## 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.

```
Arithmetic, error analysis
\mathbf{A3}
              Real
                 Standard precision
A3a
                                        Compute quotient of two real scalars, with overflow flag
                             F06BLF
              Complex
A4
A4a
                 Standard precision
                                        Modulus of complex number
                             A02ABF
                             A02ACF
                                        Quotient of two complex numbers
                             F06CLF
                                         Compute quotient of two complex scalars, with overflow flag
A7
              Sequences (e.g., convergence acceleration)
                             CO6BAF
                                         Acceleration of convergence of sequence, Shanks' transformation and epsilon
                                        algorithm
\mathbf{C}
            Elementary and special functions (search also class L5)
              Integer-valued functions (e.g., factorial, binomial coefficient, permutations, combinations, floor, ceiling)
C1
C2
              Powers, roots, reciprocals
                                        Square root of complex number
                             A02AAF
C3
              Polynomials
C<sub>3</sub>a
                 Orthogonal
                   Chebyshev, Legendre
C3a2
                             CO6DBF
                                        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
                 Trigonometric, inverse trigonometric
C<sub>4</sub>a
                             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
                             S09AAF
                                        \arcsin x
                             S09ABF
                                        \arccos x
                 Exponential, logarithmic
C<sub>4</sub>b
                             S01BAF
                                        \ln(1+x)
                             S01EAF
                                        Complex exponential, e^z
                 Hyperbolic, inverse hyperbolic
C4c
                             S10AAF
                                        \tanh x
                             S10ABF
                                        \sinh x
                             S10ACF
                                        \cosh x
                             S11AAF
                                        arctanhx
                             S11ABF
                                        \operatorname{arcsinh} x
                             S11ACF
                                        \operatorname{arccosh} x
              Exponential and logarithmic integrals
C5
                             S13AAF
                                         Exponential integral E_1(x)
              Cosine and sine integrals
C6
                                         Cosine integral Ci(x)
                             S13ACF
                             S13ADF
                                        Sine integral Si(x)
C7
              Gamma.
C7a
                 Gamma, log gamma, reciprocal gamma
                                        Gamma function
                             S14AAF
                                        Log Gamma function
                             S14ABF
C7c
                 Psi function
                             S14ACF
                             S14ADF
                                        Scaled derivatives of \psi(x)
                 Incomplete gamma
C7e
                             S14BAF
                                        Incomplete Gamma functions P(a, x) and Q(a, x)
C8
               Error functions
                 Error functions, their inverses, integrals, including the normal distribution function
C8a
                             S15ABF
                                        Cumulative normal distribution function P(x)
                             S15ACF
                                        Complement of cumulative normal distribution function Q(x)
                             S15ADF
                                        Complement of error function \operatorname{erfc}(x)
                             S15AEF
                                        Error function erf(x)
                                        Scaled complex complement of error function, \exp(-z^2)\operatorname{erfc}(-iz)
                             S15DDF
```

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```
C8b
                 Fresnel integrals
                            S20ACF
                                        Fresnel integral S(x)
                            S20ADF
                                        Fresnel integral C(x)
C8c
                 Dawson's integral
                            S15AFF
                                        Dawson's integral
C10
               Bessel functions
C<sub>10</sub>a
                 J, Y, H_1, H_2
C10a1
                   Real argument, integer order
                                        Bessel function Y_0(x)
                            S17ACF
                            S17ADF
                                        Bessel function Y_1(x)
                            S17AEF
                                        Bessel function J_0(x)
                            S17AFF
                                        Bessel function J_1(x)
                                       real order
                   Complex argument,
C10a4
                            S17DCF
                                        Bessel functions Y_{\nu+a}(z), real a \ge 0, complex z, \nu = 0, 1, 2, \dots
                            S17DEF
                                        Bessel functions J_{\nu+a}(z), real a \geq 0, complex z, \nu = 0, 1, 2, \dots
                                        Hankel functions H_{\nu+a}^{(j)}(z), j=1,2, real a\geq 0, complex z, \nu=0,1,2,\ldots
                            S17DLF
                 I, K
C10b
                   Real argument, integer order
C10b1
                            S18ACF
                                        Modified Bessel function K_0(x)
                            S18ADF
                                        Modified Bessel function K_1(x)
                            S18AEF
                                        Modified Bessel function I_0(x)
                            S18AFF
                                        Modified Bessel function I_1(x)
                            S18CCF
                                        Modified Bessel function e^x K_0(x)
                                        Modified Bessel function e^x K_1(x)
                            S18CDF
                                        Modified Bessel function e^{-|x|}I_0(x)
                            S18CEF
                                        Modified Bessel function e^{-|x|}I_1(x)
                            S18CFF
C10b4
                   Complex argument,
                                        real order
                                        Modified Bessel functions K_{\nu+a}(z), real a \geq 0, complex z, \nu = 0, 1, 2, ...
                            S18DCF
                                        Modified Bessel functions I_{\nu+a}(z), real a \geq 0, complex z, \nu = 0, 1, 2, \dots
                            S18DEF
C10c
                 Kelvin functions
                            S19AAF
                                        Kelvin function ber x
                            S19ABF
                                        Kelvin function bei x
                            S19ACF
                                        Kelvin function ker x
                            S19ADF
                                        Kelvin function kei x
C10d
                 Airy and Scorer functions
                            S17AGF
                                        Airy function Ai(x)
                                        Airy function Bi(x)
                            S17AHF
                            S17AJF
                                        Airy function Ai'(x)
                            S17AKF
                                        Airy function Bi'(x)
                            S17DGF
                                        Airy functions Ai(z) and Ai'(z), complex z
                            S17DHF
                                        Airy functions Bi(z) and Bi'(z), complex z
C13
              Jacobian elliptic functions, theta functions
                            S21CAF
                                        Jacobian elliptic functions sn, cn and dn
C14
              Elliptic integrals
                            S21BAF
                                        Degenerate symmetrised elliptic integral of 1st kind R_C(x,y)
                            S21BBF
                                        Symmetrised elliptic integral of 1st kind R_F(x, y, z)
                            S21BCF
                                        Symmetrised elliptic integral of 2nd kind R_D(x, y, z)
                            S21BDF
                                        Symmetrised elliptic integral of 3rd kind R_J(x, y, z, r)
\mathbf{D}
            Linear Algebra
D1
              Elementary vector and matrix operations
D1a
                 Elementary vector operations
D1a1
                   Set to constant
                            F06DBF
                                        Broadcast scalar into integer vector
                            F06EVF
                                        (SGTHRZ/DGTHRZ) Gather and set to zero real sparse vector
                            F06FBF
                                        Broadcast scalar into real vector
                                        (CGTHRZ/ZGTHRZ) Gather and set to zero complex sparse vector
                            F06GVF
