GAMS Index for the NAG Fortran 77 Library

This index classifies NAG Fortran 77 Library routines according to Version 2 of the GAMS classification scheme described in [1]. Note that only those GAMS classes which contain Library routines, either directly or in a subclass, are included below.

A Arithmetic, error analysis
A3 Real
A3a Standard precision
`F06BLF` Compute quotient of two real scalars, with overflow flag
A4 Complex
A4a Standard precision
`A02ABF` Modulus of complex number
`A02ACF` Quotient of two complex numbers
`F06CLF` Compute quotient of two complex scalars, with overflow flag
A7 Sequences (e.g., convergence acceleration)
`C06BAF` Acceleration of convergence of sequence, Shanks' transformation and epsilon algorithm
C Elementary and special functions (*search also class L5*)
C1 Integer-valued functions (e.g., factorial, binomial coefficient, permutations, combinations, floor, ceiling)
C2 Powers, roots, reciprocals
`A02AAF` Square root of complex number
C3 Polynomials
C3a Orthogonal
C3a2 Chebyshev, Legendre
`C06DBF` Sum of a Chebyshev series
`E02AEF` Evaluation of fitted polynomial in one variable from Chebyshev series form (simplified parameter list)
`E02AHF` Derivative of fitted polynomial in Chebyshev series form
`E02AJF` Integral of fitted polynomial in Chebyshev series form
`E02AKF` Evaluation of fitted polynomial in one variable from Chebyshev series form
C4 Elementary transcendental functions
C4a Trigonometric, inverse trigonometric
`F06BCF` Recover cosine and sine from given real tangent
`F06CCF` Recover cosine and sine from given complex tangent, real cosine
`F06CDF` Recover cosine and sine from given complex tangent, real sine
`S07AAF` $\tan x$
`S09AAF` $\arcsin x$
`S09ABF` $\arccos x$
C4b Exponential, logarithmic
`S01BAF` $\ln(1+x)$
`S01EAF` Complex exponential, e^z
C4c Hyperbolic, inverse hyperbolic
`S10AAF` $\tanh x$
`S10ABF` $\sinh x$
`S10ACF` $\cosh x$
`S11AAF` $\text{arctanh} x$
`S11ABF` $\text{arcsinh} x$
`S11ACF` $\text{arccosh} x$
C5 Exponential and logarithmic integrals
`S13AAF` Exponential integral $E_1(x)$
C6 Cosine and sine integrals
`S13ACF` Cosine integral $\text{Ci}(x)$
`S13ADF` Sine integral $\text{Si}(x)$
C7 Gamma
C7a Gamma, log gamma, reciprocal gamma
`S14AAF` Gamma function
`S14ABF` Log Gamma function
C7c Psi function
`S14ACF` $\psi(x) - \ln x$
`S14ADF` Scaled derivatives of $\psi(x)$
C7e Incomplete gamma
`S14BAF` Incomplete Gamma functions $P(a,x)$ and $Q(a,x)$
C8 Error functions
C8a Error functions, their inverses, integrals, including the normal distribution function
`S15ABF` Cumulative normal distribution function $P(x)$
`S15ACF` Complement of cumulative normal distribution function $Q(x)$
`S15ADF` Complement of error function $\text{erfc}(x)$
`S15AEF` Error function $\text{erf}(x)$
`S15DDF` Scaled complex complement of error function, $\exp(-z^2)\text{erfc}(-iz)$

D2d Complex Hermitian matrices
D2d1 General
D2d1a Indefinite

`F07MRF` (CHETRF/ZHETRF) Bunch–Kaufman factorization of complex Hermitian indefinite matrix
`F07MSF` (CHETRS/ZHETRS) Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07MRF
`F07MUF` (CHECON/ZHECON) Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07MRF
`F07MVF` (CHERFS/ZHERFS) Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides
`F07MWF` (CHETRI/ZHETRI) Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07MRF
`F07PRF` (CHPTRF/ZHPTRF) Bunch–Kaufman factorization of complex Hermitian indefinite matrix, packed storage
`F07PSF` (CHPTRS/ZHPTRS) Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07PRF, packed storage
`F07PUF` (CHPCON/ZHPCON) Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07PRF, packed storage
`F07PVF` (CHPRFS/ZHPRFS) Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides, packed storage
`F07PWF` (CHPTRI/ZHPTRI) Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07PRF, packed storage

