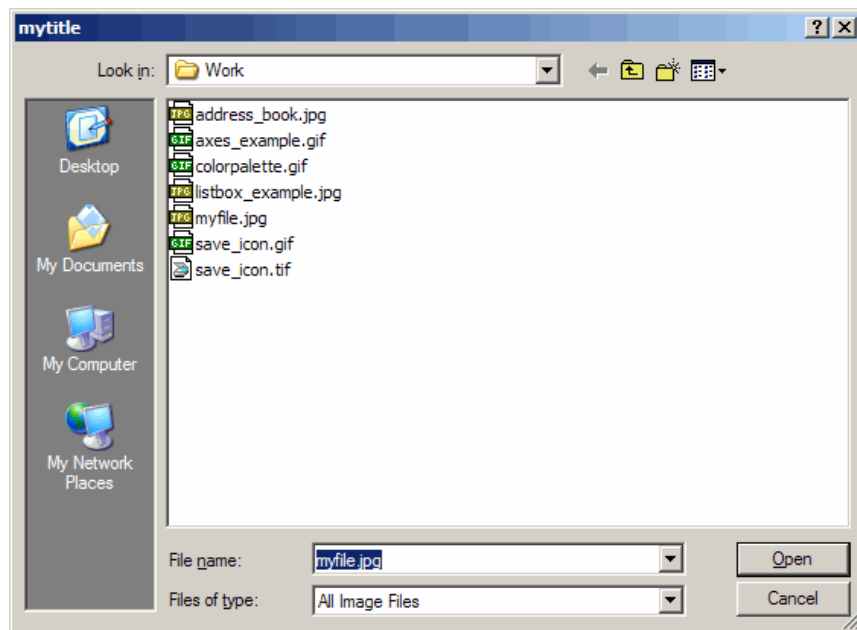


## Example 6

This example uses the `DefaultName` argument to specify a start path and a default filename for the dialog box.

```
uigetfile({'*.jpg;*.tif;*.png;*.gif','All Image Files';...
          '*.*','All Files'},'mytitle',...
          'C:\Work\myfile.jpg')
```

# uigetfile



**See Also** `uigetdir`, `uiputfile`



**Purpose**

Open dialog box for retrieving preferences

**Syntax**

```
value = uigetpref(group,pref,title,question,pref_choices)
[val,dlgshown] = uigetpref(...)
```

**Description**

`value = uigetpref(group,pref,title,question,pref_choices)` returns one of the strings in `pref_choices`, by doing one of the following:

- Prompting the user with a multiple-choice question dialog box
- Returning a previous answer stored in the preferences database

By default, the dialog box is shown, with each choice on a different pushbutton, and with a checkbox controlling whether the returned value should be stored in preferences and automatically reused in subsequent invocations.

If the user checks the checkbox before choosing one of the push buttons, the push button choice is stored in preferences and returned in `value`. Subsequent calls to `uigetpref` detect that the last choice was stored in preferences, and return that choice immediately without displaying the dialog.

If the user does not check the checkbox before choosing a pushbutton, the selected preference is not stored in preferences. Rather, a special value, 'ask', is stored, indicating that subsequent calls to `uigetpref` should display the dialog box.

---

**Note** `uigetpref` uses the same preference database as `addpref`, `getpref`, `ispref`, `rmpref`, and `setpref`. However, it registers the preferences it sets in a separate list so that it, and `uisetpref`, can distinguish those preferences that are being managed with `uigetpref`.

For preferences registered with `uigetpref`, you can use `setpref` and `uisetpref` to explicitly change preference values to 'ask'.

---

group and pref define the preference. If the preference does not already exist, uigetpref creates it.

title defines the string displayed in the dialog box titlebar.

question is a descriptive paragraph displayed in the dialog, specified as a string array or cell array of strings. This should contain the question the user is being asked, and should be detailed enough to give the user a clear understanding of their choice and its impact. uigetpref inserts line breaks between rows of the string array, between elements of the cell array of strings, or between ' | ' or newline characters in the string vector.

pref\_choices is either a string, cell array of strings, or '|'-separated strings specifying the strings to be displayed on the push buttons. Each string element is displayed in a separate push button. The string on the selected pushbutton is returned.

Make pref\_choices a 2-by-n cell array of strings if the internal preference values are different from the strings displayed on the pushbuttons. The first row contains the preference strings, and the second row contains the related pushbutton strings. Note that the preference values are returned in value, not the button labels.

[val,dlgshown] = uigetpref(...) returns whether or not the dialog was shown.

Additional arguments can be passed in as parameter-value pairs:

(... 'CheckboxState', state) sets the initial state of the checkbox, either checked or unchecked. state can be either 0 (unchecked) or 1 (checked). By default it is 0.

(... 'CheckboxString', cbstr) sets the string cbstr on the checkbox. By default it is 'Never show this dialog again'.

(... 'HelpString', hstr) sets the string hstr on the help button. By default the string is empty and there is no help button.

(... 'HelpFcn', hfcn) sets the callback that is executed when the help button is pressed. By default it is doc('uigetpref'). Note that if there is no 'HelpString' option, a button is not created.

(... 'ExtraOptions', eo) creates extra buttons which are not mapped to any preference settings. eo can be a string or a cell array of strings. By default it is {} and no extra buttons are created. If the user chooses one of these buttons, the dialog is closed and the string is returned in value.

(... 'DefaultButton', dbstr) sets the string value dbstr that is returned if the dialog is closed. By default, it is the first button. Note that dbstr does not have to correspond to a preference or ExtraOption.

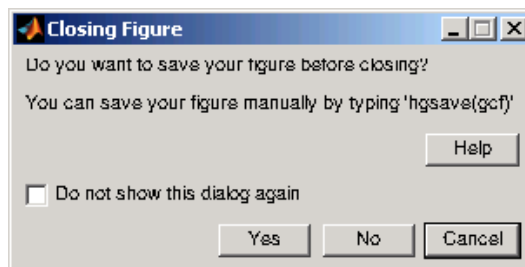
---

**Note** If the preference does not already exist in the preference database, uigetpref creates it. Preference values are persistent and maintain their values between MATLAB sessions. Where they are stored is system dependent.

---

## Examples

This example creates the following preference dialog for the 'savefigurebeforeclosing' preference in the 'mygraphics' group.



It uses the cell array {'always', 'never'; 'Yes', 'No'} to define the preference values as 'always' and 'never', and their corresponding button labels as 'Yes' and 'No'.

```
[selectedButton,dlgShown]=uigetpref('mygraphics',... % Group
    'savefigurebeforeclosing',...           % Preference
    'Closing Figure',...                   % Window title
    {'Do you want to save your figure before closing?'
```

# uigetpref

---

```
''
    'You can save your figure manually by typing ''hgsave(gcf)''},...
{'always','never';'Yes','No'},...      % Values and button strings
'ExtraOptions','Cancel',...           % Additional button
'DefaultButton','Cancel',...          % Default choice
'HelpString','Help',...               % String for Help button
'HelpFcn','doc(''closereq'');')       % Callback for Help button
```

## See Also

addpref, getpref, ispref, rmpref, setpref, uisetpref

**Purpose** Open Import Wizard to import data

**Syntax**

```
uiimport
uiimport(filename)
uiimport('-file')
uiimport('-pastespecial')
S = uiimport(...)
```

**Description** `uiimport` starts the Import Wizard in the current directory, presenting options to load data from a file or the clipboard.

`uiimport(filename)` starts the Import Wizard, opening the file specified in `filename`. The Import Wizard displays a preview of the data in the file.

`uiimport('-file')` works as above but presents the file selection dialog first.

`uiimport('-pastespecial')` works as above but presents the clipboard contents first.

`S = uiimport(...)` works as above with resulting variables stored as fields in the struct `S`.

---

**Note** For ASCII data, you must verify that the Import Wizard correctly identified the column delimiter.

---

**See Also** `load`, `clipboard`

# uimenu

---

**Purpose** Create menus on figure windows

**Syntax**  
`handle = uimenu('PropertyName',PropertyValue,...)`  
`handle = uimenu(parent,'PropertyName',PropertyValue,...)`

**Description** `uimenu` creates a hierarchy of menus and submenus that are displayed in the figure window's menu bar. You also use `uimenu` to create menu items for context menus.

`handle = uimenu('PropertyName',PropertyValue,...)` creates a menu in the current figure's menu bar using the values of the specified properties and assigns the menu handle to `handle`.

See the Uimenu Properties reference page for more information.

`handle = uimenu(parent,'PropertyName',PropertyValue,...)` creates a submenu of a parent menu or a menu item on a context menu specified by `parent` and assigns the menu handle to `handle`. If `parent` refers to a figure instead of another `uimenu` object or a `uicontextmenu`, MATLAB creates a new menu on the referenced figure's menu bar.

## Remarks

MATLAB adds the new menu to the existing menu bar. If the figure does not have a menu bar, MATLAB creates one. Each menu choice can itself be a menu that displays its submenu when selected. `uimenu` accepts property name/property value pairs, as well as structures and cell arrays of properties as input arguments.

The `uimenu` `Callback` property defines the action taken when you activate the created menu item.

Uimenus only appear in figures whose `Window Style` is `normal`. If a figure containing `uimenu` children is changed to `modal`, the `uimenu` children still exist and are contained in the `Children` list of the figure, but are not displayed until the `WindowStyle` is changed to `normal`.

The value of the figure `MenuBar` property affects the content of the figure menu bar. When `MenuBar` is `figure`, a set of built-in menus precedes any user-created `uimenu`s on the menu bar (MATLAB controls the built-in menus and their handles are not available to the user).

When `MenuBar` is `none`, `uimenu`s are the only items on the menu bar (that is, the built-in menus do not appear).

You can set and query property values after creating the menu using `set` and `get`.

## Examples

This example creates a menu labeled **Workspace** whose choices allow users to create a new figure window, save workspace variables, and exit out of MATLAB. In addition, it defines an accelerator key for the Quit option.

```
f = uimenu('Label','Workspace');
uimenu(f,'Label','New Figure','Callback','figure');
uimenu(f,'Label','Save','Callback','save');
uimenu(f,'Label','Quit','Callback','exit',...
        'Separator','on','Accelerator','Q');
```

## See Also

`uicontrol`, `uicontextmenu`, `gcb0`, `set`, `get`, `figure`

# Uimenu Properties

---

## Purpose

Describe menu properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The set and get commands enable you to set and query the values of properties

You can set default Uimenu properties on the root, figure and menu levels:

```
set(0, 'DefaultUimenuPropertyName', PropertyValue...)  
set(gcf, 'DefaultUimenuPropertyName', PropertyValue...)  
set(menu_handle, 'DefaultUimenuPropertyName', PropertyValue...)
```

Where *PropertyName* is the name of the Uimenu property and *PropertyValue* is the value you specify as the default for that property.

For more information about changing the default value of property see “Setting Default Property Values”

## Uimenu Properties

This section lists all properties useful to uimenu objects along with valid values and instructions for their use. Curly braces { } enclose default values.

| Property Name | Property Description          |
|---------------|-------------------------------|
| Accelerator   | Keyboard equivalent           |
| BusyAction    | Callback routine interruption |
| Callback      | Control action                |
| Checked       | Menu check indicator          |
| Children      | Handles of submenus           |



| Property Name    | Property Description                                    |
|------------------|---------------------------------------------------------|
| CreateFcn        | Callback routine executed during object creation        |
| DeleteFcn        | Callback routine executed during object deletion        |
| Enable           | Enable or disable the uimenu                            |
| ForegroundColor  | Color of text                                           |
| HandleVisibility | Whether handle is accessible from command line and GUIs |
| Interruptible    | Callback routine interruption mode                      |
| Label            | Menu label                                              |
| Parent           | Uimenu object's parent                                  |
| Position         | Relative uimenu position                                |
| Separator        | Separator line mode                                     |
| Tag              | User-specified object identifier                        |
| Type             | Class of graphics object                                |
| UserData         | User-specified data                                     |
| Visible          | Uimenu visibility                                       |

Accelerator  
character

*Keyboard equivalent.* An alphabetic character specifying the keyboard equivalent for the menu item. This allows users to select a particular menu choice by pressing the specified character in conjunction with another key, instead of selecting the menu item with the mouse. The key sequence is platform specific:

# Uimenu Properties

---

- For Microsoft Windows systems, the sequence is **Ctrl**+Accelerator. These keys are reserved for default menu items: c, v, and x.
- For UNIX systems, the sequence is **Ctrl**+Accelerator. These keys are reserved for default menu items: o, p, s, and w.

You can define an accelerator only for menu items that do not have children menus. Accelerators work only for menu items that directly execute a callback routine, not items that bring up other menus.

Note that the menu item does not have to be displayed (e.g., a submenu) for the accelerator key to work. However, the window focus must be in the figure when the key sequence is entered.

To remove an accelerator, set Accelerator to an empty string, ''.

BusyAction  
cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new event uses the value of BusyAction to decide whether or not to attempt to interrupt the executing callback.

- If the value is cancel, the event is discarded and the second callback does not execute.
- If the value is queue, and the Interruptible property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

---

## Callback

string or function handle

*Menu action.* A callback routine that executes whenever you select the menu. Define this routine as a string that is a valid MATLAB expression or the name of an M-file. The expression executes in the MATLAB workspace.

A menu with children (submenus) executes its callback routine before displaying the submenus. A menu without children executes its callback routine when you *release* the mouse button (i.e., on the button up event).

## Checked

on | {off}

*Menu check indicator.* Setting this property to `on` places a check mark next to the corresponding menu item. Setting it to `off` removes the check mark. You can use this feature to create menus that indicate the state of a particular option. For example, suppose you have a menu item called **Show axes** that toggles the visibility of an axes between visible and invisible each time the user selects the menu item. If you want a check to appear next to the menu item when the axes are visible, add the following code to the callback for the **Show axes** menu item:

```
if strcmp(get(gcbo, 'Checked'), 'on')
    set(gcbo, 'Checked', 'off');
else
```

# Uimenu Properties

---

```
        set(gcbo, 'Checked', 'on');  
    end
```

This changes the value of the Checked property of the menu item from on to off or vice versa each time a user selects the menu item.

Note that there is no formal mechanism for indicating that an unchecked menu item will become checked when selected.

---

**Note** This property is ignored for top level and parent menus.

---

**Children**  
vector of handles

*Handles of submenus.* A vector containing the handles of all children of the uimenu object. The children objects of uimenu are other uimenu, which function as submenus. You can use this property to reorder the menus.

**CreateFcn**  
string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a uimenu object. MATLAB sets all property values for the uimenu before executing the CreateFcn callback so these values are available to the callback. Within the function, use gcbo to get the handle of the uimenu being created.

Setting this property on an existing uimenu object has no effect.

You can define a default CreateFcn callback for all new uimenu. This default applies unless you override it by specifying a different CreateFcn callback when you call uimenu. For example, the code

```
set(0, 'DefaultUimenuCreateFcn', 'set(gcbo,...  
    'Visible','on'))
```

creates a default `CreateFcn` callback that runs whenever you create a new menu. It sets the default `Visible` property of a `uimenu` object.

To override this default and create a menu whose `Visible` property is set to a different value, call `uimenu` with code similar to

```
hpt = uimenu(..., 'CreateFcn', 'set(gcbo,...  
    'Visible','off'))
```

---

**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uimenu` call. In the example above, if instead of redefining the `CreateFcn` property for this `uimenu`, you had explicitly set `Visible` to `off`, the default `CreateFcn` callback would have set `Visible` back to the default, i.e., `on`.

---

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

`DeleteFcn`  
string or function handle

*Delete uimenu callback routine.* A callback routine that executes when you delete the `uimenu` object (e.g., when you issue a `delete` command or cause the figure containing the `uimenu` to reset). MATLAB executes the routine before destroying the object’s properties so these values are available to the callback routine.

# Uimenu Properties

---

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which is more simply queried using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

## Enable

{on} | off

*Enable or disable the uimenu.* This property controls whether a menu item can be selected. When not enabled (set to off), the menu `Label` appears dimmed, indicating the user cannot select it.

## ForegroundColor

ColorSpec X-Windows only

*Color of menu label string.* This property determines color of the text defined for the `Label` property. Specify a color using a three-element RGB vector or one of the MATLAB predefined names. The default text color is black. See `ColorSpec` for more information on specifying color.

## HandleVisibility

{on} | callback | off

*Control access to object’s handle.* This property determines when an object’s handle is visible in its parent’s list of children. When a handle is not visible in its parent’s list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`. Neither is the handle visible in the parent figure’s `CurrentObject` property. Handles that are hidden are still valid. If you know an object’s handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when `HandleVisibility` is on.

- Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.

`Interruptible`  
{on} | off

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The `Interruptible` property of the object whose callback is executing
- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the `Interruptible` property of the object whose callback is executing is `on` (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`,

# Uimenu Properties

---

getframe, pause, or waitfor functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the Interruptible property of the object whose callback is executing is off, the callback cannot be interrupted (except by certain callbacks; see the note below). The BusyAction property of the object whose callback is waiting to execute determines what happens to the callback.

---

**Note** If the interrupting callback is a DeleteFcn or CreateFcn callback or a figure's CloseRequest or ResizeFcn callback, it interrupts an executing callback regardless of the value of that object's Interruptible property. The interrupting callback starts execution at the next drawnow, figure, getframe, pause, or waitfor statement. A figure's WindowButtonDownFcn callback routine, or an object's ButtonDownFcn or Callback routine are processed according to the rules described above.

---

## Label

string

*Menu label.* A string specifying the text label on the menu item. You can specify a mnemonic for the label using the '&' character. Except as noted below, the character that follows the '&' in the string appears underlined and selects the menu item when you type **Alt+** followed by that character while the menu is visible. The '&' character is not displayed. To display the '&' character in a label, use two '&' characters in the string:

'O&pen selection' yields **Open selection**

'Save && Go' yields **Save & Go**

'Save&&Go' yields **Save & Go**



'Save& Go' yields **Save& Go** (the space is not a mnemonic)

There are three reserved words: default, remove, factory (case sensitive). If you want to use one of these reserved words in the Label property, you must precede it with a backslash ('\ ') character. For example:

'\remove' yields **remove**

'\default' yields **default**

'\factory' yields **factory**

## Parent

handle

*Uimenu's parent.* The handle of the uimenu's parent object. The parent of a uimenu object is the figure on whose menu bar it displays, or the uimenu of which it is a submenu. You can move a uimenu object to another figure by setting this property to the handle of the new parent.

## Position

scalar

*Relative menu position.* The value of Position indicates placement on the menu bar or within a menu. Top-level menus are placed from left to right on the menu bar according to the value of their Position property, with 1 representing the left-most position. The individual items within a given menu are placed from top to bottom according to the value of their Position property, with 1 representing the top-most position.

## Separator

on | {off}

*Separator line mode.* Setting this property to on draws a dividing line above the menu item.

# Uimenu Properties

---

## Tag

string

*User-specified object label.* The Tag property provides a means to identify graphics objects with a user-specified label. This is particularly useful when constructing interactive graphics programs that would otherwise need to define object handles as global variables or pass them as arguments between callback routines. You can define Tag as any string.

## Type

string (read only)

*Class of graphics object.* For uimenu objects, Type is always the string 'uimenu'.

## UserData

matrix

*User-specified data.* Any matrix you want to associate with the uimenu object. MATLAB does not use this data, but you can access it using the set and get commands.

## Visible

{on} | off

*Uimenu visibility.* By default, all uimenu are visible. When set to off, the uimenu is not visible, but still exists and you can query and set its properties.

**Purpose** Convert to unsigned integer

**Syntax**

```
I = uint8(X)
I = uint16(X)
I = uint32(X)
I = uint64(X)
```

**Description** `I = uint*(X)` converts the elements of array `X` into unsigned integers. `X` can be any numeric object (such as a double). The results of a `uint*` operation are shown in the next table.

| Operation | Output Range                    | Output Type             | Bytes per Element | Output Class |
|-----------|---------------------------------|-------------------------|-------------------|--------------|
| uint8     | 0 to 255                        | Unsigned 8-bit integer  | 1                 | uint8        |
| uint16    | 0 to 65,535                     | Unsigned 16-bit integer | 2                 | uint16       |
| uint32    | 0 to 4,294,967,295              | Unsigned 32-bit integer | 4                 | uint32       |
| uint64    | 0 to 18,446,744,073,709,551,615 | Unsigned 64-bit integer | 8                 | uint64       |

double and single values are rounded to the nearest `uint*` value on conversion. A value of `X` that is above or below the range for an integer class is mapped to one of the endpoints of the range. For example,

```
uint16(70000)
ans =
    65535
```

If `X` is already an unsigned integer of the same class, then `uint*` has no effect.

# uint8, uint16, uint32, uint64

---

You can define or overload your own methods for `uint*` (as you can for any object) by placing the appropriately named method in an `@uint*` directory within a directory on your path. Type `help datatypes` for the names of the methods you can overload.

## Remarks

Most operations that manipulate arrays without changing their elements are defined for integer values. Examples are `reshape`, `size`, the logical and relational operators, subscripted assignment, and subscripted reference.

Some arithmetic operations are defined for integer arrays on interaction with other integer arrays of the same class (e.g., where both operands are `uint16`). Examples of these operations are `+`, `-`, `.*`, `./`, `.\` and `.^`. If at least one operand is scalar, then `*`, `/`, `\`, and `^` are also defined. Integer arrays may also interact with scalar `double` variables, including constants, and the result of the operation is an integer array of the same class. Integer arrays saturate on overflow in arithmetic.

A particularly efficient way to initialize a large array is by specifying the data type (i.e., class name) for the array in the `zeros`, `ones`, or `eye` function. For example, to create a 100-by-100 `uint64` array initialized to zero, type

```
I = zeros(100, 100, 'uint64');
```

An easy way to find the range for any MATLAB integer type is to use the `intmin` and `intmax` functions as shown here for `uint32`:

```
intmin('uint32')           intmax('uint32')
ans =                      ans =
    0                      4294967295
```

## See Also

`double`, `single`, `int8`, `int16`, `int32`, `int64`, `intmax`, `intmin`

**Purpose**

Open file selection dialog box with appropriate file filters

**Syntax**

```
uiopen  
uiopen('MATLAB')  
uiopen('LOAD')  
uiopen('FIGURE')  
uiopen('SIMULINK')  
uiopen('EDITOR')
```

**Description**

uiopen displays a modal file selection dialog from which a user can select a file to open. The dialog is the same as the one displayed when you select **Open** from the **File** menu in the MATLAB desktop.

Selecting a file in the dialog and clicking **Open** does the following:

- Gets the file using `uigetfile`
- Opens the file in the base workspace using the `open` command

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. For more information, see `WindowState` in the MATLAB Figure Properties.

---

---

**Note** `uiopen` cannot be compiled. If you want to create a file selection dialog that can be compiled, use `uigetfile`.

---

`uiopen` or `uiopen('MATLAB')` displays the dialog with the file filter set to all MATLAB files.

`uiopen('LOAD')` displays the dialog with the file filter set to MAT-files (\*.mat).

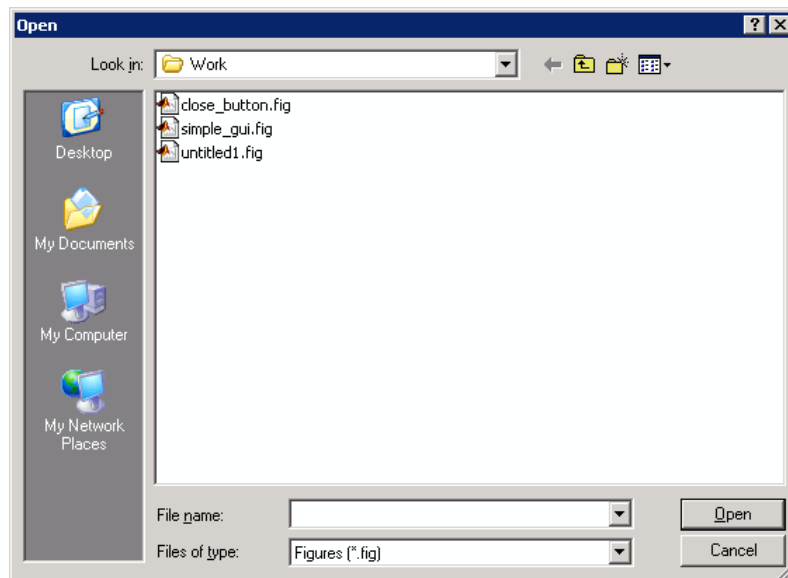
`uiopen('FIGURE')` displays the dialog with the file filter set to figure files (\*.fig).

`uiopen('SIMULINK')` displays the dialog with the file filter set to model files (\*.mdl).

`uiopen('EDITOR')` displays the dialog with the file filter set to all MATLAB files except for MAT-files and FIG-files. All files are opened in the MATLAB Editor.

## Examples

Typing `uiopen('figure')` sets the **Files of type** field to Figures (\*.fig):



## See Also

`uigetfile`, `uiputfile`, `uisave`

---

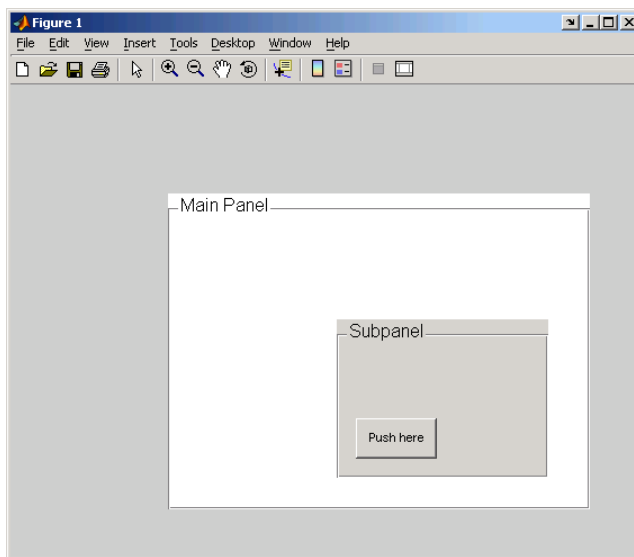
|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Create panel container object                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Syntax</b>      | <pre>h = uipanel('PropertyName1',value1,'PropertyName2',value2, ... ) h = uipanel(parent,'PropertyName1',value1,'PropertyName2', value2,...)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Description</b> | <p>A uipanel groups components. It can contain user interface controls with which the user interacts directly. It can also contain axes, other uipanels, and uibuttongroups. It cannot contain ActiveX controls.</p> <p><code>h = uipanel('PropertyName1',value1,'PropertyName2',value2,...)</code> creates a uipanel container object in a figure, uipanel, or uibuttongroup. Use the Parent property to specify the parent figure, uipanel, or uibuttongroup. If you do not specify a parent, uipanel adds the panel to the current figure. If no figure exists, one is created. See the Uipanel Properties reference page for more information.</p> <p><code>h = uipanel(parent,'PropertyName1',value1,'PropertyName2',value2,...)</code> creates a uipanel in the object specified by the handle, parent. If you also specify a different value for the Parent property, the value of the Parent property takes precedence. parent must be a figure, uipanel, or uibuttongroup.</p> <p>A uipanel object can have axes, uicontrol, uipanel, and uibuttongroup objects as children. For the children of a uipanel, the Position property is interpreted relative to the uipanel. If you move the panel, the children automatically move with it and maintain their positions relative to the panel.</p> <p>After creating a uipanel object, you can set and query its property values using set and get.</p> |
| <b>Examples</b>    | This example creates a uipanel in a figure, then creates a subpanel in the first panel. Finally, it adds a pushbutton to the subpanel. Both                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

# uipanel

---

panels use the default `Units` property value, normalized. Note that default `Units` for the `uicontrol` `pushbutton` is pixels.

```
h = figure;  
hp = uipanel('Title','Main Panel','FontSize',12,...  
            'BackgroundColor','white',...  
            'Position',[.25 .1 .67 .67]);  
hsp = uipanel('Parent',hp,'Title','Subpanel','FontSize',12,...  
             'Position',[.4 .1 .5 .5]);  
hbsp = uicontrol('Parent',hsp,'String','Push here',...  
                'Position',[18 18 72 36]);
```



## See Also

`hgtransform`, `uibuttongroup`, `uicontrol`



## Purpose

Describe panel properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` functions enable you to set and query the values of properties.

You can set default uipanel properties by typing:

```
set(h, 'DefaultUipanelPropertyName', PropertyValue...)
```

Where `h` can be the root handle (0), a figure handle, or a uipanel handle. `PropertyName` is the name of the uipanel property and `PropertyValue` is the value you specify as the default for that property.

---

**Note** Default properties you set for uipanel also apply to `uibuttongroups`.

---

For more information about changing the default value of a property see “Setting Default Property Values”. For an example, see the `CreateFcn` property.

## Uipanel Properties

This section lists all properties useful to `uipanel` objects along with valid values and a descriptions of their use. Curly braces { } enclose default values.

| Property Name                | Description                             |
|------------------------------|-----------------------------------------|
| <code>BackgroundColor</code> | Color of the uipanel background         |
| <code>BorderType</code>      | Type of border around the uipanel area. |

# Uipanel Properties

---

| Property Name    | Description                                                                                           |
|------------------|-------------------------------------------------------------------------------------------------------|
| BorderWidth      | Width of the panel border.                                                                            |
| BusyAction       | Interruption of other callback routines                                                               |
| ButtonDownFcn    | Button-press callback routine                                                                         |
| Children         | All children of the uipanel                                                                           |
| Clipping         | Clipping of child axes, uipanel, and uibuttongroups to the uipanel. Does not affect child uicontrols. |
| CreateFcn        | Callback routine executed during object creation                                                      |
| DeleteFcn        | Callback routine executed during object deletion                                                      |
| FontAngle        | Title font angle                                                                                      |
| FontName         | Title font name                                                                                       |
| FontSize         | Title font size                                                                                       |
| FontUnits        | Title font units                                                                                      |
| FontWeight       | Title font weight                                                                                     |
| ForegroundColor  | Title font color and/or color of 2-D border line                                                      |
| HandleVisibility | Handle accessibility from commandline and GUIs                                                        |
| HighlightColor   | 3-D frame highlight color                                                                             |
| Interruptible    | Callback routine interruption mode                                                                    |
| Parent           | Uipanel object's parent                                                                               |
| Position         | Panel position relative to parent figure or uipanel                                                   |
| ResizeFcn        | User-specified resize routine                                                                         |
| Selected         | Whether object is selected                                                                            |

| Property Name      | Description                                                                                                                                                 |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SelectionHighlight | Object highlighted when selected                                                                                                                            |
| ShadowColor        | 3-D frame shadow color                                                                                                                                      |
| Tag                | User-specified object identifier                                                                                                                            |
| Title              | Title string                                                                                                                                                |
| TitlePosition      | Location of title string in relation to the panel                                                                                                           |
| Type               | Object class                                                                                                                                                |
| UIContextMenu      | Associates uicontextmenu with the uipanel                                                                                                                   |
| Units              | Units used to interpret the position vector                                                                                                                 |
| UserData           | User-specified data                                                                                                                                         |
| Visible            | Uipanel visibility.<br><hr/> <b>Note</b> Controls the Visible property of child axes, uibuttongroups. and uipanels. Does not affect child uicontrols. <hr/> |

BackgroundColor  
ColorSpec

*Color of the uipanel background.* A three-element RGB vector or one of the MATLAB predefined names, specifying the background color. See the ColorSpec reference page for more information on specifying color.

BorderType  
none | {etchedin} | etchedout | beveledin | beveledout  
| line

*Border of the uipanel area.* Used to define the panel area graphically. Etched and beveled borders provide a 3-D look. Use

# Uipanel Properties

---

the `HighlightColor` and `ShadowColor` properties to specify the border color of etched and beveled borders. A line border is 2-D. Use the `ForegroundColor` property to specify its color.

`BorderWidth`  
integer

*Width of the panel border.* The width of the panel borders in pixels. The default border width is 1 pixel. 3-D borders wider than 3 may not appear correctly at the corners.

`BusyAction`  
cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new event uses the value of `BusyAction` to decide whether or not to attempt to interrupt the executing callback.

- If the value is `cancel`, the event is discarded and the second callback does not execute.
- If the value is `queue`, and the `Interruptible` property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

---

`ButtonDownFcn`  
string or function handle

*Button-press callback routine.* A callback routine that executes when you press a mouse button while the pointer is in a 5-pixel wide border around the uipanel. This is useful for implementing actions to interactively modify control object properties, such as size and position, when they are clicked on (using the `selectmoveresize` function, for example).

If you define this routine as a string, the string can be a valid MATLAB expression or the name of an M-file. The expression executes in the MATLAB workspace.

## Children

vector of handles

*Children of the uipanel.* A vector containing the handles of all children of the uipanel. A `uipanel` object's children are axes, uipanels, `uibuttongroups`, and `uicontrols`. You can use this property to reorder the children.

## Clipping

{on} | off

*Clipping mode.* By default, MATLAB clips a `uipanel`'s child axes, uipanels, and `uibuttongroups` to the `uipanel` rectangle. If you set `Clipping` to `off`, the axis, `uipanel`, or `uibuttongroup` is displayed outside the panel rectangle. This property does not affect child `uicontrols` which, by default, can display outside the panel rectangle.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a `uipanel` object. MATLAB sets all property values for the `uipanel` before executing the `CreateFcn` callback so these values are available to the callback. Within the function, use `gcb0` to get the handle of the `uipanel` being created.

# Uipanel Properties

---

Setting this property on an existing uipanel object has no effect.

You can define a default `CreateFcn` callback for all new uipanel. This default applies unless you override it by specifying a different `CreateFcn` callback when you call `uipanel`. For example, the code

```
set(0, 'DefaultUipanelCreateFcn', 'set(gcbo,...  
    ' 'FontName', 'arial', 'FontSize', 12)')
```

creates a default `CreateFcn` callback that runs whenever you create a new panel. It sets the default font name and font size of the uipanel title.

---

**Note** `Uibuttongroup` takes its default property values from `uipanel`. Defining a default property for all uipanel defines the same default property for all `uibuttongroups`.

---

To override this default and create a panel whose `FontName` and `FontSize` properties are set to different values, call `uipanel` with code similar to

```
hpt = uipanel(..., 'CreateFcn', 'set(gcbo,...  
    ' 'FontName', 'times', 'FontSize', 14)')
```

---

**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uipushtool` call. In the example above, if instead of redefining the `CreateFcn` property for this uipanel, you had explicitly set `FontSize` to 14, the default `CreateFcn` callback would have set `FontSize` back to the system dependent default.

---

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

DeleteFcn  
string or function handle

*Callback routine executed during object deletion.* A callback routine that executes when you delete the uipanel object (e.g., when you issue a delete command or clear the figure containing the uipanel). MATLAB executes the routine before destroying the object’s properties so these values are available to the callback routine. The handle of the object whose DeleteFcn is being executed is accessible only through the root CallbackObject property, which you can query using gcbo.

FontAngle  
{normal} | italic | oblique

*Character slant used in the Title.* MATLAB uses this property to select a font from those available on your particular system. Setting this property to italic or oblique selects a slanted version of the font, when it is available on your system.

FontName  
string

*Font family used in the Title.* The name of the font in which to display the Title. To display and print properly, this must be a font that your system supports. The default font is system dependent. To eliminate the need to hard code the name of a fixed-width font, which may not display text properly on systems that do not use ASCII character encoding (such as in Japan), set FontName to the string FixedWidth (this string value is case insensitive).

```
set(uicontrol_handle, 'FontName', 'FixedWidth')
```

This then uses the value of the root FixedWidthFontName property which can be set to the appropriate value for a locale

# Uipanel Properties

---

from `startup.m` in the end user's environment. Setting the root `FixedWidthFontName` property causes an immediate update of the display to use the new font

`FontSize`  
integer

*Title font size.* A number specifying the size of the font in which to display the Title, in units determined by the `FontUnits` property. The default size is system dependent.

`FontUnits`  
inches | centimeters | normalized | {points} | pixels

*Title font size units.* Normalized units interpret `FontSize` as a fraction of the height of the uipanel. When you resize the uipanel, MATLAB modifies the screen `FontSize` accordingly. `pixels`, `inches`, `centimeters`, and `points` are absolute units (1 point = 1/72 inch).

`FontWeight`  
light | {normal} | demi | bold

*Weight of characters in the title.* MATLAB uses this property to select a font from those available on your particular system. Setting this property to `bold` causes MATLAB to use a bold version of the font, when it is available on your system.

`ForegroundColor`  
`ColorSpec`

*Color used for title font and 2-D border line.* A three-element RGB vector or one of the MATLAB predefined names, specifying the font or line color. See the `ColorSpec` reference page for more information on specifying color.

`HandleVisibility`  
{on} | callback | off



*Control access to object's handle.* This property determines when an object's handle is visible in its parent's list of children. When a handle is not visible in its parent's list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`. Neither is the handle visible in the parent figure's `CurrentObject` property. Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when `HandleVisibility` is `on`.
- Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.

`HighlightColor`  
`ColorSpec`

*3-D frame highlight color.* A three-element RGB vector or one of the MATLAB predefined names, specifying the highlight color. See the `ColorSpec` reference page for more information on specifying color.

# Uipanel Properties

---

Interruptible  
{on} | off

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The Interruptible property of the object whose callback is executing
- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the Interruptible property of the object whose callback is executing is on (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the Interruptible property of the object whose callback is executing is off, the callback cannot be interrupted (except by certain callbacks; see the note below). The `BusyAction` property of the object whose callback is waiting to execute determines what happens to the callback.

---

**Note** If the interrupting callback is a DeleteFcn or CreateFcn callback or a figure's CloseRequest or ResizeFcn callback, it interrupts an executing callback regardless of the value of that object's Interruptible property. The interrupting callback starts execution at the next drawnow, figure, getframe, pause, or waitfor statement. A figure's WindowButtonDownFcn callback routine, or an object's ButtonDownFcn or Callback routine are processed according to the rules described above.

---

## Parent

handle

*Uipanel parent.* The handle of the uipanel's parent figure, uipanel, or uibuttongroup. You can move a uipanel object to another figure, uipanel, or uibuttongroup by setting this property to the handle of the new parent.

## Position

position rectangle

*Size and location of uipanel relative to parent.* The rectangle defined by this property specifies the size and location of the panel within the parent figure window, uipanel, or uibuttongroup. Specify Position as

```
[left bottom width height]
```

left and bottom are the distance from the lower-left corner of the parent object to the lower-left corner of the uipanel object. width and height are the dimensions of the uipanel rectangle, including the title. All measurements are in units specified by the Units property.

## ResizeFcn

string or function handle

# Uipanel Properties

---

*Resize callback routine.* MATLAB executes this callback routine whenever a user resizes the uipanel and the figure `Resize` property is set to `on`, or in GUIDE, the `Resize` behavior option is set to `Other`. You can query the uipanel `Position` property to determine its new size and position. During execution of the callback routine, the handle to the figure being resized is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

You can use `ResizeFcn` to maintain a GUI layout that is not directly supported by the MATLAB `Position/Units` paradigm.

For example, consider a GUI layout that maintains an object at a constant height in pixels and attached to the top of the figure, but always matches the width of the figure. The following `ResizeFcn` accomplishes this; it keeps the uicontrol whose `Tag` is `'StatusBar'` 20 pixels high, as wide as the figure, and attached to the top of the figure. Note the use of the `Tag` property to retrieve the uicontrol handle, and the `gcbo` function to retrieve the figure handle. Also note the defensive programming regarding figure `Units`, which the callback requires to be in pixels in order to work correctly, but which the callback also restores to their previous value afterwards.

```
u = findobj('Tag','StatusBar');
fig = gcbo;
old_units = get(fig,'Units');
set(fig,'Units','pixels');
figpos = get(fig,'Position');
upos = [0, figpos(4) - 20, figpos(3), 20];
set(u,'Position',upos);
set(fig,'Units',old_units);
```

You can change the figure `Position` from within the `ResizeFcn` callback; however, the `ResizeFcn` is not called again as a result.