                            F06HBF
                                        Broadcast scalar into complex vector
                   Minimum and maximum components
D1a2
                            F06FLF
                                        Elements of real vector with largest and smallest absolute value
                            F06JLF
                                        (ISAMAX/IDAMAX) Index, real vector element with largest absolute value
                            F06JMF
                                        (ICAMAX/IZAMAX) Index, complex vector element with largest absolute value
                            F06KLF
                                        Last non-negligible element of real vector
                   Norm
D1a3
                     L_1 (sum of magnitudes)
D1a3a
                            F06EKF
                                        (SASUM/DASUM) Sum absolute values of real vector elements
                                        (SCASUM/DZASUM) Sum absolute values of complex vector elements
D1a3b
                     L_2 (Euclidean norm)
                            F06BMF
                                        Compute Euclidean norm from scaled form
                                        Compute square root of (a^2 + b^2), real a and b
                            F06BNF
                                        (SNRM2/DNRM2) Compute Euclidean norm of real vector
                            F06EJF
                            F06FJF
                                        Update Euclidean norm of real vector in scaled form
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GAMS.2 [NP3445/2/pdf]

|       | F06FKF                       | Compute weighted Euclidean norm of real vector   |
|-------|------------------------------|--|
|       | F06JJF<br>F06KJF             | (SCNRM2/DZNRM2) Compute Euclidean norm of complex vector<br>Update Euclidean norm of complex vector in scaled form                               |
| D1a3c | $L_{\infty}$ (maximum        |  |
|       | F06FLF                       | Elements of real vector with largest and smallest absolute value   |
|       | F06JLF<br>F06JMF             | (ISAMAX/IDAMAX) Index, real vector element with largest absolute value (ICAMAX/IZAMAX) Index, complex vector element with largest absolute value |
| D1a4  | Dot product (inne            | , , , -  |
|       | F06EAF                       | (SDOT/DDOT) Dot product of two real vectors  |
|       | F06ERF                       | (SDOTI/DDOTI) Dot product of two real sparse vectors   |
|       | F06GAF<br>F06GBF             | (CDOTU/ZDOTU) Dot product of two complex vectors, unconjugated (CDOTC/ZDOTC) Dot product of two complex vectors, conjugated                      |
|       | F06GRF                       | (CDOTUI/ZDOTUI) Dot product of two complex sparse vector, unconjugated   |
|       | F06GSF                       | (CDOTCI/ZDOTCI) Dot product of two complex sparse vector, conjugated   |
|       | XO3AAF                       | Real inner product added to initial value, basic/additional precision  |
| D1a5  | X03ABF<br>Copy or exchange   | Complex inner product added to initial value, basic/additional precision (swap)  |
| Dias  | F06DFF                       | Copy integer vector  |
|       | F06EFF                       | (SCOPY/DCOPY) Copy real vector   |
|       | F06EGF                       | (SSWAP/DSWAP) Swap two real vectors  |
|       | F06GFF<br>F06GGF             | (CCOPY/ZCOPY) Copy complex vector<br>(CSWAP/ZSWAP) Swap two complex vectors  |
|       | F06KFF                       | Copy real vector to complex vector   |
| D1a6  | Multiplication by            |  |
|       | F06EDF<br>F06FDF             | (SSCAL/DSCAL) Multiply real vector by scalar<br>Multiply real vector by scalar, preserving input vector  |
|       | F06FGF                       | Negate real vector   |
|       | F06GDF                       | (CSCAL/ZSCAL) Multiply complex vector by complex scalar  |
|       | F06HDF                       | Multiply complex vector by complex scalar, preserving input vector   |
|       | F06HGF<br>F06JDF             | Negate complex vector (CSSCAL/ZDSCAL) Multiply complex vector by real scalar   |
|       | F06KDF                       | Multiply complex vector by real scalar, preserving input vector  |
| D1a7  | ,                            | vectors $x$ , $y$ and scalar $\alpha$ )  |
|       | F06ECF<br>F06ETF             | (SAXPY/DAXPY) Add scalar times real vector to real vector (SAXPYI/DAXPYI) Add scalar times real sparse vector to real sparse vector              |
|       | F06GCF                       | (CAXPY/ZAXPY) Add scalar times complex vector to complex vector  |
|       | F06GTF                       | (CAXPYI/ZAXPYI) Add scalar times complex sparse vector to complex sparse   |
| D1 0  | [7]                          | vector   |
| D1a8  | F06AAF                       | on (Givens transformation) (SROTG/DROTG) Generate real plane rotation  |
|       | F06BAF                       | Generate real plane rotation, storing tangent  |
|       | F06BEF                       | Generate real Jacobi plane rotation  |
|       | F06BHF<br>F06CAF             | Apply real similarity rotation to 2 by 2 symmetric matrix<br>Generate complex plane rotation, storing tangent, real cosine                       |
|       | F06CBF                       | Generate complex plane rotation, storing tangent, real sine  |
|       | F06CHF                       | Apply complex similarity rotation to 2 by 2 Hermitian matrix   |
|       | F06EPF                       | (SROT/DROT) Apply real plane rotation  |
|       | F06EXF<br>F06FPF             | (SROTI/DROTI) Apply plane rotation to two real sparse vectors  Apply real symmetric plane rotation to two vectors                                |
|       | F06FQF                       | Generate sequence of real plane rotations  |
|       | F06HPF                       | Apply complex plane rotation   |
|       | F06HQF<br>F06KPF             | Generate sequence of complex plane rotations  Apply real plane rotation to two complex vectors   |
| D1a9  |                              | ion (Householder transformation)   |
|       | F06FRF                       | Generate real elementary reflection, NAG style   |
|       | F06FSF                       | Generate real elementary reflection, LINPACK style   |
|       | F06FTF<br>F06FUF             | Apply real elementary reflection, NAG style Apply real elementary reflection, LINPACK style  |
|       | F06HRF                       | Generate complex elementary reflection   |
|       | F06HTF                       | Apply complex elementary reflection  |
| D1a10 | Convolutions<br>C06EKF       | Circular convolution or correlation of two real vectors, no extra workspace  |
|       | CO6FKF                       | Circular convolution or correlation of two real vectors, no extra workspace for greater  |
|       |                              | speed  |
|       | CO6PKF                       | Circular convolution or correlation of two complex vectors   |
| D1a11 | CO6PKF<br>Other vector opera | Circular convolution or correlation of two complex vectors   |
|       | F06EUF                       | (SGTHR/DGTHR) Gather real sparse vector  |
|       | F06EVF                       | (SGTHRZ/DGTHRZ) Gather and set to zero real sparse vector  |
|       | FO6EWF<br>FO6FAF             | (SSCTR/DSCTR) Scatter real sparse vector<br>Compute cosine of angle between two real vectors   |
|       | FOOTAL                       | Compare cosme of angle between two real vectors  |

|      | F06GUF                           | (CGTHR/ZGTHR) Gather complex sparse vector  |
|------|----------------------------------|---|
|      | F06GVF                           | (CGTHRZ/ZGTHRZ) Gather and set to zero complex sparse vector  |
|      | F06GWF<br>F06KLF                 | (CSCTR/ZSCTR) Scatter complex sparse vector  Last non-negligible element of real vector   |
| D1b  | Elementary matrix of             |   |
| DID  | F06QJF                           | Permute rows or columns, real rectangular matrix, permutations represented by an  |
|      |                                  | integer array   |
|      | F06QKF                           | Permute rows or columns, real rectangular matrix, permutations represented by a   |
|      | F06VJF                           | real array  Permute rows or columns, complex rectangular matrix, permutations represented   |
|      | 100431                           | by an integer array   |
|      | F06VKF                           | Permute rows or columns, complex rectangular matrix, permutations represented   |
|      | T 1. /                           | by a real array   |
| D1b1 | Initialize (e.g., to z<br>FO6QHF | • /   |
|      | F06THF                           | Matrix initialisation, real rectangular matrix  Matrix initialisation, complex rectangular matrix   |
| D1b2 | Norm                             |   |
|      | F04YCF                           | Norm estimation (for use in condition estimation), real matrix  |
|      | F04ZCF                           | Norm estimation (for use in condition estimation), complex matrix   |
|      | FOGRAF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real general matrix   |
|      | F06RBF<br>F06RCF                 | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real band matrix 1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric matrix  |
|      | F06RDF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric matrix,  |
|      |                                  | packed storage  |
|      | F06REF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric band matrix  |
|      | F06RJF                           | 1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real trapezoidal/triangular matrix  |