D2d1b Positive-definite

`F07FRF` (CPOTRF/ZPOTRF) Cholesky factorization of complex Hermitian positive-definite matrix
`F07FSF` (CPOTRS/ZPOTRS) Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FRF
`F07FUF` (CPOCON/ZPOCON) Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF
`F07FVF` (CPORFS/ZPORFS) Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides
`F07FWF` (CPOTRI/ZPOTRI) Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF
`F07GRF` (CPPTRF/ZPPTRF) Cholesky factorization of complex Hermitian positive-definite matrix, packed storage
`F07GSF` (CPPTRS/ZPPTRS) Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GRF, packed storage
`F07GUF` (CPPCON/ZPPCON) Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF, packed storage
`F07GVF` (CPPRFS/ZPPRFS) Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, packed storage
`F07GWF` (CPPTRI/ZPPTRI) Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF, packed storage

D2d2 Positive-definite banded

`F07HRF` (CPBTRF/ZPBTRF) Cholesky factorization of complex Hermitian positive-definite band matrix
`F07HSF` (CPBTRS/ZPBTRS) Solution of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HRF
`F07HUF` (CPBCON/ZPBCON) Estimate condition number of complex Hermitian positive-definite band matrix, matrix already factorized by F07HRF
`F07HVF` (CPBRFS/ZPBRFS) Refined solution with error bounds of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides

D2d4 Sparse

`F11JNF` Complex sparse Hermitian matrix, incomplete Cholesky factorization
`F11JPF` Solution of complex linear system involving incomplete Cholesky preconditioning matrix generated by F11JNF
`F11JQF` Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JNF (Black Box)
`F11JRF` Solution of linear system involving preconditioning matrix generated by applying SSOR to complex sparse Hermitian matrix
`F11JSF` Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)

D2e Associated operations (e.g., matrix reorderings)

`F11DKF` Real sparse nonsymmetric linear systems, line Jacobi preconditioner
`F11XAF` Real sparse nonsymmetric matrix vector multiply
`F11XEF` Real sparse symmetric matrix vector multiply
`F11XNF` Complex sparse non-Hermitian matrix vector multiply
`F11XSF` Complex sparse Hermitian matrix vector multiply
`F11ZAF` Real sparse nonsymmetric matrix reorder routine

D5 QR decomposition, Gram–Schmidt orthogonalization

- F01QGF RQ factorization of real m by n upper trapezoidal matrix ($m \leq n$)
- F01QJF RQ factorization of real m by n matrix ($m \leq n$)
- F01QKF Operations with orthogonal matrices, form rows of Q, after RQ factorization by F01QJF
- F01RGF RQ factorization of complex m by n upper trapezoidal matrix ($m \leq n$)
- F01RJF RQ factorization of complex m by n matrix ($m \leq n$)
- F01RKF Operations with unitary matrices, form rows of Q, after RQ factorization by F01RJF
- F05AAF Gram–Schmidt orthogonalisation of n vectors of order m
- F06QPF QR factorization by sequence of plane rotations, rank-1 update of real upper triangular matrix
- F06QQF QR factorization by sequence of plane rotations, real upper triangular matrix augmented by a full row
- F06QRF QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix
- F06QSF QR or RQ factorization by sequence of plane rotations, real upper spiked matrix
- F06QTF QR factorization of UZ or RQ factorization of ZU, U real upper triangular, Z a sequence of plane rotations
- F06TPF QR factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix
- F06TQF $QRxk$ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row
- F06TRF QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix
- F06TSF QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix
- F06TTF QR factorization of UZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations
- F08AEF (SGEQRF/DGEQRF) QR factorization of real general rectangular matrix
- F08AFF (SORGQR/DORGQR) Form all or part of orthogonal Q from QR factorization determined by F08AEF or F08BEF
- F08AGF (SORMQR/DORMQR) Apply orthogonal transformation determined by F08AEF or F08BEF
- F08AHF (SGELQF/DGELQF) LQ factorization of real general rectangular matrix
- F08AJF (SORGLQ/DORGLQ) Form all or part of orthogonal Q from LQ factorization determined by F08AHF
- F08AKF (SORMLQ/DORMLQ) Apply orthogonal transformation determined by F08AHF
- F08ASF (CGEQRF/ZGEQRF) QR factorization of complex general rectangular matrix
- F08ATF (CUNGQR/ZUNGQR) Form all or part of unitary Q from QR factorization determined by F08ASF or F08BSF
- F08AUF (CUNMQR/ZUNMQR) Apply unitary transformation determined by F08ASF or F08BSF
- F08AVF (CGELQF/ZGELQF) LQ factorization of complex general rectangular matrix
- F08AWF (CUNGLQ/ZUNGLQ) Form all or part of unitary Q from LQ factorization determined by F08AVF
- F08AXF (CUNMLQ/ZUNMLQ) Apply unitary transformation determined by F08AVF
- F08BEF (SGEQPF/DGEQPF) QR factorization of real general rectangular matrix with column pivoting
- F08BSF (CGEQPF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting

D6 Singular value decomposition

- F02WDF QR factorization, possibly followed by SVD
- F02WEF SVD of real matrix (Black Box)
- F02WUF SVD of real upper triangular matrix (Black Box)
- F02XEF SVD of complex matrix (Black Box)
- F02XUF SVD of complex upper triangular matrix (Black Box)
- F08KEF (SGEBRD/DGEBRD) Orthogonal reduction of real general rectangular matrix to bidiagonal form
- F08KFF (SORGBR/DORGBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF
- F08KGF (SORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF
- F08KSF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form
- F08KTF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF
- F08KUF (CUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF
- F08MEF (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix
- F08MSF (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general matrix

D8 Other matrix equations (e.g., $AX + XB = C$)
- `F08QHF` (STRSYL/DTRSYL) Solve real Sylvester matrix equation $AX + XB = C$, A and B are upper quasi-triangular or transposes
- `F08QVF` (CTRSYL/ZTRSYL) Solve complex Sylvester matrix equation $AX + XB = C$, A and B are upper triangular or conjugate-transposes

D9 Singular, overdetermined or underdetermined systems of linear equations, generalized inverses

D9a Unconstrained

D9a1 Least squares (L_2) solution
- `F04AMF` Least-squares solution of m real equations in n unknowns, rank $= n$, $m \geq n$ using iterative refinement (Black Box)
- `F04JAF` Minimal least-squares solution of m real equations in n unknowns, rank $\leq n$, $m \geq n$
- `F04JDF` Minimal least-squares solution of m real equations in n unknowns, rank $\leq n$, $m \geq n$
- `F04JGF` Least-squares (if rank $= n$) or minimal least-squares (if rank $< n$) solution of m real equations in n unknowns, rank $\leq n$, $m \geq n$
- `F04JLF` Real general Gauss–Markov linear model (including weighted least-squares)
- `F04KLF` Complex general Gauss–Markov linear model (including weighted least-squares)
- `F04QAF` Sparse linear least-squares problem, m real equations in n unknowns
- `F04YAF` Covariance matrix for linear least-squares problems, m real equations in n unknowns

D9a2 Chebyshev (L_∞) solution
- `E02GCF` L_∞-approximation by general linear function

D9a3 Least absolute value (L_1) solution
- `E02GAF` L_1-approximation by general linear function

D9b Constrained

D9b1 Least squares (L_2) solution
- `E04NCF` Convex QP problem or linearly-constrained linear least-squares problem (dense)
- `F04JMF` Equality-constrained real linear least-squares problem
- `F04KMF` Equality-constrained complex linear least-squares problem

D9b3 Least absolute value (L_1)
- `E02GBF` L_1-approximation by general linear function subject to linear inequality constraints

D9c Generalized inverses
- `F01BLF` Pseudo-inverse and rank of real m by n matrix ($m \geq n$)

E Interpolation

E1 Univariate data (curve fitting)

E1a Polynomial splines (piecewise polynomials)
- `E01BAF` Interpolating functions, cubic spline interpolant, one variable
- `E01BEF` Interpolating functions, monotonicity-preserving, piecewise cubic Hermite, one variable
- `E02BAF` Least-squares curve cubic spline fit (including interpolation)

E1b Polynomials
- `E01AAF` Interpolated values, Aitken's technique, unequally spaced data, one variable
- `E01ABF` Interpolated values, Everett's formula, equally spaced data, one variable
- `E01AEF` Interpolating functions, polynomial interpolant, data may include derivative values, one variable
- `E02AFF` Least-squares polynomial fit, special data points (including interpolation)

E1c Other functions (e.g., rational, trigonometric)
- `E01RAF` Interpolating functions, rational interpolant, one variable

E2 Multivariate data (surface fitting)

E2a Gridded
- `E01DAF` Interpolating functions, fitting bicubic spline, data on rectangular grid

E2b Scattered
- `E01SAF` Interpolating functions, method of Renka and Cline, two variables
- `E01SEF` Interpolating functions, modified Shepard's method, two variables
- `E01SGF` Interpolating functions, modified Shepard's method, two variables
- `E01SHF` Interpolated values, evaluate interpolant computed by E01SGF, function and first derivatives, two variables
- `E01TGF` Interpolating functions, modified Shepard's method, three variables
- `E01THF` Interpolated values, evaluate interpolant computed by E01TGF, function and first derivatives, three variables

E3 Service routines for interpolation

E3a Evaluation of fitted functions, including quadrature

E3a1 Function evaluation
- `E01BFF` Interpolated values, interpolant computed by E01BEF, function only, one variable
- `E01RBF` Interpolated values, evaluate rational interpolant computed by E01RAF, one variable
- `E01SBF` Interpolated values, evaluate interpolant computed by E01SAF, two variables
- `E01SFF` Interpolated values, evaluate interpolant computed by E01SEF, two variables
- `E02AEF` Evaluation of fitted polynomial in one variable from Chebyshev series form (simplified parameter list)
- `E02AKF` Evaluation of fitted polynomial in one variable from Chebyshev series form
- `E02BBF` Evaluation of fitted cubic spline, function only
- `E02BCF` Evaluation of fitted cubic spline, function and derivatives
- `E02CBF` Evaluation of fitted polynomial in two variables