Note that the `print` command can cause the `ResizeFcn` to be called if the `PaperPositionMode` property is set to `manual` and you have defined a resize function. If you do not want your resize function called by `print`, set the `PaperPositionMode` to `auto`.

See “Function Handle Callbacks” for information on how to use function handles to define the callback function.

See [Resize Behavior](#) for information on creating resize functions using GUIDE.

## Selected

on | off (read only)

*Is object selected?* This property indicates whether the panel is selected. When this property is on, MATLAB displays selection handles if the `SelectionHighlight` property is also on. You can, for example, define the `ButtonDownFcn` to set this property, allowing users to select the object with the mouse.

## SelectionHighlight

{on} | off

*Object highlighted when selected.* When the `Selected` property is on, MATLAB indicates the selected state by drawing four edge handles and four corner handles. When `SelectionHighlight` is off, MATLAB does not draw the handles.

## ShadowColor

ColorSpec

*3-D frame shadow color.* A three-element RGB vector or one of the MATLAB predefined names, specifying the shadow color. See the [ColorSpec](#) reference page for more information on specifying color.

## Tag

string

# Uipanel Properties

---

*User-specified object identifier.* The Tag property provides a means to identify graphics objects with a user-specified label. You can define Tag as any string.

With the `findobj` function, you can locate an object with a given Tag property value. This saves you from defining object handles as global variables. For example, this function call returns the handles of all children (of the specified figures) that have the Tag value 'FormatTb'.

```
h = findobj(figurehandles,'Tag','FormatTb')
```

## Title

string

*Title string.* The text displayed in the panel title. You can position the title using the `TitlePosition` property.

If the string value is specified as a cell array of strings or padded string matrix, only the first string of a cell array or of a padded string matrix is displayed; the rest are ignored. Vertical slash ('|') characters are not interpreted as line breaks and instead show up in the text displayed in the uipanel title.

Setting a property value to `default`, `remove`, or `factory` produces the effect described in “Defining Default Values”. To set `Title` to one of these words, you must precede the word with the backslash character. For example,

```
hp = uipanel(...,'Title','\Default');
```

## TitlePosition

{lefttop} | centertop | righttop | leftbottom |  
centerbottom | rightbottom

*Location of the title.* This property determines the location of the title string, in relation to the uipanel.

## Type

string (read-only)

*Object class.* This property identifies the kind of graphics object. For uipanel objects, Type is always the string 'uipanel'.

## UIContextMenu

handle

*Associate a context menu with a uipanel.* Assign this property the handle of a Uicontextmenu object. MATLAB displays the context menu whenever you right-click the uipanel. Use the uicontextmenu function to create the context menu.

## Units

inches | centimeters | {normalized} | points | pixels  
| characters

*Units of measurement.* MATLAB uses these units to interpret the Position property. For the panel itself, units are measured from the lower-left corner of the figure window. For children of the panel, they are measured from the lower-left corner of the panel.

- Normalized units map the lower-left corner of the panel or figure window to (0,0) and the upper-right corner to (1.0,1.0).
- pixels, inches, centimeters, and points are absolute units (1 point = 1/72 inch).
- Character units are characters using the default system font; the width of one character is the width of the letter x, the height of one character is the distance between the baselines of two lines of text.

If you change the value of Units, it is good practice to return it to its default value after completing your computation so as not to affect other functions that assume Units is set to the default value.

# Uipanel Properties

---

UserData  
matrix

*User-specified data.* Any data you want to associate with the uipanel object. MATLAB does not use this data, but you can access it using set and get.

Visible  
{on} | off

*Uipanel visibility.* By default, a uipanel object is visible. When set to off, the uipanel is not visible, but still exists and you can query and set its properties.

---

**Note** The value of a uipanel's Visible property also controls the Visible property of child axes, uipanel, and uibuttongroups. This property does not affect the Visible property of child uicontrols.

---

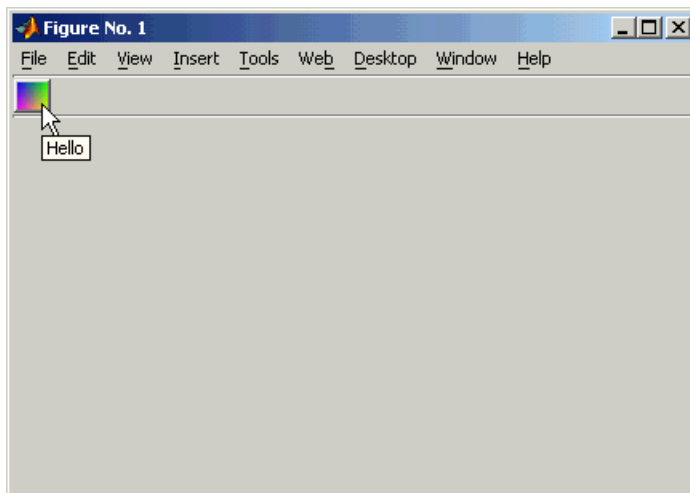


|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Create push button on toolbar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>      | <pre>hpt = uipushtool('PropertyName1',value1,'PropertyName2',<br/>value2,...)<br/>hpt = uipushtool(ht,...)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Description</b> | <p><code>hpt = uipushtool('PropertyName1',value1,'PropertyName2',value2,...)</code> creates a push button on the <code>uitoolbar</code> at the top of the current figure window, and returns a handle to it. <code>uipushtool</code> assigns the specified property values, and assigns default values to the remaining properties. You can change the property values at a later time using the <code>set</code> function.</p> <p>Type <code>get(hpt)</code> to see a list of <code>uipushtool</code> object properties and their current values. Type <code>set(hpt)</code> to see a list of <code>uipushtool</code> object properties that you can set and their legal property values. See the <a href="#">Uipushtool Properties</a> reference page for more information.</p> <p><code>hpt = uipushtool(ht,...)</code> creates a button with <code>ht</code> as a parent. <code>ht</code> must be a <code>uitoolbar</code> handle.</p> |
| <b>Remarks</b>     | <p><code>uipushtool</code> accepts property name/property value pairs, as well as structures and cell arrays of properties as input arguments.</p> <p><code>Uipushtools</code> appear in figures whose <code>Window Style</code> is <code>normal</code> or <code>docked</code>. They do not appear in figures whose <code>WindowStyle</code> is <code>modal</code>. If the <code>WindowStyle</code> of a figure containing a <code>uitoolbar</code> and its <code>uipushtool</code> children is changed to <code>modal</code>, the <code>uipushtools</code> still exist and are contained in the <code>Children</code> list of the <code>uitoolbar</code>, but are not displayed until the figure <code>WindowStyle</code> is changed to <code>normal</code> or <code>docked</code>.</p>                                                                                                                                                   |
| <b>Examples</b>    | <p>This example creates a <code>uitoolbar</code> object and places a <code>uipushtool</code> object on it.</p> <pre>h = figure('ToolBar','none')<br/>ht = uitoolbar(h)<br/>a = [.20:.05:0.95];</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

# uipushtool

---

```
b(:,:,1) = repmat(a,16,1)';  
b(:,:,2) = repmat(a,16,1);  
b(:,:,3) = repmat(flipdim(a,2),16,1);  
hpt = uipushtool(ht,'CData',b,'TooltipString','Hello')
```



## See Also

[get](#), [set](#), [uicontrol](#), [uitoggletool](#), [uitoolbar](#)

## Purpose

Describe push tool properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` functions enable you to set and query the values of properties.

You can set default Uipushtool properties by typing:

```
set(h, 'DefaultUipushtoolPropertyName', PropertyValue...)
```

Where `h` can be the root handle (0), a figure handle, a uicontrol handle, or a uipushtool handle. *PropertyName* is the name of the Uipushtool property and *PropertyValue* is the value you specify as the default for that property.

For more information about changing the default value of a property see [Setting Default Property Values](#).

## Uipushtool Properties

This section lists all properties useful to uipushtool objects along with valid values and a descriptions of their use. Curly braces { } enclose default values.

| Property        | Purpose                                           |
|-----------------|---------------------------------------------------|
| BeingDeleted    | This object is being deleted.                     |
| BusyAction      | Callback routine interruption.                    |
| CData           | Truecolor image displayed on the control.         |
| ClickedCallback | Control action.                                   |
| CreateFcn       | Callback routine executed during object creation. |
| DeleteFcn       | Delete uipushtool callback routine.               |

# Uipushtool Properties

---

| Property         | Purpose                                             |
|------------------|-----------------------------------------------------|
| Enable           | Enable or disable the uipushtool.                   |
| HandleVisibility | Control access to object's handle.                  |
| HitTest          | Whether selectable by mouse click                   |
| Interruptible    | Callback routine interruption mode.                 |
| Parent           | Handle of uipushtool's parent.                      |
| Separator        | Separator line mode                                 |
| Tag              | User-specified object label.                        |
| TooltipString    | Content of object's tooltip.                        |
| Type             | Object class.                                       |
| UicontextMenu    | Uicontextmenu object associated with the uipushtool |
| UserData         | User specified data.                                |
| Visible          | Uipushtool visibility.                              |

BeingDeleted  
on | {off} (read only)

*This object is being deleted.* The BeingDeleted property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the BeingDeleted property to on when the object's delete function callback is called (see the DeleteFcn property). It remains set to on while the delete function executes, after which the object no longer exists.

For example, some functions may not need to perform actions on objects that are being deleted, and therefore, can check the object's BeingDeleted property before acting.

BusyAction  
cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new event uses the value of `BusyAction` to decide whether or not to attempt to interrupt the executing callback.

- If the value is `cancel`, the event is discarded and the second callback does not execute.
- If the value is `queue`, and the `Interruptible` property of the first callback is `on`, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

---

## `CData`

3-dimensional array

*Tricolor image displayed on control.* An  $n$ -by- $m$ -by-3 array of RGB values that defines a tricolor image displayed on either a push button or toggle button. Each value must be between 0.0 and 1.0. If your `CData` array is larger than 16 in the first or second dimension, it may be clipped or cause other undesirable effects. If the array is clipped, only the center 16-by-16 part of the array is used.

## `ClickedCallback`

string or function handle

# Uipushtool Properties

---

*Control action.* A routine that executes when the uipushtool's Enable property is set to on, and you press a mouse button while the pointer is on the push tool itself or in a 5-pixel wide border around it.

CreateFcn  
string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a uipushtool object. MATLAB sets all property values for the uipushtool before executing the CreateFcn callback so these values are available to the callback. Within the function, use gcb0 to get the handle of the push tool being created.

Setting this property on an existing uipushtool object has no effect.

You can define a default CreateFcn callback for all new uipushtools. This default applies unless you override it by specifying a different CreateFcn callback when you call uipushtool. For example, the code

```
imga(:,:,1) = rand(20);  
imga(:,:,2) = rand(20);  
imga(:,:,3) = rand(20);  
set(0,'DefaultUipushtoolCreateFcn','set(gcf,'Cdata',imga)')
```

creates a default CreateFcn callback that runs whenever you create a new push tool. It sets the default image imga on the push tool.

To override this default and create a push tool whose Cdata property is set to a different image, call uipushtool with code similar to

```
a = [.05:.05:0.95];  
imgb(:,:,1) = repmat(a,19,1)';  
imgb(:,:,2) = repmat(a,19,1);
```

```
imgb(:,:,3) = repmat(flipdim(a,2),19,1);  
hpt = uipushtool(...,'CreateFcn','set(gcbo,'CData',imgb)',...
```

---

**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uipushtool` call. In the example above, if instead of redefining the `CreateFcn` property for this push tool, you had explicitly set `CData` to `imgb`, the default `CreateFcn` callback would have set `CData` back to `imga`.

---

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

## DeleteFcn

string or function handle

*Callback routine executed during object deletion.* A callback routine that executes when you delete the `uipushtool` object (e.g., when you call the `delete` function or cause the figure containing the `uipushtool` to reset). MATLAB executes the routine before destroying the object’s properties so these values are available to the callback routine.

The handle of the object whose `DeleteFcn` is being executed is accessible only through the root `CallbackObject` property, which you can query using `gcbo`.

See “Function Handle Callbacks” for information on how to use function handles to define a callback function.

## Enable

{on} | off

# Uipushtool Properties

---

*Enable or disable the uipushtool.* This property controls how uipushtools respond to mouse button clicks, including which callback routines execute.

- on – The uipushtool is operational (the default).
- off – The uipushtool is not operational and its image (set by the Cdata property) is grayed out.

When you left-click on a uipushtool whose Enable property is on, MATLAB performs these actions in this order:

- 1** Sets the figure's SelectionType property.
- 2** Executes the push tool's ClickedCallback routine.
- 3** Does not set the figure's CurrentPoint property and does not execute the figure's WindowButtonDownFcn callback.

When you left-click on a uipushtool whose Enable property is off, or when you right-click a uipushtool whose Enable property has any value, MATLAB performs these actions in this order:

- 4** Sets the figure's SelectionType property.
- 5** Sets the figure's CurrentPoint property.
- 6** Executes the figure's WindowButtonDownFcn callback.
- 7** Does not execute the push tool's ClickedCallback routine.

HandleVisibility  
{on} | callback | off

*Control access to object's handle.* This property determines when an object's handle is visible in its parent's list of children. When a handle is not visible in its parent's list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes get, findobj, gca, gcf, gco, newplot, cla, clf, and close. Neither is the handle visible in the parent figure's CurrentObject property. Handles that are hidden are still valid. If you know an object's



handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when `HandleVisibility` is `on`.
- Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.

`HitTest`  
{on} | off

*Selectable by mouse click.* This property has no effect on uipushtool objects.

`Interruptible`  
{on} | off

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The `Interruptible` property of the object whose callback is executing

# Uipushtool Properties

---

- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the `Interruptible` property of the object whose callback is executing is on (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the `Interruptible` property of the object whose callback is executing is off, the callback cannot be interrupted (except by certain callbacks; see the note below). The `BusyAction` property of the object whose callback is waiting to execute determines what happens to the callback.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. The interrupting callback starts execution at the next `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statement. A figure's `WindowButtonDownFcn` callback routine, or an object's `ButtonDownFcn` or `Callback` routine are processed according to the rules described above.

---

Parent  
handle

*Uipushtool parent.* The handle of the uipushtool's parent toolbar. You can move a uipushtool object to another toolbar by setting this property to the handle of the new parent.

Separator

on | {off}

*Separator line mode.* Setting this property to on draws a dividing line to the left of the uipushtool.

Tag

string

*User-specified object identifier.* The Tag property provides a means to identify graphics objects with a user-specified label. You can define Tag as any string.

With the `findobj` function, you can locate an object with a given Tag property value. This saves you from defining object handles as global variables. For example, this function call returns the handles of all children (of the specified toolbars) that have the Tag value 'Copy'.

```
h = findobj(uitoolbarhandles,'Tag','Copy')
```

TooltipString

string

*Content of tooltip for object.* The TooltipString property specifies the text of the tooltip associated with the uipushtool. When the user moves the mouse pointer over the control and leaves it there, the tooltip is displayed.

Type

string (read-only)

Object class. This property identifies the kind of graphics object. For uipushtool objects, Type is always the string 'uipushtool'.

UIContextMenu

handle

# Uipushtool Properties

---

*Associate a context menu with uicontrol.* This property has no effect on uipushtool objects.

UserData  
array

*User specified data.* You can specify UserData as any array you want to associate with the uipushtool object. The object does not use this data, but you can access it using the set and get functions.

Visible  
{on} | off

*Uipushtool visibility.* By default, all uipushtools are visible. When set to off, the uipushtool is not visible, but still exists and you can query and set its properties.

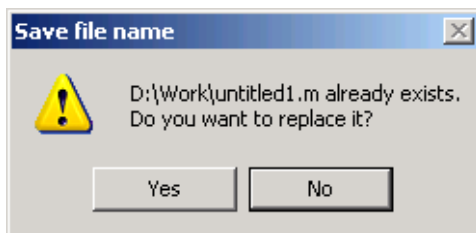
**Purpose** Open standard dialog box for saving files

**Syntax**

```
uiputfile  
[FileName,PathName,FilterIndex] = uiputfile(FilterSpec)  
[FileName,PathName,FilterIndex] = uiputfile(FilterSpec,  
    DialogTitle)  
[FileName,PathName,FilterIndex] = uiputfile(FilterSpec,  
    DialogTitle,DefaultName)
```

**Description** uiputfile displays a modal dialog box used to select or specify a file for saving. The dialog box lists the files and directories in the current directory. If the selected or specified filename is valid, it is returned in ans.

If an existing filename is selected or specified, the following warning dialog box is displayed.



The user can select **Yes** to replace the existing file or **No** to return to the dialog to select another filename. If the user selects **Yes**, uiputfile returns the name of the file. If the user selects **No**, uiputfile returns 0.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. To block MATLAB program execution as well, use theuiwait function. For more information about modal dialog boxes, see WindowStyle in the MATLAB Figure Properties.

---

`[FileName,PathName,FilterIndex] = uiputfile(FilterSpec)` displays only those files with extensions that match `FilterSpec`. `FilterSpec` can be a string or a cell array of strings, and can include the \* wildcard. For example, `'*.m'` lists all the MATLAB M-files. A `FilterSpec` string can also be a filename. In this case the filename becomes the default filename and the file's extension is used as the default filter. If `FilterSpec` is a string, `uiputfile` appends 'All Files' to the list of file types.

If `FilterSpec` is a cell array, the first column contains a list of file extensions. The optional second column contains a corresponding list of descriptions. These descriptions replace standard descriptions in the **Files of type** field. A description cannot be an empty string. “Example 3” on page 2-3562 and “Example 4” on page 2-3563 illustrate use of a cell array as `FilterSpec`.

If `FilterSpec` is not specified, `uiputfile` uses the default list of file types (i.e., all MATLAB files).

After the user clicks **Save** and if the filename is valid, `uiputfile` returns the name of the selected file in `FileName` and its path in `PathName`. If the user clicks the **Cancel** button, closes the dialog window, or if the filename is not valid, `FileName` and `PathName` are set to 0.

`FilterIndex` is the index of the filter selected in the dialog box. Indexing starts at 1. If the user clicks the **Cancel** button, closes the dialog window, or if the file does not exist, `FilterIndex` is set to 0.

If no output arguments are specified, the filename is returned in `ans`.

`[FileName,PathName,FilterIndex] = uiputfile(FilterSpec,DialogTitle)` displays a dialog box that has the title `DialogTitle`. To use the default file types and specify a dialog title, enter

```
uiputfile('',DialogTitle)
```

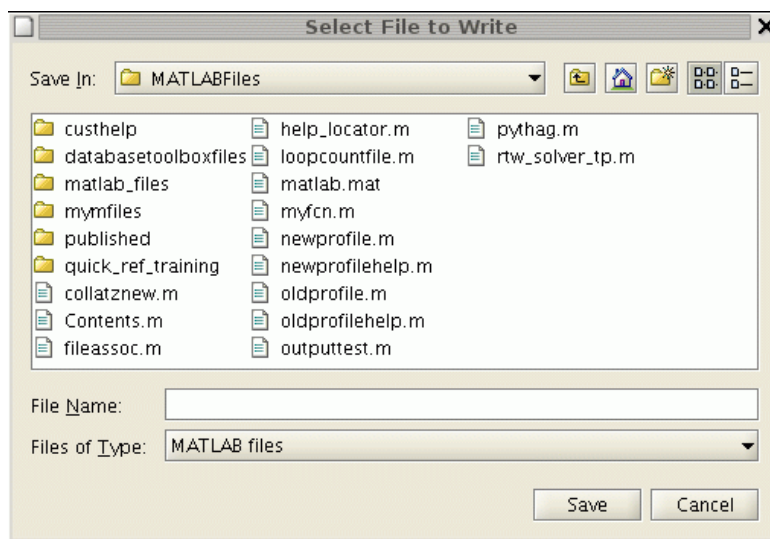
`[FileName,PathName,FilterIndex] = uiputfile(FilterSpec,DialogTitle,DefaultName)` displays a dialog box in which the filename specified by `DefaultName` appears in the

**File name** field. DefaultName can also be a path or a path/filename. In this case, `uigetfile` opens the dialog box in the directory specified by the path. See “Example 6” on page 2-3565. If the path does not include a filename, it must end with a slash (/) or backslash (\) separator. For example, 'C:\Work\'. Note that `uiputfile` recognizes both './' and './.' as valid values. If the specified path does not exist, `uiputfile` opens the dialog box in the current directory.

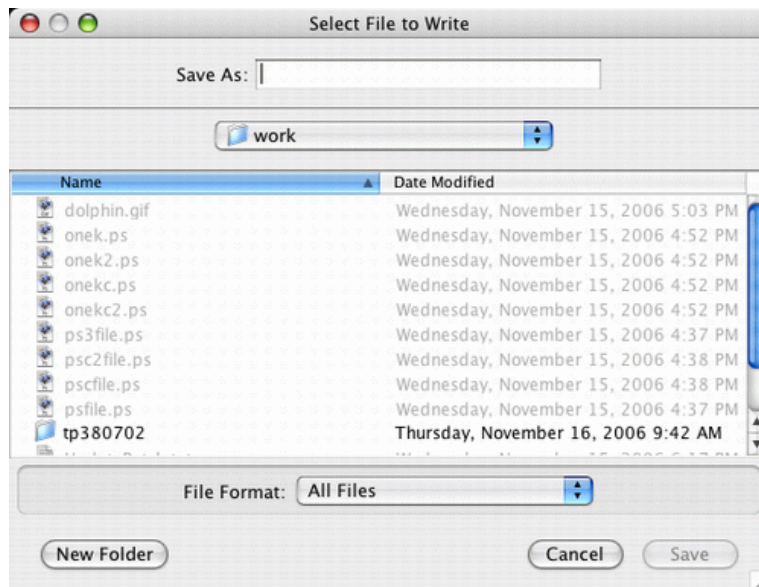
## Remarks

For Windows platforms, the dialog box is the Windows dialog box native to your platform. Because of this, it may differ from those shown in the examples below.

For UNIX platforms, the dialog box is similar to the one shown in the following figure.



For Mac platforms, the dialog box is similar to the one shown in the following figure.



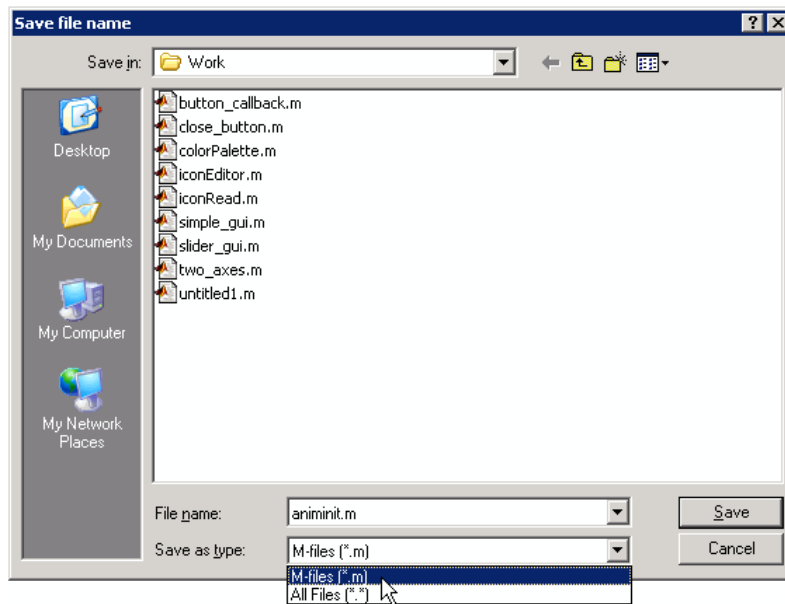
## Examples

### Example 1

The following statement displays a dialog box titled 'Save file name' with the **Filename** field set to `animinit.m` and the filter set to M-files (`*.m`). Because `FilterSpec` is a string, the filter also includes All Files (`*.*`)

```
[file,path] = uiputfile('animinit.m','Save file name');
```

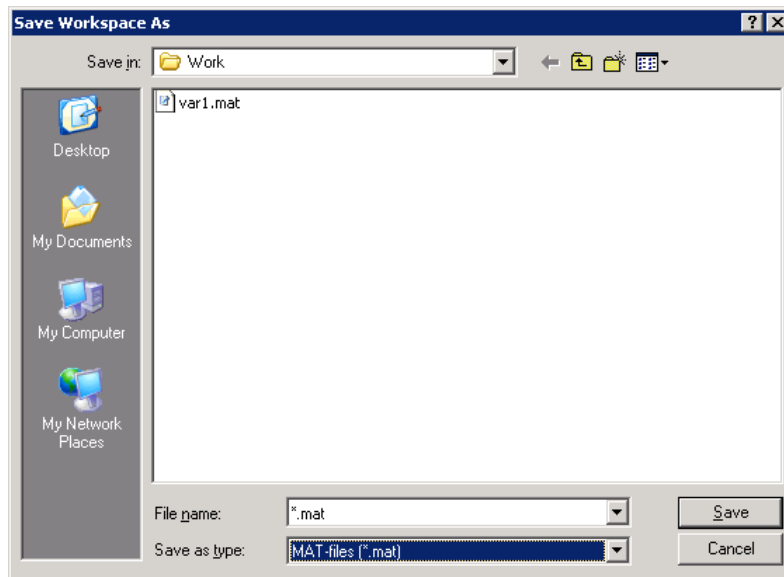




## Example 2

The following statement displays a dialog box titled 'Save Workspace As' with the filter specifier set to MAT-files.

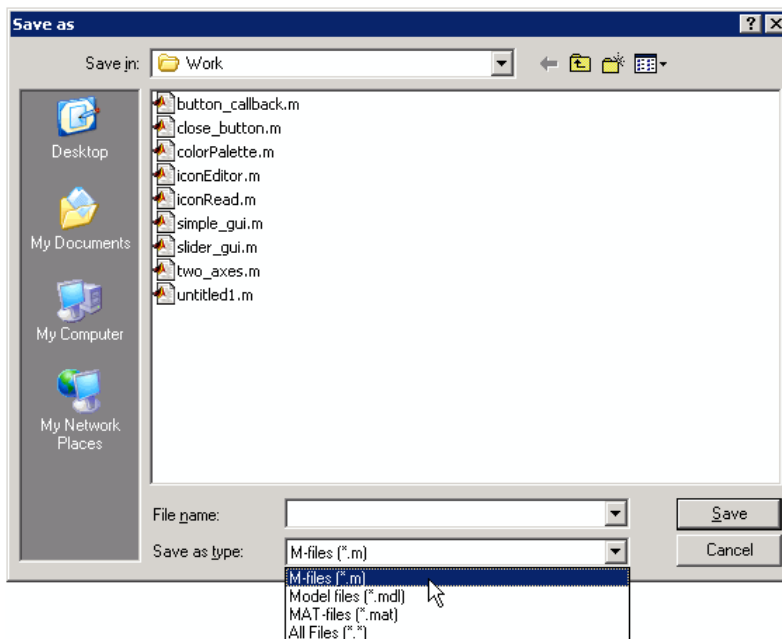
```
[file,path] = uiputfile('*.mat','Save Workspace As');
```



### Example 3

To display several file types in the **Save as type** list box, separate each file extension with a semicolon, as in the following code. Note that `uiputfile` displays a default description for each known file type, such as "Simulink Models" for `.mdl` files.

```
[filename, pathname] = uiputfile(...  
    {'*.m'; '*.mdl'; '*.mat'; '*.*'},...  
    'Save as');
```

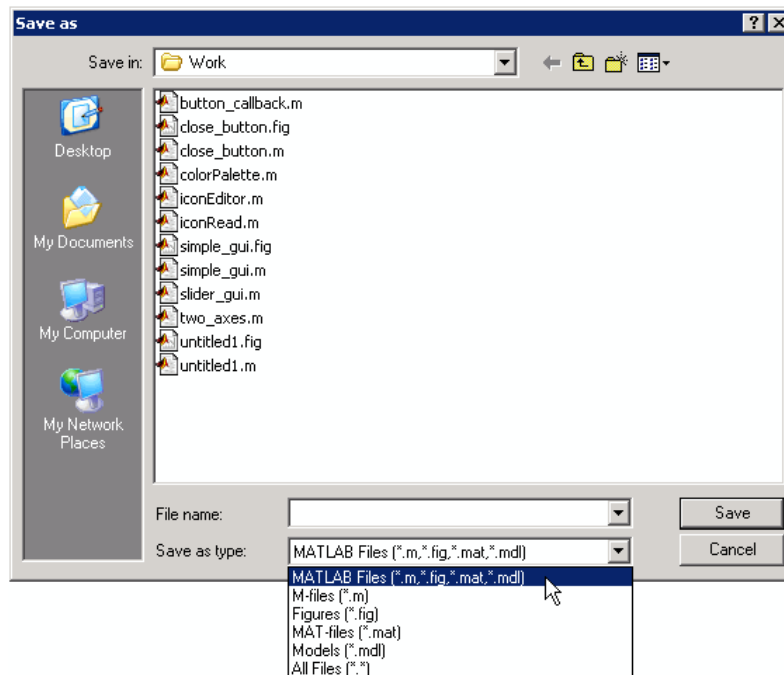


#### Example 4

If you want to create a list of file types and give them descriptions that are different from the defaults, use a cell array, as in the following code. This example also associates multiple file types with the 'MATLAB Files' description.

```
[filename, pathname, filterindex] = uiputfile( ...
{'*.m;*.fig;*.mat;*.mdl', 'MATLAB Files (*.m,*.fig,*.mat,*.mdl)';
 '*.m', 'M-files (*.m)';...
 '*.fig', 'Figures (*.fig)';...
 '*.mat', 'MAT-files (*.mat)';...
 '*.mdl', 'Models (*.mdl)';...
 '.*', 'All Files (*.*)'},...
'Save as');
```

The first column of the cell array contains the file extensions, while the second contains the descriptions you want to provide for the file types. Note that the first entry of column one contains several extensions, separated by semicolons, all of which are associated with the description 'MATLAB Files (\*.m;\*.fig;\*.mat;\*.mdl)'. The code produces the dialog box shown in the following figure.



## Example 5

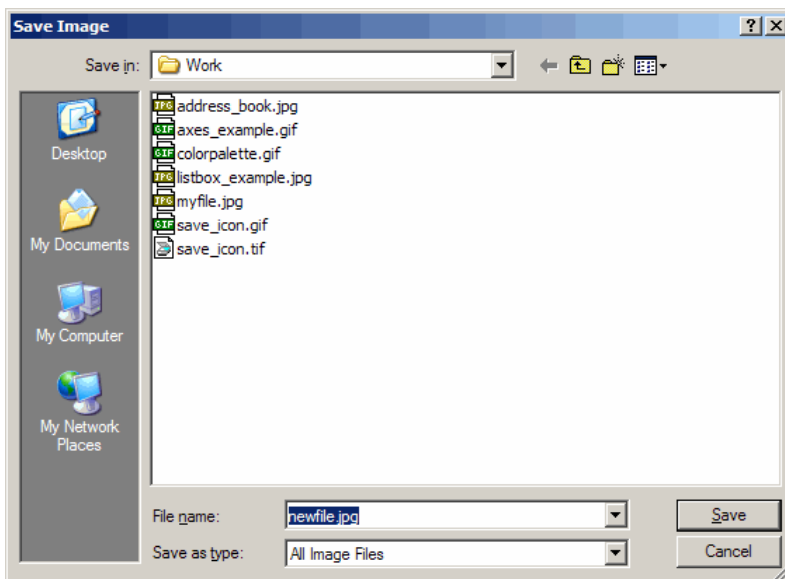
The following code checks for the existence of the file and displays a message about the result of the open operation.

```
[filename, pathname] = uiputfile('*.*','Pick an M-file');  
if isequal(filename,0) | isequal(pathname,0)  
    disp('User selected Cancel')  
else
```

```
disp(['User selected',fullfile(pathname,filename)])  
end
```

### Example 6

```
uiputfile({'*.jpg;*.tif;*.png;*.gif','All Image Files';...  
         '*.*', 'All Files' }, 'Save Image',...  
         'C:\Work\newfile.jpg')
```



**See Also** [uigetdir](#), [uigetfile](#)

# uiresume, uiwait

---

**Purpose** Control program execution

**Syntax**  
`uiwait`  
`uiwait(h)`  
`uiwait(h,timeout)`  
`uiresume(h)`

**Description** The `uiwait` and `uiresume` functions block and resume MATLAB program execution.

`uiwait` blocks execution until `uiresume` is called or the current figure is deleted. This syntax is the same as `uiwait(gcf)`.

`uiwait(h)` blocks execution until `uiresume` is called or the figure `h` is deleted.

`uiwait(h,timeout)` blocks execution until `uiresume` is called, the figure `h` is deleted, or `timeout` seconds elapse.

`uiresume(h)` resumes the M-file execution that `uiwait` suspended.

**Remarks** When creating a dialog, you should have a `uicontrol` component with a callback that calls `uiresume` or a callback that destroys the dialog box. These are the only methods that resume program execution after the `uiwait` function blocks execution.

`uiwait` is a convenient way to use the `waitfor` command. You typically use it in conjunction with a dialog box. It provides a way to block the execution of the M-file that created the dialog, until the user responds to the dialog box. When used in conjunction with a modal dialog, `uiwait/uiresume` can block the execution of the M-file *and* restrict user interaction to the dialog only.

**Example** This example creates a GUI with a **Continue** push button. The example calls `uiwait` to block MATLAB execution until `uiresume` is called. This happens when the user clicks the **Continue** push button because the push button's `Callback` callback, which responds to the click, calls `uiresume`.

```
f = figure;  
h = uicontrol('Position',[20 20 200 40],'String','Continue',...  
             'Callback','uiresume(gcf)');  
disp('This will print immediately');  
uiwait(gcf);  
disp('This will print after you click Continue');  
close(f);
```

gcbf is the handle of the figure that contains the object whose callback is executing.

“Using a Modal Dialog to Confirm an Operation” is a more complex example for a GUIDE GUI. See “Icon Editor” for an example for a programmatically created GUI.

### See Also

uicontrol, uimenu, waitfor, figure, dialog

# uisave

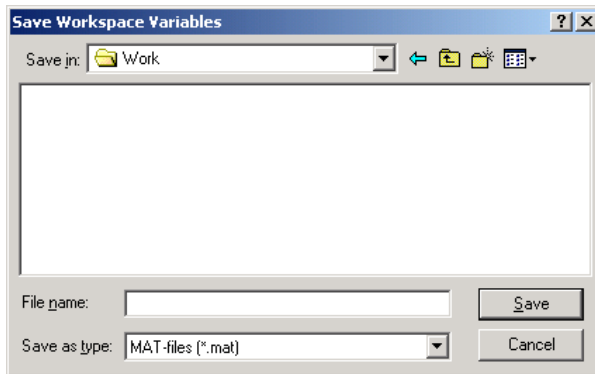
---

**Purpose** Open standard dialog box for saving workspace variables

**Syntax**

```
uisave  
uisave(variables)  
uisave(variables,filename)
```

**Description** `uisave` displays the Save Workspace Variables dialog box for saving workspace variables to a MAT-file, as shown in the figure below. By default, the dialog box opens in your current directory.



---

**Note** The `uisave` dialog box is modal. A modal dialog box prevents the user from interacting with other windows before responding. For more information, see `WindowStyle` in the MATLAB Figure Properties.

---

If you type a name in the **File name** field, such as `my_vars`, and click **Save**, the dialog saves all workspace variables in the file `my_vars.mat`. The default filename is `matlab.mat`.

`uisave(variables)` saves only the variables listed in `variables`. For a single variable, `variables` can be a string. For more than one variable, `variables` must be a cell array of strings.



`uisave(variables,filename)` uses the specified filename as the default **File name** in the Save Workspace Variables dialog box.

---

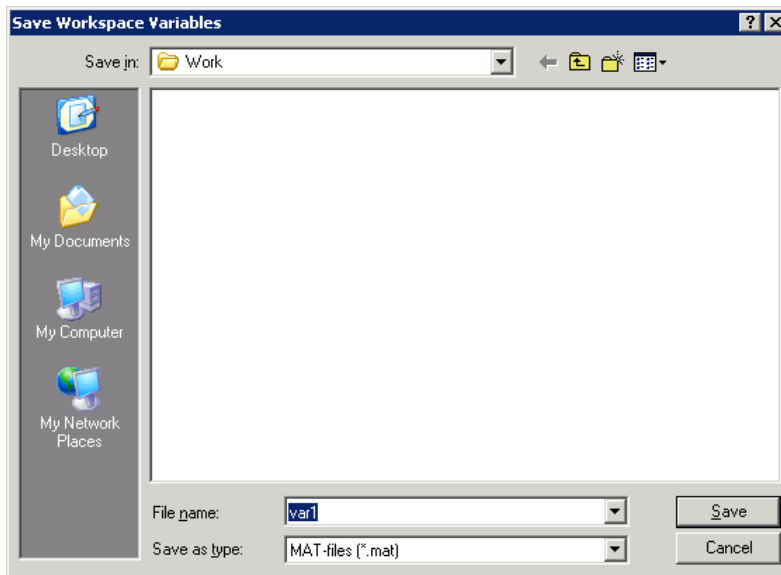
**Note** `uisave` cannot be compiled. If you want to create a dialog that can be compiled, use `uiputfile`.

---

## Example

This example creates workspace variables `h` and `g`, and then displays the Save Workspace Variables dialog box in the current directory with the default **File name** set to `var1`.

```
h = 365;  
g = 52;  
uisave({'h','g'}, 'var1');
```



Clicking **Save** stores the workspace variables `h` and `g` in the file `var1.mat` in the displayed directory.

## uisave

---

### **See Also**

uigetfile, uiputfile, uiopen

**Purpose**

Open standard dialog box for setting object's ColorSpec

**Syntax**

```
c = uicolor
c = uicolor([r g b])
c = uicolor(h)
c = uicolor(...,'dialogTitle')
```

**Description**

`c = uicolor` displays a modal color selection dialog appropriate to the platform, and returns the color selected by the user. The dialog box is initialized to white.

`c = uicolor([r g b])` displays a dialog box initialized to the specified color, and returns the color selected by the user. `r`, `g`, and `b` must be values between 0 and 1.

`c = uicolor(h)` displays a dialog box initialized to the color of the object specified by handle `h`, returns the color selected by the user, and applies it to the object. `h` must be the handle to an object containing a color property.

`c = uicolor(...,'dialogTitle')` displays a dialog box with the specified title.

If the user presses **Cancel** from the dialog box, or if any error occurs, the output value is set to the input RGB triple, if provided; otherwise, it is set to 0.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. For more information, see `WindowState` in the MATLAB Figure Properties.

---

**See Also**

ColorSpec

# uifont

---

**Purpose** Open standard dialog box for setting object's font characteristics

**Syntax**

```
uifont
uifont(h)
uifont(S)
uifont(..., 'DialogTitle')
S = uifont(...)
```

**Description** `uifont` enables you to change font properties (`FontName`, `FontUnits`, `FontSize`, `FontWeight`, and `FontAngle`) for a text, axes, or `uicontrol` object. The function returns a structure consisting of font properties and values. You can specify an alternate title for the dialog box.

`uifont` displays a modal dialog box and returns the selected font properties.

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. For more information, see `WindowState` in the MATLAB Figure Properties.