|      | F06RKF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real triangular matrix,   |
|      |                                  | packed storage  |
|      | F06RLF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real triangular band matrix   |
|      | F06RMF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, real Hessenberg matrix  |
|      | F06UAF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex general matrix  |
|      | F06UBF<br>F06UCF                 | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex band matrix 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian   |
|      | 100001                           | matrix  |
|      | F06UDF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian matrix, packed storage  |
|      | F06UEF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian band matrix   |
|      | F06UFF                           | 1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex symmetric   |
|      | F06UGF                           | matrix 1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex symmetric  |
|      |                                  | matrix, packed storage  |
|      | F06UHF                           | 1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex symmetric band matrix   |
|      | F06UJF                           | 1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex trapezoidal/triangular matrix   |
|      | F06UKF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex triangular matrix, packed storage   |
|      | F06ULF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex triangular  |
|      |                                  | band matrix   |
|      | F06UMF                           | 1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hessenberg matrix   |
| D1b3 | Transpose                        | matrix  |
|      | F01CRF                           | Matrix transposition  |
|      | F01CTF                           | Sum or difference of two real matrices, optional scaling and transposition  |
| D1b4 | F01CWF<br>Multiplication by v    | Sum or difference of two complex matrices, optional scaling and transposition   |
| D104 | F06HCF                           | Multiply complex vector by complex diagonal matrix  |
|      | F06KCF                           | Multiply complex vector by real diagonal matrix   |
|      | FO6PAF                           | (SGEMV/DGEMV) Matrix-vector product, real rectangular matrix  |
|      | F06PBF                           | (SGBMV/DGBMV) Matrix-vector product, real rectangular band matrix<br>(SSYMV/DSYMV) Matrix-vector product, real symmetric matrix   |
|      | F06PCF<br>F06PDF                 | (SSBMV/DSBMV) Matrix-vector product, real symmetric matrix (SSBMV/DSBMV) Matrix-vector product, real symmetric band matrix  |
|      | F06PEF                           | (SSPMV/DSPMV) Matrix-vector product, real symmetric packed matrix   |
|      | F06PFF                           | (STRMV/DTRMV) Matrix-vector product, real triangular matrix   |
|      | F06PGF                           | (STBMV/DTBMV) Matrix-vector product, real triangular band matrix  |
|      | F06PHF                           | (STPMV/DTPMV) Matrix-vector product, real triangular packed matrix  |
|      | F06SAF<br>F06SBF                 | (CGEMV/ZGEMV) Matrix-vector product, complex rectangular matrix (CGBMV/ZGBMV) Matrix-vector product, complex rectangular band matrix  |
|      | 100001                           | ( / _ = = / - / - / / / / / / / / / / / - / / / / / / / / / / / - / / / / / / / / / / / - / / / / / / / / / / / - |

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|       | FOCAGE                   | (CHEMA/ZHEMA) Matrice and an all the second and the |
|-------|--------------------------|--|
|       | F06SCF                   | (CHEMV/ZHEMV) Matrix-vector product, complex Hermitian matrix  |
|       | F06SDF                   | (CHBMV/ZHBMV) Matrix-vector product, complex Hermitian band matrix<br>(CHPMV/ZHPMV) Matrix-vector product, complex Hermitian packed matrix   |
|       | F06SEF                   |  |
|       | F06SFF                   | (CTRMV/ZTRMV) Matrix-vector product, complex triangular matrix<br>(CTBMV/ZTBMV) Matrix-vector product, complex triangular band matrix  |
|       | F06SGF                   | (CTPMV/ZTPMV) Matrix-vector product, complex triangular band matrix (CTPMV/ZTPMV) Matrix-vector product, complex triangular packed matrix  |
|       | F06SHF<br>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 Complex sparse Hermitian matrix vector multiply  |
| Dile  | F11XSF                   | 1 1 V  |
| D1b5  | Addition, subtracti      | on Sum or difference of two real matrices, optional scaling and transposition  |
|       | F01CTF                   | Sum or difference of two complex matrices, optional scaling and transposition  |
|       | F01CWF<br>F06PMF         | (SGER/DGER) Rank-1 update, real rectangular matrix   |
|       |                          |  |
|       | F06PPF<br>F06PQF         | (SSYR/DSYR) Rank-1 update, real symmetric matrix<br>(SSPR/DSPR) Rank-1 update, real symmetric packed matrix  |
|       | F06PRF                   | (SSYR2/DSYR2) Rank-2 update, real symmetric matrix   |
|       |                          | •  |
|       | F06PSF                   | (SSPR2/DSPR2) Rank-2 update, real symmetric packed matrix (CGERU/ZGERU) Rank-1 update, complex rectangular matrix, unconjugated  |
|       | F06SMF                   | vector vector  |
|       | F06SNF                   | (CGERC/ZGERC) Rank-1 update, complex rectangular matrix, conjugated vector   |
|       | F06SPF                   | (CHER/ZHER) Rank-1 update, complex rectangular matrix, conjugated vector (CHER/ZHER) Rank-1 update, complex Hermitian matrix   |
|       |                          |  |
|       | F06SQF                   | (CHPR/ZHPR) Rank-1 update, complex Hermitian packed matrix   |
|       | F06SRF                   | (CHER2/ZHER2) Rank-2 update, complex Hermitian matrix  |
|       | F06SSF                   | (CHPR2/ZHPR2) Rank-2 update, complex Hermitian packed matrix   |
|       | F06YPF                   | (SSYRK/DSYRK) Rank-k update of real symmetric matrix   |
|       | F06ZPF                   | (CHERK/ZHERK) Rank-k update of complex Hermitian matrix  |
|       | F06ZRF                   | (CHER2K/ZHER2K) Rank-2k update of complex Hermitian matrix (CSYRK/ZSYRK) Rank-k update of complex symmetric matrix   |
|       | F06ZUF<br>F06ZWF         | (CSYR2K/ZHER2K) Rank- $2k$ update of complex symmetric matrix  |
| Dile  |                          | (CSTR2R/ZITER2R) Rank-2k update of complex symmetric matrix  |
| D1b6  | Multiplication<br>F01CKF | Matrix multiplication  |
|       | F06FCF                   | Multiply real vector by diagonal matrix  |
|       | F06YAF                   | (SGEMM/DGEMM) Matrix-matrix product, two real rectangular matrices   |
|       | F06YCF                   | (SSYMM/DSYMM) Matrix-matrix product, two real rectangular matrices   |
|       | FOOTOF                   | rectangular matrix   |
|       | F06YFF                   | (STRMM/DTRMM) Matrix-matrix product, one real triangular matrix, one real  |
|       | FOOTF                    | rectangular matrix   |
|       | F06YRF                   | (SSYR2K/DSYR2K) Rank-2k update of real symmetric matrix  |
|       | F06ZAF                   | (CGEMM/ZGEMM) Matrix-matrix product, two complex rectangular matrices  |
|       | F06ZCF                   | (CHEMM/ZHEMM) Matrix-matrix product, one complex Hermitian matrix, one   |
|       | 1 00201                  | complex rectangular matrix   |
|       | F06ZFF                   | (CTRMM/ZTRMM) Matrix-matrix product, one complex triangular matrix, one  |
|       | 100211                   | complex rectangular matrix   |
|       | F06ZTF                   | (CSYMM/ZSYMM) Matrix-matrix product, one complex symmetric matrix, one   |
|       | 100211                   | complex rectangular matrix   |
| D1b8  | Сору                     |  |
| 2100  | F06QFF                   | Matrix copy, real rectangular or trapezoidal matrix  |
|       | F06TFF                   | Matrix copy, complex rectangular or trapezoidal matrix   |
| D1b9  | Storage mode conv        |  |
|       | F01ZAF                   | Convert real matrix between packed triangular and square storage schemes   |
|       | F01ZBF                   | Convert complex matrix between packed triangular and square storage schemes  |
|       | F01ZCF                   | Convert real matrix between packed banded and rectangular storage schemes  |
|       | F01ZDF                   | Convert complex matrix between packed banded and rectangular storage schemes   |
|       | F11ZAF                   | Real sparse nonsymmetric matrix reorder routine  |
|       | F11ZBF                   | Real sparse symmetric matrix reorder routine   |
|       | F11ZPF                   | Complex sparse Hermitian matrix reorder routine  |
|       | F11ZNF                   | Complex sparse non-Hermitian matrix reorder routine  |
| D1b10 | Elementary rotatio       | n (Givens transformation)  |
|       | F06QMF                   | Orthogonal similarity transformation of real symmetric matrix as a sequence of   |
|       |                          | plane rotations  |
|       | F06QVF                   | Compute upper Hessenberg matrix by sequence of plane rotations, real upper   |
|       |                          | triangular matrix  |
|       | F06QWF                   | Compute upper spiked matrix by sequence of plane rotations, real upper triangular  |
|       |                          | matrix   |
|       | F06QXF                   | Apply sequence of plane rotations, real rectangular matrix   |
|       | F06TMF                   | Unitary similarity transformation of Hermitian matrix as a sequence of plane   |