G4f Other

- E04DJF Read optional parameter values for E04DGF from external file
- E04DKF Supply optional parameter values to E04DGF
- E04MGF Read optional parameter values for E04MFF from external file
- E04MHF Supply optional parameter values to E04MFF
- E04NDF Read optional parameter values for E04NCF from external file
- E04NEF Supply optional parameter values to E04NCF
- E04NGF Read optional parameter values for E04NFF from external file
- E04NHF Supply optional parameter values to E04NFF
- E04NLF Read optional parameter values for E04NKF from external file
- E04NMF Supply optional parameter values to E04NKF
- E04UDF Read optional parameter values for E04UCF or E04UFF from external file
- E04UEF Supply optional parameter values to E04UCF or E04UFF
- E04UHF Read optional parameter values for E04UGF from external file
- E04UJF Supply optional parameter values to E04UGF
- E04UQF Read optional parameter values for E04UNF from external file
- E04URF Supply optional parameter values to E04UNF
- E04XAF Estimate (using numerical differentiation) gradient and/or Hessian of a function
- H02BVF Print IP or LP solutions with user specified names for rows and columns
- H02BZF Integer programming solution, supplies further information on solution obtained by H02BBF
- H02CCF Read optional parameter values for H02CBF from external file
- H02CDF Supply optional parameter values to H02CBF
- H02CFF Read optional parameter values for H02CEF from external file
- H02CGF Supply optional parameter values to H02CEF

H Differentiation, integration

H1 Numerical differentiation

- D04AAF Numerical differentiation, derivatives up to order 14, function of one real variable
- E04XAF Estimate (using numerical differentiation) gradient and/or Hessian of a function

H2 Quadrature (numerical evaluation of definite integrals)

H2a One-dimensional integrals

H2a1 Finite interval (general integrand)

H2a1a Integrand available via user-defined procedure

H2a1a1 Automatic (user need only specify required accuracy)

- D01AHF One-dimensional quadrature, adaptive, finite interval, strategy due to Patterson, suitable for well-behaved integrands
- D01AJF One-dimensional quadrature, adaptive, finite interval, strategy due to Piessens and de Doncker, allowing for badly-behaved integrands
- D01ARF One-dimensional quadrature, non-adaptive, finite interval with provision for indefinite integrals
- D01ATF One-dimensional quadrature, adaptive, finite interval, variant of D01AJF efficient on vector machines
- D01BDF One-dimensional quadrature, non-adaptive, finite interval

H2a1a2 Nonautomatic

- D01BAF One-dimensional Gaussian quadrature

H2a1b Integrand available only on grid

H2a1b2 Nonautomatic

- D01GAF One-dimensional quadrature, integration of function defined by data values, Gill–Miller method

H2a2 Finite interval (specific or special type integrand including weight functions, oscillating and singular integrands, principal value integrals, splines, etc.)

H2a2a Integrand available via user-defined procedure

H2a2a1 Automatic (user need only specify required accuracy)

- D01AKF One-dimensional quadrature, adaptive, finite interval, method suitable for oscillating functions
- D01ALF One-dimensional quadrature, adaptive, finite interval, allowing for singularities at user-specified break-points
- D01ANF One-dimensional quadrature, adaptive, finite interval, weight function $\cos(\omega x)$ or $\sin(\omega x)$
- D01APF One-dimensional quadrature, adaptive, finite interval, weight function with end-point singularities of algebraico-logarithmic type
- D01AQF One-dimensional quadrature, adaptive, finite interval, weight function $1/(x-c)$, Cauchy principal value (Hilbert transform)
- D01AUF One-dimensional quadrature, adaptive, finite interval, variant of D01AKF efficient on vector machines

H2a2b Integrand available only on grid

H2a2b1 Automatic (user need only specify required accuracy)

- E02AJF Integral of fitted polynomial in Chebyshev series form
- E02BDF Evaluation of fitted cubic spline, definite integral

References

[1] Boisvert R F, Howe S E and Kahaner D K (1990) The guide to available mathematical software problem classification scheme. *Report NISTIR 4475* Applied and Computational Mathematics Division, National Institute of Standards and Technology.

[2] Boisvert R F, Howe S E and Kahaner D K (1985) GAMS — a framework for the management of scientific software. *ACM Trans. Math. Software* **11** 313–355.

[3] Boisvert R F (1989) The guide to available mathematical software advisory system. *Math. Comput. Simul.* **31** 453–464.