---

`uifont(h)` displays a modal dialog box, initializing the font property values with the values of those properties for the object whose handle is `h`. Selected font property values are applied to the current object. If a second argument is supplied, it specifies a name for the dialog box.

`uifont(S)` displays a modal dialog box, initializing the font property values with the values defined for the specified structure (`S`). `S` must define legal values for one or more of these properties: `FontName`, `FontUnits`, `FontSize`, `FontWeight`, and `FontAngle` and the field names must match the property names exactly. If other properties are defined, they are ignored. If a second argument is supplied, it specifies a name for the dialog box.

`uisetfont(..., 'DialogTitle')` displays a modal dialog box with the title `DialogTitle` and returns the values of the font properties selected in the dialog box.

`S = uisetfont(...)` returns the properties `FontName`, `FontUnits`, `FontSize`, `FontWeight`, and `FontAngle` as fields in a structure. If the user presses **Cancel** from the dialog box or if an error occurs, the output value is set to 0.

## Example

These statements create a text object, then display a dialog box (labeled Update Font) that enables you to change the font characteristics:

```
h = text(.5,.5,'Figure Annotation');
uisetfont(h,'Update Font')
```

These statements create two push buttons, then set the font properties of one based on the values set for the other:

```
% Create push button with string ABC
c1 = uicontrol('Style', 'pushbutton', ...
    'Position', [10 10 100 20], 'String', 'ABC');
% Create push button with string XYZ
c2 = uicontrol('Style', 'pushbutton', ...
    'Position', [10 50 100 20], 'String', 'XYZ');
% Display set font dialog box for c1, make selections,
& and save to d
d = uisetfont(c1);
% Apply those settings to c2
set(c2, d)
```

## See Also

`axes`, `text`, `uicontrol`

# uisetpref

---

**Purpose** Manage preferences used in uigetpref

**Syntax** `uisetpref('clearall')`

**Description** `uisetpref('clearall')` resets the value of all preferences registered through `uigetpref` to 'ask'. This causes the dialog box to display when you call `uigetpref`.

---

**Note** Use `setpref` to set the value of a particular preference to 'ask'.

---

**See Also** `setpref`, `uigetpref`

**Purpose** Reorder visual stacking order of objects

**Syntax**

```
uistack(h)
uistack(h,stackopt)
uistack(h,stackopt,step)
```

**Description** `uistack(h)` raises the visual stacking order of the objects specified by the handles in `h` by one level (step of 1). All handles in `h` must have the same parent.

`uistack(h,stackopt)` moves the objects specified by `h` in the stacking order, where `stackopt` is one of the following:

- 'up' – moves `h` up one position in the stacking order
- 'down' – moves `h` down one position in the stacking order
- 'top' – moves `h` to the top of the current stack
- 'bottom' – moves `h` to the bottom of the current stack

`uistack(h,stackopt,step)` moves the objects specified by `h` up or down the number of levels specified by `step`.

---

**Note** In a GUI, axes objects are always at a lower level than `uicontrol` objects. You cannot stack an axes object on top of a `uicontrol` object.

---

See “Setting Tab Order” in the MATLAB documentation for information about changing the tab order.

**Example** The following code moves the child that is third in the stacking order of the figure handle `hObject` down two positions.

```
v = allchild(hObject)
uistack(v(3), 'down', 2)
```

# uitoggletool

---

**Purpose** Create toggle button on toolbar

**Syntax**

```
htt = uitoggletool('PropertyName1',value1,'PropertyName2',  
    value2,...)  
htt = uitoggletool(ht,...)
```

**Description**

htt = uitoggletool('PropertyName1',value1,'PropertyName2',value2,...) creates a toggle button on the uitoolbar at the top of the current figure window, and returns a handle to it. uitoggletool assigns the specified property values, and assigns default values to the remaining properties. You can change the property values at a later time using the set function.

Type get(htt) to see a list of uitoggletool object properties and their current values. Type set(htt) to see a list of uitoggletool object properties you can set and legal property values. See the Uitoggletool Properties reference page for more information.

htt = uitoggletool(ht,...) creates a button with ht as a parent. ht must be a uitoolbar handle.

**Remarks**

uitoggletool accepts property name/property value pairs, as well as structures and cell arrays of properties as input arguments.

Toggle tools appear in figures whose Window Style is normal or docked. They do not appear in figures whose WindowStyle is modal. If the WindowStyle property of a figure containing a tool bar and its toggle tool children is changed to modal, the toggle tools still exist and are contained in the Children list of the tool bar, but are not displayed until the WindowStyle is changed to normal or docked.

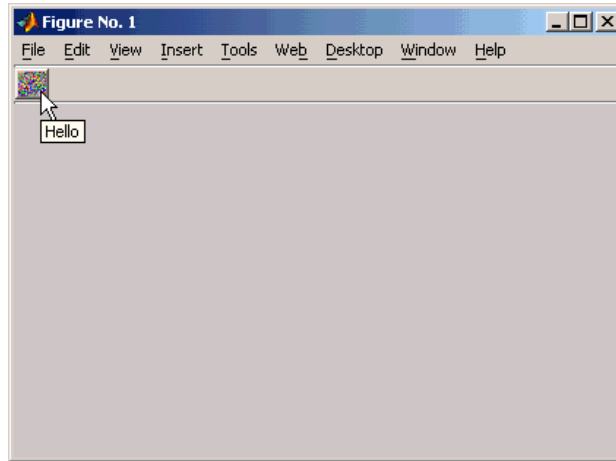
**Examples**

This example creates a uitoolbar object and places a uitoggletool object on it.

```
h = figure('ToolBar','none');  
ht = uitoolbar(h);  
a = rand(16,16,3);
```



```
htt = uitoggletool(ht,'CData',a,'TooltipString','Hello');
```



## See Also

[get](#), [set](#), [uicontrol](#), [uipushtool](#), [uitoolbar](#)

# Uitoggletool Properties

---

## Purpose

Describe toggle tool properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` functions enable you to set and query the values of properties.

You can set default Uitoggletool properties by typing:

```
set(h, 'DefaultUitoggletoolPropertyName', PropertyValue...)
```

Where `h` can be the root handle (0), a figure handle, a uitoolbar handle, or a uitoggletool handle. *PropertyName* is the name of the Uitoggletool property and *PropertyValue* is the value you specify as the default for that property.

For more information about changing the default value of a property see “Setting Default Property Values”.

## Properties

This section lists all properties useful to uitoggletool objects along with valid values and a descriptions of their use. Curly braces { } enclose default values.

| Property        | Purpose                                                 |
|-----------------|---------------------------------------------------------|
| BeingDeleted    | This object is being deleted.                           |
| BusyAction      | Callback routine interruption.                          |
| CData           | Truecolor image displayed on the toggle tool.           |
| ClickedCallback | Control action independent of the toggle tool position. |

# Uitoggletool Properties

| Property         | Purpose                                                     |
|------------------|-------------------------------------------------------------|
| CreateFcn        | Callback routine executed during object creation.           |
| DeleteFcn        | Callback routine executed during object deletion.           |
| Enable           | Enable or disable the uitoggletool.                         |
| HandleVisibility | Control access to object's handle.                          |
| HitTest          | Whether selectable by mouse click                           |
| Interruptible    | Callback routine interruption mode.                         |
| OffCallback      | Control action when toggle tool is set to the off position. |
| OnCallback       | Control action when toggle tool is set to the on position.  |
| Parent           | Handle of uitoggletool's parent toolbar.                    |
| Separator        | Separator line mode.                                        |
| State            | Uitoggletool state.                                         |
| Tag              | User-specified object label.                                |
| TooltipString    | Content of object's tooltip.                                |
| Type             | Object class.                                               |
| UIContextMenu    | Uicontextmenu object associated with the uitoggletool       |
| UserData         | User specified data.                                        |
| Visible          | Uitoggletool visibility.                                    |

BeingDeleted  
on | {off} (read only)

*This object is being deleted.* The BeingDeleted property provides a mechanism that you can use to determine if objects are in

# Uitoggletool Properties

---

the process of being deleted. MATLAB sets the `BeingDeleted` property to on when the object's delete function callback is called (see the `DeleteFcn` property) It remains set to on while the delete function executes, after which the object no longer exists.

For example, some functions may not need to perform actions on objects that are being deleted, and therefore, can check the object's `BeingDeleted` property before acting.

## BusyAction

cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new event uses the value of `BusyAction` to decide whether or not to attempt to interrupt the executing callback.

- If the value is `cancel`, the event is discarded and the second callback does not execute.
- If the value is `queue`, and the `Interruptible` property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

---

## CData

3-dimensional array

*Tricolor image displayed on control.* An  $n$ -by- $m$ -by-3 array of RGB values that defines a tricolor image displayed on either a push button or toggle button. Each value must be between 0.0 and 1.0. If your CData array is larger than 16 in the first or second dimension, it may be clipped or cause other undesirable effects. If the array is clipped, only the center 16-by-16 part of the array is used.

**ClickedCallback**  
string or function handle

*Control action independent of the toggle tool position.* A routine that executes after either the OnCallback routine or OffCallback routine runs to completion. The uitoggletool's Enable property must be set to on.

**CreateFcn**  
string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a uitoggletool object. MATLAB sets all property values for the uitoggletool before executing the CreateFcn callback so these values are available to the callback. Within the function, use gcbo to get the handle of the toggle tool being created.

Setting this property on an existing uitoggletool object has no effect.

You can define a default CreateFcn callback for all new uitoggletools. This default applies unless you override it by specifying a different CreateFcn callback when you call uitoggletool. For example, the statement,

```
set(0, 'DefaultUitoggletoolCreateFcn', ...  
    'set(gcbo, ''Enable'', ''off'')')
```

# Uitoggletool Properties

---

creates a default CreateFcn callback that runs whenever you create a new toggle tool. It sets the toggle tool Enable property to off.

To override this default and create a toggle tool whose Enable property is set to on, you could call uitoggletool with code similar to

```
htt = uitoggletool(...,'CreateFcn',...  
                    'set(gcbo,'Enable','on')',...)
```

---

**Note** To override a default CreateFcn callback you must provide a new callback and not just provide different values for the specified properties. This is because the CreateFcn callback runs after the property values are set, and can override property values you have set explicitly in the uitoggletool call. In the example above, if instead of redefining the CreateFcn property for this toggle tool, you had explicitly set Enable to on, the default CreateFcn callback would have set CData back to off.

---

See Function Handle Callbacks for information on how to use function handles to define a callback function.

DeleteFcn  
string or function handle

*Callback routine executed during object deletion.* A callback routine that executes when you delete the uitoggletool object (e.g., when you call the delete function or cause the figure containing the uitoggletool to reset). MATLAB executes the routine before destroying the object's properties so these values are available to the callback routine.

The handle of the object whose DeleteFcn is being executed is accessible only through the root CallbackObject property, which you can query using gcbo.

See [Function Handle Callbacks](#) for information on how to use function handles to define a callback function.

## Enable

{on} | off

*Enable or disable the uitoggletool.* This property controls how uitoggletools respond to mouse button clicks, including which callback routines execute.

- on – The uitoggletool is operational (the default).
- off – The uitoggletool is not operational and its image (set by the Cdata property) is grayed out.

When you left-click on a uitoggletool whose Enable property is on, MATLAB performs these actions in this order:

- 1** Sets the figure's SelectionType property.
- 2** Executes the toggle tool's ClickedCallback routine.
- 3** Does not set the figure's CurrentPoint property and does not execute the figure's WindowButtonDownFcn callback.

When you left-click on a uitoggletool whose Enable property is off, or when you right-click a uitoggletool whose Enable property has any value, MATLAB performs these actions in this order:

- 4** Sets the figure's SelectionType property.
- 5** Sets the figure's CurrentPoint property.
- 6** Executes the figure's WindowButtonDownFcn callback.
- 7** Does not execute the toggle tool's OnCallback, OffCallback, or ClickedCallback routines.

## HandleVisibility

{on} | callback | off

# Uitoggletool Properties

---

*Control access to object's handle.* This property determines when an object's handle is visible in its parent's list of children. When a handle is not visible in its parent's list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes `get`, `findobj`, `gca`, `gcf`, `gco`, `newplot`, `cla`, `clf`, and `close`. Neither is the handle visible in the parent figure's `CurrentObject` property. Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when `HandleVisibility` is on.
- Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting `HandleVisibility` to `off` makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.

`HitTest`  
{on} | off

*Selectable by mouse click.* This property has no effect on `uitoggletool` objects.

`Interruptible`  
{on} | off



*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The `Interruptible` property of the object whose callback is executing
- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the `Interruptible` property of the object whose callback is executing is `on` (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the `Interruptible` property of the object whose callback is executing is `off`, the callback cannot be interrupted (except by certain callbacks; see the note below).

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. The interrupting callback starts execution at the next `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statement.

---

`OffCallback`  
string or function handle

# Uitoggletool Properties

---

*Control action.* A routine that executes if the uitoggletool's Enable property is set to on, and either

- The toggle tool State is set to off.
- The toggle tool is set to the off position by pressing a mouse button while the pointer is on the toggle tool itself or in a 5-pixel wide border around it.

The ClickedCallback routine, if there is one, runs after the OffCallback routine runs to completion.

OnCallback  
string or function handle

*Control action.* A routine that executes if the uitoggletool's Enable property is set to on, and either

- The toggle tool State is set to on.
- The toggle tool is set to the on position by pressing a mouse button while the pointer is on the toggle tool itself or in a 5-pixel wide border around it.

The ClickedCallback routine, if there is one, runs after the OffCallback routine runs to completion.

Parent  
handle

*Uitoggletool parent.* The handle of the uitoggletool's parent toolbar. You can move a uitoggletool object to another toolbar by setting this property to the handle of the new parent.

Separator  
on | {off}

*Separator line mode.* Setting this property to on draws a dividing line to left of the uitoggletool.

## State

on | {off}

*Uitoggletool state.* When the state is on, the toggle tool appears in the down, or pressed, position. When the state is off, it appears in the up position. Changing the state causes the appropriate OnCallback or OffCallback routine to run.

## Tag

string

*User-specified object identifier.* The Tag property provides a means to identify graphics objects with a user-specified label. You can define Tag as any string.

With the findobj function, you can locate an object with a given Tag property value. This saves you from defining object handles as global variables. For example, this function call returns the handles of all children (of the specified toolbars) that have the Tag value 'Bold'.

```
h = findobj(uitoolbarhandles, 'Tag', 'Bold')
```

## TooltipString

string

*Content of tooltip for object.* The TooltipString property specifies the text of the tooltip associated with the uitoggletool. When the user moves the mouse pointer over the control and leaves it there, the tooltip is displayed.

## Type

string (read-only)

Object class. This property identifies the kind of graphics object. For uitoggletool objects, Type is always the string 'uitoggletool'.

# Uitoggletool Properties

---

UIContextMenu  
handle

*Associate a context menu with uicontrol.* This property has no effect on uitoggletool objects.

UserData  
array

*User specified data.* You can specify UserData as any array you want to associate with the uitoggletool object. The object does not use this data, but you can access it using the set and get functions.

Visible  
{on} | off

*Uitoggletool visibility.* By default, all uitoggletools are visible. When set to off, the uitoggletool is not visible, but still exists and you can query and set its properties.

**Purpose**

Create toolbar on figure

**Syntax**

```
ht =
uitoolbar('PropertyName1',value1,'PropertyName2',value2,
    ...)
ht = uitoolbar(h,...)
```

**Description**

ht = uitoolbar('PropertyName1',value1,'PropertyName2',value2,...) creates an empty toolbar at the top of the current figure window, and returns a handle to it. uitoolbar assigns the specified property values, and assigns default values to the remaining properties. You can change the property values at a later time using the set function.

Type get(ht) to see a list of uitoolbar object properties and their current values. Type set(ht) to see a list of uitoolbar object properties that you can set and legal property values. See the Uicontrol Properties reference page for more information.

ht = uitoolbar(h,...) creates a toolbar with h as a parent. h must be a figure handle.

**Remarks**

uitoolbar accepts property name/property value pairs, as well as structures and cell arrays of properties as input arguments.

Uicontrols appear in figures whose Window Style is normal or docked. They do not appear in figures whose WindowStyle is modal. If the WindowStyle property of a figure containing a uitoolbar is changed to modal, the uitoolbar still exists and is contained in the Children list of the figure, but is not displayed until the WindowStyle is changed to normal or docked.

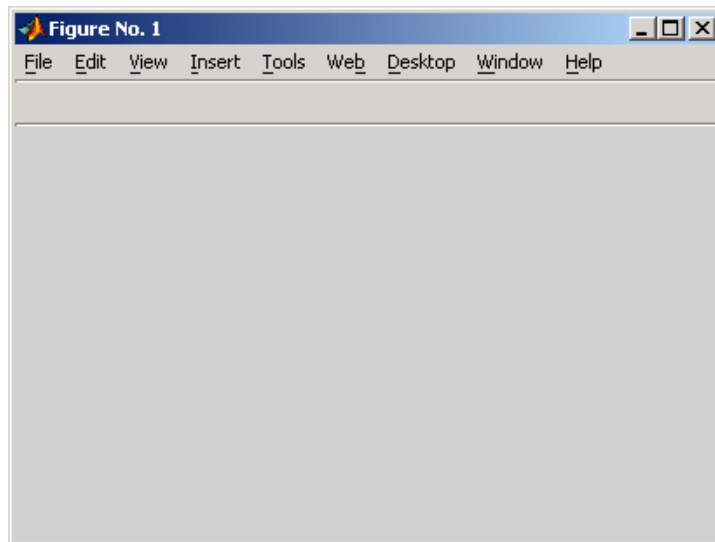
**Example**

This example creates a figure with no toolbar, then adds a toolbar to it.

```
h = figure('ToolBar','none')
ht = uitoolbar(h)
```

# uitoolbar

---



For more information on using the menus and toolbar in a MATLAB figure window, see the online [MATLAB Graphics documentation](#).

## See Also

`set`, `get`, `uicontrol`, `uipushtool`, `uitoggletool`

## Purpose

Describe toolbar properties

## Modifying Properties

You can set and query graphics object properties in two ways:

- The Property Inspector is an interactive tool that enables you to see and change object property values. The Property inspector is available from GUIDE, or use the `inspect` function at the command line.
- The `set` and `get` functions enable you to set and query the values of properties.

You can set default Uitoolbar properties by typing:

```
set(h, 'DefaultUitoolbarPropertyName', PropertyValue...)
```

Where `h` can be the root handle (0), a figure handle, or a uitoolbar handle. *PropertyName* is the name of the Uitoolbar property and *PropertyValue* is the value you specify as the default for that property.

For more information about changing the default value of a property see [Setting Default Property Values](#).

## Uitoolbar Properties

This section lists all properties useful to uitoolbar objects along with valid values and a descriptions of their use. Curly braces { } enclose default values.

| Property     | Purpose                                           |
|--------------|---------------------------------------------------|
| BeingDeleted | This object is being deleted.                     |
| BusyAction   | Callback routine interruption.                    |
| Children     | Handles of uitoolbar's children.                  |
| CreateFcn    | Callback routine executed during object creation. |
| DeleteFcn    | Callback routine executed during object deletion. |

# Uitoolbar Properties

---

| Property         | Purpose                                            |
|------------------|----------------------------------------------------|
| HandleVisibility | Control access to object's handle.                 |
| HitTest          | Whether selectable by mouse click                  |
| Interruptible    | Callback routine interruption mode.                |
| Parent           | Handle of uitoolbar's parent.                      |
| Tag              | User-specified object identifier.                  |
| Type             | Object class.                                      |
| UIContextMenu    | Uicontextmenu object associated with the uitoolbar |
| UserData         | User specified data.                               |
| Visible          | Uitoolbar visibility.                              |

**BeingDeleted**  
on | {off} (read-only)

*This object is being deleted.* The `BeingDeleted` property provides a mechanism that you can use to determine if objects are in the process of being deleted. MATLAB sets the `BeingDeleted` property to `on` when the object's delete function callback is called (see the `DeleteFcn` property) It remains set to `on` while the delete function executes, after which the object no longer exists.

For example, some functions may not need to perform actions on objects that are being deleted, and therefore, can check the object's `BeingDeleted` property before acting.

**BusyAction**  
cancel | {queue}

*Callback routine interruption.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, the callback associated with the new



event uses the value of `BusyAction` to decide whether or not to attempt to interrupt the executing callback.

- If the value is `cancel`, the event is discarded and the second callback does not execute.
- If the value is `queue`, and the `Interruptible` property of the first callback is on, the second callback is added to the event queue and executes in its turn after the first callback finishes execution.

---

**Note** If the interrupting callback is a `DeleteFcn` or `CreateFcn` callback or a figure's `CloseRequest` or `ResizeFcn` callback, it interrupts an executing callback regardless of the value of that object's `Interruptible` property. See the `Interruptible` property for information about controlling a callback's interruptibility.

---

## Children

vector of handles

*Handles of tools on the toolbar.* A vector containing the handles of all children of the `uitoolbar` object, in the order in which they appear on the toolbar. The children objects of `uitoolbars` are `uipushtools` and `uitoggletools`. You can use this property to reorder the children.

## CreateFcn

string or function handle

*Callback routine executed during object creation.* The specified function executes when MATLAB creates a `uitoolbar` object. MATLAB sets all property values for the `uitoolbar` before executing the `CreateFcn` callback so these values are available to the callback. Within the function, use `gcbo` to get the handle of the toolbar being created.

# Uitoolbar Properties

---

Setting this property on an existing uitoolbar object has no effect.

You can define a default `CreateFcn` callback for all new uitoolbars. This default applies unless you override it by specifying a different `CreateFcn` callback when you call `uitoolbar`. For example, the statement,

```
set(0, 'DefaultUitoolbarCreateFcn', ...  
    'set(gcbo, 'Visibility', 'off')')
```

creates a default `CreateFcn` callback that runs whenever you create a new toolbar. It sets the toolbar visibility to `off`.

To override this default and create a toolbar whose `Visibility` property is set to `on`, you could call `uitoolbar` with a call similar to

```
ht = uitoolbar(..., 'CreateFcn', ...  
    'set(gcbo, 'Visibility', 'on')', ...)
```

---

**Note** To override a default `CreateFcn` callback you must provide a new callback and not just provide different values for the specified properties. This is because the `CreateFcn` callback runs after the property values are set, and can override property values you have set explicitly in the `uitoolbar` call. In the example above, if instead of redefining the `CreateFcn` property for this toolbar, you had explicitly set `Visibility` to `on`, the default `CreateFcn` callback would have set `Visibility` back to `off`.

---

See [Function Handle Callbacks](#) for information on how to use function handles to define a callback function.

`DeleteFcn`  
string or function handle

*Callback routine executed during object deletion.* A callback function that executes when the uitoolbar object is deleted (e.g., when you call the delete function or cause the figure containing the uitoolbar to reset). MATLAB executes the routine before destroying the object's properties so these values are available to the callback routine.

Within the function, use gcbo to get the handle of the toolbar being deleted.

HandleVisibility  
{on} | callback | off

*Control access to object's handle.* This property determines when an object's handle is visible in its parent's list of children. When a handle is not visible in its parent's list of children, it is not returned by functions that obtain handles by searching the object hierarchy or querying handle properties. This includes get, findobj, gca, gcf, gco, newplot, cla, clf, and close. Neither is the handle visible in the parent figure's CurrentObject property. Handles that are hidden are still valid. If you know an object's handle, you can set and get its properties, and pass it to any function that operates on handles.

- Handles are always visible when HandleVisibility is on.
- Setting HandleVisibility to callback causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles.
- Setting HandleVisibility to off makes handles invisible at all times. This may be necessary when a callback routine invokes a function that might potentially damage the GUI (such as evaluating a user-typed string), and so temporarily hides its own handles during the execution of that function.

# Uitoolbar Properties

---

You can set the root `ShowHiddenHandles` property to `on` to make all handles visible, regardless of their `HandleVisibility` settings. This does not affect the values of the `HandleVisibility` properties.

`HitTest`  
{on} | off

*Selectable by mouse click.* This property has no effect on uitoolbar objects.

`Interruptible`  
{on} | off

*Callback routine interruption mode.* If a callback is executing and the user triggers an event (such as a mouse click) on an object for which a callback is defined, that callback attempts to interrupt the first callback. MATLAB processes the callbacks according to these factors:

- The `Interruptible` property of the object whose callback is executing
- Whether the executing callback contains `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` statements
- The `BusyAction` property of the object whose callback is waiting to execute

If the `Interruptible` property of the object whose callback is executing is `on` (the default), the callback can be interrupted. Whenever the callback calls one of the `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` functions, the function processes any events in the event queue, including the waiting callback, before performing its defined task.

If the `Interruptible` property of the object whose callback is executing is `off`, the callback cannot be interrupted (except by certain callbacks; see the note below). The `BusyAction` property

of the object whose callback is waiting to execute determines what happens to the callback.

---

**Note** If the interrupting callback is a DeleteFcn or CreateFcn callback or a figure's CloseRequest or ResizeFcn callback, it interrupts an executing callback regardless of the value of that object's Interruptible property. The interrupting callback starts execution at the next drawnow, figure, getframe, pause, or waitfor statement. A figure's WindowButtonDownFcn callback routine, or an object's ButtonDownFcn or Callback routine are processed according to the rules described above.

---

Parent

handle

*Uitoolbar parent.* The handle of the uitoolbar's parent figure. You can move a uitoolbar object to another figure by setting this property to the handle of the new parent.

Tag

string

*User-specified object identifier.* The Tag property provides a means to identify graphics objects with a user-specified label. You can define Tag as any string.

With the findobj function, you can locate an object with a given Tag property value. This saves you from defining object handles as global variables. For example, this function call returns the handles of all children (of the specified figures) that have the Tag value 'FormatTb'.

```
h = findobj(figurehandles,'Tag','FormatTb')
```

Type

string (read-only)

# Uitoolbar Properties

---

Object class. This property identifies the kind of graphics object. For uitoolbar objects, Type is always the string 'uitoolbar'.

UIContextMenu  
handle

*Associate a context menu with uicontrol.* This property has no effect on uitoolbar objects.

UserData  
array

*User specified data.* You can specify UserData as any array you want to associate with the uitoolbar object. The object does not use this data, but you can access it using the set and get functions.

Visible  
{on} | off

*Uitoolbar visibility.* By default, all uitoolbars are visible. When set to off, the uitoolbar is not visible, but still exists and you can query and set its properties.

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>          | Undo previous checkout from source control system (UNIX)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>GUI Alternatives</b> | As an alternative to the <code>undocheckout</code> function, select <b>Source Control &gt; Undo Checkout</b> in the <b>File</b> menu of the Editor/Debugger, Simulink, or Stateflow, or in the context menu of the Current Directory browser. For more information, see “Undoing the Checkout on UNIX”.                                                                                                                                                                                                                                                                                                                                            |
| <b>Syntax</b>           | <pre>undocheckout('filename') undocheckout({'filename1','filename2', ..., 'filenamen'})</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Description</b>      | <p><code>undocheckout('filename')</code> makes the file <code>filename</code> available for checkout, where <code>filename</code> does not reflect any of the changes you made after you last checked it out. Use the full pathname for <code>filename</code> and include the file extension.</p> <p><code>undocheckout({'filename1','filename2', ..., 'filenamen'})</code> makes <code>filename1</code> through <code>filenamen</code> available for checkout, where the files do not reflect any of the changes you made after you last checked them out. Use the full pathnames for <code>filenames</code> and include the file extensions.</p> |
| <b>Examples</b>         | <p>Typing</p> <pre>undocheckout({'/myserver/mymfiles/clock.m', ... '/myserver/mymfiles/calendar.m'})</pre> <p>undoes the checkouts of <code>/myserver/mymfiles/clock.m</code> and <code>/myserver/mymfiles/calendar.m</code> from the source control system.</p>                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>See Also</b>         | <p><code>checkin</code>, <code>checkout</code></p> <p>For Windows platforms, use <code>verctrl</code>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

# unicode2native

---

**Purpose** Convert Unicode characters to numeric bytes

**Syntax**  
`bytes = unicode2native(unicodestr)`  
`bytes = unicode2native(unicodestr, encoding)`

**Description** `bytes = unicode2native(unicodestr)` takes a char vector of Unicode characters, `unicodestr`, converts it to MATLAB's default character encoding scheme, and returns the bytes as a `uint8` vector, `bytes`. Output vector `bytes` has the same general array shape as the `unicodestr` input. You can save the output of `unicode2native` to a file using the `fwrite` function.

`bytes = unicode2native(unicodestr, encoding)` converts the Unicode characters to the character encoding scheme specified by the string `encoding`. `encoding` must be the empty string (`''`) or a name or alias for an encoding scheme. Some examples are `'UTF-8'`, `'latin1'`, `'US-ASCII'`, and `'Shift_JIS'`. For common names and aliases, see the Web site <http://www.iana.org/assignments/character-sets>. If `encoding` is unspecified or is the empty string (`''`), MATLAB's default encoding scheme is used.

**Examples** This example begins with two strings containing Unicode characters. It assumes that string `str1` contains text in a Western European language and string `str2` contains Japanese text. The example writes both strings into the same file, using the ISO-8859-1 character encoding scheme for the first string and the Shift-JIS encoding scheme for the second string. The example uses `unicode2native` to convert the two strings to the appropriate encoding schemes.

```
fid = fopen('mixed.txt', 'w');
bytes1 = unicode2native(str1, 'ISO-8859-1');
fwrite(fid, bytes1, 'uint8');
bytes2 = unicode2native(str2, 'Shift_JIS');
fwrite(fid, bytes2, 'uint8');
fclose(fid);
```

**See Also** `native2unicode`



**Purpose** Find set union of two vectors

**Syntax**

```
c = union(A, B)
c = union(A, B, 'rows')
[c, ia, ib] = union(...)
```

**Description** `c = union(A, B)` returns the combined values from A and B but with no repetitions. In set theoretic terms,  $c = A \cup B$ . Inputs A and B can be numeric or character vectors or cell arrays of strings. The resulting vector is sorted in ascending order.

`c = union(A, B, 'rows')` when A and B are matrices with the same number of columns returns the combined rows from A and B with no repetitions.

`[c, ia, ib] = union(...)` also returns index vectors ia and ib such that  $c = a(ia) \cup b(ib)$ , or for row combinations,  $c = a(ia,:) \cup b(ib,:)$ . If a value appears in both a and b, union indexes its occurrence in b. If a value appears more than once in b or in a (but not in b), union indexes the last occurrence of the value.

**Remarks** Because NaN is considered to be not equal to itself, every occurrence of NaN in A or B is also included in the result c.

**Examples**

```
a = [-1 0 2 4 6];
b = [-1 0 1 3];
[c, ia, ib] = union(a, b);
c =
```

```
    -1     0     1     2     3     4     6
```

```
ia =
```

```
    3     4     5
```

```
ib =
```

# union

---

1 2 3 4

## See Also

`intersect`, `setdiff`, `setxor`, `unique`, `ismember`, `issorted`

**Purpose** Find unique elements of vector

**Syntax**

```
b = unique(A)
b = unique(A, 'rows')
[b, m, n] = unique(...)
[b, m, n] = unique(..., occurrence)
```

**Description** `b = unique(A)` returns the same values as in `A` but with no repetitions. `A` can be a numeric or character array or a cell array of strings. If `A` is a vector or an array, `b` is a vector of unique values from `A`. If `A` is a cell array of strings, `b` is a cell vector of unique strings from `A`. The resulting vector `b` is sorted in ascending order and its elements are of the same class as `A`.

`b = unique(A, 'rows')` returns the unique rows of `A`.

`[b, m, n] = unique(...)` also returns index vectors `m` and `n` such that `b = A(m)` and `A = b(n)`. Each element of `m` is the greatest subscript such that `b = A(m)`. For row combinations, `b = A(m,:)` and `A = b(n,:)`.

`[b, m, n] = unique(..., occurrence)`, where `occurrence` can be

- 'first', which returns the vector `m` to index the first occurrence of each unique value in `A`, or
- 'last', which returns the vector `m` to index the last occurrence.

If you do not specify `occurrence`, it defaults to 'last'.

You can specify 'rows' in the same command as 'first' or 'last'. The order of appearance in the argument list is not important.

## Examples

```
A = [1 1 5 6 2 3 3
     9 8 6 2 4] A = 1 1 5 6 2 3 3 9 8 6 2 4
```

Get a sorted vector of unique elements of `A`. Also get indices of the first elements in `A` that make up vector `b`, and the first elements in `b` that make up vector `A`:

# unique

---

```
[b1,
m1, n1] = unique(A, 'first') b1 = 1 2 3 4 5 6 8 9 m1 =
1 5 6 12 3 4 9 8 n1 = 1 1 5 6 2 3 3 8
6 2 4
```

Verify that  $b1 = A(m1)$  and  $A = b1(n1)$ :

```
all(b1 == A(m1)) && all(A
== b1(n1)) ans = 1
```

Get a sorted vector of unique elements of A. Also get indices of the last elements in A that make up vector b, and the last elements in b that make up vector A:

```
[b2, m2, n2] =
unique(A, 'last') b2 = 1 2 3 4 5 6 8 9 m2 = 2 11
12 3 10 9 8 n2 = 1 1 5 6 2 3 3 8 7 6 2
```

Verify that  $b2 = A(m2)$  and  $A = b2(n2)$ :

```
all(b2
== A(m2)) && all(A == b2(n2)) ans = 1
```

Because NaNs are not equal to each other, unique treats them as unique elements.

```
unique([1 1 NaN NaN]) ans = 1 NaN NaN
```

## See Also

intersect, ismember, issorted, setdiff, setxor, union

**Purpose** Execute UNIX command and return result

**Syntax**

```
unix command
status = unix('command')
[status, result] = unix('command')
[status,result] = unix('command','-echo')
```

**Description** unix command calls upon the UNIX operating system to execute the given command.

status = unix('command') returns completion status to the status variable.

[status, result] = unix('command') returns the standard output to the result variable, in addition to completion status.

[status,result] = unix('command','-echo') displays the results in the Command Window as it executes, and assigns the results to w.

---

**Note** MATLAB uses a shell program to execute the given command. It determines which shell program to use by checking environment variables on your system. MATLAB first checks the MATLAB\_SHELL variable, and if either empty or not defined, then checks SHELL. If SHELL is also empty or not defined, MATLAB uses /bin/sh.

---

**Examples** List all users that are currently logged in.

```
[s,w] = unix('who');
```

MATLAB returns 0 (success) in s and a string containing the list of users in w.

In this example

```
[s,w] = unix('why')
s =
    1
```

```
w =  
why: Command not found.
```

MATLAB returns a nonzero value in `s` to indicate failure, and returns an error message in `w` because `why` is not a UNIX command.

## **See Also**

`dos`, `!` (exclamation point), `perl`, `system`

“Running External Programs” in the MATLAB Desktop Tools and Development Environment documentation

**Purpose** Unload external library from memory

**Syntax** `unloadlibrary('libname')`  
`unloadlibrary libname`

**Description** `unloadlibrary('libname')` unloads the functions defined in shared library `shrlib` from memory. If you need to use these functions again, you must first load them back into memory using `loadlibrary`.

`unloadlibrary libname` is the command format for this function.

If you used an alias when initially loading the library, then you must use that alias for the `libname` argument.

**Examples** Load the MATLAB sample shared library, `shrlibsample`. Call one of its functions, and then unload the library:

```
addpath([matlabroot '\extern\examples\shrlib'])  
loadlibrary shrlibsample shrlibsample.h
```

```
s.p1 = 476;    s.p2 = -299;    s.p3 = 1000;  
calllib('shrlibsample', 'addStructFields', s)  
ans =  
    1177
```

```
unloadlibrary shrlibsample
```

**See Also** `loadlibrary`, `libisloaded`, `libfunctions`, `libfunctionsview`, `libpointer`, `libstruct`, `calllib`

# unmkpp

---

**Purpose** Piecewise polynomial details

**Syntax** `[breaks,coefs,l,k,d] = unmkpp(pp)`

**Description** `[breaks,coefs,l,k,d] = unmkpp(pp)` extracts, from the piecewise polynomial `pp`, its breaks `breaks`, coefficients `coefs`, number of pieces `l`, order `k`, and dimension `d` of its target. Create `pp` using `spline` or the spline utility `mkpp`.

**Examples** This example creates a description of the quadratic polynomial

$$\frac{-x^2}{4} + x$$

as a piecewise polynomial `pp`, then extracts the details of that description.

```
pp = mkpp([-8 -4],[-1/4 1 0]);  
[breaks,coefs,l,k,d] = unmkpp(pp)
```

```
breaks =  
    -8    -4
```

```
coefs =  
 -0.2500    1.0000    0
```

```
l =  
    1
```

```
k =  
    3
```

```
d =  
    1
```

**See Also** `mkpp`, `ppval`, `spline`



**Purpose** Unregister all events for control

**Syntax** `h.unregisterallevents`  
`unregisterallevents(h)`

**Description** `h.unregisterallevents` unregisters all events that have previously been registered with control, `h`. After calling `unregisterallevents`, the control will no longer respond to any events until you register them again using the `registerevent` function.

`unregisterallevents(h)` is an alternate syntax for the same operation.

## Examples **mwsamp Control Example**

Create an `mwsamp` control, registering three events and their respective handler routines. Use the `eventlisteners` function to see the event handler used by each event:

```
f = figure ('position', [100 200 200 200]);
h = actxcontrol('mwsamp.mwsampctrl.2', ...
    [0 0 200 200], f, ...
    {'Click' 'myclick'; 'Db1Click' 'my2click'; ...
    'MouseDown' 'mymoused'});
```

```
h.eventlisteners
ans =
    'click'          'myclick'
    'dblclick'      'my2click'
    'mousedown'    'mymoused'
```

Unregister all of these events at once with `unregisterallevents`. Now, calling `eventlisteners` returns an empty cell array, indicating that there are no longer any events registered with the control:

```
h.unregisterallevents;
h.eventlisteners
ans =
```

# unregisterallevents

---

```
{}
```

To unregister specific events, use the `unregisterevent` function. First, create the control and register three events:

```
f = figure('position', [100 200 200 200]);  
h = actxcontrol('mwsamp.mwsampctrl.2', [0 0 200 200], f,...  
    {'Click' 'myclick'; 'DbClick' 'my2click'; ...  
    'MouseDown' 'mymoused'});
```

Next, unregister two of the three events. The `mousedown` event remains registered:

```
h.unregisterevent({'click' 'myclick'; ...  
                  'dblclick' 'my2click'});  
h.eventlisteners  
ans =  
    'mousedown'    'mymoused'
```

## Excel Example

Create an Excel Workbook object and register some events.

```
excel = actxserver('Excel.Application');  
wbs = excel.Workbooks;  
wb = wbs.Add;  
wb.registerevent({'Activate' 'EvtActivateHndlr'; ...  
                 'Deactivate' 'EvtDeactivateHndlr'})  
wb.eventlisteners
```

MATLAB shows the events registered to their corresponding event handlers.

```
ans =  
  
    'Activate'    'EvtActivateHndlr'  
    'Deactivate' 'EvtDeactivateHndlr'
```

Use `unregisterallevents` to clear the events.

```
wb.unregisterallevents  
wb.eventlisteners
```

MATLAB displays an empty cell array, showing that no events are registered.

```
ans =  
  
{}
```

## See Also

`events`, `eventlisteners`, `registerevent`, `unregisterevent`, `isevent`

# unregisterevent

---

**Purpose** Unregister event handler with control's event

**Syntax** `h.unregister(event_handler)`  
`unregisterevent(h, event_handler)`

**Description** `h.unregister(event_handler)` unregisters certain event handler routines with their corresponding events. Once you unregister an event, the control no longer responds to any further occurrences of the event.