|       |                          | rotations  |
|       | F06TVF                   | Compute upper Hessenberg matrix by sequence of plane rotations, complex upper  |
|       |                          | triangular matrix  |
|       |                          |  |

|       |               | F06TWF           | Compute upper spiked matrix by sequence of plane rotations, complex upper   |
|-------|---------------|------------------|---|
|       |               |                  | triangular matrix   |
|       |               | F06TXF           | Apply sequence of plane rotations, complex rectangular matrix, real cosine and complex sine   |
|       |               | F06TYF           | Apply sequence of plane rotations, complex rectangular matrix, complex cosine and real sine   |
|       |               | F06VXF           | Apply sequence of plane rotations, complex rectangular matrix, real cosine and sine   |
| D2    | Solution of s |                  | inear equations (including inversion, LU and related decompositions)  |
| D2a   |               | ymmetric m       |   |
| D2a1  | General       | ,                |   |
|       |               | FO3AFF           | LU factorization and determinant of real matrix   |
|       |               | FO4AAF           | Solution of real simultaneous linear equations with multiple right-hand sides (Black  |
|       |               |                  | Box)  |
|       |               | F04AEF           | Solution of real simultaneous linear equations with multiple right-hand sides using   |
|       |               |                  | iterative refinement (Black Box)  |
|       |               | FO4AHF           | Solution of real simultaneous linear equations using iterative refinement (coefficient  |
|       |               |                  | matrix already factorized by F03AFF)  |
|       |               | F04AJF           | Solution of real simultaneous linear equations (coefficient matrix already factorized   |
|       |               | E044DE           | by F03AFF)  |
|       |               | FO4ARF           | Solution of real simultaneous linear equations, one right-hand side (Black Box)   |
|       |               | F04ATF           | Solution of real simultaneous linear equations, one right-hand side using iterative   |
|       |               | E07ADE           | refinement (Black Box)  |
|       |               | F07ADF<br>F07AEF | (SGETRF/DGETRF) $LU$ factorization of real $m$ by $n$ matrix (SGETRS/DGETRS) Solution of real system of linear equations, multiple right- |
|       |               | FU/ AEF          | hand sides, matrix already factorized by F07ADF   |
|       |               | F07AGF           | (SGECON/DGECON) Estimate condition number of real matrix, matrix already  |
|       |               | FO7 AGF          | factorized by F07ADF  |
|       |               | F07AHF           | (SGERFS/DGERFS) Refined solution with error bounds of real system of linear   |
|       |               | 1011111          | equations, multiple right-hand sides  |
|       |               | F07AJF           | (SGETRI/DGETRI) Inverse of real matrix, matrix already factorized by F07ADF   |
| D2a2  | Banded        |                  |   |
| 2242  |               | F01LHF           | LU factorization of real almost block diagonal matrix   |
|       |               | F04LHF           | Solution of real almost block diagonal simultaneous linear equations (coefficient   |
|       |               |                  | matrix already factorized by F01LHF)  |
|       |               | F07BDF           | (SGBTRF/DGBTRF) $LU$ factorization of real $m$ by $n$ band matrix   |
|       |               | F07BEF           | (SGBTRS/DGBTRS) Solution of real band system of linear equations, multiple  |
|       |               |                  | right-hand sides, matrix already factorized by F07BDF   |
|       |               | F07BGF           | (SGBCON/DGBCON) Estimate condition number of real band matrix, matrix   |
|       |               |                  | already factorized by F07BDF  |
|       |               | F07BHF           | (SGBRFS/DGBRFS) Refined solution with error bounds of real band system of   |
|       |               |                  | linear equations, multiple right-hand sides   |
|       |               | F07VEF           | (STBTRS/DTBTRS) Solution of real band triangular system of linear equations,  |
|       |               |                  | multiple right-hand sides   |
|       |               | F07VGF           | (STBCON/DTBCON) Estimate condition number of real band triangular matrix  |
|       |               | F07VHF           | (STBRFS/DTBRFS) Error bounds for solution of real band triangular system of   |
| D2a2a | Tridia        | agonal           | linear equations, multiple right-hand sides   |
| Dzaza | Titale        | F01LEF           | LU factorization of real tridiagonal matrix   |
|       |               | FO4EAF           | Solution of real tridiagonal simultaneous linear equations, one right-hand side (Black  |
|       |               |                  | Box)  |
|       |               | F04LEF           | Solution of real tridiagonal simultaneous linear equations (coefficient matrix already  |
|       |               |                  | factorized by F01LEF)   |
| D2a3  | Triangu       |                  | (CERT CALL (TO ETT) CALL)   |
|       |               | F06PJF           | (STRSV/DTRSV) System of equations, real triangular matrix   |
|       |               | F06PKF           | (STBSV/DTBSV) System of equations, real triangular band matrix  |
|       |               | F06PLF           | (STPSV/DTPSV) System of equations, real triangular packed matrix  |
|       |               | F06YJF           | (STRSM/DTRSM) Solves system of equations with multiple right-hand sides, real   |
|       |               | D07800           | triangular coefficient matrix   |
|       |               | F07TEF           | (STRTRS/DTRTRS) Solution of real triangular system of linear equations, multiple right-hand sides   |
|       |               | FOTTCE           | (STRCON/DTRCON) Estimate condition number of real triangular matrix   |
|       |               | F07TGF<br>F07THF | (STRRFS/DTRRFS) Error bounds for solution of real triangular system of linear   |
|       |               | 1011111          | equations, multiple right-hand sides  |
|       |               | F07TJF           | (STRTRI/DTRTRI) Inverse of real triangular matrix   |
|       |               | F07UEF           | (STPTRS/DTPTRS) Solution of real triangular system of linear equations, multiple  |
|       |               |                  | right-hand sides, packed storage  |
|       |               | F07UGF           | (STPCON/DTPCON) Estimate condition number of real triangular matrix, packed   |
|       |               |                  | storage   |
|       |               | F07UHF           | (STPRFS/DTPRFS) Error bounds for solution of real triangular system of linear   |
|       |               |                  | equations, multiple right-hand sides, packed storage  |
|       |               | F07UJF           | (STPTRI/DTPTRI) Inverse of real triangular matrix, packed storage   |
|       |               |                  |   |

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|       | F07VEF               | (STBTRS/DTBTRS) Solution of real band triangular system of linear equations,  |
|-------|----------------------|---|
|       |                      | multiple right-hand sides   |
|       | F07VGF               | (STBCON/DTBCON) Estimate condition number of real band triangular matrix  |
|       | F07VHF               | (STBRFS/DTBRFS) Error bounds for solution of real band triangular system of   |
| D204  | Sparse               | linear equations, multiple right-hand sides   |
| D2a4  | F01BRF               | LU factorization of real sparse matrix  |
|       | F01BSF               | LU factorization of real sparse matrix with known sparsity pattern  |
|       | F04AXF               | Solution of real sparse simultaneous linear equations (coefficient matrix already   |
|       |                      | factorized)   |
|       | F04QAF               | Sparse linear least-squares problem, $m$ real equations in $n$ unknowns   |
|       | F11BAF               | Real sparse nonsymmetric linear systems, set-up for F11BBF  |
|       | F11BBF               | Real sparse nonsymmetric linear systems, preconditioned RGMRES, CGS or Bi-  |
|       | F11BCF               | CGSTAB Real sparse nonsymmetric linear systems, diagnostic for F11BBF   |
|       | F11BDF               | Real sparse nonsymmetric linear systems, set-up for F11BEF  |
|       | F11BEF               | Real sparse nonsymmetric linear systems, preconditioned RGMRES, CGS, Bi-  |
|       |                      | CGSTAB or TFQMR method  |
|       | F11BFF               | Real sparse nonsymmetric linear systems, diagnostic for F11BEF  |
|       | F11BRF               | Complex sparse non-Hermitian linear systems, set-up for F11BSF  |
|       | F11BSF               | Complex sparse non-Hermitian linear systems, preconditioned RGMRES, CGS, Bi-  |
|       | E4.4 DTE             | CGSTAB or TFQMR method  |
|       | F11BTF<br>F11DAF     | Complex sparse non-Hermitian linear systems, diagnostic for F11BSF Real sparse nonsymmetric linear systems, incomplete $LU$ factorization         |
|       | F11DBF               | Solution of linear system involving incomplete $LU$ preconditioning matrix generated  |
|       | 111221               | by F11DAF   |
|       | F11DCF               | Solution of real sparse nonsymmetric linear system, RGMRES, CGS or Bi-CGSTAB  |
|       |                      | method, preconditioner computed by F11DAF (Black Box)   |
|       | F11DDF               | Solution of linear system involving preconditioning matrix generated by applying  |