`unregisterevent(h, event_handler)` is an alternate syntax for the same operation.

You can unregister events at any time after a control has been created. The `event_handler` argument, which is a cell array, specifies both events and event handlers. For example,

```
h.unregister({'event_name', @event_handler});
```

See "Writing Event Handlers" in the External Interfaces documentation.

You must specify events in the `event_handler` argument using the names of the events. Strings used in the `event_handler` argument are not case sensitive. Unlike `actxcontrol` and `registerevent`, `unregisterevent` does not accept numeric event identifiers.

## Examples

### Control Example

Create an `mwsamp` control and register all events with the same handler routine, `sampev`. Use `eventlisteners` to see the event handler used by each event. In this case, each event, when fired, calls `sampev.m`:

```
f = figure('position', [100 200 200 200]);  
h = actxcontrol('mwsamp.mwsampctrl1.2', ...  
               [0 0 200 200], f, ...  
               'sampev');
```

```
h.eventlisteners  
ans =
```

```
'click'      'sampev'  
'dblclick'   'sampev'  
'mousedown'  'sampev'
```

Unregister just the `dblclick` event. Now, when you list the registered events using `eventlisteners`, `dblclick` is no longer registered and the control does not respond when you double-click the mouse over it:

```
h.unregisterevent({'dblclick' 'sampev'});  
h.eventlisteners  
ans =  
  'click'      'sampev'  
  'mousedown'  'sampev'
```

This time, register the `click` and `dblclick` events with a different event handler for `myclick` and `my2click`, respectively:

```
h.unregisterallevents;  
h.registerevent({'click' 'myclick'; ...  
                'dblclick' 'my2click'});  
h.eventlisteners  
ans =  
  'click'      'myclick'  
  'dblclick'   'my2click'
```

You can unregister these same events by specifying event names and their handler routines in a cell array. `eventlisteners` now returns an empty cell array, meaning no events are registered for the `mwsamp` control:

```
h.unregisterevent({'click' 'myclick'; ...  
                  'dblclick' 'my2click'});  
h.eventlisteners  
ans =  
  {}
```

# unregisterevent

---

In this last example, you could have used `unregisterallevents` instead:

```
h.unregisterallevents;
```

## Excel Example

Create an Excel Workbook object

```
excel = actxserver('Excel.Application');  
wbs = excel.Workbooks;  
wb = wbs.Add;
```

Register two events with the your event handler routines, `EvtActivateHndlr` and `EvtDeactivateHndlr`.

```
wb.registerevent({'Activate' 'EvtActivateHndlr'; ...  
                'Deactivate' 'EvtDeactivateHndlr'})  
wb.eventlisteners
```

MATLAB shows the events with the corresponding event handlers.

```
ans =  
  
    'Activate'    'EvtActivateHndlr'  
    'Deactivate' 'EvtDeactivateHndlr'
```

Next, unregister the Deactivate event handler.

```
wb.unregisterevent({'Deactivate' 'EvtDeactivateHndlr'})  
wb.eventlisteners
```

MATLAB shows the remaining registered event (Activate) with its corresponding event handler.

```
ans =  
  
    'Activate'    'EvtActivateHndlr'
```

## See Also

events, eventlisteners, registerevent, unregisterallevents, isevent

# untar

---

**Purpose** Extract contents of tar file

**Syntax**

```
untar(tarfilename)
untar(tarfilename,outputdir)
untar(url, ...)
filenames = untar(...)
```

**Description** `untar(tarfilename)` extracts the archived contents of `tarfilename` into the current directory and sets the files' attributes. It overwrites any existing files with the same names as those in the archive if the existing files' attributes and ownerships permit it. For example, files from rerunning `untar` on the same tar filename do not overwrite any of those files that have a read-only attribute; instead, `untar` issues a warning for such files. On Windows platforms, the hidden, system, and archive attributes are not set.

`tarfilename` is a string specifying the name of the tar file. `tarfilename` is gunzipped to a temporary directory and deleted if its extension ends in `.tgz` or `.gz`. If an extension is omitted, `untar` searches for `tarfilename` appended with `.tgz`, `.tar.gz`, or `.tar` until a file exists. `tarfilename` can include the directory name; otherwise, the file must be in the current directory or in a directory on the MATLAB path.

`untar(tarfilename,outputdir)` uncompresses the archive `tarfilename` into the directory `outputdir`. `outputdir` is created if it does not exist.

`untar(url, ...)` extracts the tar archive from an Internet URL. The URL must include the protocol type (e.g., `'http://'` or `'ftp://'`). The URL is downloaded to a temporary directory and deleted.

`filenames = untar(...)` extracts the tar archive and returns the relative pathnames of the extracted files into the string cell array `filenames`.

**Examples** Copy all `.m` files in the current directory to the directory `backup`:

```
tar('mymfiles.tar.gz','*.m');
untar('mymfiles','backup');
```



Run `untar` to list Cleve Moler's "Numerical Computing with MATLAB" examples to the output directory `ncm`:

```
url = 'http://www.mathworks.com/moler/ncm.tar.gz';  
ncmFiles = untar(url, 'ncm')
```

**See Also**

`gzip`, `gunzip`, `tar`, `unzip`, `zip`

# unwrap

---

**Purpose** Correct phase angles to produce smoother phase plots

**Syntax**

```
Q = unwrap(P)
Q = unwrap(P,tol)
Q = unwrap(P,[],dim)
Q = unwrap(P,tol,dim)
```

**Description** `Q = unwrap(P)` corrects the radian phase angles in a vector `P` by adding multiples of  $\pm 2\pi$  when absolute jumps between consecutive elements of `P` are greater than or equal to the default jump tolerance of  $\pi$  radians. If `P` is a matrix, `unwrap` operates columnwise. If `P` is a multidimensional array, `unwrap` operates on the first nonsingleton dimension.

`Q = unwrap(P,tol)` uses a jump tolerance `tol` instead of the default value,  $\pi$ .

`Q = unwrap(P,[],dim)` unwraps along `dim` using the default tolerance.

`Q = unwrap(P,tol,dim)` uses a jump tolerance of `tol`.

---

**Note** A jump tolerance less than  $\pi$  has the same effect as a tolerance of  $\pi$ . For a tolerance less than  $\pi$ , if a jump is greater than the tolerance but less than  $\pi$ , adding  $\pm 2\pi$  would result in a jump larger than the existing one, so `unwrap` chooses the current point. If you want to eliminate jumps that are less than  $\pi$ , try using a finer grid in the domain.

---

## Examples

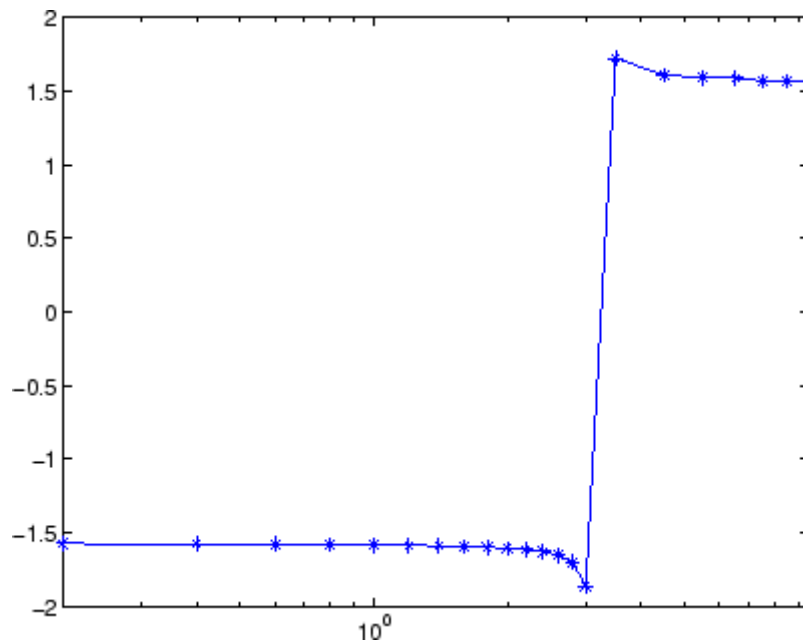
### Example 1

The following phase data comes from the frequency response of a third-order transfer function. The phase curve jumps 3.5873 radians between `w = 3.0` and `w = 3.5`, from -1.8621 to 1.7252.

```
w = [0:.2:3,3.5:1:10];
p = [    0
     -1.5728
     -1.5747
     -1.5772
```

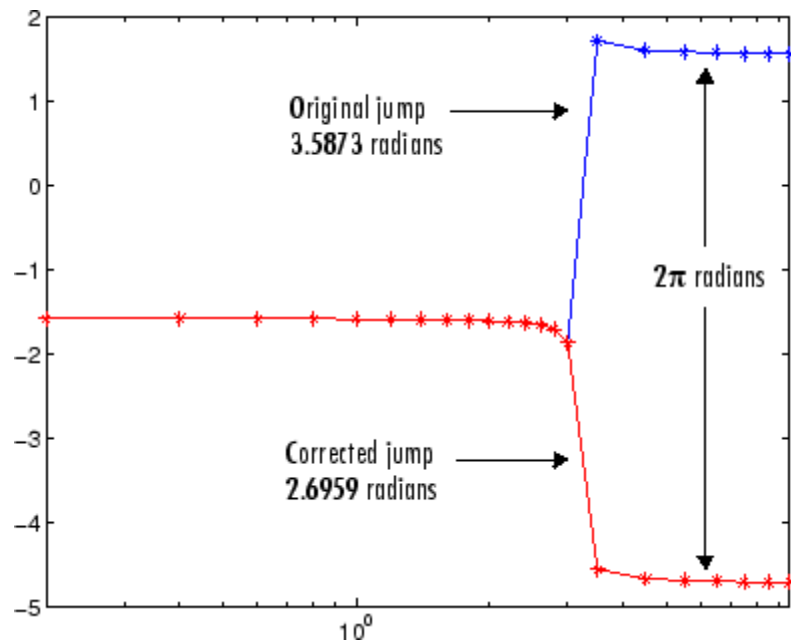
```
-1.5790  
-1.5816  
-1.5852  
-1.5877  
-1.5922  
-1.5976  
-1.6044  
-1.6129  
-1.6269  
-1.6512  
-1.6998  
-1.8621  
1.7252  
1.6124  
1.5930  
1.5916  
1.5708  
1.5708  
1.5708 ];  
semilogx(w,p,'b*-' ), hold
```

# unwrap



Using `unwrap` to correct the phase angle, the resulting jump is 2.6959, which is less than the default jump tolerance  $\pi$ . This figure plots the new curve over the original curve.

```
semilogx(w,unwrap(p),'r*-')
```



**Note** If you have the “Control System Toolbox”, you can create the data for this example with the following code.

```
h = freqresp(tf(1,[1 .1 10 0]));
p = angle(h(:));
```

## Example 2

Array P features smoothly increasing phase angles except for discontinuities at elements (3,1) and (1,2).

```
P = [      0      7.0686      1.5708      2.3562
      0.1963      0.9817      1.7671      2.5525
      6.6759      1.1781      1.9635      2.7489
      0.5890      1.3744      2.1598      2.9452 ]
```

# unwrap

---

The function  $Q = \text{unwrap}(P)$  eliminates these discontinuities.

Q =

|        |        |        |        |
|--------|--------|--------|--------|
| 0      | 7.0686 | 1.5708 | 2.3562 |
| 0.1963 | 7.2649 | 1.7671 | 2.5525 |
| 0.3927 | 7.4613 | 1.9635 | 2.7489 |
| 0.5890 | 7.6576 | 2.1598 | 2.9452 |

## See Also

abs, angle

**Purpose**

Extract contents of zip file

**Syntax**

```
unzip(zipfilename)
unzip(zipfilename,outputdir)
unzip(url, ...)
filenames = unzip(...)
unzip
```

**Description**

`unzip(zipfilename)` extracts the archived contents of `zipfilename` into the current directory and sets the files' attributes. It overwrites any existing files with the same names as those in the archive if the existing files' attributes and ownerships permit it. For example, files from rerunning `unzip` on the same zip filename do not overwrite any of those files that have a read-only attribute; instead, `unzip` issues a warning for such files.

`zipfilename` is a string specifying the name of the zip file. The `.zip` extension is appended to `zipfilename` if omitted. `zipfilename` can include the directory name; otherwise, the file must be in the current directory or in a directory on the MATLAB path.

`unzip(zipfilename,outputdir)` extracts the contents of `zipfilename` into the directory `outputdir`.

`unzip(url, ...)` extracts the zipped contents from an Internet URL. The URL must include the protocol type (e.g., `http://`). The URL is downloaded to the temp directory and deleted.

`filenames = unzip(...)` extracts the zip archive and returns the relative pathnames of the extracted files into the string cell array `filenames`.

`unzip` does not support password-protected or encrypted zip archives.

**Examples****Example 1**

Copy the demos HTML files to the directory archive:

```
% Zip the demos html files to demos.zip
zip('demos.zip','*.html',fullfile(matlabroot,'demos'))
```

# unzip

---

```
% Unzip demos.zip to the 'directory' archive
unzip('demos','archive')
```

## Example 2

Run `unzip` to list Cleve Moler's "Numerical Computing with MATLAB" examples to the output directory `ncm`.

```
url = 'http://www.mathworks.com/moler/ncm.zip';
ncmFiles = unzip(url,'ncm')
```

## See Also

`fileattrib`, `gzip`, `gunzip`, `tar`, `untar`, `zip`



|                    |                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Convert string to uppercase                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Syntax</b>      | <code>t = upper('str')</code><br><code>B = upper(A)</code>                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Description</b> | <p><code>t = upper('str')</code> converts any lowercase characters in the string <code>str</code> to the corresponding uppercase characters and leaves all other characters unchanged.</p> <p><code>B = upper(A)</code> when <code>A</code> is a cell array of strings, returns a cell array the same size as <code>A</code> containing the result of applying <code>upper</code> to each string within <code>A</code>.</p> |
| <b>Examples</b>    | <code>upper('attention!')</code> is ATTENTION!.                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Remarks</b>     | Character sets supported: <ul style="list-style-type: none"><li>• PC: Windows Latin-1</li><li>• Other: ISO Latin-1 (ISO 8859-1)</li></ul>                                                                                                                                                                                                                                                                                   |
| <b>See Also</b>    | <code>lower</code>                                                                                                                                                                                                                                                                                                                                                                                                          |

# urlread

---

**Purpose** Read content at URL

**Syntax**

```
s = urlread('url')
s = urlread('url','method','params')
[s,status] = urlread(...)
```

**Description**

`s = urlread('url')` reads the content at a URL into the string `s`. If the server returns binary data, `s` will be unreadable.

`s = urlread('url','method','params')` reads the content at a URL into the string `s`, passing information to the server as part of the request where *method* can be `get` or `post`, and *params* is a cell array of parameter name/parameter value pairs.

`[s,status] = urlread(...)` catches any errors and returns the error code.

---

**Note** If you need to specify a proxy server to connect to the Internet, select **File -> Preferences -> Web** and enter your proxy server address and port. Use this feature if you have a firewall.

---

## Examples

### Download Content from Web Page

Use `urlread` to download the contents of the Authors list at the MATLAB Central File Exchange:

```
urlstring = sprintf('%s%s', ...
    'http://www.mathworks.com/matlabcentral/', ...
    'fileexchange/loadAuthorIndex.do');

s = urlread(urlstring);
```

### Download Content from File on FTP Server

```
page = 'ftp://ftp.mathworks.com/pub/doc/';
s=urlread(page);
```

```
s
```

MATLAB displays

```
s =
```

```
-rw-r--r--  1 ftpuser  ftpusers    448 Nov 15  2004 README  
drwxr-xr-x  2 ftpuser  ftpusers    512 Jul 26  13:52 papers
```

### Download Content from Local File

```
s = urlread('file:///c:/winnt/matlab.ini')
```

### See Also

urlwrite

tcpip if the Instrument Control Toolbox is installed

# urlwrite

---

**Purpose** Save contents of URL to file

**Syntax**

```
urlwrite('url','filename')
f = urlwrite('url','filename')
f = urlwrite('url','method','params')
[f,status] = urlwrite(...)
```

**Description** `urlwrite('url','filename')` reads the contents of the specified URL, saving the contents to `filename`. If you do not specify the path for `filename`, the file is saved in the MATLAB current directory.

`f = urlwrite('url','filename')` reads the contents of the specified URL, saving the contents to `filename` and assigning `filename` to `f`.

`f = urlwrite('url','method','params')` saves the contents of the specified URL to `filename`, passing information to the server as part of the request where `method` can be `get` or `post`, and `params` is a cell array of parameter name/parameter value pairs.

`[f,status] = urlwrite(...)` catches any errors and returns the error code.

---

**Note** If you need to specify a proxy server to connect to the Internet, select **File -> Preferences -> Web** and enter your proxy server address and port. Use this feature if you have a firewall.

---

**Examples** Download the files submitted to the MATLAB Central File Exchange, saving the results to `samples.html` in the MATLAB current directory.

```
urlstring = sprintf('%s%s', ...
'http://www.mathworks.com/matlabcentral/', ...
'fileexchange/Category.jsp?type=category&id=1');

urlwrite(urlstring, 'samples.html');
```

View the file in the Help browser.

```
open('samples.html')
```

## See Also

`urlread`

**Purpose** Determine whether Java feature is supported in MATLAB

**Syntax** `usejava(feature)`

**Description** `usejava(feature)` returns 1 if the specified feature is supported and 0 otherwise. Possible feature arguments are shown in the following table.

| Feature   | Description                                                   |
|-----------|---------------------------------------------------------------|
| 'awt'     | Abstract Window Toolkit components <sup>1</sup> are available |
| 'desktop' | The MATLAB interactive desktop is running                     |
| 'jvm'     | The Java Virtual Machine is running                           |
| 'swing'   | Swing components <sup>2</sup> are available                   |

1. Java's GUI components in the Abstract Window Toolkit
2. Java's lightweight GUI components in the Java Foundation Classes

## Examples

The following conditional code ensures that the AWT's GUI components are available before the M-file attempts to display a Java Frame.

```
if usejava('awt')
    myFrame = java.awt.Frame;
else
    disp('Unable to open a Java Frame');
end
```

The next example is part of an M-file that includes Java code. It fails gracefully when run in a MATLAB session that does not have access to a JVM.

```
if ~usejava('jvm')
    error(['filename ' requires Java to run.']);
end
```

**See Also**

javachk

# validateattributes

---

**Purpose** Check validity of array

**Syntax**

```
validateattributes(A, classes, attributes)
validateattributes(A, classes, attributes, position)
validateattributes(A, classes, attributes, funname)
validateattributes(A, classes, attributes, funname, varname)
validateattributes(A, classes, attributes, funname, varname,
    position)
```

**Description** `validateattributes(A, classes, attributes)` validates that array `A` belongs to at least one of the classes specified by the `classes` input and also has at least one of the attributes specified by the `attributes` input. If the validation succeeds, the command completes without displaying any output and without throwing an error. If the validation does not succeed, MATLAB issues a formatted error message.

The `classes` input is a cell array of one or more strings, each string containing the name of a MATLAB class (i.e., one of the 15 MATLAB data types), the name of a MATLAB class, or the keyword `numeric`. (See the Class Values on page 2-3633 table, below.)

The `attributes` input is a cell array of one or more strings, each string describing an array attribute. (See the Attribute Values on page 2-3634 table, below.)

`validateattributes(A, classes, attributes, position)` validates array `A` as described above and, if the validation fails, displays an error message that includes the position of the failing variable in the function argument list. The `position` input must be a positive integer.

`validateattributes(A, classes, attributes, funname)` validates array `A` as described above and, if the validation fails, displays an error message that includes the name of the function performing the validation (`funname`). The `funname` input must be a string enclosed in single quotation marks.

`validateattributes(A, classes, attributes, funname, varname)` validates array `A` as described above and, if the validation fails, displays an error message that includes the name of the function



performing the validation (funname), and the name of the variable being validated (varname). The funname and varname inputs must be strings enclosed in single quotation marks.

`validateattributes(A, classes, attributes, funname, varname, position)` validates array A as described above and, if the validation fails, displays an error message that includes the name of the function performing the validation (funname), the name of the variable being validated (varname), and the position of this variable in the function argument list (position). The funname and varname inputs must be strings enclosed in single quotation marks. The position input must be a positive integer.

## Class Values

| <b>classes Argument</b> | <b>Contents of Array A</b> |
|-------------------------|----------------------------|
| 'numeric'               | Any numeric value          |
| 'single'                | Single-precision number    |
| 'double'                | Double-precision number    |
| 'int8'                  | Signed 8-bit integer       |
| 'int16'                 | Signed 16-bit integer      |
| 'int32'                 | Signed 32-bit integer      |
| 'int64'                 | Signed 64-bit integer      |
| 'uint8'                 | Unsigned 8-bit integer     |
| 'uint16'                | Unsigned 16-bit integer    |
| 'uint32'                | Unsigned 32-bit integer    |
| 'uint64'                | Unsigned 64-bit integer    |
| 'logical'               | Logical true or false      |
| 'char'                  | Character or string        |
| 'struct'                | MATLAB structure           |

# validateattributes

---

## Class Values (Continued)

| <b>classes Argument</b> | <b>Contents of Array A</b> |
|-------------------------|----------------------------|
| 'cell'                  | Cell array                 |
| 'function_handle'       | Scalar function handle     |
| <i>class name</i>       | Object of any MATLAB class |

## Attribute Values

| <b>attributes Argument</b> | <b>Description of array A</b>                                                              |
|----------------------------|--------------------------------------------------------------------------------------------|
| '2d'                       | Array having dimensions M-by-N (includes scalars, vectors, 2-D matrices, and empty arrays) |
| 'column'                   | Array having dimensions N-by-1                                                             |
| 'even'                     | Numeric or logical array in which all elements are even (includes zero)                    |
| 'finite'                   | Numeric array in which all elements are finite                                             |
| 'integer'                  | Numeric array in which all elements are integer-valued                                     |
| 'nonempty'                 | Array having no dimension equal to zero                                                    |
| 'nonnan'                   | Numeric array in which there are no elements equal to NaN (Not a Number)                   |
| 'nonnegative'              | Numeric array in which all elements are zero or greater than zero                          |
| 'nonsparse'                | Array that is not sparse                                                                   |
| 'nonzero'                  | Numeric or logical array in which all elements are less than or greater than zero          |
| 'odd'                      | Numeric or logical array in which all elements are odd integers                            |

## Attribute Values (Continued)

| attributes Argument | Description of array A                                                      |
|---------------------|-----------------------------------------------------------------------------|
| 'positive'          | Numeric or logical array in which all elements are <u>greater than zero</u> |
| 'real'              | Numeric array in which all elements are real                                |
| 'row'               | Array having dimensions 1-by-N                                              |
| 'scalar'            | Array having dimensions 1-by-1                                              |
| 'vector'            | Array having dimensions N-by-1 or 1-by-N (includes scalar arrays)           |

Numeric properties, such as `positive` and `nonnan`, do not apply to strings. If you attempt to validate numeric properties on a string, `validateattributes` generates an error.

## Examples

### Example 1

This function, which resides in M-file `empl_profile`, compares the values passed in each argument with the specified classes and attributes and throws an error if they are not correct:

```
function empl_profile(empl_id, empl_info, healthplan, ...
    vacation)
    validateattributes(empl_id, {'numeric'}, {'integer', ...
        'nonempty'});
    validateattributes(empl_info, {'struct'}, {'vector'});
    validateattributes(healthplan, {'cell', 'char'}, {'vector'});
    validateattributes(vacation, {'numeric'}, {'nonnegative', ...
        'scalar'});
```

Call the function, passing the expected argument types, and the example completes without error:

```
empl_id = 51723;
```

# validateattributes

---

```
empl_info.name = 'John Miller';
empl_info.address = '128 Forsythe St.';
empl_info.town = 'Duluth'; empl_info.state='MN';

empl_profile(empl_id, empl_info, 'HCP Medical Plus', 14.3)
```

If you accidentally pass the argument values out of their correct sequence, MATLAB throws an error in response to the first argument that is not a match:

```
empl_profile(empl_id, empl_info, 14.3, 'HCP Medical Plus')

??? Error using ==> empl_profile1 at 4
Expected input to be one of these types:

    cell, char

Instead its type was double.
```

## Example 2

Modify the `empl_profile` M-file shown in the last example, adding arguments to `validateattributes` to display the function name, variable name, and position of the argument:

```
function empl_profile(empl_id, empl_info, healthplan, ...
    vacation)
    validateattributes(empl_id, {'numeric'}, {'integer', ...
        'nonempty'}, mfilename, 'Employee Identification', 1);
    validateattributes(empl_info, {'struct'}, {'vector'}, ...
        mfilename, 'Employee Info', 2);
    validateattributes(healthplan, {'cell', 'char'}, ...
        {'vector'}, mfilename, 'Health Plan', 3);
    validateattributes(vacation, {'numeric'}, {'nonnegative', ...
        'scalar'}, mfilename, 'Vacation Accrued', 4);
```

Call `empl_profile` with the argument values out of their correct sequence, MATLAB throws an error that includes the name of the function validating the attributes, the name of the variable that was in error, and its position in the input argument list:

```
??? Error using ==> empl_profile
Expected input number 3, Health Plan, to be one of these types:

    cell, char

Instead its type was double.

Error in ==> empl_profile at 6
validateattributes(healthplan,{'cell', 'char'}, {'vector'}, ...
```

### Example 3

Modify the `empl_profile` M-file so that it checks the function inputs using the MATLAB `inputParser`. Use `validateattributes` as the validating function for the `inputParser` methods:

```
function empl_profile(empl_id, varargin)
p = inputParser;

% Validate the input arguments.
addRequired(p, 'empl_id', @(x)validateattributes(x, ...
    {'numeric'}, {'integer'}));
addOptional(p, 'empl_info', '', @(x)validateattributes(...
    x, {'struct'}, {'nonempty'}));
addParamValue(p, 'health', 'HCP Medical Plus', ...
    @(x)validateattributes(x, {'cell', 'char'}, {'vector'}));
addParamValue(p, 'vacation', [], @(x)validateattributes(x, ...
    {'numeric'}, {'nonnegative', 'scalar'}));
parse(p, empl_id, varargin{:});
p.Results
```

Call `empl_profile` using appropriate input arguments:

## validateattributes

---

```
empl_info.name = 'John Miller';
empl_info.address = '128 Forsythe St.';
empl_info.town = 'Duluth'; empl_info.state='MN';

empl_profile(51723, empl_info, 'vacation', 14.3)

ans =
    empl_id: 51723
    empl_info: [1x1 struct]
               health: 'HCP Medical Plus'
               vacation: 14.3000
```

Call `empl_profile` using a character string where a structure is expected:

```
empl_profile(51723, empl_info.name, 'vacation', 14.3)
```

```
??? Error using ==> empl_profile at 12
Argument 'empl_info' failed validation with error:
Expected input to be one of these types:
```

```
    struct
```

Instead its type was char.

### See Also

`validatestring`, `is*`, `isa`, `inputparser`

**Purpose** Check validity of text string

**Syntax**

```
validstr = validatestring(str, strarray)
validstr = validatestring(str, strarray, position)
validstr = validatestring(str, strarray, funname)
validstr = validatestring(str, strarray, funname, varname)
validstr = validatestring(str, strarray, funname, varname,
    position)
```

**Description** `validstr = validatestring(str, strarray)` checks the validity of text string `str`. If `str` matches one or more of the text strings in the cell array `strarray`, then MATLAB returns the matching string in `validstr`. If `str` does not match any of the strings in `strarray`, MATLAB issues a formatted error message. MATLAB compares the strings without respect to letter case.

This table shows how `validatestring` determines what value to return. If multiple matches are found, `validatestring` returns the shortest matching string:

| Type of Match                                                     | Example – Match 'ball' with . . . | Return Value |
|-------------------------------------------------------------------|-----------------------------------|--------------|
| Exact match                                                       | ball, barn, bell                  | ball         |
| Partial match (leading characters)                                | balloon, barn                     | balloon      |
| Multiple partial matches where each string is a subset of another | ball, ballo, balloo, balloon      | ball         |
| Multiple partial matches where strings are unique                 | balloon, ballet                   | Error        |
| No match                                                          | barn, bell                        | Error        |

`validstr = validatestring(str, strarray, position)` checks the validity of text string `str` as described above and, if the validation fails, displays an error message that includes the position of the failing

# validatestring

---

variable in the function argument list. The position input must be a positive integer.

`validstr = validatestring(str, strarray, funname)` checks the validity of text string `str` as described above and, if the validation fails, displays an error message that includes the name of the function performing the validation (`funname`). The `funname` input must be a string enclosed in single quotation marks.

`validstr = validatestring(str, strarray, funname, varname)` checks the validity of text string `str` as described above and, if the validation fails, displays an error message that includes the name of the function performing the validation (`funname`), and the name of the variable being validated (`varname`). The `funname` and `varname` inputs must be strings enclosed in single quotation marks.

`validstr = validatestring(str, strarray, funname, varname, position)` checks the validity of text string `str` as described above and, if the validation fails, displays an error message that includes the name of the function performing the validation (`funname`), the name of the variable being validated (`varname`), and the position of this variable in the function argument list (`position`). The `funname` and `varname` inputs must be strings enclosed in single quotation marks. The `position` input must be a positive integer.

## Examples

### Example 1

Use `validatestring` to find the word `won` in the cell array of strings:

```
validatestring('won', {'wind', 'won', 'when'})
ans =
    won
```

Replace the word `won` with `wonder` in the string array. Because the leading characters of the input string and `wonder` are the same, `validatestring` finds a partial match between the two words and returns the full word `wonder`:

```
validatestring('won', {'wind', 'wonder', 'when'})
```



```
ans =  
wonder
```

If there is more than one partial match, and each string in the array is a subset or superset of the others, `validatestring` returns the shortest matching string:

```
validatestring('wond', {'won', 'wonder', 'wonderful'})  
ans =  
wonder
```

However, if each string in the array is not subset or superset of each other, MATLAB throws an error because there is no exact match and it is not clear which of the two partial matches should be returned:

```
validatestring('wond', {'won', 'wonder', 'wondrous'})  
??? Error using ==> validatestring at 89  
Function VALIDATESTRING expected its input argument to match one of  
  
won, wonder, wondrous
```

The input, 'wond', matched more than one valid string.

## Example 2

This function returns the flight numbers for routes between two cities: a point of origin and point of destination. The function uses `validatestring` to see if the origin and destination are among those covered by the airline. If not, then an error message is displayed:

```
function get_flight_numbers(origin, destination)  
% Only part of the airline's flight data is shown here.  
flights.chi2rio = [503, 196, 331, 373, 1475];  
flights.chi2par = [718, 9276, 172, 903, 7724 992, 1158];  
flights.chi2hon = [9193, 880, 471, 391];  
  
routes = {'Athens', 'Paris', 'Chicago', 'Sydney', ...  
          'Cancun', 'London', 'Rio de Janeiro', 'Honolulu', ...  
          'Rome', 'New York City'};
```

# validatestring

---

```
orig = ''; dest = '';

% See if the cities entered are covered by this airline.
try
    orig = validatestring(origin, routes);
    dest = validatestring(destination, routes);
catch
    % If not covered, then display error message.
    if isempty(orig)
        fprintf(...
            'We have no flights with origin: %s.\n', ...
            origin)
    elseif isempty(dest)
        fprintf(...
            'We have no flights with destination: %s.\n', ...
            destination)
    end
    return
end

% If covered, display the flights from 'orig' to 'dest'.
fprintf(...
    'Flights available from %s to %s are:\n', orig, dest)
reply = eval(...
    ['flights.' lower(orig(1:3)) '2' lower(dest(1:3))]);
fprintf('    Flight %d\n', reply)
```

Enter a point of origin that is not covered by this airline:

```
get_flight_numbers('San Diego', 'Rio de Janeiro')
ans =
We have no flights with origin: San Diego.
```

Enter a destination that is misspelled:

```
get_flight_numbers('Chicago', 'Reo de Janeiro')
ans =
```

We have no flights with destination: Reo de Janeiro.

Enter a route that is covered:

```
get_flight_numbers('Chicago', 'Rio de Janeiro')
ans =
Flights available from Chicago to Rio de Janeiro are:
    Flight 503
    Flight 196
    Flight 331
    Flight 373
    Flight 1475
```

### Example 3

Rewrite the try-catch block of Example 2, above by adding funname, varname, and position arguments to the call to validatestring and replacing the return statement with rethrow:

```
% See if the cities entered are covered by this airline.
try
    orig = validatestring(...
        origin, routes, mfilename, 'Flight Origin', 1);
    dest = validatestring(...
        destination, routes, mfilename, ...
        'Flight Destination', 2);
catch e
    % If not covered, then display error message.
    if isempty(orig)
        fprintf(...
            'We have no flights with origin: %s.\n', ...
            origin)
    elseif isempty(dest)
        fprintf(...
            'We have no flights with destination: %s.\n', ...
            destination)
    end
    rethrow(e);
```

# validatestring

---

```
end
```

In response to the rethrow command, MATLAB displays an error message that includes the function name `get_flight_numbers`, the failing variable name `Flight Destination`, and its position in the argument list, 2:

```
get_flight_numbers('Chicago', 'Reo de Janeiro')
We have no flights with destination: Reo de Janeiro.

??? Error using ==> validatestring at 89
Function GET_FLIGHT_NUMBERS expected its input argument
    number 2, Flight Destination, to match one of these strings:

    Athens, Paris, Chicago, Sydney, Cancun, London, Rio de
    Janeiro, Honolulu, Rome

The input, 'Reo de Janeiro', did not match any of the valid strings.

Error in ==> get_flight_numbers at 17
    dest = validatestring(destination, routes, mfilename,
    'destination', 2);
```

## See Also

`validateattributes`, `is*`, `isa`, `inputparser`

**Purpose** Vandermonde matrix

**Syntax** `A = vander(v)`

**Description** `A = vander(v)` returns the Vandermonde matrix whose columns are powers of the vector `v`, that is,  $A(i, j) = v(i)^{(n-j)}$ , where  $n = \text{length}(v)$ .

**Examples** `vander(1:.5:3)`

`ans =`

|         |         |        |        |        |
|---------|---------|--------|--------|--------|
| 1.0000  | 1.0000  | 1.0000 | 1.0000 | 1.0000 |
| 5.0625  | 3.3750  | 2.2500 | 1.5000 | 1.0000 |
| 16.0000 | 8.0000  | 4.0000 | 2.0000 | 1.0000 |
| 39.0625 | 15.6250 | 6.2500 | 2.5000 | 1.0000 |
| 81.0000 | 27.0000 | 9.0000 | 3.0000 | 1.0000 |

**See Also** `gallery`

# var

---

## Purpose

Variance

## Syntax

```
V = var(X)
V = var(X,1)
V = var(X,w)
V = var(X,w,dim)
```

## Description

`V = var(X)` returns the variance of `X` for vectors. For matrices, `var(X)` is a row vector containing the variance of each column of `X`. For `N`-dimensional arrays, `var` operates along the first nonsingleton dimension of `X`. The result `V` is an unbiased estimator of the variance of the population from which `X` is drawn, as long as `X` consists of independent, identically distributed samples.

`var` normalizes `V` by `N-1` if `N>1`, where `N` is the sample size. This is an unbiased estimator of the variance of the population from which `X` is drawn, as long as `X` consists of independent, identically distributed samples. For `N=1`, `V` is normalized by `N`.

`V = var(X,1)` normalizes by `N` and produces the second moment of the sample about its mean. `var(X,0)` is equivalent to `var(X)`.

`V = var(X,w)` computes the variance using the weight vector `w`. The length of `w` must equal the length of the dimension over which `var` operates, and its elements must be nonnegative. The elements of `w` must be positive. `var` normalizes `w` to sum of 1.

`V = var(X,w,dim)` takes the variance along the dimension `dim` of `X`. Pass in 0 for `w` to use the default normalization by `N-1`, or 1 to use `N`.

The variance is the square of the standard deviation (STD).

## See Also

`corrcoef`, `cov`, `mean`, `median`, `std`

**Purpose** Variance of timeseries data

**Syntax**

```
ts_var = var(ts)
ts_var = var(ts, 'PropertyName1', PropertyValue1, ...)
```

**Description** `ts_var = var(ts)` returns the variance of `ts.data`. When `ts.Data` is a vector, `ts_var` is the variance of `ts.Data` values. When `ts.Data` is a matrix, `ts_var` is a row vector containing the variance of each column of `ts.Data` (when `IsTimeFirst` is true and the first dimension of `ts` is aligned with time). For the N-dimensional `ts.Data` array, `var` always operates along the first nonsingleton dimension of `ts.Data`.

```
ts_var = var(ts, 'PropertyName1', PropertyValue1, ...)
```

specifies the following optional input arguments:

- 'MissingData' property has two possible values, 'remove' (default) or 'interpolate', indicating how to treat missing data during the calculation.
- 'Quality' values are specified by an integer vector, indicating which quality codes represent missing samples (for vector data) or missing observations (for data arrays with two or more dimensions).
- 'Weighting' property has two possible values, 'none' (default) or 'time'. When you specify 'time', larger time values correspond to larger weights.

**Examples** The following example shows how to calculate the variance values of a multi-variate timeseries object.

**1** Load a 24-by-3 data array.

```
load count.dat
```

**2** Create a timeseries object with 24 time values.

```
count_ts = timeseries(count,[1:24], 'Name', 'CountPerSecond')
```

## var (timeseries)

---

- 3** Calculate the variance of each data column for this timeseries object.

```
var(count_ts)
ans =
    1.0e+003 *
    0.6437    1.7144    4.6278
```

The variance is calculated independently for each data column in the timeseries object.

### See Also

```
iqr (timeseries), mean (timeseries), median (timeseries), std
(timeseries), timeseries
```



**Purpose** Variable length input argument list

**Syntax** `function y = bar(varargin)`

**Description** `function y = bar(varargin)` accepts a variable number of arguments into function `bar.m`.

The `varargin` statement is used only inside a function M-file to contain optional input arguments passed to the function. The `varargin` argument must be declared as the last input argument to a function, collecting all the inputs from that point onwards. In the declaration, `varargin` must be lowercase.

## Examples **Example 1**

Write an M-file function that displays the expected and optional arguments you pass to it

```
function vartest(argA, argB, varargin)

optargin = size(varargin,2);
stdargin = nargin - optargin;

fprintf('Number of inputs = %d\n', nargin)

fprintf(' Inputs from individual arguments(%d):\n', stdargin)
if stdargin >= 1
    fprintf('     %d\n', argA)
end
if stdargin == 2
    fprintf('     %d\n', argB)
end

fprintf(' Inputs packaged in varargin(%d):\n', optargin)
for k= 1 : size(varargin,2)
    fprintf('     %d\n', varargin{k})
end
```

# varargin

---

Call this function and observe that MATLAB extracts those arguments that are not individually-specified from the varargin cell array:

```
varitest(10,20,30,40,50,60,70)
Number of inputs = 7
Inputs from individual arguments(2):
    10
    20
Inputs packaged in varargin(5):
    30
    40
    50
    60
    70
```

## Example 2

The function

```
function myplot(x,varargin)
plot(x,varargin{:})
```

collects all the inputs starting with the second input into the variable varargin. myplot uses the comma-separated list syntax varargin{:} to pass the optional parameters to plot. The call

```
myplot(sin(0:.1:1),'color',[.5 .7 .3],'linestyle',':')
```

results in varargin being a 1-by-4 cell array containing the values 'color', [.5 .7 .3], 'linestyle', and ':'.

## See Also

varargout, nargin, nargout, nargchk, nargoutchk, inputname

**Purpose** Variable length output argument list

**Syntax** `function varargout = foo(n)`

**Description** `function varargout = foo(n)` returns a variable number of arguments from function `foo.m`.

The `varargout` statement is used only inside a function M-file to contain the optional output arguments returned by the function. The `varargout` argument must be declared as the last output argument to a function, collecting all the outputs from that point onwards. In the declaration, `varargout` must be lowercase.

**Examples** The function

```
function [s,varargout] = mysize(x)
nout = max(nargout,1)-1;
s = size(x);
for k=1:nout, varargout(k) = {s(k)}; end
```

returns the size vector and, optionally, individual sizes. So

```
[s,rows,cols] = mysize(rand(4,5));
```

returns `s = [4 5]`, `rows = 4`, `cols = 5`.

**See Also** `varargin`, `nargin`, `nargout`, `nargchk`, `nargoutchk`, `inputname`

# vectorize

---

**Purpose** Vectorize expression

**Syntax** `vectorize(s)`  
`vectorize(fun)`

**Description** `vectorize(s)` where `s` is a string expression, inserts a `.` before any `^`, `*` or `/` in `s`. The result is a character string.

`vectorize(fun)` when `fun` is an inline function object, vectorizes the formula for `fun`. The result is the vectorized version of the inline function.

**See Also** `inline`, `cd`, `dbtype`, `delete`, `dir`, `partialpath`, `path`, `what`, `who`

---

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>             | Version information for MathWorks products                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Graphical Interface</b> | As an alternative to the <code>ver</code> function, select <b>About</b> from the <b>Help</b> menu in any product that has a <b>Help</b> menu.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Syntax</b>              | <pre>ver ver product v = ver('product')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Description</b>         | <p><code>ver</code> displays a header containing the current version number, license number, operating system, and Java VM version for MATLAB, followed by the version numbers for Simulink, if installed, and all other MathWorks products installed.</p> <p><code>ver product</code> displays the MATLAB header information followed by the current version number for product. The name <code>product</code> corresponds to the directory name that holds the <code>Contents.m</code> file for that product. For example, <code>Contents.m</code> for the Control System Toolbox resides in the <code>control</code> directory. You therefore use <code>ver control</code> to obtain the version of this toolbox.</p> <p><code>v = ver('product')</code> returns the version information to structure array, <code>v</code>, having fields <code>Name</code>, <code>Version</code>, <code>Release</code>, and <code>Date</code>.</p> |
| <b>Remarks</b>             | <p>To use <code>ver</code> with your own product, the first two lines of the <code>Contents.m</code> file for the product must be of the form</p> <pre>    % Toolbox Description     % Version xxx dd-mmm-yyyy</pre> <p>Do not include any spaces in the date and use a two-character day; that is, use <code>02-Sep-2002</code> instead of <code>2-Sep-2002</code>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Examples</b>            | <p>Return version information for the Control System Toolbox by typing</p> <pre>ver control</pre> <p>MATLAB returns</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

```
-----  
MATLAB Version 7.3.0.22078 (R2006b)  
MATLAB License Number: unknown  
Operating System: Microsoft Windows XP Version 5.1 (Build 2600: Service Pack 2)  
Java VM Version: Java 1.5.0_07 with Sun Microsystems Inc. Java HotSpot(TM) Client VM mixed  
-----  
Control System Toolbox                               Version 7.1           (R2006b)
```

Return version information for the Control System Toolbox in a structure array, `v`.

```
v = ver('control')  
v =  
  
    Name: 'Control System Toolbox'  
  Version: '7.1'  
  Release: '(R2006b)'  
    Date: '19-Sep-2006'
```

Display version information on MathWorks 'Real-Time' products:

```
v = ver;  
for k=1:length(v)  
    if strfind(v(k).Name, 'Real-Time')  
        disp(sprintf('%s, Version %s', ...  
                    v(k).Name, v(k).Version))  
    end  
end  
  
Real-Time Windows Target, Version 2.6.2  
Real-Time Workshop, Version 6.5  
Real-Time Workshop Embedded Coder, Version 4.5
```

## See Also

`help`, `hostid`, `license`, `version`, `whatsnew`

**Help > Check for Updates** in the MATLAB desktop.

**Purpose**

Source control actions (Windows)

**GUI Alternatives**

As an alternative to the `verctrl` function, use **Source Control** in the **File** menu of the Editor/Debugger, Simulink, or Stateflow, or in the context menu of the Current Directory browser.

**Syntax**

```
verctrl('action',{'filename1','filename2',...},0)
result=verctrl('action',{'filename1','filename2',...},0)
verctrl('action','filename',0)
result=verctrl('isdiff','filename',0)
list = verctrl('all_systems')
```

**Description**

`verctrl('action',{'filename1','filename2',...},0)` performs the source control operation specified by `'action'` for a single file or multiple files. Enter one file as a string; specify multiple files using a cell array of strings. Use the full paths for each filename and include the extensions. Specify 0 as the last argument. Complete the resulting dialog box to execute the operation; for details about the dialog boxes, see the topic “Source Control Interface on Windows” in the MATLAB Desktop Tools and Development Environment documentation. Available values for `'action'` are as follows:

| <b>action Argument</b> | <b>Purpose</b>                                                                                                      |
|------------------------|---------------------------------------------------------------------------------------------------------------------|
| 'add'                  | Adds files to the source control system. Files can be open in the Editor/Debugger or closed when added.             |
| 'checkin'              | Checks files into the source control system, storing the changes and creating a new version.                        |
| 'checkout'             | Retrieves files for editing.                                                                                        |
| 'get'                  | Retrieves files for viewing and compiling, but not editing. When you open the files, they are labeled as read-only. |
| 'history'              | Displays the history of files.                                                                                      |

# verctrl

| <b>action Argument</b> | <b>Purpose</b>                                                                                                                                                               |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'remove'               | Removes files from the source control system. It does not delete the files from disk, but only from the source control system.                                               |
| 'runsc'                | Starts the source control system. The filename can be an empty string.                                                                                                       |
| 'uncheckout'           | Cancels a previous checkout operation and restores the contents of the selected files to the precheckout version. All changes made to the files since the checkout are lost. |

`result=verctrl('action',{'filename1','filename2',...},0)` performs the source control operation specified by '*action*' on a single file or multiple files. The action can be any one of: 'add', 'checkin', 'checkout', 'get', 'history', or 'undocheckout'. `result` is a logical 1 (true) when you complete the operation by clicking **OK** in the resulting dialog box, and is a logical 0 (false) when you abort the operation by clicking **Cancel** in the resulting dialog box.

`verctrl('action','filename',0)` performs the source control operation specified by '*action*' for a single file. Use the full pathname for '*filename*'. Specify 0 as the last argument. Complete any resulting dialog boxes to execute the operation. Available values for '*action*' are as follows:

| <b>action Argument</b> | <b>Purpose</b>                                                                                                      |
|------------------------|---------------------------------------------------------------------------------------------------------------------|
| 'showdiff'             | Displays the differences between a file and the latest checked in version of the file in the source control system. |
| 'properties'           | Displays the properties of a file.                                                                                  |



`result=verctrl('isdiff','filename',0)` compares `filename` with the latest checked in version of the file in the source control system. `result` is a logical 1 (true) when the files are different, and is a logical 0 (false) when the files are identical. Use the full path for `'filename'`. Specify 0 as the last argument.

`list = verctrl('all_systems')` displays in the Command Window a list of all source control systems installed on your computer.

## Examples

### Check In a File

Check in `D:\file1.ext` to the source control system.

```
result = verctrl('checkin','D:\file1.ext', 0)
```

This opens the **Check in file(s)** dialog box. Click **OK** to complete the check in. MATLAB displays `result = 1`, indicating the checkin was successful.

### Add Files to the Source Control System

Add `D:\file1.ext` and `D:\file2.ext` to the source control system.

```
verctrl('add',{'D:\file1.ext','D:\file2.ext'}, 0)
```

This opens the **Add to source control** dialog box. Click **OK** to complete the operation.

### Display the Properties of a File

Display the properties of `D:\file1.ext`.

```
verctrl('properties','D:\file1.ext', 0)
```

This opens the source control properties dialog box for your source control system. The function is complete when you close the properties dialog box.

## Show Differences for a File

To show the differences between the version of `file1.ext` that you just edited and saved, with the last version in source control, run

```
verctrl('showdiff','D:\file1.ext',0)
```

MATLAB displays differences dialog boxes and results specific to your source control system. After checking in the file, if you run this statement again, MATLAB displays

```
??? The file is identical to latest version under source control.
```

## List All Installed Source Control Systems

To view all of the source control systems installed on your computer, type

```
list = verctrl('all_systems')
```

MATLAB displays all the source control systems currently installed on your computer. For example:

```
list =  
'Microsoft Visual SourceSafe'  
'ComponentSoftware RCS'
```

## See Also

`checkin`, `checkout`, `undocheckout`, `cmopts`

“Source Control Interface on Windows” in MATLAB Desktop Tools and Development Environment documentation

**Purpose** Compare toolbox version to specified version string

**Syntax** `verLessThan(toolbox, version)`

**Description** `verLessThan(toolbox, version)` returns logical 1 (true) if the version of the toolbox specified by the string `toolbox` is older than the version specified by the string `version`, and logical 0 (false) otherwise. Use this function when you want to write code that can run across multiple versions of MATLAB.

The `toolbox` argument is a string enclosed within single quotation marks that contains the name of a MATLAB toolbox directory. The `version` argument is a string enclosed within single quotation marks that contains the version to compare against. This argument must be in the form `major[.minor[.revision]]`, such as 7, 7.1, or 7.0.1. If `toolbox` does not exist, MATLAB generates an error.

To specify `toolbox`, find the directory that holds the `Contents.m` file for the desired toolbox and use that directory name. To see a list of all toolbox directory names, enter the following command at the MATLAB prompt:

```
dir([matlabroot ' /toolbox'])
```

**Remarks** The `verLessThan` function is available with MATLAB Version 7.4. If you are running a version of MATLAB earlier than 7.4, you can download the `verLessThan` M-file from the following MathWorks Technical Support solution. You must be running MATLAB Version 6.0 or higher to use this M-file:

<http://www.mathworks.com/support/solutions/data/1-38LI61.html?solution>

**Examples** These examples illustrate the proper usage of the `verLessThan` function.

### **Example 1 – Checking For the Minimum Required Version**

```
if verLessThan('simulink', '4.0')
    error('Simulink 4.0 or higher is required.');
```

end

# verLessThan

---

## Example 2 – Choosing Which Code to Run

```
if verLessThan('matlab', '7.0.1')
% -- Put code to run under MATLAB 7.0.0 and earlier here --
else
% -- Put code to run under MATLAB 7.0.1 and later here --
end
```

## Example 3 – Looking Up the Directory Name

Find the name of the Data Acquisition Toolbox directory:

```
dir([matlabroot '/toolbox/d*'])

      daq      database      des      distcomp      dotnetbuilder
      dastudio  datafeed      dials      dml      dspblks
```

Use the toolbox directory name, daq, to compare the Data Acquisition version that MATLAB is currently running against version 3:

```
verLessThan('daq', '3')
ans =
     1
```

## See Also

ver, version, license, ispc, isunix, ismac, dir

**Purpose**

Version number for MATLAB

**Graphical Interface**

As an alternative to the version function, select **About** from the **Help** menu in the MATLAB desktop.

**Syntax**

```
version
v = version
[v d] = version
version option
v = version('option')
```

**Description**

version displays the MATLAB version number.

v = version returns the MATLAB version number in v.

[v d] = version also returns a string d containing the date of the version.

version option displays the following additional information about the version.

| Option              | Description                                                 |
|---------------------|-------------------------------------------------------------|
| <b>-date</b>        | Release date                                                |
| <b>-description</b> | Release description. Mostly used for Service Pack releases. |
| <b>-java</b>        | Java VM (JVM) version used by MATLAB                        |
| <b>-release</b>     | Release number                                              |

v = version('option') returns additional information about the version. Valid string values for option are listed in the table above. You can only specify one output when using this syntax.

**Remarks**

On Windows and UNIX platforms, MATLAB includes a JVM and uses that version. If you use the MATLAB Java interface and the Java classes you want to use require a different JVM than the version provided with MATLAB, it is possible to run MATLAB with a different

# version

---

JVM. For details, see Solution 1-1812J on the MathWorks Support Web site.

On the Macintosh platform, MATLAB does not include a JVM, but uses whatever JVM is currently running on the machine.

## Examples

```
[v,d] = version
v =
    7.3.0.22078 (R2006b)

d =
    September 19, 2006
```

Run the following command in MATLAB R14 Service Pack 3:

```
['Release R' version('-release') ', ' ...
    version('-description')]

ans =
    Release R14, Service Pack 3
```

## See Also

`ver`, `whatsnew`

**Help > Check for Updates** in the MATLAB desktop.

**Purpose** Concatenate arrays vertically

**Syntax** `C = vertcat(A1, A2, ...)`

**Description** `C = vertcat(A1, A2, ...)` vertically concatenates matrices `A1`, `A2`, and so on. All matrices in the argument list must have the same number of columns.

`vertcat` concatenates N-dimensional arrays along the first dimension. The remaining dimensions must match.

MATLAB calls `C = vertcat(A1, A2, ...)` for the syntax `C = [A1; A2; ...]` when any of `A1`, `A2`, etc. is an object.

**Examples** Create a 5-by-3 matrix, `A`, and a 3-by-3 matrix, `B`. Then vertically concatenate `A` and `B`.

```
A = magic(5);           % Create 5-by-3 matrix, A
A(:, 4:5) = []
```

```
A =
    17    24     1
    23     5     7
     4     6    13
    10    12    19
    11    18    25
```

```
B = magic(3)*100       % Create 3-by-3 matrix, B
```

```
B =
    800    100    600
    300    500    700
    400    900    200
```

## vertcat

---

```
C = vertcat(A,B)           % Vertically concatenate A and B
```

```
C =
```

```
    17    24     1
    23     5     7
     4     6    13
    10    12    19
    11    18    25
   800   100   600
   300   500   700
   400   900   200
```

**See Also** horzcat, cat



**Purpose** Vertical concatenation of `timeseries` objects

**Syntax** `ts = vertcat(ts1,ts2,...)`

**Description** `ts = vertcat(ts1,ts2,...)` performs  
`ts = [ts1;ts2;...]`

This operation appends `timeseries` objects. The time vectors must not overlap. The last time in `ts1` must be earlier than the first time in `ts2`. The data sample size of the `timeseries` objects must agree.

**See Also** `timeseries`

## vertcat (tscollection)

---

**Purpose** Vertical concatenation for tscollection objects

**Syntax** `tsc = vertcat(tsc1,tsc2,...)`

**Description** `tsc = vertcat(tsc1,tsc2,...)` performs

`tsc = [tsc1;tsc2;...]`

This operation appends tscollection objects. The time vectors must not overlap. The last time in tsc1 must be earlier than the first time in tsc2. All tscollection objects to be concatenated must have the same timeseries members.

**See Also** `horzcat (tscollection), tscollection`

**Purpose**

Viewpoint specification

**Syntax**

```
view(az,e1)
view([x,y,z])
view(2)
view(3)
view(ax,...)
view(T)
[az,e1] = view
T = view
```

**Description**

The position of the viewer (the viewpoint) determines the orientation of the axes. You specify the viewpoint in terms of azimuth and elevation, or by a point in three-dimensional space.

`view(az,e1)` and `view([az,e1])` set the viewing angle for a three-dimensional plot. The azimuth, `az`, is the horizontal rotation about the  $z$ -axis as measured in degrees from the negative  $y$ -axis. Positive values indicate counterclockwise rotation of the viewpoint. `e1` is the vertical elevation of the viewpoint in degrees. Positive values of elevation correspond to moving above the object; negative values correspond to moving below the object.

`view([x,y,z])` sets the viewpoint to the Cartesian coordinates  $x$ ,  $y$ , and  $z$ . The magnitude of  $(x,y,z)$  is ignored.

`view(2)` sets the default two-dimensional view, `az = 0`, `e1 = 90`.

`view(3)` sets the default three-dimensional view, `az = 37.5`, `e1 = 30`.

`view(ax,...)` uses axes `ax` instead of the current axes.

`view(T)` sets the view according to the transformation matrix `T`, which is a 4-by-4 matrix such as a perspective transformation generated by `viewmtx`.

`[az,e1] = view` returns the current azimuth and elevation.

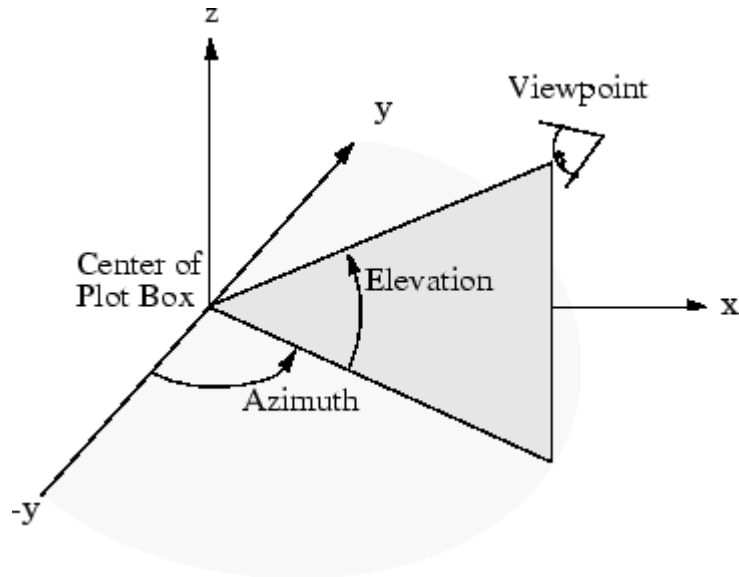
`T = view` returns the current 4-by-4 transformation matrix.

# view

## Remarks

Azimuth is a polar angle in the  $x$ - $y$  plane, with positive angles indicating counterclockwise rotation of the viewpoint. Elevation is the angle above (positive angle) or below (negative angle) the  $x$ - $y$  plane.

This diagram illustrates the coordinate system. The arrows indicate positive directions.



## Examples

View the object from directly overhead.

```
az = 0;  
el = 90;  
view(az, el);
```

Set the view along the  $y$ -axis, with the  $x$ -axis extending horizontally and the  $z$ -axis extending vertically in the figure.

```
view([0 0]);
```

Rotate the view about the  $z$ -axis by  $180^\circ$ .

```
az = 180;  
el = 90;  
view(az, el);
```

**See Also**

`viewmtx`, `hgtransform`, `rotate3d`

“Controlling the Camera Viewpoint” on page 1-99 for related functions

Axes graphics object properties `CameraPosition`, `CameraTarget`, `CameraViewAngle`, `Projection`

Defining the View for more information on viewing concepts and techniques

Transforming Objects for information on moving and scaling objects in groups

# viewmtx

---

**Purpose** View transformation matrices

**Syntax**

```
viewmtx
T = viewmtx(az,e1)
T = viewmtx(az,e1,phi)
T = viewmtx(az,e1,phi,xc)
```

**Description** `viewmtx` computes a 4-by-4 orthographic or perspective transformation matrix that projects four-dimensional homogeneous vectors onto a two-dimensional view surface (e.g., your computer screen).

`T = viewmtx(az,e1)` returns an *orthographic* transformation matrix corresponding to azimuth `az` and elevation `e1`. `az` is the azimuth (i.e., horizontal rotation) of the viewpoint in degrees. `e1` is the elevation of the viewpoint in degrees. This returns the same matrix as the commands

```
view(az,e1)
T = view
```

but does not change the current view.

`T = viewmtx(az,e1,phi)` returns a *perspective* transformation matrix. `phi` is the perspective viewing angle in degrees. `phi` is the subtended view angle of the normalized plot cube (in degrees) and controls the amount of perspective distortion.

| Phi        | Description                |
|------------|----------------------------|
| 0 degrees  | Orthographic projection    |
| 10 degrees | Similar to telephoto lens  |
| 25 degrees | Similar to normal lens     |
| 60 degrees | Similar to wide-angle lens |

You can use the matrix returned to set the view transformation with `view(T)`. The 4-by-4 perspective transformation matrix transforms four-dimensional homogeneous vectors into unnormalized vectors of the

form  $(x,y,z,w)$ , where  $w$  is not equal to 1. The  $x$ - and  $y$ -components of the normalized vector  $(x/w, y/w, z/w, 1)$  are the desired two-dimensional components (see example below).

`T = viewmtx(az,el,phi,xc)` returns the perspective transformation matrix using `xc` as the target point within the normalized plot cube (i.e., the camera is looking at the point `xc`). `xc` is the target point that is the center of the view. You specify the point as a three-element vector, `xc = [xc,yc,zc]`, in the interval  $[0,1]$ . The default value is `xc = [0,0,0]`.

## Remarks

A four-dimensional homogenous vector is formed by appending a 1 to the corresponding three-dimensional vector. For example,  $[x, y, z, 1]$  is the four-dimensional vector corresponding to the three-dimensional point  $[x, y, z]$ .

## Examples

Determine the projected two-dimensional vector corresponding to the three-dimensional point  $(0.5,0.0,-3.0)$  using the default view direction. Note that the point is a column vector.

```
A = viewmtx(-37.5,30);
x4d = [.5 0 -3 1]';
x2d = A*x4d;
x2d = x2d(1:2)
x2d =
    0.3967
   -2.4459
```

Vectors that trace the edges of a unit cube are

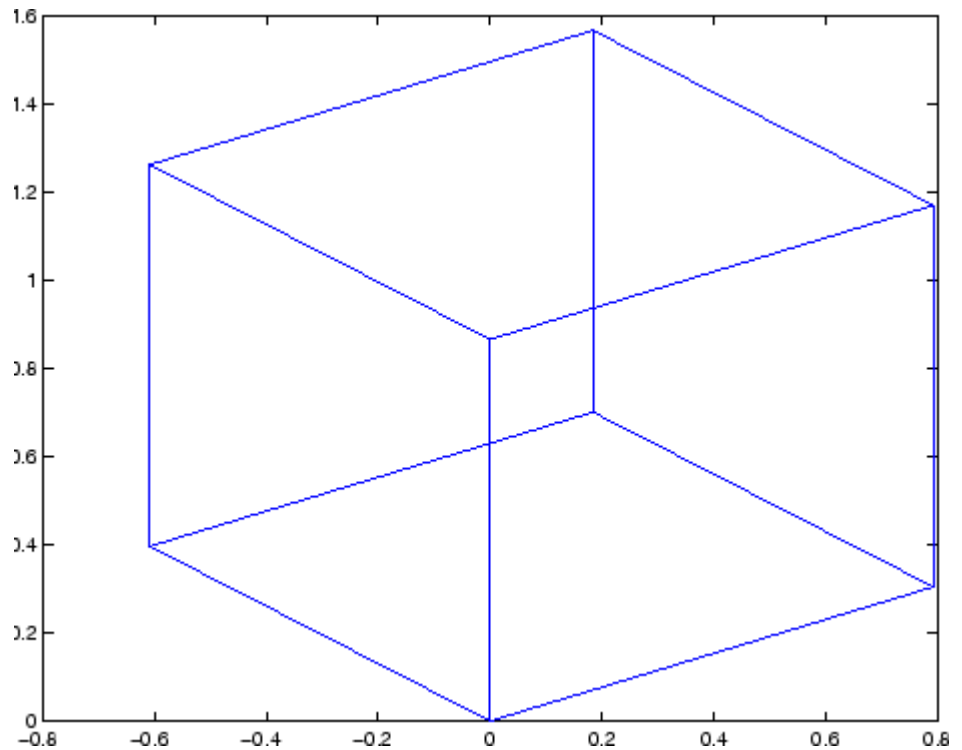
```
x = [0 1 1 0 0 0 1 1 0 0 1 1 1 1 0 0];
y = [0 0 1 1 0 0 0 1 1 0 0 0 1 1 1 1];
z = [0 0 0 0 0 0 1 1 1 1 1 1 0 0 1 1];
```

Transform the points in these vectors to the screen, then plot the object.

```
A = viewmtx(-37.5,30);
[m,n] = size(x);
x4d = [x(:),y(:),z(:),ones(m*n,1)]';
```

# viewmtx

```
x2d = A*x4d;  
x2 = zeros(m,n); y2 = zeros(m,n);  
x2(:) = x2d(1,:);  
y2(:) = x2d(2,:);  
plot(x2,y2)
```



Use a perspective transformation with a 25 degree viewing angle:

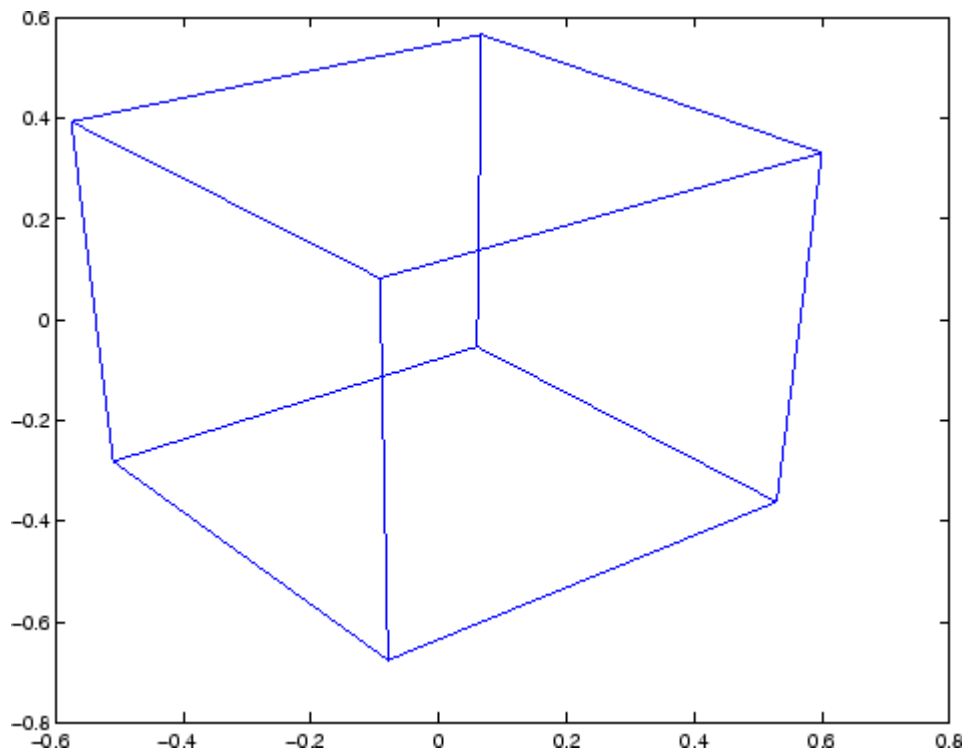
```
A = viewmtx(-37.5,30,25);  
x4d = [.5 0 -3 1]';  
x2d = A*x4d;  
x2d = x2d(1:2)/x2d(4) % Normalize  
x2d =
```



0.1777  
-1.8858

Transform the cube vectors to the screen and plot the object:

```
A = viewmtx(-37.5,30,25);  
[m,n] = size(x);  
x4d = [x(:),y(:),z(:),ones(m*n,1)]';  
x2d = A*x4d;  
x2 = zeros(m,n); y2 = zeros(m,n);  
x2(:) = x2d(1,:)./x2d(4,:);  
y2(:) = x2d(2,:)./x2d(4,:);  
plot(x2,y2)
```



# viewmtx

---

## **See Also**

view, hgtransform

“Controlling the Camera Viewpoint” on page 1-99 for related functions

Defining the View for more information on viewing concepts and techniques

## Purpose

Coordinate and color limits for volume data

## Syntax

```
lims = volumebounds(X,Y,Z,V)
lims = volumebounds(X,Y,Z,U,V,W)
lims = volumebounds(V), lims = volumebounds(U,V,W)
```

## Description

`lims = volumebounds(X,Y,Z,V)` returns the x, y, z, and color limits of the current axes for scalar data. `lims` is returned as a vector:

```
[xmin xmax ymin ymax zmin zmax cmin cmax]
```

You can pass this vector to the `axis` command.

`lims = volumebounds(X,Y,Z,U,V,W)` returns the x, y, and z limits of the current axes for vector data. `lims` is returned as a vector:

```
[xmin xmax ymin ymax zmin zmax]
```

`lims = volumebounds(V)`, `lims = volumebounds(U,V,W)` assumes X, Y, and Z are determined by the expression

```
[X Y Z] = meshgrid(1:n,1:m,1:p)
```

where `[m n p] = size(V)`.

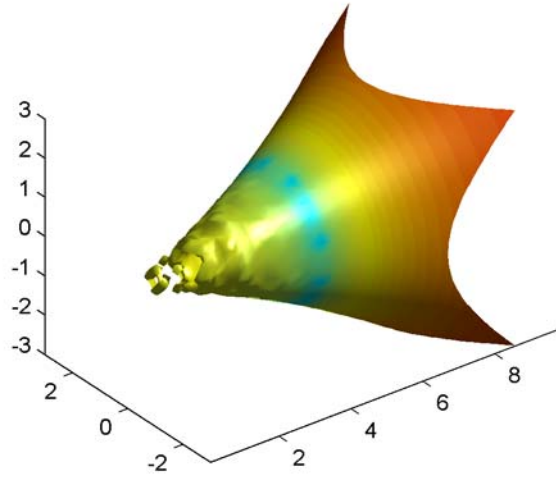
## Examples

This example uses `volumebounds` to set the axis and color limits for an isosurface generated by the flow function.

```
[x y z v] = flow;
p = patch(isosurface(x,y,z,v,-3));
isonormals(x,y,z,v,p)
daspect([1 1 1])
isocolors(x,y,z,flipdim(v,2),p)
shading interp
axis(volumebounds(x,y,z,v))
view(3)
camlight
lighting phong
```

# volumebounds

---



## See Also

`isosurface`, `streamslice`

“Volume Visualization” on page 1-102 for related functions

**Purpose**

Voronoi diagram

**Syntax**

```

voronoi(x,y)
voronoi(x,y,TRI)
voronoi(X,Y,options)
voronoi(AX,...)
voronoi(...,'LineStyle')
h = voronoi(...)
[vx,vy] = voronoi(...)

```

**Definition**

Consider a set of coplanar points  $P$ . For each point  $P_x$  in the set  $P$ , you can draw a boundary enclosing all the intermediate points lying closer to  $P_x$  than to other points in the set  $P$ . Such a boundary is called a *Voronoi polygon*, and the set of all Voronoi polygons for a given point set is called a *Voronoi diagram*.

**Description**

`voronoi(x,y)` plots the bounded cells of the Voronoi diagram for the points  $x,y$ . Lines-to-infinity are approximated with an arbitrarily distant endpoint.

`voronoi(x,y,TRI)` uses the triangulation `TRI` instead of computing it via `delaunay`.

`voronoi(X,Y,options)` specifies a cell array of strings to be used as options in `Qhull` via `delaunay`.

If `options` is `[]`, the default `delaunay` options are used. If `options` is `{ '' }`, no options are used, not even the default.

`voronoi(AX,...)` plots into `AX` instead of `gca`.

`voronoi(...,'LineStyle')` plots the diagram with color and line style specified.

`h = voronoi(...)` returns, in `h`, handles to the line objects created.

`[vx,vy] = voronoi(...)` returns the finite vertices of the Voronoi edges in `vx` and `vy` so that `plot(vx,vy,'-',x,y,'.')` creates the Voronoi diagram. The lines-to-infinity are the last columns of `vx` and

# voronoi

---

`vy`. To ensure the lines-to-infinity do not affect the settings of the axis limits, use the commands:

```
h = plot(VX,VY,'-',X,Y,'. ');
set(h(1:end-1),'xliminclude','off','yliminclude','off')
```

---

**Note** For the topology of the Voronoi diagram, i.e., the vertices for each Voronoi cell, use `voronoin`.

```
[v,c] = voronoin([x(:) y(:)])
```

---

## Visualization

Use one of these methods to plot a Voronoi diagram:

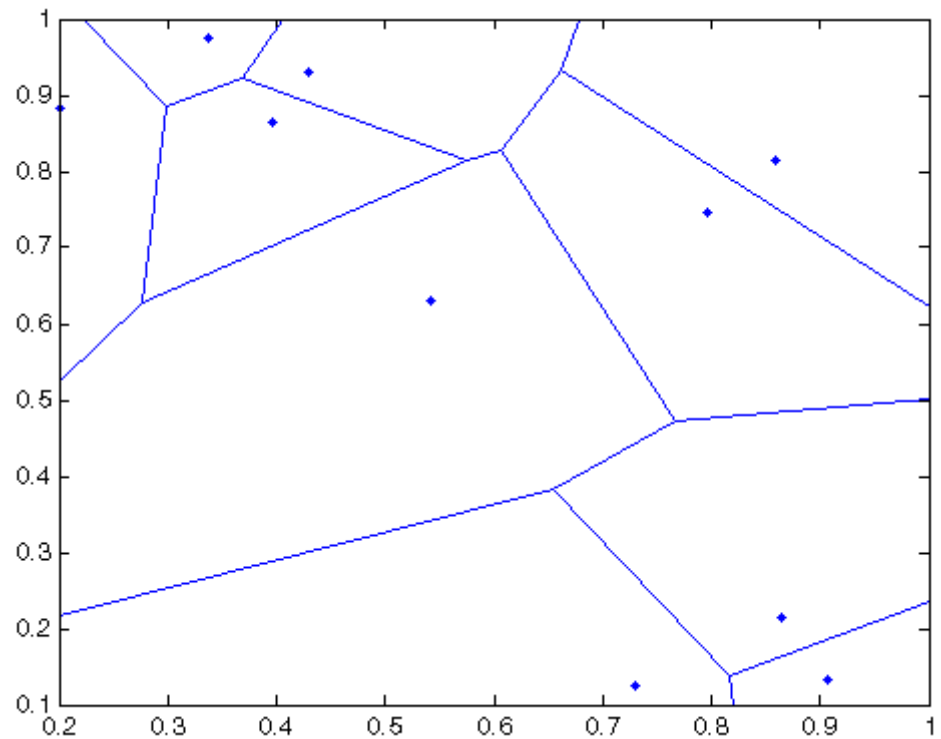
- If you provide no output argument, `voronoi` plots the diagram. See Example 1.
- To gain more control over color, line style, and other figure properties, use the syntax `[vx,vy] = voronoi(...)`. This syntax returns the vertices of the finite Voronoi edges, which you can then plot with the `plot` function. See Example 2.
- To fill the cells with color, use `voronoin` with `n = 2` to get the indices of each cell, and then use `patch` and other plot functions to generate the figure. Note that `patch` does not fill unbounded cells with color. See Example 3.

## Examples

### Example 1

This code uses the `voronoi` function to plot the Voronoi diagram for 10 randomly generated points.

```
rand('state',5);
x = rand(1,10); y = rand(1,10);
voronoi(x,y)
```



### Example 2

This code uses the vertices of the finite Voronoi edges to plot the Voronoi diagram for the same 10 points.

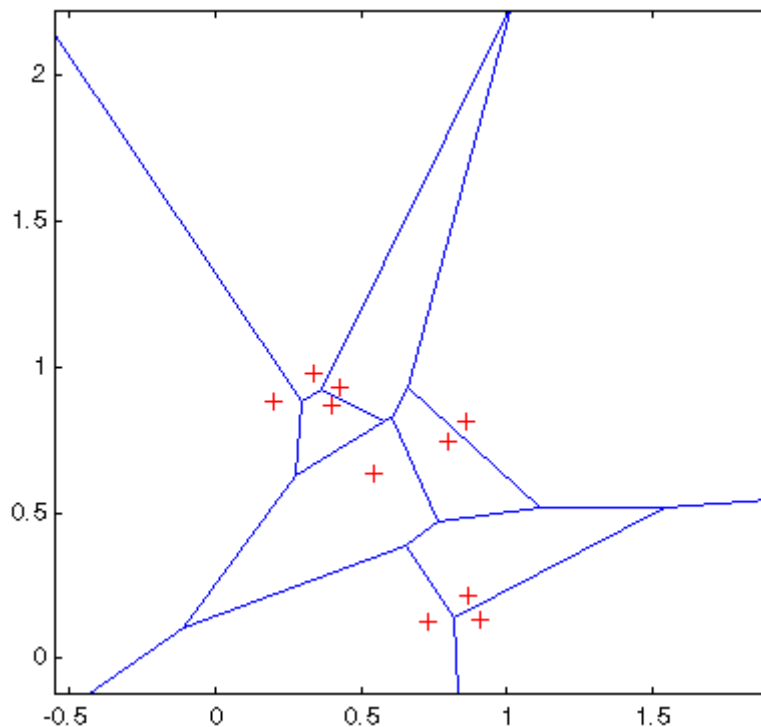
```
rand('state',5);  
x = rand(1,10); y = rand(1,10);  
[vx, vy] = voronoi(x,y);  
plot(x,y,'r+',vx,vy,'b-'); axis equal
```

Note that you can add this code to get the figure shown in Example 1.

```
xlim([min(x) max(x)])
```

# voronoi

```
ylim([min(y) max(y)])
```



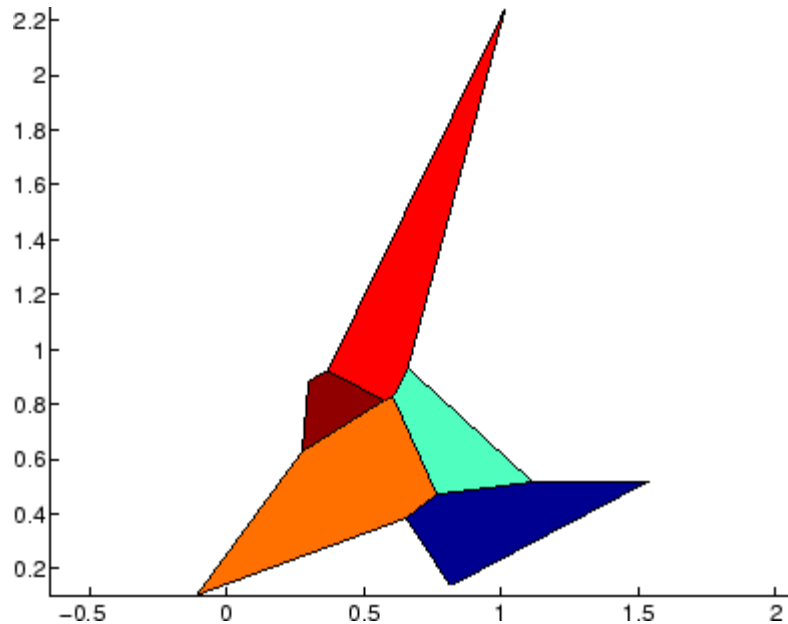
### Example 3

This code uses `voronoin` and `patch` to fill the bounded cells of the same Voronoi diagram with color.

```
rand('state',5);  
x=rand(10,2);  
[v,c]=voronoin(x);  
for i = 1:length(c)  
    if all(c{i}~=1) % If at least one of the indices is 1,  
                   % then it is an open region and we can't  
                   % patch that.
```



```
patch(v(c{i},1),v(c{i},2),i); % use color i.  
end  
end  
axis equal
```



## Algorithm

If you supply no triangulation TRI, the voronoi function performs a Delaunay triangulation of the data that uses Qhull [1]. For information about Qhull, see <http://www.qhull.org/>. For copyright information, see <http://www.qhull.org/COPYING.txt>.