|       | F11DEF               | SSOR to real sparse nonsymmetric matrix Solution of real sparse nonsymmetric linear system, RGMRES, CGS or Bi-CGSTAB                              |
|       | FIIDEF               | method, Jacobi or SSOR preconditioner (Black Box)   |
| D2b   | Real symmetric matri | - ,   |
| D2b1  | General              |   |
| D2b1a | Indefinite           | (227,177,77,177,177,177,177,177,177,177,1   |
|       | F07MDF               | (SSYTRF/DSYTRF) Bunch–Kaufman factorization of real symmetric indefinite  |
|       | FO7MEF               | matrix (SSYTRS/DSYTRS) Solution of real symmetric indefinite system of linear equa-   |
|       | TOTTILL              | tions, multiple right-hand sides, matrix already factorized by F07MDF   |
|       | F07MGF               | (SSYCON/DSYCON) Estimate condition number of real symmetric indefinite  |
|       |                      | matrix, matrix already factorized by F07MDF   |
|       | F07MHF               | (SSYRFS/DSYRFS) Refined solution with error bounds of real symmetric indefinite   |
|       | POZN IP              | system of linear equations, multiple right-hand sides   |
|       | F07MJF               | (SSYTRI/DSYTRI) Inverse of real symmetric indefinite matrix, matrix already factorized by F07MDF  |
|       | F07PDF               | (SSPTRF/DSPTRF) Bunch–Kaufman factorization of real symmetric indefinite  |
|       |                      | matrix, packed storage  |
|       | F07PEF               | (SSPTRS/DSPTRS) Solution of real symmetric indefinite system of linear equa-  |
|       |                      | tions, multiple right-hand sides, matrix already factorized by F07PDF, packed   |
|       | F07PGF               | storage (SSPCON/DSPCON) Estimate condition number of real symmetric indefinite  |
|       | rorrar               | matrix, matrix already factorized by F07PDF, packed storage   |
|       | F07PHF               | (SSPRFS/DSPRFS) Refined solution with error bounds of real symmetric indefinite   |
|       |                      | system of linear equations, multiple right-hand sides, packed storage   |
|       | F07PJF               | (SSPTRI/DSPTRI) Inverse of real symmetric indefinite matrix, matrix already   |
| D2b1b | Positive-definite    | factorized by F07PDF, packed storage  |
| D2010 | F01ABF               | Inverse of real symmetric positive-definite matrix using iterative refinement   |
|       | F01ADF               | Inverse of real symmetric positive-definite matrix  |
|       | F01BUF               | $ULDL^TU^T$ factorization of real symmetric positive-definite band matrix   |
|       | FO3AEF               | $LL^T$ factorization and determinant of real symmetric positive-definite matrix   |
|       | F04ABF               | Solution of real symmetric positive-definite simultaneous linear equations with   |
|       | EOAAEE               | multiple right-hand sides using iterative refinement (Black Box) Solution of real symmetric positive-definite simultaneous linear equations using |
|       | F04AFF               | iterative refinement (coefficient matrix already factorized by F03AEF)  |
|       | F04AGF               | Solution of real symmetric positive-definite simultaneous linear equations (coeffi-   |
|       |                      | cient matrix already factorized by F03AEF)  |
|       | F04ASF               | Solution of real symmetric positive-definite simultaneous linear equations, one right-  |
|       |                      | hand side using iterative refinement (Black Box)  |
|       | F04FEF               | Solution of the Yule–Walker equations for real symmetric positive-definite Toeplitz   |
|       | F04FFF               | matrix, one right-hand side Solution of real symmetric positive-definite Toeplitz system, one right-hand side                                     |
|       | IOTIT                | Solution of four symmetric positive definite roophez system, one figur-hand side  |

|       | FO4MEF               | Update solution of the Yule–Walker equations for real symmetric positive-definite Toeplitz matrix  |
|-------|----------------------|--|
|       | F04MFF<br>F07FDF     | Update solution of real symmetric positive-definite Toeplitz system (SPOTRF/DPOTRF) Cholesky factorization of real symmetric positive-definite   |
|       | FO7FEF               | matrix (SPOTRS/DPOTRS) Solution of real symmetric positive-definite system of linear   |
|       | F07FGF               | equations, multiple right-hand sides, matrix already factorized by F07FDF (SPOCON/DPOCON) Estimate condition number of real symmetric positive-  |
|       | F07FHF               | definite matrix, matrix already factorized by F07FDF (SPORFS/DPORFS) Refined solution with error bounds of real symmetric positive-  |
|       | F07FJF               | definite system of linear equations, multiple right-hand sides (SPOTRI/DPOTRI) Inverse of real symmetric positive-definite matrix, matrix already factorized by FOZEDE   |
|       | F07GDF               | already factorized by F07FDF (SPPTRF/DPPTRF) Cholesky factorization of real symmetric positive-definite matrix, packed storage   |
|       | F07GEF               | (SPPTRS/DPPTRS) Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GDF, packed storage  |
|       | F07GGF               | (SPPCON/DPPCON) Estimate condition number of real symmetric positive-definite matrix, matrix already factorized by F07GDF, packed storage  |
|       | F07GHF               | (SPPRFS/DPPRFS) Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides, packed storage   |
|       | F07GJF               | (SPPTRI/DPPTRI) Inverse of real symmetric positive-definite matrix, matrix already factorized by F07GDF, packed storage  |
| D2b2  | Positive-definite ba |  |
|       | F01MCF               | $LDL^T$ factorization of real symmetric positive-definite variable-bandwidth matrix  |
|       | F04ACF               | Solution of real symmetric positive-definite banded simultaneous linear equations with multiple right-hand sides (Black Box)   |
|       | F04MCF               | Solution of real symmetric positive-definite variable-bandwidth simultaneous linear equations (coefficient matrix already factorized by F01MCF)  |
|       | FO7HDF<br>FO7HEF     | (SPBTRF/DPBTRF) Cholesky factorization of real symmetric positive-definite<br>band matrix<br>(SPBTRS/DPBTRS) Solution of real symmetric positive-definite band system of   |
|       | FO7HEF               | linear equations, multiple right-hand sides, matrix already factorized by F07HDF (SPBCON/DPBCON) Estimate condition number of real symmetric positive-   |
|       | F07ННF               | definite band matrix, matrix already factorized by F07HDF (SPBRFS/DPBRFS) Refined solution with error bounds of real symmetric positive-   |
|       | F08UFF               | definite band system of linear equations, multiple right-hand sides (SPBSTF/DPBSTF) Computes a split Cholesky factorization of real symmetric  |
|       | F08UTF               | positive-definite band matrix $A$ (CPBSTF/ZPBSTF) Computes a split Cholesky factorization of complex Hermitian   |
|       |                      | positive-definite band matrix $A$  |
| D2b2a | Tridiagonal          |  |
|       | F04FAF               | Solution of real symmetric positive-definite tridiagonal simultaneous linear equa-   |
|       | a                    | tions, one right-hand side (Black Box)   |
| D2b4  | Sparse               | D I C E11CDE   |
|       | F11GAF               | Real sparse symmetric linear systems, set-up for F11GBF  |
|       | F11GBF               | Real sparse symmetric linear systems, preconditioned conjugate gradient or Lanczos   |
|       | F11GCF               | Real sparse symmetric linear systems, diagnostic for F11GBF  |
|       | F11GDF               | Real sparse symmetric linear systems, set-up for F11GEF  |
|       | F11GEF               | Real sparse symmetric linear systems, preconditioned conjugate gradient or Lanczos, threadsafe   |
|       | F11GFF               | Real sparse symmetric linear systems, diagnostic for F11GEF  |
|       | F11JAF               | Real sparse symmetric matrix, incomplete Cholesky factorization<br>Solution of linear system involving incomplete Cholesky preconditioning matrix  |
|       | F11JBF               | generated by F11JAF  |
|       | F11JCF<br>F11JDF     | Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JAF (Black Box) Solution of linear system involving preconditioning matrix generated by applying |
|       | F11JEF               | SSOR to real sparse symmetric matrix Solution of real sparse symmetric linear system, conjugate gradient/Lanczos   |
|       | TIIJEF               | method, Jacobi or SSOR preconditioner (Black Box)  |
| D2c   | Complex non-Hermit   |  |
| D2c1  | General<br>F04ADF    | Solution of complex simultaneous linear equations with multiple right-hand sides   |
|       |                      | (Black Box)  |
|       | FO7ARF<br>FO7ASF     | (CGETRF/ZGETRF) $LU$ factorization of complex $m$ by $n$ matrix (CGETRS/ZGETRS) Solution of complex system of linear equations, multiple   |
|       | F07AUF               | right-hand sides, matrix already factorized by F07ARF (CGECON/ZGECON) Estimate condition number of complex matrix, matrix  |
|       |                      | already factorized by F07ARF   |
|       | F07AVF               | (CGERFS/ZGERFS) Refined solution with error bounds of complex system of linear equations, multiple right-hand sides  |

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|      | F07AWF   | (CGETRI/ZGETRI) Inverse of complex matrix, matrix already factorized by  |
|------|--|--|
|      | F07NRF   | F07ARF (CSYTRF/ZSYTRF) Bunch-Kaufman factorization of complex symmetric matrix   |
|      | F07NSF   | (CSYTRS/ZSYTRS) Solution of complex symmetric system of linear equations,  |