## See Also

convhull, delaunay, LineSpec, plot, voronoin

## Reference

[1] Barber, C. B., D.P. Dobkin, and H.T. Huhdanpaa, "The Quickhull Algorithm for Convex Hulls," *ACM Transactions on Mathematical Software*, Vol. 22, No. 4, Dec. 1996, p. 469-483. Available in PDF

format at <http://www.acm.org/pubs/citations/journals/toms/1996-22-4/p469-barber/>.

**Purpose**

N-D Voronoi diagram

**Syntax**

[V,C] = voronoin(X)  
 [V,C] = voronoin(X,options)

**Description**

[V,C] = voronoin(X) returns Voronoi vertices V and the Voronoi cells C of the Voronoi diagram of X. V is a numv-by-n array of the numv Voronoi vertices in n-dimensional space, each row corresponds to a Voronoi vertex. C is a vector cell array where each element contains the indices into V of the vertices of the corresponding Voronoi cell. X is an m-by-n array, representing m n-dimensional points, where  $n > 1$  and  $m \geq n+1$ .

The first row of V is a point at infinity. If any index in a cell of the cell array is 1, then the corresponding Voronoi cell contains the first point in V, a point at infinity. This means the Voronoi cell is unbounded.

voronoin uses Qhull.

[V,C] = voronoin(X,options) specifies a cell array of strings options to be used in Qhull. The default options are

- { 'Qbb' } for 2- and 3-dimensional input
- { 'Qbb', 'Qx' } for 4 and higher-dimensional input

If options is [], the default options are used. If code is { '' }, no options are used, not even the default. For more information on Qhull and its options, see <http://www.qhull.org>.

**Visualization**

You can plot individual bounded cells of an n-dimensional Voronoi diagram. To do this, use convhulln to compute the vertices of the facets that make up the Voronoi cell. Then use patch and other plot functions to generate the figure. For an example, see “Tessellation and Interpolation of Scattered Data in Higher Dimensions” in the MATLAB Mathematics documentation.

**Examples**

**Example 1**

Let

# voronoin

---

```
x = [ 0.5    0
      0     0.5
      -0.5  -0.5
      -0.2  -0.1
      -0.1   0.1
       0.1  -0.1
       0.1   0.1 ]
```

then

```
[V,C] = voronoin(x)
```

```
V =
      Inf      Inf
      0.3833   0.3833
      0.7000  -1.6500
      0.2875   0.0000
     -0.0000   0.2875
     -0.0000  -0.0000
     -0.0500  -0.5250
     -0.0500  -0.0500
     -1.7500   0.7500
     -1.4500   0.6500
```

C =

```
[1x4 double]
[1x5 double]
[1x4 double]
[1x4 double]
[1x4 double]
[1x4 double]
[1x5 double]
[1x4 double]
```

Use a for loop to see the contents of the cell array C.

```
for i=1:length(C), disp(C{i}), end
```

```
4    2    1    3
```

```

10    5    2    1    9
 9    1    3    7
10    8    7    9
10    5    6    8
 8    6    4    3    7
 6    4    2    5

```

In particular, the fifth Voronoi cell consists of 4 points:  $V(10, :)$ ,  $V(5, :)$ ,  $V(6, :)$ ,  $V(8, :)$ .

### Example 2

The following example illustrates the options input to voronoin. The commands

```

X = [-1 -1; 1 -1; 1 1; -1 1];
[V,C] = voronoin(X)

```

return an error message.

```

? qhull input error: can not scale last coordinate. Input is
cocircular
or cospherical. Use option 'Qz' to add a point at infinity.

```

The error message indicates that you should add the option 'Qz'. The following command passes the option 'Qz', along with the default 'Qbb', to voronoin.

```

[V,C] = voronoin(X,{'Qbb','Qz'})
V =

```

```

    Inf    Inf
     0     0

```

C =

```

[1x2 double]
[1x2 double]

```

# voronoin

---

[1x2 double]  
[1x2 double]

## Algorithm

voronoin is based on Qhull [1]. For information about Qhull, see <http://www.qhull.org/>. For copyright information, see <http://www.qhull.org/COPYING.txt>.

## See Also

convhull, convhulln, delaunay, delaunayn, voronoi

## Reference

[1] Barber, C. B., D.P. Dobkin, and H.T. Huhdanpaa, "The Quickhull Algorithm for Convex Hulls," *ACM Transactions on Mathematical Software*, Vol. 22, No. 4, Dec. 1996, p. 469-483. Available in PDF format at <http://www.acm.org/pubs/citations/journals/toms/1996-22-4/p469-barber/>.

**Purpose** Wait until timer stops running

**Syntax** `wait(obj)`

**Description** `wait(obj)` blocks the MATLAB command line and waits until the timer, represented by the timer object `obj`, stops running. When a timer stops running, the value of the timer object's `Running` property changes from 'on' to 'off'.

If `obj` is an array of timer objects, `wait` blocks the MATLAB command line until all the timers have stopped running.

If the timer is not running, `wait` returns immediately.

**See Also** `timer`, `start`, `stop`

# waitbar

---

**Purpose** Open waitbar

**Syntax**

```
h = waitbar(x,'message')
waitbar(x,'message','CreateCancelBtn','button_callback')
waitbar(...,property_name,property_value,...)
waitbar(x)
waitbar(x,h)
waitbar(x,h,'updated message')
```

**Description** A waitbar shows what percentage of a calculation is complete, as the calculation proceeds.

`h = waitbar(x,'message')` displays a waitbar of fractional length `x`. The waitbar figure is modal. Its handle is returned in `h`. The argument `x` must be between 0 and 1.

---

**Note** A modal figure prevents the user from interacting with other windows before responding. For more information, see `WindowState` in the MATLAB Figure Properties.

---

`waitbar(x,'message','CreateCancelBtn','button_callback')` specifying **CreateCancelBtn** adds a cancel button to the figure that executes the MATLAB commands specified in `button_callback` when the user clicks the cancel button or the close figure button. `waitbar` sets both the cancel button callback and the figure `CloseRequestFcn` to the string specified in `button_callback`.

`waitbar(...,property_name,property_value,...)` optional arguments `property_name` and `property_value` enable you to set figure properties for the waitbar.

`waitbar(x)` subsequent calls to `waitbar(x)` extend the length of the bar to the new position `x`.

`waitbar(x,h)` extends the length of the bar in the waitbar `h` to the new position `x`.

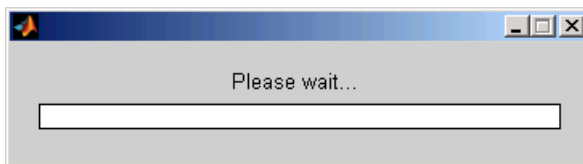


`waitbar(x,h,'updated message')` updates the message text in the waitbar figure, in addition to setting the fractional length to `x`.

## Example

`waitbar` is typically used inside a for loop that performs a lengthy computation. For example,

```
h = waitbar(0,'Please wait...');  
for i=1:100, % computation here %  
    waitbar(i/100)  
end  
close(h)
```



## See Also

“Predefined Dialog Boxes” on page 1-104 for related functions

# waitfor

---

**Purpose** Wait for condition before resuming execution

**Syntax**  
`waitfor(h)`  
`waitfor(h, 'PropertyName')`  
`waitfor(h, 'PropertyName', PropertyValue)`

**Description** The waitfor function blocks the caller's execution stream so that command-line expressions, callbacks, and statements in the blocked M-file do not execute until a specified condition is satisfied.

`waitfor(h)` returns when the graphics object identified by `h` is deleted or when a **Ctrl+C** is typed in the Command Window. If `h` does not exist, `waitfor` returns immediately without processing any events.

`waitfor(h, 'PropertyName')`, in addition to the conditions in the previous syntax, returns when the value of 'PropertyName' for the graphics object `h` changes. If 'PropertyName' is not a valid property for the object, `waitfor` returns immediately without processing any events.

`waitfor(h, 'PropertyName', PropertyValue)`, in addition to the conditions in the previous syntax, `waitfor` returns when the value of 'PropertyName' for the graphics object `h` changes to `PropertyValue`. `waitfor` returns immediately without processing any events if 'PropertyName' is set to `PropertyValue`.

**Remarks** While `waitfor` blocks an execution stream, other execution streams in the form of callbacks may execute as a result of various events (e.g., pressing a mouse button).

`waitfor` can block nested execution streams. For example, a callback invoked during a `waitfor` statement can itself invoke `waitfor`.

**See Also** `uiresume`, `uiwait`  
“Developing User Interfaces” on page 1-105 for related functions

**Purpose** Wait for key press or mouse-button click

**Syntax** `k = waitforbuttonpress`

**Description** `k = waitforbuttonpress` blocks the caller's execution stream until the function detects that the user has clicked a mouse button or pressed a key while the figure window is active. The function returns

- 0 if it detects a mouse button click
- 1 if it detects a key press

Additional information about the event that causes execution to resume is available through the figure's `CurrentCharacter`, `SelectionType`, and `CurrentPoint` properties.

If a `WindowButtonDownFcn` is defined for the figure, its callback is executed before `waitforbuttonpress` returns a value.

**Example** These statements display text in the Command Window when the user either clicks a mouse button or types a key in the figure window:

```
w = waitforbuttonpress;  
if w == 0  
    disp('Button click')  
else  
    disp('Key press')  
end
```

**See Also** `dragrect`, `ginput`, `rbbox`, `waitfor`

“Developing User Interfaces” on page 1-105 for related functions

# warndlg

---

**Purpose** Open warning dialog box

**Syntax**

```
h = warndlg
h = warndlg(warningstring)
h = warndlg(warningstring,dlgname)
h = warndlg(warningstring,dlgname,createmode)
```

**Description** `h = warndlg` displays a dialog box named Warning Dialog containing the string `This is the default warning string`. The `warndlg` function returns the handle of the dialog box in `h`. The warning dialog box disappears after the user clicks **OK**.

`h = warndlg(warningstring)` displays a dialog box with the title Warning Dialog containing the string specified by `warningstring`. The `warningstring` argument can be any valid string format – cell arrays are preferred.

To use multiple lines in your warning, define `warningstring` using either of the following:

- `sprintf` with newline characters separating the lines

```
warndlg(sprintf('Message line 1 \n Message line 2'))
```

- Cell arrays of strings

```
warndlg({'Message line 1';'Message line 2'})
```

`h = warndlg(warningstring,dlgname)` displays a dialog box with title `dlgname`.

`h = warndlg(warningstring,dlgname,createmode)` specifies whether the warning dialog box is modal or nonmodal. Optionally, it can also specify an interpreter for `warningstring` and `dlgname`. The `createmode` argument can be a string or a structure.

If `createmode` is a string, it must be one of the values shown in the following table.

| createmode Value    | Description                                                                                                                                                                                                                                                                                       |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| modal               | Replaces the warning dialog box having the specified <code>Title</code> , that was last created or clicked on, with a modal warning dialog box as specified. All other warning dialog boxes with the same title are deleted. The dialog box which is replaced can be either modal or nonmodal.    |
| non-modal (default) | Creates a new nonmodal warning dialog box with the specified parameters. Existing warning dialog boxes with the same title are not deleted.                                                                                                                                                       |
| replace             | Replaces the warning dialog box having the specified <code>Title</code> , that was last created or clicked on, with a nonmodal warning dialog box as specified. All other warning dialog boxes with the same title are deleted. The dialog box which is replaced can be either modal or nonmodal. |

---

**Note** A modal dialog box prevents the user from interacting with other windows before responding. To block MATLAB program execution as well, use `thuiwait` function. For more information about modal dialog boxes, see `WindowState` in the `Figure` Properties.

---

If `CreateMode` is a structure, it can have fields `WindowState` and `Interpreter`. `WindowState` must be one of the options shown in the table above. `Interpreter` is one of the strings `'tex'` or `'none'`. The default value for `Interpreter` is `'none'`.

## Examples

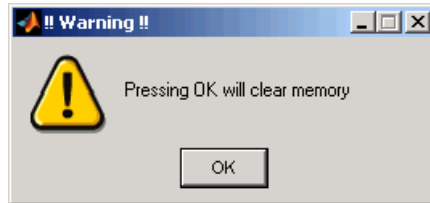
The statement

```
warndlg('Pressing OK will clear memory','!! Warning !!')
```

# warndlg

---

displays this dialog box:



## See Also

dialog, errordlg, helpdlg, inputdlg, listdlg, msgbox, questdlg  
figure, uiwait, uiresume, warning  
“Predefined Dialog Boxes” on page 1-104 for related functions

**Purpose**

Warning message

**Syntax**

```
warning('message')
warning('message', a1, a2,...)
warning('message_id', 'message')
warning('message_id', 'message', a1, a2, ..., an)
s = warning(state, 'message_id')
s = warning(state, mode)
```

**Description**

`warning('message')` displays the text 'message' like the `disp` function, except that with `warning`, message display can be suppressed.

`warning('message', a1, a2,...)` displays a message string that contains formatting conversion characters, such as those used with the MATLAB `sprintf` function. Each conversion character in `message` is converted to one of the values `a1, a2, ...` in the argument list.

---

**Note** MATLAB converts special characters (like `\n` and `%d`) in the warning message string only when you specify more than one input argument with `warning`. See Example 4 below.

---

`warning('message_id', 'message')` attaches a unique identifier, or `message_id`, to the warning message. The identifier enables you to single out certain warnings during the execution of your program, controlling what happens when the warnings are encountered. See and “Warning Control” in the MATLAB Programming documentation for more information on the `message_id` argument and how to use it.

`warning('message_id', 'message', a1, a2, ..., an)` includes formatting conversion characters in `message`, and the character translations in arguments `a1, a2, ..., an`.

`s = warning(state, 'message_id')` is a warning control statement that enables you to indicate how you want MATLAB to act on certain warnings. The `state` argument can be 'on', 'off', or 'query'. The `message_id` argument can be a message identifier string, 'all',

# warning

---

or 'last'. See “Warning Control Statements” in the MATLAB Programming documentation for more information.

Output `s` is a structure array that indicates the previous state of the selected warnings. The structure has the fields `identifier` and `state`. See “Output from Control Statements” in the MATLAB Programming documentation for more.

`s = warning(state, mode)` is a warning control statement that enables you to display an M-stack trace or display more information with each warning. The `state` argument can be 'on', 'off', or 'query'. The `mode` argument can be 'backtrace' or 'verbose'. See “Backtrace and Verbose Modes” in the MATLAB Programming documentation for more information.

## Examples

### Example 1

Generate a warning that displays a simple string:

```
if ~ischar(p1)
    warning('Input must be a string')
end
```

### Example 2

Generate a warning string that is defined at run-time. The first argument defines a message identifier for this warning:

```
warning('MATLAB:paramAmbiguous', ...
    'Ambiguous parameter name, "%s".', param)
```

### Example 3

Using a message identifier, enable just the `actionNotTaken` warning from Simulink by first turning off all warnings and then setting just that warning to on:

```
warning off all
warning on Simulink:actionNotTaken
```



Use `query` to determine the current state of all warnings. It reports that you have set all warnings to off with the exception of `Simulink:actionNotTaken`:

```
warning query all
The default warning state is 'off'. Warnings not set to the default are

State Warning Identifier

on Simulink:actionNotTaken
```

#### Example 4

MATLAB converts special characters (like `\n` and `%d`) in the warning message string only when you specify more than one input argument with `warning`. In the single argument case shown below, `\n` is taken to mean backslash-n. It is not converted to a newline character:

```
warning('In this case, the newline \n is not converted.')
Warning: In this case, the newline \n is not converted.
```

But, when more than one argument is specified, MATLAB does convert special characters. This is true regardless of whether the additional argument supplies conversion values or is a message identifier:

```
warning('WarnTests:convertTest', ...
        'In this case, the newline \n is converted.')
Warning: In this case, the newline
is converted.
```

#### Example 5

Turn on one particular warning, saving the previous state of this one warning in `s`. Remember that this nonquery syntax performs an implicit query prior to setting the new state:

```
s = warning('on', 'Control:parameterNotSymmetric');
```

After doing some work that includes making changes to the state of some warnings, restore the original state of all warnings:

# warning

---

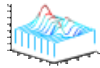
warning(s)


## **See Also**

lastwarn, warndlg, error, lasterror, errordlg, dbstop, disp,  
sprintf

**Purpose**

Waterfall plot

**GUI Alternatives**

To graph selected variables, use the Plot Selector  in the Workspace Browser, or use the Figure Palette Plot Catalog. Manipulate graphs in *plot edit* mode with the Property Editor. For details, see [Plotting Tools — Interactive Plotting in the MATLAB Graphics documentation](#) and [Creating Graphics from the Workspace Browser in the MATLAB Desktop Tools documentation](#).

**Syntax**

```
waterfall(Z)
waterfall(X,Y,Z)
waterfall(...,C)
waterfall(axes_handles,...)
h = waterfall(...)
```

**Description**

The `waterfall` function draws a mesh similar to the `meshz` function, but it does not generate lines from the columns of the matrices. This produces a “waterfall” effect.

`waterfall(Z)` creates a waterfall plot using  $x = 1:\text{size}(Z,1)$  and  $y = 1:\text{size}(Z,1)$ .  $Z$  determines the color, so color is proportional to surface height.

`waterfall(X,Y,Z)` creates a waterfall plot using the values specified in  $X$ ,  $Y$ , and  $Z$ .  $Z$  also determines the color, so color is proportional to the surface height. If  $X$  and  $Y$  are vectors,  $X$  corresponds to the columns of  $Z$ , and  $Y$  corresponds to the rows, where  $\text{length}(x) = n$ ,  $\text{length}(y) = m$ , and  $[m,n] = \text{size}(Z)$ .  $X$  and  $Y$  are vectors or matrices that define the  $x$ - and  $y$ -coordinates of the plot.  $Z$  is a matrix that defines the  $z$ -coordinates of the plot (i.e., height above a plane). If  $C$  is omitted, color is proportional to  $Z$ .

`waterfall(...,C)` uses scaled color values to obtain colors from the current colormap. Color scaling is determined by the range of  $C$ , which

# waterfall

---

must be the same size as Z. MATLAB performs a linear transformation on C to obtain colors from the current colormap.

`waterfall(axes_handles, ...)` plots into the axes with handle `axes_handle` instead of the current axes (`gca`).

`h = waterfall(...)` returns the handle of the patch graphics object used to draw the plot.

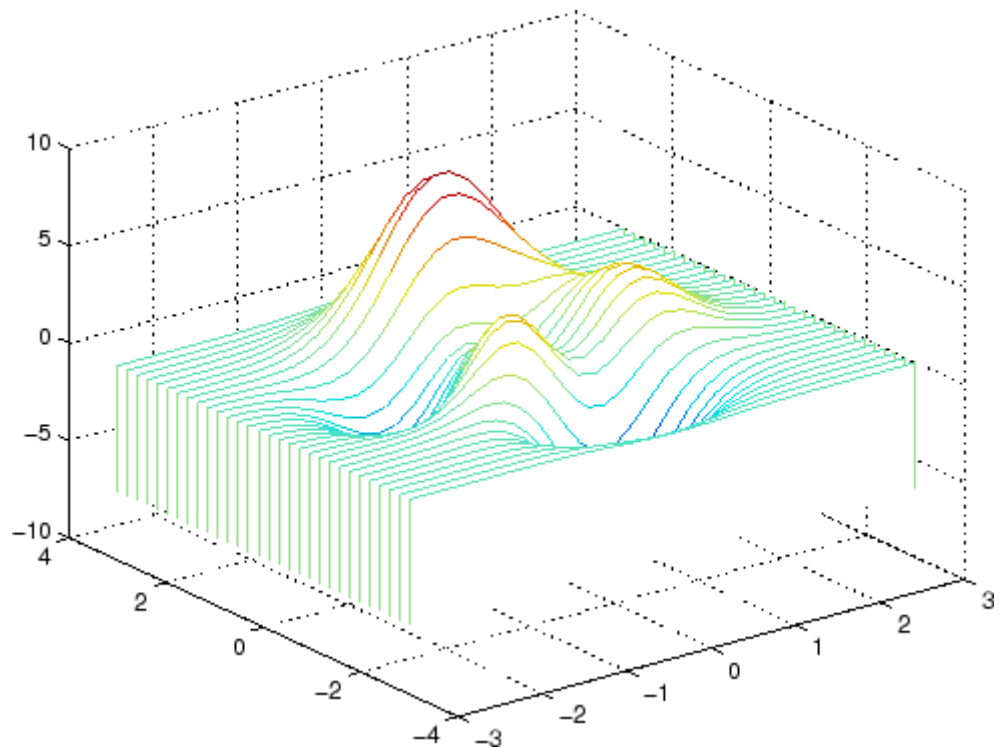
## Remarks

For column-oriented data analysis, use `waterfall(Z')` or `waterfall(X',Y',Z')`.

## Examples

Produce a waterfall plot of the peaks function.

```
[X,Y,Z] = peaks(30);  
waterfall(X,Y,Z)
```



## Algorithm

The range of X, Y, and Z, or the current setting of the axes `Llim`, `YLim`, and `ZLim` properties, determines the range of the axes (also set by `axis`). The range of C, or the current setting of the axes `CLim` property, determines the color scaling (also set by `caxis`).

The `CData` property for the patch graphics objects specifies the color at every point along the edge of the patch, which determines the color of the lines.

The `waterfall` plot looks like a mesh surface; however, it is a patch graphics object. To create a surface plot similar to `waterfall`, use the `meshz` function and set the `MeshStyle` property of the surface to `'Row'`.

# waterfall

---

For a discussion of parametric surfaces and related color properties, see surf.

## **See Also**

axes, axis, caxis, meshz, ribbon, surf

Properties for patch graphics objects

**Purpose** Information about Microsoft WAVE (.wav) sound file

**Syntax** [m d] = wavfinfo(filename)

**Description** [m d] = wavfinfo(filename) returns information about the contents of the WAVE sound file specified by the string filename. Enclose the filename input in single quotes.

m is the string 'Sound (WAV) file', if filename is a WAVE file. Otherwise, it contains an empty string ('').

d is a string that reports the number of samples in the file and the number of channels of audio data. If filename is not a WAVE file, it contains the string 'Not a WAVE file'.

**See Also** wavread

# wavplay

---

**Purpose** Play recorded sound on PC-based audio output device

**Syntax** `wavplay(y,Fs)`  
`wavplay(...,'mode')`

**Description** `wavplay(y,Fs)` plays the audio signal stored in the vector `y` on a PC-based audio output device. You specify the audio signal sampling rate with the integer `Fs` in samples per second. The default value for `Fs` is 11025 Hz (samples per second). `wavplay` supports only 1- or 2-channel (mono or stereo) audio signals.

`wavplay(...,'mode')` specifies how `wavplay` interacts with the command line, according to the string `'mode'`. The string `'mode'` can be

- `'async'`: You have immediate access to the command line as soon as the sound begins to play on the audio output device (a nonblocking device call).
- `'sync'` (default value): You don't have access to the command line until the sound has finished playing (a blocking device call).

The audio signal `y` can be one of four data types. The number of bits used to quantize and play back each sample depends on the data type.

## Data Types for wavplay

| Data Type                        | Quantization   |
|----------------------------------|----------------|
| Double-precision (default value) | 16 bits/sample |
| Single-precision                 | 16 bits/sample |
| 16-bit signed integer            | 16 bits/sample |
| 8-bit unsigned integer           | 8 bits/sample  |

**Remarks** You can play your signal in stereo if `y` is a two-column matrix.



**Examples**

The MAT-files `gong.mat` and `chirp.mat` both contain an audio signal `y` and a sampling frequency `Fs`. Load and play the gong and the chirp audio signals. Change the names of these signals in between load commands and play them sequentially using the 'sync' option for `wavplay`.

```
load chirp;
y1 = y; Fs1 = Fs;
load gong;
wavplay(y1,Fs1,'sync') % The chirp signal finishes before the
wavplay(y,Fs)          % gong signal begins playing.
```

**See Also**

`wavrecord`

# wavread

---

**Purpose** Read Microsoft WAVE (.wav) sound file

**Graphical Interface** As an alternative to wavread, use the Import Wizard. To activate the Import Wizard, select **Import Data** from the **File** menu.

**Syntax**

```
y = wavread(filename)
[y, Fs, nbits] = wavread(filename)
[...] = wavread(filename, N)
[...] = wavread(filename, [N1 N2])
y = wavread(filename, fmt)
siz = wavread(filename, 'size')
[y, fs, nbits, opts] = wavread(...)
```

**Description** `y = wavread(filename)` loads a WAVE file specified by `filename`, returning the sampled data in `y`. The `filename` input is a string enclosed in single quotes. The `.wav` extension is appended if no extension is given.

`[y, Fs, nbits] = wavread(filename)` returns the sample rate (`Fs`) in Hertz and the number of bits per sample (`nbits`) used to encode the data in the file.

`[...] = wavread(filename, N)` returns only the first `N` samples from each channel in the file.

`[...] = wavread(filename, [N1 N2])` returns only samples `N1` through `N2` from each channel in the file.

`y = wavread(filename, fmt)` specifies the data type format of `y` used to represent samples read from the file. `fmt` can be either of the following values.

| Value    | Description                                                                                                                                        |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 'double' | y contains double-precision normalized samples. This is the default value, if <i>fmt</i> is omitted.                                               |
| 'native' | y contains samples in the native data type found in the file. Interpretation of <i>fmt</i> is case-insensitive, and partial matching is supported. |

`siz = wavread(filename, 'size')` returns the size of the audio data contained in `filename` in place of the actual audio data, returning the vector `siz = [samples channels]`.

`[y, fs, nbits, opts] = wavread(...)` returns a structure `opts` of additional information contained in the WAV file. The content of this structure differs from file to file. Typical structure fields include `opts.fmt` (audio format information) and `opts.info` (text which may describe title, author, etc.).

### Output Scaling

The range of values in `y` depends on the data format *fmt* specified. Some examples of output scaling based on typical bit-widths found in a WAV file are given below for both 'double' and 'native' formats.

### Native Formats

| Number of Bits | MATLAB Data Type         | Data Range                  |
|----------------|--------------------------|-----------------------------|
| 8              | uint8 (unsigned integer) | $0 \leq y \leq 255$         |
| 16             | int16 (signed integer)   | $-32768 \leq y \leq +32767$ |

## Native Formats (Continued)

| Number of Bits | MATLAB Data Type        | Data Range                     |
|----------------|-------------------------|--------------------------------|
| 24             | int32 (signed integer)  | $-2^{23} \leq y \leq 2^{23}-1$ |
| 32             | single (floating point) | $-1.0 \leq y < +1.0$           |

## Double Formats

| Number of Bits | MATLAB Data Type | Data Range                                                                                                                           |
|----------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| N<32           | double           | $-1.0 \leq y < +1.0$                                                                                                                 |
| N=32           | double           | $-1.0 \leq y \leq +1.0$<br>Note: Values in y might exceed -1.0 or +1.0 for the case of N=32 bit data samples stored in the WAV file. |

wavread supports multi-channel data, with up to 32 bits per sample.

wavread supports Pulse-code Modulation (PCM) data format only.

## See Also

auread, auwrite, wavwrite

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Record sound using PC-based audio input device                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Syntax</b>      | <pre>y = wavrecord(n,Fs) y = wavrecord(...,ch) y = wavrecord(...,'dtype')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Description</b> | <p><code>y = wavrecord(n,Fs)</code> records <code>n</code> samples of an audio signal, sampled at a rate of <code>Fs</code> Hz (samples per second). The default value for <code>Fs</code> is 11025 Hz.</p> <p><code>y = wavrecord(...,ch)</code> uses <code>ch</code> number of input channels from the audio device. <code>ch</code> can be either 1 or 2, for mono or stereo, respectively. The default value for <code>ch</code> is 1.</p> <p><code>y = wavrecord(...,'dtype')</code> uses the data type specified by the string <code>'dtype'</code> to record the sound. The string <code>'dtype'</code> can be one of the following:</p> <ul style="list-style-type: none"><li>• <code>'double'</code> (default value), 16 bits/sample</li><li>• <code>'single'</code>, 16 bits/sample</li><li>• <code>'int16'</code>, 16 bits/sample</li><li>• <code>'uint8'</code>, 8 bits/sample</li></ul> |
| <b>Remarks</b>     | Standard sampling rates for PC-based audio hardware are 8000, 11025, 2250, and 44100 samples per second. Stereo signals are returned as two-column matrices. The first column of a stereo audio matrix corresponds to the left input channel, while the second column corresponds to the right input channel.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Examples</b>    | <p>Record 5 seconds of 16-bit audio sampled at 11025 Hz. Play back the recorded sound using <code>wavplay</code>. Speak into your audio device (or produce your audio signal) while the <code>wavrecord</code> command runs.</p> <pre>Fs = 11025; y = wavrecord(5*Fs,Fs,'int16'); wavplay(y,Fs);</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

# wavrecord

---

## See Also

wavplay

**Purpose** Write Microsoft WAVE (.wav) sound file

**Syntax**

```
wavwrite(y,filename)
wavwrite(y,Fs,filename)
wavwrite(y,Fs,N,filename)
```

**Description** wavwrite writes data to 8-, 16-, 24-, and 32-bit .wav files.

wavwrite(y,filename) writes the data stored in the variable y to a WAVE file called filename. The filename input is a string enclosed in single quotes. The data has a sample rate of 8000 Hz and is assumed to be 16-bit. Each column of the data represents a separate channel. Therefore, stereo data should be specified as a matrix with two columns. Amplitude values outside the range [-1,+1] are clipped prior to writing.

wavwrite(y,Fs,filename) writes the data stored in the variable y to a WAVE file called filename. The data has a sample rate of Fs Hz and is assumed to be 16-bit. Amplitude values outside the range [-1,+1] are clipped prior to writing.

wavwrite(y,Fs,N,filename) writes the data stored in the variable y to a WAVE file called filename. The data has a sample rate of Fs Hz and is N-bit, where N is 8, 16, 24, or 32. For N < 32, amplitude values outside the range [-1,+1] are clipped.

---

**Note** 8-, 16-, and 24-bit files are type 1 integer pulse code modulation (PCM). 32-bit files are written as type 3 normalized floating point.

---

**See Also** auwrite, wavread

**Purpose** Open Web site or file in Web browser or Help browser

**Syntax**

```
web
web url
web url -new
web url -notoolbar
web url -noaddressbox
web url -helpbrowser
web url -browser
web(...)
stat = web('url', '-browser')
[stat, h1] = web
[stat, h1, url] = web
```

**Description** `web` opens an empty MATLAB “Web Browser”. The MATLAB Web browser includes an address field where you can enter a URL, for example, to a Web site or file, a toolbar with common browser buttons, and a MATLAB desktop menu.

`web url` displays the specified URL, `url`, in the MATLAB Web browser. If any MATLAB Web browsers are already open, it displays the page in the browser that last had focus. Files up to 1.5MB in size display in the MATLAB Web browser, while larger files instead display in the default Web browser for your system. If `url` is located in the directory returned when you run `docroot` (an unsupported utility), the URL displays in the MATLAB Help browser instead of the MATLAB Web browser.

`web url -new` displays the specified URL, `url`, in a new MATLAB Web browser.

`web url -notoolbar` displays the specified URL, `url`, in a MATLAB Web browser that does not include the toolbar and address field. If any MATLAB Web browsers are already open, also use the `-new` option; otherwise `url` displays in the browser that last had focus, regardless of its toolbar status.

`web url -noaddressbox` displays the specified URL, `url`, in a MATLAB Web browser that does not include the address field. If any MATLAB Web browsers are already open, also use the `-new` option; otherwise `url`



displays in the browser that last had focus, regardless of its address field status.

`web url -helpbrowser` displays the specified URL, `url`, in the MATLAB Help browser.

`web url -browser` displays the default Web browser for your system and loads the file or Web site specified by the URL `url` in it. Generally, `url` specifies a local file or a Web site on the Internet. The URL can be in any form that the browser supports. On Windows and Macintosh, the default Web browser is determined by the operating system. On UNIX, the Web browser used is specified via `docopt` in the `doccmd` string.

`web(...)` is the functional form of `web`.

`stat = web('url', '-browser')` runs `web` and returns the status of `web` to the variable `stat`.

| Value of <code>stat</code> | Description                                  |
|----------------------------|----------------------------------------------|
| 0                          | Browser was found and launched.              |
| 1                          | Browser was not found.                       |
| 2                          | Browser was found but could not be launched. |

`[stat, h1] = web` returns the status of `web` to the variable `stat`, and returns a handle to the Java class, `h1`, for the last active browser.

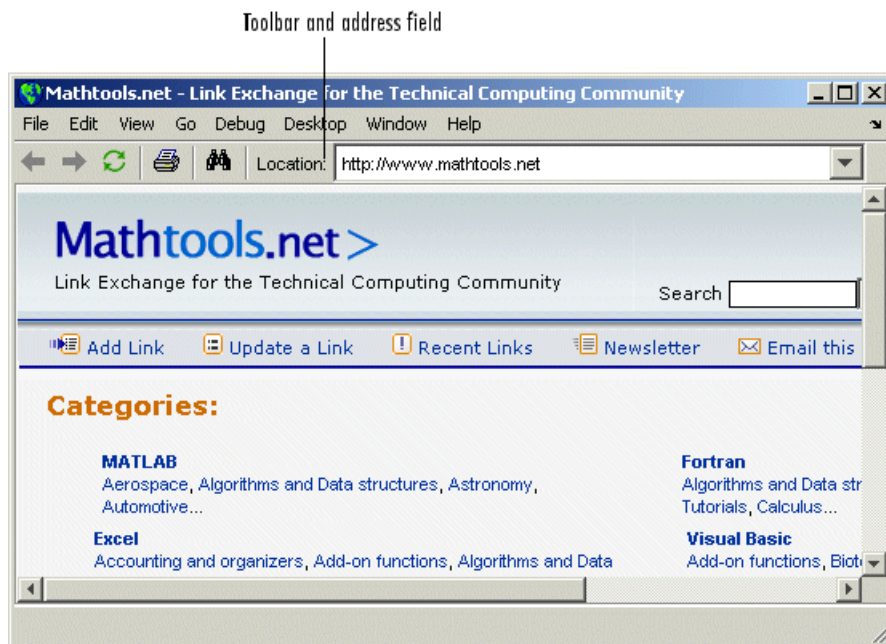
`[stat, h1, url] = web` returns the status of `web` to the variable `stat`, returns a handle to the Java class `h1`, for the last active browser, and returns its current URL to `url`.

## Examples

Run

```
web http://www.mathtools.net
```

and MATLAB displays



`web http://www.mathworks.com` loads the MathWorks Web site home page into the MATLAB Web browser.

`web file:///disk/dir1/dir2/foo.html` opens the file `foo.html` in the MATLAB Web browser.

`web(['file:/// ' which('foo.html')])` opens `foo.html` if the file is on the MATLAB path or in the current directory.

`web('text://<html><h1>Hello World</h1></html>')` displays the HTML-formatted text `Hello World`.

`web ('http://www.mathworks.com', '-new', '-notoolbar')` loads the MathWorks Web site home page into a new MATLAB Web browser that does not include a toolbar or address field.

`web file:///disk/dir1/foo.html -helpbrowser` opens the file `foo.html` in the MATLAB Help browser.

`web file:///disk/dir1/foo.html` -browser opens the file `foo.html` in the system Web browser.

`web mailto:email_address` uses your system browser's default e-mail application to send a message to `email_address`.

`web http://www.mathtools.net` -browser opens a browser to `mathtools.net`. Then `[stat,h1,url]=web` returns

```
stat =  
      0  
  
h1 =  
com.mathworks.mde.webbrowser.WebBrowser[,0,0,591x140,  
layout=java.awt.BorderLayout,alignmentX=null,alignmentY=null,  
border=,flags=9,maximumSize=,minimumSize=,preferredSize=]  
  
url =  
http://www.mathtools.net/
```

Run `methods(h1)` to view allowable methods for the class. As an example, you can use the method `setCurrentLocation` to change the URL displayed in `h1`, as in

```
setCurrentLocation(h1,'http://www.mathworks.com')
```

## See Also

`doc`, `docopt`, `helpbrowser`, `matlabcolon`

“Web Browser” in the MATLAB Desktop Tools and Development Environment documentation

# weekday

---

**Purpose** Day of week

**Syntax**  
[N, S] = weekday(D)  
[N, S] = weekday(D, form)  
[N, S] = weekday(D, locale)  
[N, S] = weekday(D, form, locale)

**Description** [N, S] = weekday(D) returns the day of the week in numeric (N) and string (S) form for a given serial date number or date string D. Input argument D can represent more than one date in an array of serial date numbers or a cell array of date strings.

[N, S] = weekday(D, form) returns the day of the week in numeric (N) and string (S) form, where the content of S depends on the form argument. If form is **'long'**, then S contains the full name of the weekday (e.g., Tuesday). If form is **'short'**, then S contains an abbreviated name (e.g., Tues) from this table.

The days of the week are assigned these numbers and abbreviations.

| <b>N</b> | <b>S (short)</b> | <b>S (long)</b> |
|----------|------------------|-----------------|
| 1        | Sun              | Sunday          |
| 2        | Mon              | Monday          |
| 3        | Tue              | Tuesday         |
| 4        | Wed              | Wednesday       |
| 5        | Thu              | Thursday        |
| 6        | Fri              | Friday          |
| 7        | Sat              | Saturday        |

[N, S] = weekday(D, locale) returns the day of the week in numeric (N) and string (S) form, where the format of the output depends on the locale argument. If locale is **'local'**, then weekday uses local format for its output. If locale is **'en\_US'**, then weekday uses US English.

`[N, S] = weekday(D, form, locale)` returns the day of the week using the formats described above for `form` and `locale`.

## Examples

Either

```
[n, s] = weekday(728647)
```

or

```
[n, s] = weekday('19-Dec-1994')
```

returns `n = 2` and `s = Mon`.

## See Also

`datenum`, `datevec`, `eomday`

# what

---

**Purpose** List MATLAB files in current directory

**Graphical Interface** As an alternative to the `what` function, use the “Current Directory Browser”. To open it, select **Current Directory** from the **Desktop** menu in the MATLAB desktop.

**Syntax**

```
what
what dirname
what class
s = what('dirname')
```

**Description** `what` lists the M, MAT, MEX, MDL, and P-files and the class directories that reside in the current working directory.

`what dirname` lists the files in directory `dirname` on the MATLAB search path. It is not necessary to enter the full pathname of the directory. The last component, or last two components, is sufficient.

`what class` lists the files in method directory, `@class`. For example, `what cfit` lists the MATLAB files in `toolbox/curvefit/curvefit/@cfit`.

`s = what('dirname')` returns the results in a structure array with these fields.

| Field   | Description                  |
|---------|------------------------------|
| path    | Path to directory            |
| m       | Cell array of M-file names   |
| mat     | Cell array of MAT-file names |
| mex     | Cell array of MEX-file names |
| mdl     | Cell array of MDL-file names |
| p       | Cell array of P-file names   |
| classes | Cell array of class names    |

## Examples

List the files in toolbox/matlab/audiovideo:

```
what audiovideo
```

M-files in directory matlabroot\toolbox\matlab\audiovideo

```
Contents          aviinfo          render_uimgaudiotoolbar
audiodevinfo      aviread         sound
audioplayerreg    lin2mu          soundsc
audiorecorderreg mmcompinfo      wavfinfo
audiouniquename  mmfileinfo      wavplay
aufinfo          movie2avi       wavread
auread           mu2lin          wavrecord
auwrite          prefspanel      wavwrite
avifinfo         render_fullaudiotoolbar
```

MAT-files in directory matlabroot\toolbox\matlab\audiovideo

```
chirp            handel          splat
gong             laughter        train
```

MEX-files in directory matlabroot\toolbox\matlab\audiovideo

```
winaudioplayer    winaudiorecorder
```

Classes in directory matlabroot\toolbox\matlab\audiovideo

```
audioplayer      audiorecorder   avifile         mmreader
```

Obtain a structure array containing the MATLAB filenames in toolbox/matlab/general:

```
s = what('general')
s =
    path: 'matlabroot:\toolbox\matlab\general'
      m: {87x1 cell}
      mat: {0x1 cell}
```

# what

---

```
mex: {2x1 cell}
mdl: {0x1 cell}
  p: {'callgraphviz.p'}
classes: {0x1 cell}
```

## See Also

dir, exist, lookfor, mfilename, path, which, who



**Purpose** Release Notes for MathWorks products

**Syntax** `whatsnew`

**Description** `whatsnew` displays the Release Notes in the Help browser, presenting information about new features, problems from previous releases that have been fixed in the current release, and compatibility issues, all organized by product.

**See Also** `help`, `version`

# which

---

## Purpose

Locate functions and files

## Graphical Interface

As an alternative to the `which` function, use the “Current Directory Browser”.

## Syntax

```
which fun
which classname/fun
which private/fun
which classname/private/fun
which fun1 in fun2
which fun(a,b,c,...)
which file.ext
which fun -all
s = which('fun',...)
```

## Description

`which fun` displays the full pathname for the argument `fun`. If `fun` is a

- MATLAB function or Simulink model in an M, P, or MDL file on the MATLAB path, then `which` displays the full pathname for the corresponding file
- Workspace variable, then `which` displays a message identifying `fun` as a variable
- Method in a loaded Java class, then `which` displays the package, class, and method name for that method

If `fun` is an overloaded function or method, then `which fun` returns only the pathname of the first function or method found.

`which classname/fun` displays the full pathname for the M-file defining the `fun` method in MATLAB class, `classname`. For example, `which serial/fopen` displays the path for `fopen.m` in the MATLAB class directory, `@serial`.

`which private/fun` limits the search to private functions. For example, `which private/orthog` displays the path for `orthog.m` in the `/private` subdirectory of `toolbox/matlab/elmata`.

`which classname/private/fun` limits the search to private methods defined by the MATLAB class, `classname`. For example, `which dfilt/private/todtf` displays the path for `todtf.m` in the private directory of the `dfilt` class.

`which fun1 in fun2` displays the pathname to function `fun1` in the context of the M-file `fun2`. You can use this form to determine whether a subfunction is being called instead of a function on the path. For example, `which get in editpath` tells you which `get` function is called by `editpath.m`.

During debugging of `fun2`, using `which fun1` gives the same result.

`which fun(a,b,c,...)` displays the path to the specified function with the given input arguments. For example, `which feval(g)`, when `g=inline('sin(x)')`, indicates that `inline/feval.m` would be invoked. `which toLowerCase(s)`, when `s=java.lang.String('my Java string')`, indicates that the `toLowerCase` method in class `java.lang.String` would be invoked.

`which file.ext` displays the full pathname of the specified file if that file is in the current working directory or on the MATLAB path. To display the path for a file that has no file extension, type “`which file.`” (the period following the filename is required). Use `exist` to check for the existence of files anywhere else.

`which fun -all d` displays the paths to all items on the MATLAB path with the name `fun`. You may use the `-all` qualifier with any of the above formats of the `which` function.

`s = which('fun',...)` returns the results of `which` in the string `s`. For workspace variables, `s` is the string `'variable'`. You may specify an output variable in any of the above formats of the `which` function.

If `-all` is used with this form, the output `s` is always a cell array of strings, even if only one string is returned.

## Examples

The statement below indicates that `pinv` is in the `matfun` directory of MATLAB.

# which

---

```
which pinv
matlabroot\toolbox\matlab\matfun\pinv.m
```

To find the fopen function used on MATLAB serial class objects

```
which serial/fopen
matlabroot\toolbox\matlab\iofun\@serial\fopen.m % serial method
```

To find the setTitle method used on objects of the Java Frame class, the class must first be loaded into MATLAB. The class is loaded when you create an instance of the class:

```
frameObj = java.awt.Frame;

which setTitle
java.awt.Frame.setTitle % Frame method
```

When you specify an output variable, which returns a cell array of strings to the variable. You must use the *function* form of which, enclosing all arguments in parentheses and single quotes:

```
s = which('private/stradd', '-all');
whos s
  Name      Size      Bytes  Class
  s         3x1         562   cell array
Grand total is 146 elements using 562 bytes
```

## See Also

dir, doc, exist, lookfor, mfilename, path, type, what, who

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Repeatedly execute statements while condition is true                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>      | <code>while expression, statements, end</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Description</b> | <p><code>while expression, statements, end</code> repeatedly executes one or more MATLAB <i>statements</i> in a loop, continuing until <i>expression</i> no longer holds true or until MATLAB encounters a <code>break</code>, or <code>return</code> instruction, thus forcing an immediate exit of the loop. If MATLAB encounters a <code>continue</code> statement in the loop code, it immediately exits the current pass at the location of the <code>continue</code> statement, skipping any remaining code in that pass, and begins another pass at the start of the loop <i>statements</i> with the value of the loop counter incremented by 1.</p> <p><i>expression</i> is a MATLAB expression that evaluates to a result of logical 1 (true) or logical 0 (false). <i>expression</i> can be scalar or an array. It must contain all real elements, and the statement <code>all(A(:))</code> must be equal to logical 1 for the expression to be true.</p> <p><i>expression</i> usually consists of variables or smaller expressions joined by relational operators (e.g., <code>count &lt; limit</code>) or logical functions (e.g., <code>isreal(A)</code>). Simple expressions can be combined by logical operators (<code>&amp;&amp;</code>, <code>  </code>, <code>~</code>) into compound expressions such as the following. MATLAB evaluates compound expressions from left to right, adhering to “Operator Precedence” rules.</p> <pre>(count &lt; limit) &amp;&amp; ((height - offset) &gt;= 0)</pre> <p><i>statements</i> is one or more MATLAB statements to be executed only while the <i>expression</i> is true or nonzero.</p> <p>The scope of a <code>while</code> statement is always terminated with a matching <code>end</code>.</p> <p>See “Program Control Statements” in the MATLAB Programming documentation for more information on controlling the flow of your program code.</p> |

## Remarks

### Nonscalar Expressions

If the evaluated expression yields a nonscalar value, then every element of this value must be true or nonzero for the entire expression to be considered true. For example, the statement `while (A < B)` is true only if each element of matrix A is less than its corresponding element in matrix B. See “Example 2 – Nonscalar Expression” on page 2-3727, below.

### Partial Evaluation of the Expression Argument

Within the context of an `if` or `while` expression, MATLAB does not necessarily evaluate all parts of a logical expression. In some cases it is possible, and often advantageous, to determine whether an expression is true or false through only partial evaluation.

For example, if A equals zero in statement 1 below, then the expression evaluates to false, regardless of the value of B. In this case, there is no need to evaluate B and MATLAB does not do so. In statement 2, if A is nonzero, then the expression is true, regardless of B. Again, MATLAB does not evaluate the latter part of the expression.

```
1)   while (A && B)           2)   while (A || B)
```

You can use this property to your advantage to cause MATLAB to evaluate a part of an expression only if a preceding part evaluates to the desired state. Here are some examples.

```
while (b ~= 0) && (a/b > 18.5)
if exist('myfun.m') && (myfun(x) >= y)
if iscell(A) && all(cellfun('isreal', A))
```

### Empty Arrays

In most cases, using `while` on an empty array returns false. There are some conditions however under which `while` evaluates as true on an empty array. Two examples of this are

```
A = [];
while all(A), do_something, end
while 1|A, do_something, end
```

## Short-Circuiting Behavior

When used in the context of a `while` or `if` expression, and only in this context, the element-wise `|` and `&` operators use short-circuiting in evaluating their expressions. That is, `A|B` and `A&B` ignore the second operand, `B`, if the first operand, `A`, is sufficient to determine the result.

See “Short-Circuiting in Elementwise Operators” for more information on this.

## Examples

### Example 1 – Simple while Statement

The variable `eps` is a tolerance used to determine such things as near singularity and rank. Its initial value is the *machine epsilon*, the distance from 1.0 to the next largest floating-point number on your machine. Its calculation demonstrates `while` loops.

```
eps = 1;
while (1+eps) > 1
    eps = eps/2;
end
eps = eps*2
```

This example is for the purposes of illustrating `while` loops only and should not be executed in your MATLAB session. Doing so will disable the `eps` function from working in that session.

### Example 2 – Nonscalar Expression

Given matrices `A` and `B`,

```
A =           B =
     1     0     1     1
     2     3     3     4
```

| Expression            | Evaluates As | Because                                                    |
|-----------------------|--------------|------------------------------------------------------------|
| <code>A &lt; B</code> | false        | <code>A(1,1)</code> is not less than <code>B(1,1)</code> . |

# while

---

| Expression    | Evaluates As | Because                                                              |
|---------------|--------------|----------------------------------------------------------------------|
| $A < (B + 1)$ | true         | Every element of A is less than that same element of B with 1 added. |
| $A \& B$      | false        | $A(1,2)$ is false, and B is ignored due to short-circuiting.         |
| $B < 5$       | true         | Every element of B is less than 5.                                   |

## See Also

end, for, break, continue, return, all, any, if, switch



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Change axes background color                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Syntax</b>      | <pre>whitebg whitebg(fig) whitebg(ColorSpec) whitebg(fig, ColorSpec) whitebg(fig, ColorSpec) whitebg(fig)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Description</b> | <p><code>whitebg</code> complements the colors in the current figure.</p> <p><code>whitebg(fig)</code> complements colors in all figures specified in the vector <code>fig</code>.</p> <p><code>whitebg(ColorSpec)</code> and <code>whitebg(fig, ColorSpec)</code> change the color of the axes, which are children of the figure, to the color specified by <code>ColorSpec</code>. Without a figure specification, <code>whitebg</code> or <code>whitebg(ColorSpec)</code> affects the current figure and the root's default properties so subsequent plots and new figures use the new colors.</p> <p><code>whitebg(fig, ColorSpec)</code> sets the default axes background color of the figures in the vector <code>fig</code> to the color specified by <code>ColorSpec</code>. Other axes properties and the figure background color can change as well so that graphs maintain adequate contrast. <code>ColorSpec</code> can be a 1-by-3 RGB color or a color string such as 'white' or 'w'.</p> <p><code>whitebg(fig)</code> complements the colors of the objects in the specified figures. This syntax is typically used to toggle between black and white axes background colors, and is where <code>whitebg</code> gets its name. Include the root window handle (0) in <code>fig</code> to affect the default properties for new windows or for <code>clf</code> reset.</p> |
| <b>Remarks</b>     | <p><code>whitebg</code> works best in cases where all the axes in the figure have the same background color.</p> <p><code>whitebg</code> changes the colors of the figure's children, with the exception of shaded surfaces. This ensures that all objects are visible against the new background color. <code>whitebg</code> sets the default properties on the root such that all subsequent figures use the new background color.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

# whitebg

---

## Examples

Set the background color to blue-gray.

```
whitebg([0 .5 .6])
```

Set the background color to blue.

```
whitebg('blue')
```

## See Also

ColorSpec, colordef

The figure graphics object property `InvertHardCopy`

“Color Operations” on page 1-98 for related functions

**Purpose**

List variables in workspace

**Graphical Interface**

As an alternative to whos, use the Workspace browser. Or use the Current Directory browser to view the contents of MAT-files without loading them.

**Syntax**

```
who
whos
who(variable_list)
whos(variable_list)
who(variable_list, qualifiers)
whos(variable_list, qualifiers)
s = who(variable_list, qualifiers)
s = whos(variable_list, qualifiers)
who variable_list qualifiers
whos variable_list qualifiers
```

Each of these syntaxes apply to both who and whos:

**Description**

who lists in alphabetical order all variables in the currently active workspace.

whos lists in alphabetical order all variables in the currently active workspace along with their sizes and types. It also reports the totals for sizes.

---

**Note** If who or whos is executed within a nested function, MATLAB lists the variables in the workspace of that function and in the workspaces of all functions containing that function. See the Remarks section, below.

---

who(variable\_list) and whos(variable\_list) list only those variables specified in variable\_list, where variable\_list is a comma-delimited list of quoted strings: 'var1', 'var2', ..., 'varN'. You can use the wildcard character \* to display variables that

# who, whos

---

match a pattern. For example, `who('A*')` finds all variables in the current workspace that start with A.

`who(variable_list, qualifiers)` and `whos(variable_list, qualifiers)` list those variables in `variable_list` that meet all qualifications specified in `qualifiers`. You can specify any or all of the following qualifiers, and in any order.

| Qualifier Syntax      | Description                                                                        | Example                                       |
|-----------------------|------------------------------------------------------------------------------------|-----------------------------------------------|
| 'global'              | List variables in the global workspace.                                            | <code>whos('global')</code>                   |
| '-file',<br>filename  | List variables in the specified MAT-file. Use the full path for filename.          | <code>whos('-file', 'mydata')</code>          |
| '-regexp',<br>explist | List variables that match any of the regular expressions in <code>explist</code> . | <code>whos('-regexp', '[AB].', '\w\d')</code> |

`s = who(variable_list, qualifiers)` returns cell array `s` containing the names of the variables specified in `variable_list` that meet the conditions specified in `qualifiers`.

`s = whos(variable_list, qualifiers)` returns structure `s` containing the following fields for the variables specified in `variable_list` that meet the conditions specified in `qualifiers`:

| Field Name | Description                                                                           |
|------------|---------------------------------------------------------------------------------------|
| name       | Name of the variable                                                                  |
| size       | Dimensions of the variable array                                                      |
| bytes      | Number of bytes allocated for the variable array                                      |
| class      | Class of the variable. Set to the string '(unassigned)' if the variable has no value. |

| Field Name | Description                                                                                                                                                                                                        |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| global     | True if the variable is global; otherwise false                                                                                                                                                                    |
| sparse     | True if the variable is sparse; otherwise false                                                                                                                                                                    |
| complex    | True if the variable is complex; otherwise false                                                                                                                                                                   |
| nesting    | Structure having the following fields: <ul style="list-style-type: none"> <li>function — Name of the nested or outer function that defines the variable</li> <li>level — Nesting level of that function</li> </ul> |
| persistent | True if the variable is persistent; otherwise false                                                                                                                                                                |

`who` `variable_list` `qualifiers` and `whos` `variable_list` `qualifiers` are the unquoted forms of the syntax. Both `variable_list` and `qualifiers` are space-delimited lists of unquoted strings.

## Remarks

**Nested Functions.** When you use `who` or `whos` inside of a nested function, MATLAB returns or displays all variables in the workspace of that function, and in the workspaces of all functions in which that function is nested. This applies whether you include calls to `who` or `whos` in your M-file code or if you call `who` or `whos` from the MATLAB debugger.

If your code assigns the output of `whos` to a variable, MATLAB returns the information in a structure array containing the fields described above. If you do not assign the output to a variable, MATLAB displays the information at the Command Window, grouped according to workspace.

If your code assigns the output of `who` to a variable, MATLAB returns the variable names in a cell array of strings. If you do not assign the output, MATLAB displays the variable names at the Command Window, but not grouped according to workspace.

**Compressed Data.** Information returned by the command `whos -file` is independent of whether the data in that file is compressed or not. The byte counts returned by this command represent the number of bytes data occupies in the MATLAB workspace, and not in the file the data was saved to. See the function reference for `save` for more information on data compression.

**MATLAB Objects.** `whos -file filename` does not return the sizes of any MATLAB objects that are stored in file `filename`.

## Examples

### Example 1

Show variable names starting with the letter a:

```
who a*
```

Show variables stored in MAT-file `mydata.mat`:

```
who -file mydata
```

### Example 2

Return information on variables stored in file `mydata.mat` in structure array `s`:

```
s = whos('-file', 'mydata1')
s =
6x1 struct array with fields:
    name
    size
    bytes
    class
    global
    sparse
    complex
    nesting
    persistent
```

Display the name, size, and class of each of the variables returned by whos:

```
for k=1:length(s)
disp([' ' s(k).name ' ' mat2str(s(k).size) ' ' s(k).class])
end
A [1 1] double
spArray [5 5] double
strArray [2 5] cell
x [3 2 2] double
y [4 5] cell
```

### Example 3

Show variables that start with java and end with Array. Also show their dimensions and class name:

```
whos -file mydata2 -regexp \<java.*Array\>
Name           Size           Bytes  Class

javaCharArray  3x1             24      java.lang.String[][][]
javaDb1Array   4x1             32      java.lang.Double[][]
javaIntArray   14x1            112     java.lang.Integer[][]
```

### Example 4

The function shown here uses variables with persistent, global, sparse, and complex attributes:

```
function show_attributes
persistent p;
global g;
o = 1; g = 2;
s = sparse(eye(5));
c = [4+5i 9-3i 7+6i];
whos
```

When the function is run, whos displays these attributes:

```
show_attributes
```

# who, whos

---

| Name | Size | Bytes | Class  | Attributes |
|------|------|-------|--------|------------|
| c    | 1x3  | 48    | double | complex    |
| g    | 1x1  | 8     | double | global     |
| p    | 1x1  | 8     | double | persistent |
| s    | 5x5  | 84    | double | sparse     |

## Example 5

Function `whos_demo` contains two nested functions. One of these functions calls `whos`; the other calls `who`:

```
function whos_demo
date_time = datestr(now);

[str pos] = textscan(date_time, '%s%s%s', ...
                    1, 'delimiter', '- :');
get_date(str);

str = textscan(date_time(pos+1:end), '%s%s%s', ...
              1, 'delimiter', '- :');
get_time(str);

function get_date(d)
    day = d{1};    mon = d{2};    year = d{3};
    whos
end
function get_time(t)
    hour = t{1};    min = t{2};    sec = t{3};
    who
end
end
```

When nested function `get_date` calls `whos`, MATLAB displays information on the variables in all workspaces that are in scope at the time. This includes nested function `get_date` and also the function in which it is nested, `whos_demo`. The information is grouped by workspace:



```
whos_demo
  Name          Size          Bytes  Class

---- get_date -----
  d             1x3             378   cell
  day           1x1             64   cell
  mon           1x1             66   cell
  year          1x1             68   cell

---- whos_demo -----
  ans           0x0              0   (unassigned)
  date_time     1x20             40   char
  pos           1x1              8   double
  str           1x3             378   cell
```

When nested function `get_time` calls `who`, MATLAB displays names of the variables in the workspaces that are in scope at the time. This includes nested function `get_time` and also the function in which it is nested, `whos_demo`. The information is not grouped by workspace in this case:

Your variables are:

```
hour      min      sec      t      ans      date_time
pos       str
```

## See Also

`assignin`, `clear`, `computer`, `dir`, `evalin`, `exist`, `inmem`, `load`, `save`, `what`, `workspace`

# wilkinson

---

**Purpose** Wilkinson's eigenvalue test matrix

**Syntax** `W = wilkinson(n)`

**Description** `W = wilkinson(n)` returns one of J. H. Wilkinson's eigenvalue test matrices. It is a symmetric, tridiagonal matrix with pairs of nearly, but not exactly, equal eigenvalues.

**Examples** `wilkinson(7)`

`ans =`

```
    3    1    0    0    0    0    0
    1    2    1    0    0    0    0
    0    1    1    1    0    0    0
    0    0    1    0    1    0    0
    0    0    0    1    1    1    0
    0    0    0    0    1    2    1
    0    0    0    0    0    1    3
```

The most frequently used case is `wilkinson(21)`. Its two largest eigenvalues are both about 10.746; they agree to 14, but not to 15, decimal places.

**See Also** `eig`, `gallery`, `pascal`

**Purpose** Open file in appropriate application (Windows)

**Syntax** `winopen(filename)`

**Description** `winopen(filename)` opens `filename` in the appropriate Microsoft Windows application. The `filename` input is a string enclosed in single quotes. The `winopen` function uses the appropriate Windows shell command, and performs the same action as if you double-click the file in the Windows Explorer. If `filename` is not in the current directory, specify the absolute path for `filename`.

**Examples** Open the file `thesis.doc`, located in the current directory, in Microsoft Word:

```
winopen('thesis.doc')
```

Open `myresults.html` in your system's default Web browser:

```
winopen('D:/myfiles/myresults.html')
```

**See Also** `dos`, `open`, `web`

# winqueryreg

---

**Purpose** Item from Microsoft Windows registry

**Syntax**

```
valnames = winqueryreg('name', 'rootkey', 'subkey')  
value = winqueryreg('rootkey', 'subkey', 'valname')  
value = winqueryreg('rootkey', 'subkey')
```

**Description** `valnames = winqueryreg('name', 'rootkey', 'subkey')` returns all value names in `rootkey\subkey` in a cell array of strings. The first argument is the literal quoted string, 'name'.

`value = winqueryreg('rootkey', 'subkey', 'valname')` returns the value for value name `valname` in `rootkey\subkey`.

If the value retrieved from the registry is a string, `winqueryreg` returns a string. If the value is a 32-bit integer, `winqueryreg` returns the value as an integer of MATLAB type `int32`.

`value = winqueryreg('rootkey', 'subkey')` returns a value in `rootkey\subkey` that has no value name property.

---

**Note** The literal **name** argument and the `rootkey` argument are case-sensitive. The `subkey` and `valname` arguments are not.

---

**Remarks** This function works only for the following registry value types:

- strings (`REG_SZ`)
- expanded strings (`REG_EXPAND_SZ`)
- 32-bit integer (`REG_DWORD`)

## Examples

### Example 1

Get the value of CLSID for the MATLAB sample COM control `mwsampctrl.2`:

```
winqueryreg 'HKEY_CLASSES_ROOT' 'mwsamp.mwsampctrl.2\clsid'
```

```
ans =  
    {5771A80A-2294-4CAC-A75B-157DCDDD3653}
```

## Example 2

Get a list in variable `mousechar` for registry subkey `Mouse`, which is under subkey `Control Panel`, which is under root key `HKEY_CURRENT_USER`.

```
mousechar = winqueryreg('name', 'HKEY_CURRENT_USER', ...  
    'control panel\mouse');
```

For each name in the `mousechar` list, get its value from the registry and then display the name and its value:

```
for k=1:length(mousechar)  
    setting = winqueryreg('HKEY_CURRENT_USER', ...  
        'control panel\mouse', mousechar{k});  
    str = sprintf('%s = %s', mousechar{k}, num2str(setting));  
    disp(str)  
end
```

```
ActiveWindowTracking = 0  
DoubleClickHeight = 4  
DoubleClickSpeed = 830  
DoubleClickWidth = 4  
MouseSpeed = 1  
MouseThreshold1 = 6  
MouseThreshold2 = 10  
SnapToDefaultButton = 0  
SwapMouseButtons = 0
```

# wk1finfo

---

**Purpose** Determine whether file contains 1-2-3 WK1 worksheet

**Syntax** `[extens, typ] = wk1finfo(filename)`

**Description** `[extens, typ] = wk1finfo(filename)` returns the string 'WK1' in `extens`, and ' 1-2-3 Spreadsheet' in `typ` if the file `filename` contains a readable worksheet. The `filename` input is a string enclosed in single quotes.

**Examples** This example returns information on spreadsheet file `matA.wk1`:

```
[extens, typ] = wk1finfo('matA.wk1')  
  
extens =  
    WK1  
typ =  
    123 Spreadsheet
```

**See Also** `wk1read`, `wk1write`, `csvread`, `csvwrite`

**Purpose** Read Lotus 1-2-3 WK1 spreadsheet file into matrix

**Syntax**

```
M = wk1read(filename)
M = wk1read(filename,r,c)
M = wk1read(filename,r,c,range)
```

**Description**

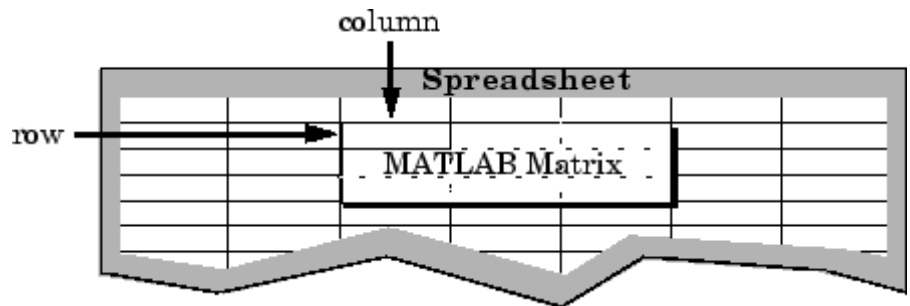
`M = wk1read(filename)` reads a Lotus1-2-3 WK1 spreadsheet file into the matrix `M`. The `filename` input is a string enclosed in single quotes.

`M = wk1read(filename,r,c)` starts reading at the row-column cell offset specified by `(r,c)`. `r` and `c` are zero based so that `r=0, c=0` specifies the first value in the file.

`M = wk1read(filename,r,c,range)` reads the range of values specified by the parameter `range`, where `range` can be

- A four-element vector specifying the cell range in the format

```
[upper_left_row upper_left_col lower_right_row lower_right_col]
```



- A cell range specified as a string, for example, 'A1...C5'
- A named range specified as a string, for example, 'Sales'

**Examples** Create a 8-by-8 matrix `A` and export it to Lotus spreadsheet `matA.wk1`:

```
A = [1:8; 11:18; 21:28; 31:38; 41:48; 51:58; 61:68; 71:78]
A =
```

# wk1read

---

```
    1    2    3    4    5    6    7    8
  11   12   13   14   15   16   17   18
  21   22   23   24   25   26   27   28
  31   32   33   34   35   36   37   38
  41   42   43   44   45   46   47   48
  51   52   53   54   55   56   57   58
  61   62   63   64   65   66   67   68
  71   72   73   74   75   76   77   78
```

```
wk1write('matA.wk1', A);
```

To read in a limited block of the spreadsheet data, specify the upper left row and column of the block using zero-based indexing:

```
M = wk1read('matA.wk1', 3, 2)
M =
    33    34    35    36    37    38
    43    44    45    46    47    48
    53    54    55    56    57    58
    63    64    65    66    67    68
    73    74    75    76    77    78
```

To select a more restricted block of data, you can specify both the upper left and lower right corners of the block you want imported. Read in a range of values from row 4, column 3 (defining the upper left corner) to row 6, column 6 (defining the lower right corner). Note that, unlike the second and third arguments, the range argument [4 3 6 6] is one-based:

```
M = wk1read('matA.wk1', 3, 2, [4 3 6 6])
M =
    33    34    35    36
    43    44    45    46
    53    54    55    56
```

## See Also

`wk1write`

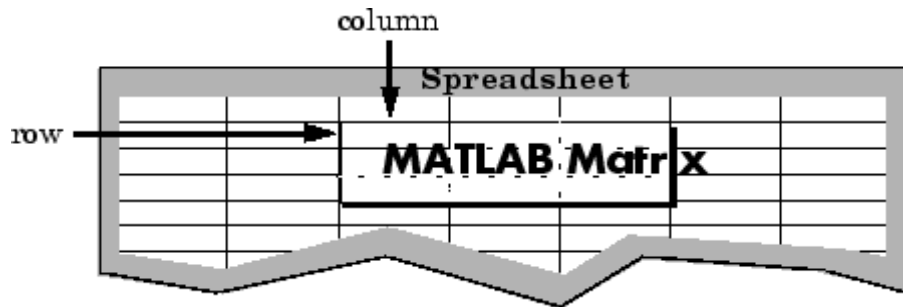


**Purpose** Write matrix to Lotus 1-2-3 WK1 spreadsheet file

**Syntax**  
`wk1write(filename,M)`  
`wk1write(filename,M,r,c)`

**Description** `wk1write(filename,M)` writes the matrix `M` into a Lotus1-2-3 WK1 spreadsheet file named `filename`. The `filename` input is a string enclosed in single quotes.

`wk1write(filename,M,r,c)` writes the matrix starting at the spreadsheet location `(r,c)`. `r` and `c` are zero based so that `r=0, c=0` specifies the first cell in the spreadsheet.



**Examples** Write a 4-by-5 matrix `A` to spreadsheet file `matA.wk1`. Place the matrix with its upper left corner at row 2, column 3 using zero-based indexing:

```
A = [1:5; 11:15; 21:25; 31:35]
```

```
A =
```

```

     1     2     3     4     5
    11    12    13    14    15
    21    22    23    24    25
    31    32    33    34    35
```

```
wk1write('matA.wk1', A, 2, 3)
```

```
M = wk1read('matA.wk1')
```

```
M =
```

# wk1write

---

```
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 1 2 3 4 5
0 0 0 11 12 13 14 15
0 0 0 21 22 23 24 25
0 0 0 31 32 33 34 35
```

## See Also

wk1read, dlmwrite, dlmread, csvwrite, csvread

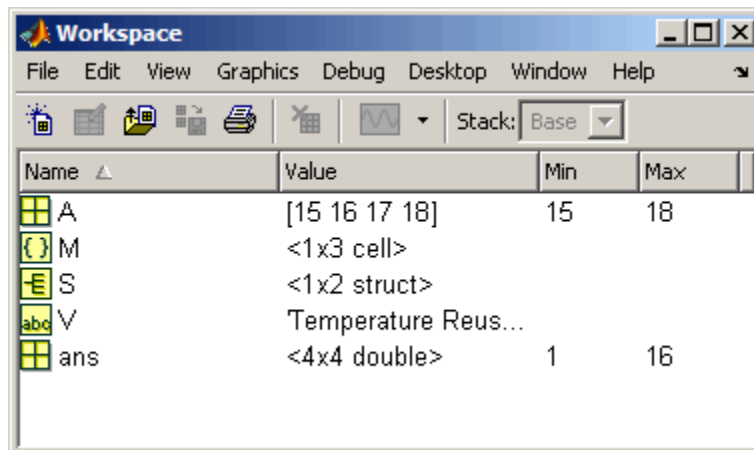
**Purpose** Open Workspace browser to manage workspace

**GUI Alternatives** As an alternative to the workspace function, select **Desktop > Workspace** in the MATLAB desktop.

**Syntax** workspace

**Description** workspace displays the Workspace browser, a graphical user interface that allows you to view and manage the contents of the MATLAB workspace. It provides a graphical representation of the whos display, and allows you to perform the equivalent of the clear, load, open, and save functions.

The Workspace browser also displays and automatically updates statistical calculations for each variable that you can choose to show or hide.



You can edit the value directly in the Workspace browser for small numeric and character arrays. To see and edit a graphical representation of larger variables and for other types, double-click the variable in the Workspace browser. The variable displays in the Array Editor, where you can view the full contents and edit it.

# workspace

---


## See Also

who

## Purpose

Label  $x$ -,  $y$ -, and  $z$ -axis

## GUI Alternative

To control the presence and appearance of axis labels on a graph, use the Property Editor, one of the plotting tools . For details, see The Property Editor in the MATLAB Graphics documentation.

## Syntax

```
xlabel('string')  
xlabel(fname)  
xlabel(..., 'PropertyName', PropertyValue, ...)  
xlabel(axes_handle, ...)  
h = xlabel(...)
```

```
ylabel(...)  
ylabel(axes_handle, ...)  
h = ylabel(...)
```

```
zlabel(...)  
zlabel(axes_handle, ...)  
h = zlabel(...)
```

## Description

Each axes graphics object can have one label for the  $x$ -,  $y$ -, and  $z$ -axis. The label appears beneath its respective axis in a two-dimensional plot and to the side or beneath the axis in a three-dimensional plot.

`xlabel('string')` labels the  $x$ -axis of the current axes.

`xlabel(fname)` evaluates the function `fname`, which must return a string, then displays the string beside the  $x$ -axis.

`xlabel(..., 'PropertyName', PropertyValue, ...)` specifies property name and property value pairs for the text graphics object created by `xlabel`.

# xlabel, ylabel, zlabel

---

`xlabel(axes_handle,...)`, `ylabel(axes_handle,...)`, and `zlabel(axes_handle,...)` plot into the axes with handle `axes_handle` instead of the current axes (`gca`).

`h = xlabel(...)`, `h = ylabel(...)`, and `h = zlabel(...)` return the handle to the text object used as the label.

`ylabel(...)` and `zlabel(...)` label the *y*-axis and *z*-axis, respectively, of the current axes.

## Remarks

Reissuing an `xlabel`, `ylabel`, or `zlabel` command causes the new label to replace the old label.

For three-dimensional graphics, MATLAB puts the label in the front or side, so that it is never hidden by the plot.

## Examples

Create a multiline label for the *x*-axis using a multiline cell array:

```
xlabel({'first line';'second line'})
```

Create a bold label for the *y*-axis that contains a single quote:

```
ylabel('George' 's Popularity','fontsize',12,'fontweight','b')
```

## See Also

`strings`, `text`, `title`


“Annotating Plots” on page 1-87 for related functions

“Adding Axis Labels to Graphs” for more information about labeling axes

## Purpose

Set or query axis limits

## GUI Alternative

To control the upper and lower axis limits on a graph, use the Property Editor, one of the plotting tools . For details, see The Property Editor in the MATLAB Graphics documentation.

## Syntax

```
xlim
xlim([xmin xmax])
xlim('mode')
xlim('auto')
xlim('manual')
xlim(axes_handle,...)
```

Note that the syntax for each of these three functions is the same; only the `xlim` function is used for simplicity. Each operates on the respective  $x$ -,  $y$ -, or  $z$ -axis.

## Description

`xlim` with no arguments returns the respective limits of the current axes.

`xlim([xmin xmax])` sets the axis limits in the current axes to the specified values.

`xlim('mode')` returns the current value of the axis limits mode, which can be either `auto` (the default) or `manual`.

`xlim('auto')` sets the axis limit mode to `auto`.

`xlim('manual')` sets the respective axis limit mode to `manual`.

`xlim(axes_handle,...)` performs the set or query on the axes identified by the first argument, `axes_handle`. When you do not specify an axes handle, these functions operate on the current axes.

## Remarks

`xlim`, `ylim`, and `zlim` set or query values of the axes object `XLim`, `YLim`, `ZLim`, and `XLimMode`, `YLimMode`, `ZLimMode` properties.

When the axis limit modes are `auto` (the default), MATLAB uses limits that span the range of the data being displayed and are round numbers.

# xlim, ylim, zlim

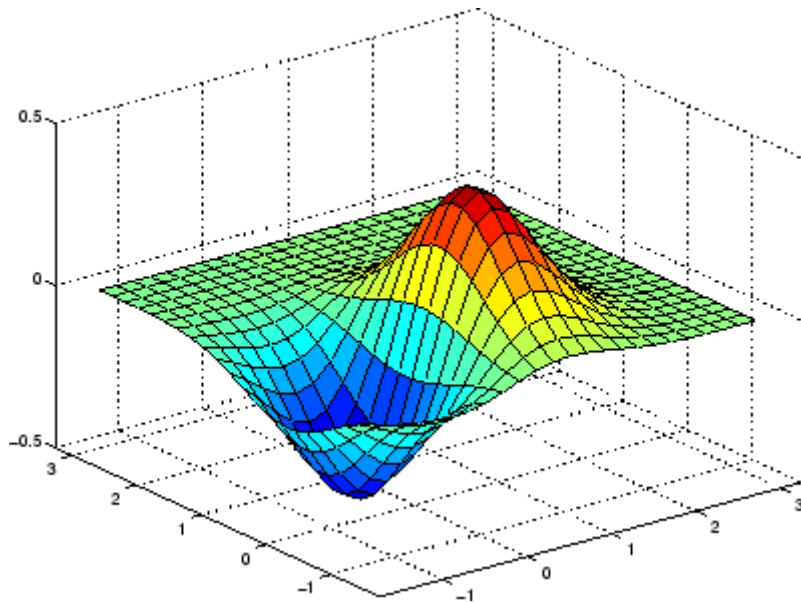
---

Setting a value for any of the limits also sets the corresponding mode to manual. Note that high-level plotting functions like `plot` and `surf` reset both the modes and the limits. If you set the limits on an existing graph and want to maintain these limits while adding more graphs, use the `hold` command.

## Examples

This example illustrates how to set the  $x$ - and  $y$ -axis limits to match the actual range of the data, rather than the rounded values of  $[-2 \ 3]$  for the  $x$ -axis and  $[-2 \ 4]$  for the  $y$ -axis originally selected by MATLAB.

```
[x,y] = meshgrid([-1.75:.2:3.25]);  
z = x.*exp(-x.^2-y.^2);  
surf(x,y,z)  
xlim([-1.75 3.25])  
ylim([-1.75 3.25])
```





## See Also

axis

The axes properties XLim, YLim, ZLim

“Setting the Aspect Ratio and Axis Limits” on page 1-100 for related functions

Understanding Axes Aspect Ratio for more information on how axis limits affect the axes

# xlsfinfo

---

**Purpose** Determine whether file contains Microsoft Excel (.xls) spreadsheet

**Syntax**

```
typ = xlsfinfo(filename)
[typ, desc] = xlsfinfo(filename)
[typ, desc, fmt] = xlsfinfo(filename)
xlsfinfo filename
```

**Description**

`typ = xlsfinfo(filename)` returns the string 'Microsoft Excel Spreadsheet' if the file specified by `filename` is an XLS file that can be read by the MATLAB `xlsread` function. Otherwise, `typ` is the empty string, (''). The `filename` input is a string enclosed in single quotes.

`[typ, desc] = xlsfinfo(filename)` returns in `desc` a cell array of strings containing the names of each spreadsheet in the file. If a spreadsheet is unreadable, the cell in `desc` that represents that spreadsheet contains an error message.

`[typ, desc, fmt] = xlsfinfo(filename)` returns in the `fmt` output a string containing the actual format of the file as obtained from the Excel COM server. On UNIX systems, or on Windows when the COM server is not available, `fmt` is returned as an empty string, ('').

---

**Note** In the case where an Excel COM server cannot be started, functionality is limited in that some Excel files might not be readable.

---

`xlsfinfo filename` is the command format for `xlsfinfo`. It returns only the first output, `typ`, assigning it to the MATLAB default variable `ans`.

**Examples** Get information about an .xls file:

```
[typ, desc, fmt] = xlsfinfo('myaccount.xls')

typ =
    Microsoft Excel Spreadsheet
```

```
desc =  
    'Sheet1'    'Income'    'Expenses'  
  
fmt =  
    xlWorkbookNormal
```

Export the .xls file to comma-separated value (CSV) format. Use `xlsfinfo` to see the format of the exported file:

```
[typ, desc, fmt] = xlsfinfo('myaccount.csv');  
fmt  
  
fmt =  
    xlCSV
```

Export the .xls file to HTML format. `xlsfinfo` returns the following format string:

```
[typ, desc, fmt] = xlsfinfo('myaccount.html');  
fmt  
  
fmt =  
    xlHtml
```

Export the .xls file to XML format. `xlsfinfo` returns the following format string:

```
[typ, desc, fmt] = xlsfinfo('myaccount.xml');  
fmt  
  
fmt =  
    xlXMLSpreadsheet
```

**See Also**`xlsread`, `xlswrite`

# xlsread

---

**Purpose** Read Microsoft Excel spreadsheet file (.xls)

**Syntax**

```
num = xlsread(filename)
num = xlsread(filename, -1)
num = xlsread(filename, sheet)
num = xlsread(filename, 'range')
num = xlsread(filename, sheet, 'range')
num = xlsread(filename, sheet, 'range', 'basic')
num = xlsread(filename, ..., functionhandle)
[num, txt]= xlsread(filename, ...)
[num, txt, raw] = xlsread(filename, ...)
[num, txt, raw, X] = xlsread(filename, ..., functionhandle)
xlsread filename sheet range basic
```

**Description** num = xlsread(filename) returns numeric data in double array num from the first sheet in the Microsoft Excel spreadsheet file named filename. The filename argument is a string enclosed in single quotes.

xlsread ignores any *outer* rows or columns of the spreadsheet that contain no numeric data. If there are single or multiple nonnumeric rows at the top or bottom, or single or multiple nonnumeric columns to the left or right, xlsread does not include these rows or columns in the output. For example, one or more header lines appearing at the top of a spreadsheet are ignored by xlsread. Any *inner* rows or columns in which some or all cells contain nonnumeric data are *not* ignored. The nonnumeric cells are instead assigned a value of NaN.