|      |  | multiple right-hand sides, matrix already factorized by F07NRF   |
|      | F07NUF   | (CSYCON/ZSYCON) Estimate condition number of complex symmetric matrix,<br>matrix already factorized by F07NRF  |
|      | F07NVF   | (CSYRFS/ZSYRFS) Refined solution with error bounds of complex symmetric  |
|      |  | system of linear equations, multiple right-hand sides  |
|      | FO7NWF   | (CSYTRI/ZSYTRI) Inverse of complex symmetric matrix, matrix already factorized by F07NRF   |
|      | F07QRF   | (CSPTRF/ZSPTRF) Bunch–Kaufman factorization of complex symmetric matrix,   |
|      | F07QSF   | packed storage (CSPTRS/ZSPTRS) Solution of complex symmetric system of linear equations,   |
|      | F07QUF   | multiple right-hand sides, matrix already factorized by F07QRF, packed storage (CSPCON/ZSPCON) Estimate condition number of complex symmetric matrix,  |
|      | F07QVF   | matrix already factorized by F07QRF, packed storage (CSPRFS/ZSPRFS) Refined solution with error bounds of complex symmetric  |
|      | F07QWF   | system of linear equations, multiple right-hand sides, packed storage (CSPTRI/ZSPTRI) Inverse of complex symmetric matrix, matrix already factorized   |
|      | ·  | by F07QRF, packed storage  |
| D2c2 | Banded<br>F07BRF   | (CGBTRF/ZGBTRF) $LU$ factorization of complex $m$ by $n$ band matrix   |
|      | F07BSF   | (CGBTRS/ZGBTRS) Solution of complex band system of linear equations, multiple right-hand sides, matrix already factorized by F07BRF  |
|      | F07BUF   | (CGBCON/ZGBCON) Estimate condition number of complex band matrix, matrix   |
|      |  | already factorized by F07BRF   |
|      | F07BVF   | (CGBRFS/ZGBRFS) Refined solution with error bounds of complex band system of linear equations, multiple right-hand sides   |
|      | F07VSF   | (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equa-   |
|      |  | tions, multiple right-hand sides   |
|      | F07VUF   | (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix  |
|      | F07VVF   | (CTBRFS/ZTBRFS) Error bounds for solution of complex band triangular system  |
| D2.2 | Triangular   | of linear equations, multiple right-hand sides   |
|      |  |  |
| D2c3 | F06SJF   | (CTRSV/ZTRSV) System of equations, complex triangular matrix   |
| D203 | F06SJF<br>F06SKF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix  |
| D263 | F06SJF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides,   |
| D203 | F06SJF<br>F06SKF<br>F06SLF<br>F06ZJF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix   |
| D263 | F06SJF<br>F06SKF<br>F06SLF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides,   |
| D2C3 | F06SJF<br>F06SKF<br>F06SLF<br>F06ZJF<br>F07TSF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix   |
| D203 | F06SJF<br>F06SKF<br>F06SLF<br>F06ZJF<br>F07TSF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of   |
| D263 | F06SJF<br>F06SKF<br>F06SLF<br>F06ZJF<br>F07TSF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix  |
| DZCS | F06SJF<br>F06SKF<br>F06SLF<br>F06ZJF<br>F07TSF<br>F07TUF<br>F07TVF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations,   |
| D203 | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TSF<br>FO7TUF<br>FO7TVF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix  |
| DZC3 | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TSF<br>FO7TUF<br>FO7TVF<br>FO7TWF<br>FO7USF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage  |
| DZCS | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TSF<br>FO7TUF<br>FO7TVF<br>FO7TWF<br>FO7USF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRTRS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of  |
| DZCS | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TSF<br>FO7TUF<br>FO7TVF<br>FO7TWF<br>FO7USF   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage  |
| DZC3 | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TSF<br>FO7TUF<br>FO7TVF<br>FO7TWF<br>FO7UF<br>FO7UF   | (CTBSV/ZTPSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage  |
| DZCS | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TSF<br>FO7TUF<br>FO7TVF<br>FO7TWF<br>FO7UF<br>FO7UF<br>FO7UF  | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTPTRI/ZTPTRI) Solution of complex band triangular system of linear equa-   |
| DZCS | FO6SJF<br>FO6SKF<br>FO6SLF<br>FO6ZJF<br>FO7TUF<br>FO7TUF<br>FO7TVF<br>FO7UF<br>FO7UF<br>FO7UF<br>FO7UF<br>FO7UF<br>FO7UF                           | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular   |
| D2c4 | FO6SJF FO6SKF FO6SLF FO6SLF FO6ZJF FO7TUF FO7TUF FO7TUF FO7TUF FO7UF FO7UF FO7UF FO7UF FO7UF FO7UF FO7VF FO7VF FO7VF FO7VF                         | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBCFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides  |
|      | FO6SJF FO6SKF FO6SLF FO6SLF FO6ZJF FO7TUF FO7TUF FO7TVF FO7TVF FO7UF FO7UF FO7UF FO7UF FO7UF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBRFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides  |
|      | FO6SJF FO6SKF FO6SLF FO6SLF FO6ZJF FO7TUF FO7TUF FO7TUF FO7TUF FO7UF FO7UF FO7UF FO7UF FO7UF FO7UF FO7VF FO7VF FO7VF FO7VF                         | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBCFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides  |
|      | FO6SJF FO6SKF FO6SLF FO6SLF FO6ZJF FO7TUF FO7TUF FO7TVF FO7TVF FO7UF FO7UF FO7UF FO7UF FO7UF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF FO7VF | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTPTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBRFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides  |
|      | F06SJF F06SKF F06SLF F06SLF F06ZJF  F07TSF  F07TVF F07TVF  F07TVF  F07UVF  F07UVF  F07UVF  F07VVF  F07VVF  Sparse  F11DNF F11DPF                   | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPCS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBRFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides   |
|      | FO6SJF FO6SKF FO6SLF FO6SLF FO6ZJF  FO7TUF FO7TVF FO7TVF FO7UVF FO7UVF FO7UVF FO7VVF Sparse  F11DNF F11DPF F11DRF                                  | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBRFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides  Complex sparse non-Hermitian linear systems, incomplete LU factorization Solution of complex linear system involving incomplete LU preconditioning matrix generated by F11DNF  Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DNF (Black Box) Solution of linear system involving preconditioning matrix generated by applying SSOR to complex sparse non-Hermitian matrix |
|      | F06SJF F06SKF F06SLF F06SLF F06ZJF  F07TUF F07TVF  F07TVF  F07UVF  F07UVF  F07UVF  F07VVF  Sparse  F11DNF F11DPF F11DQF                            | (CTBSV/ZTBSV) System of equations, complex triangular band matrix (CTPSV/ZTPSV) System of equations, complex triangular packed matrix (CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix (CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides (CTRCON/ZTRCON) Estimate condition number of complex triangular matrix (CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides (CTRTRI/ZTRTRI) Inverse of complex triangular matrix (CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage (CTPTRI/ZTPTRS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage (CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage (CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, multiple right-hand sides (CTBCON/ZTBCON) Estimate condition number of complex band triangular matrix (CTBRFS/ZTBRFS) Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides  Complex sparse non-Hermitian linear systems, incomplete LU factorization Solution of complex linear system involving incomplete LU preconditioning matrix generated by F11DNF Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DNF (Black Box) Solution of linear system involving preconditioning matrix generated by applying  |

| D2d<br>D2d1 | Complex Hermitian m                       | natrices  |
|-------------|---|---|
| D2d1a       | Indefinite                                |   |
|             | F07MRF<br>F07MSF                          | (CHETRF/ZHETRF) Bunch–Kaufman factorization of complex Hermitian indefi-<br>nite matrix<br>(CHETRS/ZHETRS) Solution of complex Hermitian indefinite system of linear  |
|             | FO7MUF                                    | equations, multiple right-hand sides, matrix already factorized by F07MRF (CHECON/ZHECON) Estimate condition number of complex Hermitian indefinite   |
|             | FO7MVF                                    | matrix, matrix already factorized by F07MRF (CHERFS/ZHERFS) Refined solution with error bounds of complex Hermitian   |
|             | F07MWF                                    | indefinite system of linear equations, multiple right-hand sides (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<br>F07FVF                          | (CPOCON/ZPOCON) Estimate condition number of complex Hermitian positive-<br>definite matrix, matrix already factorized by F07FRF<br>(CPORFS/ZPORFS) Refined solution with error bounds of complex Hermitian |
|             | FO7FWF                                    | positive-definite system of linear equations, multiple right-hand sides (CPOTRI/ZPOTRI) Inverse of complex Hermitian positive-definite matrix, matrix   |
|             | F07GRF                                    | already factorized by F07FRF (CPPTRF/ZPPTRF) Cholesky factorization of complex Hermitian positive-definite  |
|             | F07GSF                                    | matrix, packed storage (CPPTRS/ZPPTRS) Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GRF,                          |
|             | F07GUF                                    | packed storage<br>(CPPCON/ZPPCON) Estimate condition number of complex Hermitian positive-<br>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   |