The full functionality of xlsread depends on the ability to start Excel as a COM server from MATLAB. If your system does not have this capability, the xlsread syntax that passes the 'basic' keyword is recommended. As long as the COM server is available, you can use xlsread on Excel files having formats other than XLS (for example, HTML).

---

**Note** xlsread on UNIX is being grandfathered. If the Excel COM server is not available, xlsread reads only strictly XLS files. It cannot read Excel files saved in HTML or other formats.

---

`num = xlsread(filename, -1)` opens the file `filename` in an Excel window, enabling you to interactively select the worksheet to be read and the range of data on that worksheet to import. To import an entire worksheet, first select the sheet in the Excel window and then click the **OK** button in the Data Selection Dialog box. To import a certain range of data from the sheet, select the worksheet in the Excel window, drag and drop the mouse over the desired range, and then click **OK**. (See “COM Server Requirements” on page 2-3760 below.)

`num = xlsread(filename, sheet)` reads the specified worksheet, where `sheet` is either a positive, double scalar value or a quoted string containing the sheet name. To determine the names of the sheets in a spreadsheet file, use `xlsfinfo`.

`num = xlsread(filename, 'range')` reads data from a specific rectangular region of the default worksheet (Sheet1). Specify range using the syntax '`C1:C2`', where `C1` and `C2` are two opposing corners that define the region to be read. For example, '`D2:H4`' represents the 3-by-5 rectangular region between the two corners `D2` and `H4` on the worksheet. The range input is not case sensitive and uses Excel A1 notation. (See help in Excel for more information on this notation.) (Also, see “COM Server Requirements” on page 2-3760 below.)

`num = xlsread(filename, sheet, 'range')` reads data from a specific rectangular region (`range`) of the worksheet specified by `sheet`. See the previous two syntax formats for further explanation of the `sheet` and `range` inputs. (See “COM Server Requirements” on page 2-3760 below.)

`num = xlsread(filename, sheet, 'range', 'basic')` imports data from the spreadsheet in basic import mode. This is the mode used on UNIX platforms as well as on Windows when Excel is not available as a COM server. In this mode, xlsread does not use Excel as a COM server,

and this limits import ability. Without Excel as a COM server, range is ignored and, consequently, the whole active range of a sheet is imported. (You can set range to the empty string ('')). Also, in basic mode, sheet is case-sensitive and must be a quoted string.

`num = xlsread(filename, ..., functionhandle)` calls the function associated with `functionhandle` just prior to obtaining spreadsheet values. This enables you to operate on the spreadsheet data (for example, convert it to a numeric type) before reading it in. (See “COM Server Requirements” on page 2-3760 below.)

You can write your own custom function and pass a handle to this function to `xlsread`. When `xlsread` executes, it reads from the spreadsheet, executes your function on the data read from the spreadsheet, and returns the final results to you. When `xlsread` calls your function, it passes a range interface from Excel to provide access to the data read from the spreadsheet. Your function must include this interface both as an input and output argument. Example 5 below shows how you might use this syntax.

`[num, txt] = xlsread(filename, ...)` returns numeric data in array `num` and text data in cell array `txt`. All cells in `txt` that correspond to numeric data contain the empty string.

If `txt` includes data that was previously written to the file using `xlswrite`, and the range specified for that `xlswrite` operation caused undefined data ('#N/A') to be written to the worksheet, then cells containing that undefined data are represented in the `txt` output as 'ActiveX VT\_ERROR: '.

`[num, txt, raw] = xlsread(filename, ...)` returns numeric and text data in `num` and `txt`, and unprocessed cell content in cell array `raw`, which contains both numeric and text data. (See “COM Server Requirements” on page 2-3760 below.)

`[num, txt, raw, X] = xlsread(filename, ..., functionhandle)` calls the function associated with `functionhandle` just prior to reading from the spreadsheet file. This syntax returns one additional output `X` from the function mapped to by `functionhandle`. Example 6 below

shows how you might use this syntax. (See “COM Server Requirements” on page 2-3760 below.)

`xlsread filename sheet range basic` is the command format for `xlsread`, showing its usage with all input arguments specified. When using this format, you must specify `sheet` as a string, (for example, `Income` or `Sheet4`) and not a numeric index. If the `sheet` name contains space characters, then quotation marks are required around the string, (for example, `'Income 2002'`).

## Remarks

### Handling Excel Date Values

MATLAB imports date fields from Excel files in the format in which they were stored in the Excel file. If stored in string or date format, `xlsread` returns the date as a string. If stored in a numeric format, `xlsread` returns a numeric date.

Both Excel and MATLAB represent numeric dates as a number of serial days elapsed from a specific reference date. However, Excel uses January 1, 1900 as the reference date while MATLAB uses January 0, 0000. Due to this difference in the way Excel and MATLAB compute numeric date values, any numeric date imported from Excel into MATLAB must first be converted before being used in the MATLAB application.

You can do this conversion after the `xlsread` completes, as shown below:

```
excelDates = xlsread(filename)
matlabDates = datenum('30-Dec-1899') + excelDates
datestr(matlabDates,2)
```

You can also do this as part of the `xlsread` operation by writing a conversion routine that acts directly on the Excel COM Range object, and then passing a function handle for your routine as an input to `xlsread`. The description above for the following syntax, along with Examples 5 and 6, explain how to do this:

```
[num, txt, raw, X] = xlsread(filename, ..., functionhandle)
```

## COM Server Requirements

The following six syntax formats are supported only on computer systems capable of starting Excel as a COM server from MATLAB. They are not supported in basic mode.

```
num = xlsread(filename, -1)
num = xlsread(filename, 'range')
num = xlsread(filename, sheet, 'range')
[num, txt, raw] = xlsread(filename, ...)
num = xlsread(filename, ..., functionhandle)
[num, txt, raw, opt] = xlsread(filename, ..., functionhandle)
```

## Examples

### Example 1 – Reading Numeric Data

The Microsoft Excel spreadsheet file `testdata1.xls` contains this data:

```
1    6
2    7
3    8
4    9
5   10
```

To read this data into MATLAB, use this command:

```
A = xlsread('testdata1.xls')
A =
     1     6
     2     7
     3     8
     4     9
     5    10
```

### Example 2 – Handling Text Data

The Microsoft Excel spreadsheet file `testdata2.xls` contains a mix of numeric and text data:

```
1    6
2    7
```



```
3    8
4    9
5    text
```

xlsread puts a NaN in place of the text data in the result:

```
A = xlsread('testdata2.xls')
A =
     1     6
     2     7
     3     8
     4     9
     5    NaN
```

### Example 3 – Selecting a Range of Data

To import only rows 4 and 5 from worksheet 1, specify the range as 'A4:B5':

```
A = xlsread('testdata2.xls', 1, 'A4:B5')

A =
     4     9
     5    NaN
```

### Example 4 – Handling Files with Row or Column Headers

A Microsoft Excel spreadsheet labeled Temperatures in file tempdata.xls contains two columns of numeric data with text headers for each column:

```
Time  Temp
12    98
13    99
14    97
```

If you want to import only the numeric data, use xlsread with a single return argument. Specify the filename and sheet name as inputs.

xlsread ignores any leading row or column of text in the numeric result.

```
ndata = xlsread('tempdata.xls', 'Temperatures')
```

```
ndata =  
    12    98  
    13    99  
    14    97
```

To import both the numeric data and the text data, specify two return values for `xlsread`:

```
[ndata, headertext] = xlsread('tempdata.xls', 'Temperatures')
```

```
ndata =  
    12    98  
    13    99  
    14    97  
  
headertext =  
    'Time'    'Temp'
```

## Example 5 — Passing a Function Handle

This example calls `xlsread` twice, the first time as a simple read from a file, and the second time requesting that `xlsread` execute some user-defined modifications on the data prior to returning the results of the read. These modifications are performed by a user-written function, `setMinMax`, that you pass as a function handle in the call to `xlsread`. When `xlsread` executes, it reads from the spreadsheet, executes the function on the data read from the spreadsheet, and returns the final results to you.

---

**Note** The function passed to `xlsread` operates on the copy of the data read from the spreadsheet. It does not modify data in the spreadsheet itself.

---

Read a 10-by-3 numeric array from Excel spreadsheet `testsheet.xls` with a simple `xlsread` statement that does not pass a function handle. Note that the values returned range from -587 to +4,149:

```
arr = xlsread('testsheet.xls')
arr =
    1.0e+003 *
    1.0020    4.1490    0.2300
    1.0750    0.1220   -0.4550
   -0.0301    3.0560    0.2471
    0.4070    0.1420   -0.2472
    2.1160   -0.0557   -0.5870
    0.4040    2.9280    0.0265
    0.1723    3.4440    0.1112
    4.1180    0.1820    2.8630
    0.9000    0.0573    1.9750
    0.0163    0.2000   -0.0223
```

In preparation for the second part of this example, write a function `setMinMax` that restricts the values returned from the read to be in the range of 0 to 2000. You will need to pass this function in the call to `xlsread` which will then execute the function on the data it has read before returning it to you.

When `xlsread` calls your function, it passes a range interface from Excel to provide access to the data read from the spreadsheet. This is shown as `DataRange` in this example. Your function must include this interface both as an input and output argument. The output argument allows your function to pass modified data back to `xlsread`:

```
function [DataRange] = setMinMax(DataRange)
maxval = 2000; minval = 0;

for k = 1:DataRange.Count
    v = DataRange.Value{k};
    if v > maxval || v < minval
        if v > maxval
            DataRange.Value{k} = maxval;
```

```
        else
            DataRange.Value{k} = minval;
        end
    end
end
end
```

Now call `xlsread`, passing a function handle for the `setMinMax` function as the final argument. Note the changes from the values returned from the last call to `xlsread`:

```
arr = xlsread('testsheet.xls', '', '', '', @setMinMax)
arr =
    1.0e+003 *
    1.0020    2.0000    0.2300
    1.0750    0.1220         0
         0    2.0000    0.2471
    0.4070    0.1420         0
    2.0000         0         0
    0.4040    2.0000    0.0265
    0.1723    2.0000    0.1112
    2.0000    0.1820    2.0000
    0.9000    0.0573    1.9750
    0.0163    0.2000         0
```

## Example 6 – Passing a Function Handle with Additional Output

This example adds onto the previous one by returning an additional output from the call to `setMinMax`. Modify the function so that it not only limits the range of values returned, but also reports which elements of the spreadsheet matrix have been altered. Return this information in a new output argument, `indices`:

```
function [DataRange, indices] = setMinMax(DataRange)
maxval = 2000; minval = 0;
indices = [];

for k = 1:DataRange.Count
    v = DataRange.Value{k};
```

```

if v > maxval || v < minval
    if v > maxval
        DataRange.Value{k} = maxval;
    else
        DataRange.Value{k} = minval;
    end
end
indices = [indices k];
end
end

```

When you call `xlsread` this time, account for the three initial outputs, and add a fourth called `idx` to accept the indices returned from `setMinMax`. Call `xlsread` again, and you will see just where the returned matrix has been modified:

```

[arr txt raw idx] = xlsread('testsheet.xls', ...
                            '', '', '', @setMinMax);

idx
idx =
    3     5     8    11    13    15    16    17    22    24    25    28    30
arr
arr =
    1.0e+003 *
    1.0020     2.0000     0.2300
    1.0750     0.1220         0
         0     2.0000     0.2471
    0.4070     0.1420         0
    2.0000         0         0
    0.4040     2.0000     0.0265
    0.1723     2.0000     0.1112
    2.0000     0.1820     2.0000
    0.9000     0.0573     1.9750
    0.0163     0.2000         0

```

## See Also

`xlswrite`, `xlsinfo`, `wk1read`, `textread`, `function_handle`

# xlswrite

---

**Purpose** Write Microsoft Excel spreadsheet file (.xls)

**Syntax**

```
xlswrite(filename, M)
xlswrite(filename, M, sheet)
xlswrite(filename, M, 'range')
xlswrite(filename, M, sheet, 'range')
status = xlswrite(filename, ...)
[status, message] = xlswrite(filename, ...)
xlswrite filename M sheet range
```

**Description** `xlswrite(filename, M)` writes matrix `M` to the Excel file `filename`. The `filename` input is a string enclosed in single quotes. The input matrix `M` is an `m`-by-`n` numeric, character, or cell array, where `m` < 65536 and `n` < 256. The matrix data is written to the first worksheet in the file, starting at cell A1.

`xlswrite(filename, M, sheet)` writes matrix `M` to the specified worksheet `sheet` in the file `filename`. The `sheet` argument can be either a positive, double scalar value representing the worksheet index, or a quoted string containing the sheet name.

If `sheet` does not exist, a new sheet is added at the end of the worksheet collection. If `sheet` is an index larger than the number of worksheets, empty sheets are appended until the number of worksheets in the workbook equals `sheet`. In either case, MATLAB generates a warning indicating that it has added a new worksheet.

`xlswrite(filename, M, 'range')` writes matrix `M` to a rectangular region specified by `range` in the first worksheet of the file `filename`. Specify `range` using one of the following quoted string formats:

- A cell designation, such as 'D2', to indicate the upper left corner of the region to receive the matrix data.
- Two cell designations separated by a colon, such as 'D2:H4', to indicate two opposing corners of the region to receive the matrix data. The range 'D2:H4' represents the 3-by-5 rectangular region between the two corners D2 and H4 on the worksheet.

The range input is not case sensitive and uses Excel A1 notation. (See help in Excel for more information on this notation.)

The size defined by range should fit the size of M or contain only the first cell, (e.g., 'A2'). If range is larger than the size of M, Excel fills the remainder of the region with #N/A. If range is smaller than the size of M, only the submatrix that fits into range is written to the file specified by filename.

`xlswrite(filename, M, sheet, 'range')` writes matrix M to a rectangular region specified by range in worksheet sheet of the file filename. See the previous two syntax formats for further explanation of the sheet and range inputs.

`status = xlswrite(filename, ...)` returns the completion status of the write operation in status. If the write completed successfully, status is equal to logical 1 (true). Otherwise, status is logical 0 (false). Unless you specify an output for xlswrite, no status is displayed in the Command Window.

`[status, message] = xlswrite(filename, ...)` returns any warning or error message generated by the write operation in the MATLAB structure message. The message structure has two fields:

- `message` — String containing the text of the warning or error message
- `identifier` — String containing the message identifier for the warning or error

`xlswrite filename M sheet range` is the command format for xlswrite, showing its usage with all input arguments specified. When using this format, you must specify sheet as a string (for example, Income or Sheet4). If the sheet name contains space characters, then quotation marks are required around the string (for example, 'Income 2002').

---

**Note** The above functionality depends upon having Microsoft Excel as a COM server. In absence of Excel, matrix M is written as a text file in Comma-Separated Value (CSV) format. In this mode, the sheet and range arguments are ignored.

---

## Examples

### Example 1 – Writing Numeric Data to the Default Worksheet

Write a 7-element vector to Microsoft Excel file `testdata.xls`. By default, the data is written to cells A1 through G1 in the first worksheet in the file:

```
xlswrite('testdata', [12.7 5.02 -98 63.9 0 -.2 56])
```

### Example 2 – Writing Mixed Data to a Specific Worksheet

This example writes the following mixed text and numeric data to the file `tempdata.xls`:

```
d = {'Time', 'Temp'; 12 98; 13 99; 14 97};
```

Call `xlswrite`, specifying the worksheet labeled `Temperatures`, and the region within the worksheet to write the data to. The 4-by-2 matrix will be written to the rectangular region that starts at cell E1 in its upper left corner:

```
s = xlswrite('tempdata.xls', d, 'Temperatures', 'E1')
s =
    1
```

The output status `s` shows that the write operation succeeded. The data appears as shown here in the output file:

| Time | Temp |
|------|------|
| 12   | 98   |
| 13   | 99   |
| 14   | 97   |



### Example 3 – Appending a New Worksheet to the File

Now write the same data to a worksheet that doesn't yet exist in `tempdata.xls`. In this case, MATLAB appends a new sheet to the workbook, calling it by the name you supplied in the `sheets` input argument, `'NewTemp'`. MATLAB displays a warning indicating that it has added a new worksheet to the file:

```
xlswrite('tempdata.xls', d, 'NewTemp', 'E1')  
Warning: Added specified worksheet.
```

If you don't want to see these warnings, you can turn them off using the command indicated in the message above:

```
warning off MATLAB:xlswrite:AddSheet
```

Now try the command again, this time creating another new worksheet, `NewTemp2`. Although the message is not displayed this time, you can still retrieve it and its identifier from the second output argument, `m`:

```
[stat msg] = xlswrite('tempdata.xls', d, 'NewTemp2', 'E1');  
  
msg  
msg =  
    message: 'Added specified worksheet.'  
    identifier: 'MATLAB:xlswrite:AddSheet'
```

### See Also

`xlsread`, `xlsfinfo`, `wk1read`, `textread`

# xmlread

---

**Purpose** Parse XML document and return Document Object Model node

**Syntax** DOMnode = xmlread(filename)

**Description** DOMnode = xmlread(filename) reads a URL or filename and returns a Document Object Model node representing the parsed document. The filename input is a string enclosed in single quotes. The node can be manipulated by using standard DOM functions.

A properly parsed document displays to the screen as

```
xDoc = xmlread(...)  
xDoc =  
    [#document: null]
```

**Remarks** Find out more about the Document Object Model at the World Wide Web Consortium (W3C) Web site, <http://www.w3.org/DOM/>. For specific information on using Java DOM objects, visit the Sun Web site, <http://www.java.sun.com/xml/docs/api>.

## Examples

### Example 1

All XML files have a single root element. Some XML files declare a preferred schema file as an attribute of this element. Use the `getAttribute` method of the DOM node to get the name of the preferred schema file:

```
xDoc = xmlread(fullfile(matlabroot, ...  
                        'toolbox/matlab/general/info.xml'));  
  
xRoot = xDoc.getDocumentElement;  
schemaURL = ...  
    char(xRoot.getAttribute('xsi:noNamespaceSchemaLocation'))  
  
schemaURL =  
    http://www.mathworks.com/namespace/info/v1/info.xsd
```

## Example 2

Each info.xml file on the MATLAB path contains several listitem elements with a label and callback element. This script finds the callback that corresponds to the label 'Plot Tools':

```
infoLabel = 'Plot Tools';
infoCbk = '';
itemFound = false;

xDoc = xmlread(fullfile(matlabroot, ...
    'toolbox/matlab/general/info.xml'));

% Find a deep list of all listitem elements.
allListItems = xDoc.getElementsByTagName('listitem');

% Note that the item list index is zero-based.
for k = 0:allListItems.getLength-1
    thisListItem = allListItems.item(k);
    childNode = thisListItem.getFirstChild;

    while ~isempty(childNode)
        %Filter out text, comments, and processing instructions.
        if childNode.getNodeType == childNode.ELEMENT_NODE
            % Assume that each element has a single
            % org.w3c.dom.Text child.
            childText = char(childNode.getFirstChild.getData);

            switch char(childNode.getTagname)
            case 'label';
                itemFound = strcmp(childText, infoLabel);
            case 'callback' ;
                infoCbk = childText;
            end
        end % End IF
        childNode = childNode.getNextSibling;
    end % End WHILE
```

```
        if itemFound
            break;
        else
            infoCbk = '';
        end
    end % End FOR

    disp(sprintf('Item "%s" has a callback of "%s".', ...
                infoLabel, infoCbk))
```

### Example 3

This function parses an XML file using methods of the DOM node returned by `xmlread`, and stores the data it reads in the `Name`, `Attributes`, `Data`, and `Children` fields of a MATLAB structure:

```
function theStruct = parseXML(filename)
% PARSEXML Convert XML file to a MATLAB structure.
try
    tree = xmlread(filename);
catch
    error('Failed to read XML file %s.',filename);
end

% Recurse over child nodes. This could run into problems
% with very deeply nested trees.
try
    theStruct = parseChildNodes(tree);
catch
    error('Unable to parse XML file %s.');
```

```
end

% ----- Subfunction PARSECHILDNODES -----
function children = parseChildNodes(theNode)
% Recurse over node children.
children = [];
if theNode.hasChildNodes
```

```

childNodes = theNode.getChildNodes;
numChildNodes = childNodes.getLength();
allocCell = cell(1, numChildNodes);

children = struct(
    'Name', allocCell, 'Attributes', allocCell, ...
    'Data', allocCell, 'Children', allocCell);

for count = 1:numChildNodes
    theChild = childNodes.item(count-1);
    children(count) = makeStructFromNode(theChild);
end
end

% ----- Subfunction MAKESTRUCTFROMNODE -----
function nodeStruct = makeStructFromNode(theNode)
% Create structure of node info.

nodeStruct = struct(
    'Name', char(theNode.getNodeName), ...
    'Attributes', parseAttributes(theNode), ...
    'Data', '', ...
    'Children', parseChildNodes(theNode));

if any(strcmp(methods(theNode), 'getData'))
    nodeStruct.Data = char(theNode.getData);
else
    nodeStruct.Data = '';
end

% ----- Subfunction PARSEATTRIBUTES -----
function attributes = parseAttributes(theNode)
% Create attributes structure.

attributes = [];
if theNode.hasAttributes
    theAttributes = theNode.getAttributes;

```

# xmlread

---

```
numAttributes = theAttributes.getLength;
allocCell = cell(1, numAttributes);
attributes = struct('Name', allocCell, 'Value', ...
                   allocCell);

for count = 1:numAttributes
    attrib = theAttributes.item(count-1);
    attributes(count).Name = char(attrib.getName);
    attributes(count).Value = char(attrib.getValue);
end
end
```

## See Also

xmlwrite, xslt

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Serialize XML Document Object Model node                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Syntax</b>      | <pre>xmlwrite(filename, DOMnode) str = xmlwrite(DOMnode)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Description</b> | <p><code>xmlwrite(filename, DOMnode)</code> serializes the Document Object Model node <code>DOMnode</code> to the file specified by <code>filename</code>. The <code>filename</code> input is a string enclosed in single quotes.</p> <p><code>str = xmlwrite(DOMnode)</code> serializes the Document Object Model node <code>DOMnode</code> and returns the node tree as a string, <code>s</code>.</p>                                                                                                                                                   |
| <b>Remarks</b>     | Find out more about the Document Object Model at the World Wide Web Consortium (W3C) Web site, <a href="http://www.w3.org/DOM/">http://www.w3.org/DOM/</a> . For specific information on using Java DOM objects, visit the Sun Web site, <a href="http://www.java.sun.com/xml/docs/api">http://www.java.sun.com/xml/docs/api</a> .                                                                                                                                                                                                                        |
| <b>Example</b>     | <pre>% Create a sample XML document. docNode = com.mathworks.xml.XMLUtils.createDocument...     ('root_element') docRootNode = docNode.getDocumentElement; for i=1:20     thisElement = docNode.createElement('child_node');     thisElement.appendChild...         (docNode.createTextNode(sprintf('%i',i)));     docRootNode.appendChild(thisElement); end docNode.appendChild(docNode.createComment('this is a comment'));  % Save the sample XML document. xmlFileName = [tempname, '.xml']; xmlwrite(xmlFileName, docNode); edit(xmlFileName);</pre> |
| <b>See Also</b>    | <code>xmlread</code> , <code>xslt</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

# xor

---

**Purpose** Logical exclusive-OR

**Syntax** `C = xor(A, B)`

**Description** `C = xor(A, B)` performs an exclusive OR operation on the corresponding elements of arrays A and B. The resulting element `C(i, j, ...)` is logical true (1) if `A(i, j, ...)` or `B(i, j, ...)`, but not both, is nonzero.

| <b>A</b> | <b>B</b> | <b>C</b> |
|----------|----------|----------|
| Zero     | Zero     | 0        |
| Zero     | Nonzero  | 1        |
| Nonzero  | Zero     | 1        |
| Nonzero  | Nonzero  | 0        |

**Examples** Given `A = [0 0 pi eps]` and `B = [0 -2.4 0 1]`, then

```
C = xor(A,B)
C =
    0     1     1     0
```

To see where either A or B has a nonzero element and the other matrix does not,

```
spy(xor(A,B))
```

**See Also** `all`, `any`, `find`, Elementwise Logical Operators, Short-Circuit Logical Operators



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Transform XML document using XSLT engine                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Syntax</b>      | <pre>result = xslt(source, style, dest) [result,style] = xslt(...) xslt(...,'-web')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Description</b> | <p><code>result = xslt(source, style, dest)</code> transforms an XML document using a stylesheet and returns the resulting document's URL. The function uses these inputs, the first of which is required:</p> <ul style="list-style-type: none"><li>• <code>source</code> is the filename or URL of the source XML file. <code>source</code> can also specify a DOM node.</li><li>• <code>style</code> is the filename or URL of an XSL stylesheet.</li><li>• <code>dest</code> is the filename or URL of the desired output document. If <code>dest</code> is absent or empty, the function uses a temporary filename. If <code>dest</code> is <code>'-tostring'</code>, the function returns the output document as a MATLAB string.</li></ul> <p><code>[result,style] = xslt(...)</code> returns a processed stylesheet appropriate for passing to subsequent XSLT calls as <code>style</code>. This prevents costly repeated processing of the stylesheet.</p> <p><code>xslt(...,'-web')</code> displays the resulting document in the Help Browser.</p> |
| <b>Remarks</b>     | Find out more about XSL stylesheets and how to write them at the World Wide Web Consortium (W3C) web site, <a href="http://www.w3.org/Style/XSL/">http://www.w3.org/Style/XSL/</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Example</b>     | <p>This example converts the file <code>info.xml</code> using the stylesheet <code>info.xsl</code>, writing the output to the file <code>info.html</code>. It launches the resulting HTML file in the Help Browser. MATLAB has several <code>info.xml</code> files that are used by the <b>Start</b> menu.</p> <pre>xslt info.xml info.xsl info.html -web</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

# xslt

---

## See Also

`xmlread`, `xmlwrite`

**Purpose** Create array of all zeros

**Syntax**

```
B = zeros(n)
B = zeros(m,n)
B = zeros([m n])
B = zeros(m,n,p,...)
B = zeros([m n p ...])
B = zeros(size(A))
zeros(m, n,...,classname)
zeros([m,n,...],classname)
```

**Description**

`B = zeros(n)` returns an  $n$ -by- $n$  matrix of zeros. An error message appears if  $n$  is not a scalar.

`B = zeros(m,n)` or `B = zeros([m n])` returns an  $m$ -by- $n$  matrix of zeros.

`B = zeros(m,n,p,...)` or `B = zeros([m n p ...])` returns an  $m$ -by- $n$ -by- $p$ -by-... array of zeros.

---

**Note** The size inputs  $m$ ,  $n$ ,  $p$ , ... should be nonnegative integers. Negative integers are treated as 0.

---

`B = zeros(size(A))` returns an array the same size as  $A$  consisting of all zeros.

`zeros(m, n,...,classname)` or `zeros([m,n,...],classname)` is an  $m$ -by- $n$ -by-... array of zeros of data type `classname`. `classname` is a string specifying the data type of the output. `classname` can have the following values: 'double', 'single', 'int8', 'uint8', 'int16', 'uint16', 'int32', 'uint32', 'int64', or 'uint64'.

**Example**

```
x = zeros(2,3,'int8');
```

**Remarks** The MATLAB language does not have a dimension statement; MATLAB automatically allocates storage for matrices. Nevertheless, for large

## zeros

---

matrices, MATLAB programs may execute faster if the `zeros` function is used to set aside storage for a matrix whose elements are to be generated one at a time, or a row or column at a time. For example

```
x = zeros(1,n);  
for i = 1:n, x(i) = i; end
```

### See Also

`eye`, `ones`, `rand`, `randn`, `complex`

**Purpose** Compress files into zip file

**Syntax**

```
zip(zipfile,files)
zip(zipfile,files,rootdir)
entrynames = zip(...)
```

**Description** `zip(zipfile,files)` creates a zip file with the name `zipfile` from the list of files and directories specified in `files`. Relative paths are stored in the zip file, but absolute paths are not. Directories recursively include all of their content.

`zipfile` is a string specifying the name of the zip file. The `.zip` extension is appended to `zipfile` if omitted.

`files` is a string or cell array of strings containing the list of files or directories included in `zipfile`. Individual files that are on the MATLAB path can be specified as partial pathnames. Otherwise an individual file can be specified relative to the current directory or with an absolute path. Directories must be specified relative to the current directory or with absolute paths. On UNIX systems, directories can also start with `~/` or `~username/`, which expands to the current user's home directory or the specified user's home directory, respectively. The wildcard character `*` can be used when specifying files or directories, except when relying on the MATLAB path to resolve a filename or partial pathname.

`zip(zipfile,files,rootdir)` allows the path for `files` to be specified relative to `rootdir` rather than the current directory.

`entrynames = zip(...)` returns a string cell array of the relative path entry names contained in `zipfile`.

## Examples

### Zip a File

Create a zip file of the file `guide.viewlet`, which is in the `demos` directory of MATLAB. It saves the zip file in `d:/mymfiles/viewlet.zip`.

```
file = fullfile(matlabroot,'demos','guide.viewlet');
zip('d:/mymfiles/viewlet.zip',file)
```

Run `zip` for the files `guide.viewlet` and `import.viewlet` and save the zip file in `viewlets.zip`. The source files and zipped file are in the current directory.

```
zip('viewlets.zip',{'guide.viewlet','import.viewlet'})
```

## Zip Selected Files

Run `zip` for all `.m` and `.mat` files in the current directory to the file `backup.zip`:

```
zip('backup',{'*.m','*.mat'});
```

## Zip a Directory

Run `zip` for the directory `D:/mymfiles` and its contents to the zip file `mymfiles` in the directory one level up from the current directory.

```
zip('../mymfiles','D:/mymfiles')
```


Run `zip` for the files `thesis.doc` and `defense.ppt`, which are located in `d:/PhD`, to the zip file `thesis.zip` in the current directory.

```
zip('thesis.zip',{'thesis.doc','defense.ppt'],'d:/PhD')
```

## See Also

`gzip`, `gunzip`, `tar`, `untar`, `unzip`

**Purpose** Turn zooming on or off or magnify by factor

**GUI Alternatives** Use the **Zoom** tools  on the figure toolbar to zoom in or zoom out on a plot, or select **Zoom In** or **Zoom Out** from the figure's **Tools** menu. For details, see “Enlarging the View” in the MATLAB Graphics documentation.

**Syntax**

```
zoom on
zoom off
zoom out
zoom reset
zoom
zoom xon
zoom yon
zoom(factor)
zoom(fig, option)
h = zoom(figure_handle)
```

**Description** `zoom on` turns on interactive zooming. When interactive zooming is enabled in a figure, pressing a mouse button while your cursor is within an axes zooms into the point or out from the point beneath the mouse. Zooming changes the axes limits. When using zoom mode, you

- Zoom in by positioning the mouse cursor where you want the center of the plot to be and either
  - Press the mouse button or
  - Rotate the mouse scroll wheel away from you (upward).
- Zoom out by positioning the mouse cursor where you want the center of the plot to be and either
  - Simultaneously press **Shift** and the mouse button, or
  - Rotate the mouse scroll wheel toward you (downward).

Each mouse click or scroll wheel click zooms in or out by a factor of 2.

Clicking and dragging over an axes when zooming in is enabled draws a rubberband box. When you release the mouse button, the axes zoom in to the region enclosed by the rubberband box.

Double-clicking over an axes returns the axes to its initial zoom setting in both zoom-in and zoom-out modes.

`zoom off` turns interactive zooming off.

`zoom out` returns the plot to its initial zoom setting.

`zoom reset` remembers the current zoom setting as the initial zoom setting. Later calls to `zoom out`, or double-clicks when interactive zoom mode is enabled, will return to this zoom level.

`zoom` toggles the interactive zoom status between off and on (restoring the most recently used zoom tool).

`zoom xon` and `zoom yon` set `zoom on` for the  $x$ - and  $y$ -axis, respectively.

`zoom(factor)` zooms in or out by the specified zoom factor, without affecting the interactive zoom mode. Values greater than 1 zoom in by that amount, while numbers greater than 0 and less than 1 zoom out by  $1/\text{factor}$ .

`zoom(fig, option)` Any of the preceding options can be specified on a figure other than the current figure using this syntax.

`h = zoom(figure_handle)` returns a zoom *mode object* for the figure `figure_handle` for you to customize the mode's behavior.

### Using Zoom Mode Objects

Access the following properties of zoom mode objects via `get` and modify some of them using `set`:

*Enable* 'on' | 'off'

Specifies whether this figure mode is currently enabled on the figure.

FigureHandle <handle>

The associated figure handle. This read-only property cannot be set.

*Motion* 'horizontal' | 'vertical' | 'both'



The type of zooming enabled for the figure.

*Direction* 'in' | 'out'

The direction of the zoom operation.

*RightClickAction* 'InverseZoom' | 'PostContextMenu'

The behavior of a right-click action. A value of 'InverseZoom' causes a right-click to zoom out. A value of 'PostContextMenu' displays a context menu. This setting persists between MATLAB sessions.

*ButtonDownFilter* <function\_handle>

The application can inhibit the zoom operation under circumstances the programmer defines, depending on what the callback returns. The input function handle should reference a function with two implicit arguments (similar to handle callbacks), as follows:

```
function [res] = myfunction(obj,event_obj)
% OBJ          handle to the object that has been clicked on.
% EVENT_OBJ    handle to event object (empty in this release).
% RES          a logical flag to determine whether the zoom
%              operation should take place or the 'ButtonDownFcn'
%              property of the object should take precedence.
```

*ActionPreCallback* <function\_handle>

Set this callback to listen to when a zoom operation starts. The input function handle should reference a function with two implicit arguments (similar to handle callbacks), as follows:

```
function myfunction(obj,event_obj)
% obj          handle to the figure that has been clicked on.
% event_obj    handle to event object.
```

The event object has the following read-only property:

|      |                                             |
|------|---------------------------------------------|
| Axes | The handle of the axes that is being zoomed |
|------|---------------------------------------------|

ActionPostCallback <function\_handle>

Set this callback to listen to when a zoom operation finishes. The input function handle should reference a function with two implicit arguments (similar to handle callbacks), as follows:

```
function myfunction(obj,event_obj)
% obj          handle to the figure that has been clicked on.
% event_obj    handle to event object. The object has the same
%              properties as the event_obj of the
%              'ActionPreCallback' callback.
```

UIContextMenu <handle>

Specifies a custom context menu to be displayed during a right-click action. This property is ignored if the 'RightClickZoomOut' property has been set to 'on'.

```
flags = isAllowAxesZoom(h,axes)
```

Calling the function `isAllowAxesZoom` on the zoom object, `h`, with a vector of axes handles, `axes`, as input returns a logical array of the same dimension as the axes handle vector, which indicates whether a zoom operation is permitted on the axes objects.

```
setAllowAxesZoom(h,axes,flag)
```

Calling the function `setAllowAxesZoom` on the zoom object, `h`, with a vector of axes handles, `axes`, and a logical scalar, `flag`, either allows or disallows a zoom operation on the axes objects.

```
info = getAxesZoomMotion(h,axes)
```

Calling the function `getAxesZoomMotion` on the zoom object, `H`, with a vector of axes handles, `AXES`, as input returns a character cell array of the same dimension as the axes handle vector, which indicates the type of zoom operation for each axes. Possible values for the type of operation are 'horizontal', 'vertical', or 'both'.

```
setAxesZoomMotion(h,axes,style)
```

Calling the function `setAxesZoomMotion` on the zoom object, `h`, with a vector of axes handles, `axes`, and a character array, `style`, sets the style of zooming on each axes.

## Examples

### Example 1 – Entering Zoom Mode

Plot a graph and turn on Zoom mode:

```
plot(1:10);  
zoom on  
% zoom in on the plot
```

### Example 2 – Constrained Zoom

Create zoom mode object and constrain to *x*-axis zooming:

```
plot(1:10);  
h = zoom;  
set(h,'Motion','horizontal','Enable','on');  
% zoom in on the plot in the horizontal direction.
```

### Example 3 – Constrained Zoom in Subplots

Create four axes as subplots and set zoom style differently for each by setting a different property for each axes handle:

```
ax1 = subplot(2,2,1);  
plot(1:10);  
h = zoom;  
ax2 = subplot(2,2,2);  
plot(rand(3));  
setAllowAxesZoom(h,ax2,false);  
ax3 = subplot(2,2,3);  
plot(peaks);  
setAxesZoomMotion(h,ax3,'horizontal');  
ax4 = subplot(2,2,4);  
contour(peaks);  
setAxesZoomMotion(h,ax4,'vertical');
```

```
% Zoom in on the plots.
```

## Example 4 – Coding a ButtonDown Callback

Create a `buttonDown` callback for zoom mode objects to trigger. Copy the following code to a new M-file, execute it, and observe zooming behavior:

```
function demo
% Allow a line to have its own 'ButtonDownFcn' callback.
hLine = plot(rand(1,10));
set(hLine,'ButtonDownFcn','disp(''This executes'')');
set(hLine,'Tag','DoNotIgnore');
h = zoom;
set(h,'ButtonDownFilter',@mycallback);
set(h,'Enable','on');
% mouse click on the line
%
function [flag] = mycallback(obj,event_obj)
% If the tag of the object is 'DoNotIgnore', then return true.
objTag = get(obj,'Tag');
if strcmpi(objTag,'DoNotIgnore')
    flag = true;
else
    flag = false;
end
```

## Example 5 – Coding Pre- and Post-Callback Behavior

Create callbacks for pre- and post-`buttonDown` events for zoom mode objects to trigger. Copy the following code to a new M-file, execute it, and observe zoom behavior:

```
function demo
% Listen to zoom events
plot(1:10);
h = zoom;
set(h,'ActionPreCallback',@myprecallback);
```

```

set(h,'ActionPostCallback',@mypostcallback);
set(h,'Enable','on');
%
function myprecallback(obj,evd)
disp('A zoom is about to occur.');
```

```

%
function mypostcallback(obj,evd)
newLim = get(evd.Axes,'XLim');
msgbox(sprintf('The new X-Limits are [%.2f %.2f].',newLim));
```

### Example 6 – Creating a Context Menu for Zoom Mode

Coding a context menu that lets the user to switch to Pan mode by right-clicking:

```

figure;plot(magic(10))
hCMZ = uicontextmenu;
hZMenu = uimenu('Parent',hCMZ,'Label','Switch to pan','Callback','p
hZoom = zoom(gcf);
set(hZoom,'UIContextMenu',hCMZ);
zoom('on')
```

You cannot add items to the built-in zoom context menu, but you can replace it with your own.

### Remarks

zoom changes the axes limits by a factor of 2 (in or out) each time you press the mouse button while the cursor is within an axes. You can also click and drag the mouse to define a zoom area, or double-click to return to the initial zoom level.

You can create a zoom mode object once and use it to customize the behavior of different axes, as Example 3 illustrates. You can also change its callback functions on the fly.

When you assign different zoom behaviors to different subplot axes via a mode object and then link them using the `linkaxes` function, the behavior of the axes you manipulate with the mouse carries over

## zoom

---

to the linked axes, regardless of the behavior you previously set for the other axes.

### **See Also**

linkaxes, pan, rotate3d

“Object Manipulation” on page 1-100 for related functions

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