|             | F07GWF                                    | storage (CPPTRI/ZPPTRI) Inverse of complex Hermitian positive-definite matrix, matrix   |
| D2d2        | Positive-definite bar                     | already factorized by F07GRF, packed storage  |
| D202        | FO7HRF                                    | (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   |
| D2d4        | F07HVF<br>Sparse                          | (CPBRFS/ZPBRFS) Refined solution with error bounds of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides  |
| D2u4        | 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  |
| Da-         | F11JSF                                    | Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)  |
| D2e         | Associated operations<br>F11DKF<br>F11XAF | (e.g., matrix reorderings) Real sparse nonsymmetric linear systems, line Jacobi preconditioner Real sparse nonsymmetric matrix vector multiply  |
|             | F11XEF                                    | Real sparse symmetric matrix vector multiply  Real sparse symmetric matrix vector multiply  |
|             | F11XEF<br>F11XNF                          | Complex sparse non-Hermitian matrix vector multiply   |
|             | F11XSF                                    | Complex sparse Hermitian matrix vector multiply  Complex sparse Hermitian matrix vector multiply  |
|             | F11ZAF                                    | Real sparse nonsymmetric matrix reorder routine   |

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|                   | F11ZBF<br>F11ZNF                         | Real sparse symmetric matrix reorder routine<br>Complex sparse non-Hermitian matrix reorder routine   |
|-------------------|--|---|
|                   | F11ZPF                                   | Complex sparse Hermitian matrix reorder routine   |
| D3<br>D3a<br>D3a1 | Determinants Real nonsymmetric m General | atrices   |
| Doar              | FO3AAF                                   | Determinant of real matrix (Black Box)  |
| Del               | F03AFF                                   | LU factorization and determinant of real matrix   |
| D3b               | Real symmetric matri<br>General          | ces   |
| D3b1              | Positive-definite                        |   |
| D3b1b             | F03ABF                                   | Determinant of real symmetric positive-definite matrix (Black Box)  |
|                   | FOSAEF                                   | $LL^T$ factorization and determinant of real symmetric positive-definite matrix   |
| D3b2              | Positive-definite bar                    |   |
| D302              | FO3ACF                                   | Determinant of real symmetric positive-definite band matrix (Black Box)   |
| D3c               | Complex non-Hermitis                     |   |
| D3c1              | General                                  |   |
|                   | FO3ADF                                   | Determinant of complex matrix (Black Box)   |
| D4                | Eigenvalues, eigenvectors                |   |
| D4a               | Ordinary eigenvalue p                    | roblems $(Ax = \lambda x)$  |
| D4a1              | Real symmetric                           | All simulations of male months of the language (Dl. la D.)  |
|                   | F02FAF                                   | All eigenvalues and eigenvectors of real symmetric matrix (Black Box)   |
|                   | F02FCF<br>F06BPF                         | Selected eigenvalues and eigenvectors of real symmetric matrix (Black Box)  |
|                   | F08FCF                                   | Compute eigenvalue of 2 by 2 real symmetric matrix (SSYEVD/DSYEVD) All eigenvalues and optionally all eigenvectors of real sym-   |
|                   |  | metric matrix, using divide and conquer   |
|                   | F08GCF                                   | (SSPEVD/DSPEVD) All eigenvalues and optionally all eigenvectors of real sym-  |
|                   | F08HCF                                   | metric matrix, packed storage, using divide and conquer (SSBEVD/DSBEVD) All eigenvalues and optionally all eigenvectors of real sym-  |
|                   |  | metric band matrix, using divide and conquer  |
| D4a2              | Real nonsymmetric                        |   |
|                   | F02EAF                                   | All eigenvalues and Schur factorization of real general matrix (Black Box)  |
|                   | F02EBF                                   | All eigenvalues and eigenvectors of real general matrix (Black Box)   |
| _                 | F02ECF                                   | Selected eigenvalues and eigenvectors of real nonsymmetric matrix (Black Box)   |
| D4a3              | Complex Hermitian                        |   |
|                   | FO2HAF                                   | All eigenvalues and eigenvectors of complex Hermitian matrix (Black Box)  |
|                   | F02HCF                                   | Selected eigenvalues and eigenvectors of complex Hermitian matrix (Black Box)   |
|                   | F08FQF                                   | (CHEEVD/ZHEEVD) All eigenvalues and optionally all eigenvectors of complex Hermitian matrix, using divide and conquer   |
|                   | F08GQF                                   | (CHPEVD/ZHPEVD) All eigenvalues and optionally all eigenvectors of complex  |
|                   |  | Hermitian matrix, packed storage, using divide and conquer  |
|                   | F08HQF                                   | (CHBEVD/ZHBEVD) All eigenvalues and optionally all eigenvectors of complex<br>Hermitian band matrix, using divide and conquer   |
| D4a4              | Complex non-Herm                         | · · · · · · · · · · · · · · · · · · ·   |
| Diai              | F02GAF                                   | All eigenvalues and Schur factorization of complex general matrix (Black Box)   |
|                   | F02GBF                                   | All eigenvalues and eigenvectors of complex general matrix (Black Box)  |
|                   | F02GCF                                   | Selected eigenvalues and eigenvectors of complex nonsymmetric matrix (Black Box)  |
| D4a5              | Tridiagonal                              |   |
|                   | F08JCF                                   | (SSTEVD/DSTEVD) All eigenvalues and optionally all eigenvectors of real symmetric tridic and protein tridic and converge  |
|                   | F08JEF                                   | metric tridiagonal matrix, using divide and conquer (SSTEQR/DSTEQR) All eigenvalues and eigenvectors of real symmetric tridiagonal  |
|                   | FOOSEF                                   | matrix, reduced from real symmetric matrix using implicit $QL$ or $QR$  |
|                   | F08JFF                                   | (SSTERF/DSTERF) All eigenvalues of real symmetric tridiagonal matrix, root-free   |
|                   |  | variant of QL or QR   |
|                   | F08JGF                                   | (SPTEQR/DPTEQR) All eigenvalues and eigenvectors of real symmetric positive-<br>definite tridiagonal matrix, reduced from real symmetric positive-definite matrix   |
|                   | F08JJF                                   | (SSTEBZ/DSTEBZ) Selected eigenvalues of real symmetric tridiagonal matrix by  |
|                   |  | bisection   |
|                   | F08JKF                                   | (SSTEIN/DSTEIN) Selected eigenvectors of real symmetric tridiagonal matrix by   |
| D4a6              | Banded                                   | inverse iteration, storing eigenvectors in real array   |
| D4a0              | F08HCF                                   | (SSBEVD/DSBEVD) All eigenvalues and optionally all eigenvectors of real sym-  |
|                   |  | metric band matrix, using divide and conquer  |
|                   | F08HQF                                   | (CHBEVD/ZHBEVD) All eigenvalues and optionally all eigenvectors of complex  |
|                   | a  | Hermitian band matrix, using divide and conquer   |
| D4a7              | Sparse                                   | Colored disampless and disamples of the control of |
| D4I               | F02FJF                                   | Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)  |
| D4b               |  | e problems (e.g., $Ax = \lambda Bx$ )   |
| D4b1              | Real symmetric<br>F02FDF                 | All eigenvalues and eigenvectors of real symmetric-definite generalized problem   |
|                   | rozror                                   | (Black Box)   |
|                   | F02FJF                                   | Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)  |
|                   | =  | (3.44.1.2.4.1.4.4.4.4.4.4.4.4.4.4.4.4.4.4.  |

| D4b3 Complex Hermitian, and antires (Hales Bras) POSEP  D4b4 Complex general POSEP  D4b5 Banded POSEP  D4b6 Banded POSEP  D4b6 Banded POSEP  D502FF  D | D4b2    | Real general     |  |
|--|---------|------------------|--|
| D4b4 Complex general reports (Black Box)  D4b5 Banded 702FFF All eigenvalues and optionally eigenvectors of generalized complex eigenproblem by QZ algorithm (Black Box)  D4c Associated operations FP03FFF   All eigenvalues and optionally eigenvectors of generalized complex eigenproblem (Black Box)  D4c Associated operations   FP03FFF   All eigenvalues and optionally eigenvectors of generalized density in the part of the par |         |                  | algorithm, real matrices (Black Box)   |
| D4b5   Banded   F02FHF   All eigenvalues and optionally eigenvectors of generalized complex eigenproblem by QZ algorithm (Black Box)   QZ algorithm (Black Box)  | D4b3    | _                | All eigenvalues and eigenvectors of complex Hermitian-definite generalized problem   |
| Date   PoZFFF   All eigenvalues of generalized banded real symmetric-definite eigenproblem (Black   PoZFFF   Engometror of generalized real banded eigenproblem by inverse iteration   PoZFFF   Engometror of generalized real banded eigenproblem by inverse iteration  | D4b4    |                  | All eigenvalues and optionally eigenvectors of generalized complex eigenproblem by   |
| POSEPT   All eigenvalues of generalized banded real symmetric-definite eigenproblem (Black Box)   Possept   Eigenvector of generalized real banded eigenproblem by inverse iteration   | D4b5    | Banded           | QZ algorithm (Black Box)   |
| Associated operations FORGEF F | D400    |                  | , 0  |
| FORETY (STRENC/DTRENC) Reorder Schur factorization of real matrix, using orthogonal similarity transformation  FORETY (STRENC)/DTRENC) Reorder Schur factorization of real matrix, form orthonomals of right invariant subspace for selected eigenvalues, with estimates of sensitivities  FORETY (STRENC)/DTRENC) Reorder Schur factorization of complex matrix using unitary similarity transformation  FORETY (STRENC)/STRENC) Reorder Schur factorization of complex matrix, form orthonomal basis of right invariant subspace for selected eigenvalues and eigenvalues and eigenvalues and eigenvalues are sensitivities of sensitivi |         | F02SDF           | Eigenvector of generalized real banded eigenproblem by inverse iteration   |
| F088GF   GTRSEN/DTRSEN) Reorder Schur factorization of real matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities   | D4c     | _                | (STREXC/DTREXC) Reorder Schur factorization of real matrix using orthogonal  |
| POSUTE   CITRSINA/DTRSNA) Estimates of sensitivities of selected eigenvalues and eigenvalues are provided by the complex matrix using unitary similarity transformation  |         | F08QGF           | (STRSEN/DTRSEN) Reorder Schur factorization of real matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of |
| FORTF   CTREXC/ZTREXC) Reorder Schur factorization of complex matrix using unitary similarity transformation   (CTRSEN/ZTRSEN), Reorder Schur factorization of complex matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities   CTRSNA/ZTRSNA) Estimates of sensitivities of selected eigenvalues and eigenvectors of complex upper triangular matrix  |         | F08QLF           | (STRSNA/DTRSNA) Estimates of sensitivities of selected eigenvalues and eigen-  |
| D4c1   |         | FOSQTF           | (CTREXC/ZTREXC) Reorder Schur factorization of complex matrix using unitary  |
| D4c1 Transform problem D4c1 Balance matrix F08NFF F08NFF (CGEBAL/DGEBAL) Balance cal general matrix F08NFF F08NFF (CGEBAL/ZGEBAL) Balance can general matrix CGEBAL/DGEBAL) Balance complex general matrix to upper desember gorm CGUCGHRD/DGEHRD) Orthogonal reduction of complex general matrix to upper Hessenberg form CGUCGHRD/DGEHRD) Orthogonal reduction of complex general matrix to upper Hessenberg form CGUCGHRD/DGEHRD) Orthogonal reduction of complex general matrix to upper Hessenberg form CGUCGHRD/DGEHRD) Orthogonal reduction of complex general matrix to upper Hessenberg form CGUCGHRD/DGEHRD) Orthogonal reduction of complex general matrix to upper Hessenberg form CGUCGHRD/DGEHRD) Orthogonal reduction of  |         | F08QUF           | thonormal basis of right invariant subspace for selected eigenvalues, with estimates   |
| D4c1b   F08NFF   SGEBAL/DGEBAL) Balance real general matrix   F08NFF   F08NFF   SGEBAL/ZGEBAL) Balance complex general matrix  |         | F08QYF           | (CTRSNA/ZTRSNA) Estimates of sensitivities of selected eigenvalues and eigen-  |
| FOSHIF FOSHUF   CGEBAL/DCEBAL) Balance real general matrix   FOSHUF FO   | D4c1    | -                |  |
| D4c1b1 D4c1b2  | D4c1a   |                  | (CCEDAL (DCEDAL) D.L.  |
| D4c1b   Tridiagonal   FO8FEF   CHETRD/ZHETRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form determined by FO8FEF   FO8FEF   CUNGTR/ZUNGTR) Generate unitary transformation matrix from reduction to tridiagonal form determined by FO8FSF   FO8GEF   GSPTR/DDSPTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form determined by FO8FEF   FO8GEF   FO8GEF   GSPTR/DDPGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by FO8GEF   FO8GEF   CCHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form determined by FO8GEF   FO8GEF   GSPTR/DSPTRD) Orthogonal reduction of complex Hermitian matrix to real symmetric tridiagonal form determined by FO8GSF   FO8EF   GSBTRD/ZHBTRD) Unitary reduction of real symmetric band matrix to symmetric tridiagonal form   FO8BEF   GSBTRD/ZHBTRD) Unitary reduction of real symmetric band matrix to symmetric tridiagonal form   FO8BEF   GSGEHRD/DGEHRD) Orthogonal reduction of real general matrix to upper Hessenberg form   FO8MEF   GSGEHRD/DGEHRD) Orthogonal reduction of real general matrix to upper Hessenberg form   FO8MEF   GSGEHRD/DGHRD) Orthogonal reduction of real general matrix to upper Hessenberg form   FO8MEF   GGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by FO8NEF   GCGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by FO8NEF   GCGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by FO8NEF   GCGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by FO8NEF   GCGEHRD/ZGEHRD) Generate unitary transformation matrix from reduction to Hessenberg form determined by FO8NEF   GCGEHRD/GGBRD) Reduction   |         |                  | , , ,  |
| Tridiagonal FOSFEF (SSYTRD/DSYTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form FOSFEF (SORGTR/DORGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by FOSFEF FOSFEF (CHETRD/ZHETRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form determined by FOSFSF FOSFEF (SSPTRD/DSPTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form determined by FOSFSF FOSGEF (SSPTRD/DSPTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form, packed storage FOSGEF (SSPTRD/DSPTRD) Unitary reduction of complex Hermitian matrix from reduction to tridiagonal form, packed storage (CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form, packed storage FOSSEF (CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to symmetric tridiagonal form FOSSEF (SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form FOSSEF (SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form FOSSEF (SGEHRD/DGEHRD) Orthogonal reduction of real general matrix to upper Hessenberg form (SGCEHRD/ZGEHRD) Unitary reduction of real general matrix to upper Hessenberg form (SGCEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by FOSNEF (CUNGHR/ZUNGHR) Generate unitary transformation matrix from reduction to Hessenberg form determined by FOSNEF (CUNGHR/ZUNGHR) Generate unitary transformation matrix from reduction to Hessenberg form determined by FOSNEF (CUNGHR/ZUNGHR) Generate unitary transformation matrix to upper Hessenberg form determined by FOSNEF (CUNGHR/ZUNGHR) Generate unitary transformation matrix to upper Hessenberg form determined by FOSNEF (CUNGHR/ZUNGHR) Generate unitary transformation matrix to upper Hessenberg form determined by FOSNEF (CUNGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by FOSNEF (CUNGHR/ | D4c1b   |                  |  |
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| FO8FFF   SORĞTR/DORGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by FO8FEF (CHETRD/ZHETRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form (CUNGTR/ZUNGTR) Generate unitary transformation matrix from reduction to tridiagonal form determined by F08FSF (SSPTRD/DSPTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form packed storage (SOPGTR/DOPGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08GEF (CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form, packed storage (CUPGTR/ZUPGTR) Generate unitary transformation matrix from reduction to tridiagonal form determined by F08GEF (SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form determined by F08GEF (SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form    FO8HSF (SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to upper Hessenberg form   FO8MFF (SORGHR/DORGHR) Generate orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (CGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by F08NEF (CGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by F08NEF (CGBHRD/GGHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by F08NEF (SORGHR/DORGHR) Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NEF (CGBHRD/GGHRD) Unitary reduction of complex general matrix to upper bidiagonal form    FO8LSF (SGBRD/ZGBBRD) Reduction of real rectangular band matrix to upper bidiagonal form   F08LSF (SGBRD/ZGBBRD) Reduction of complex rectangular band matrix to upper bidiagonal form   F08LSF (SGBRD/SGBRD) Reduction of complex rectangular band matrix to upper bidiagonal form   F08LSF (SGBRD/SGBRD) Reduction of comp   | 210121  |                  | (SSYTRD/DSYTRD) Orthogonal reduction of real symmetric matrix to symmetric   |
| FORFSF   C(HETRD/ZHETRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form determined by FORFSF   |         |                  | · ·  |
| FO8FSF   CCHETRD/ZHETRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form symmetric tridiagonal form determined by FO8FSF  |         | F08FFF           |  |
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| F08GEF   (SSPTRD/DSPTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form, packed storage   (SOPGTR)/DOPGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08GEF   (CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form, packed storage   (CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form determined by F08GSF   (SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form   (CHBTRD/ZHBTRD) Unitary reduction of complex Hermitian band matrix to real symmetric tridiagonal form   (CHBTRD/ZHBTRD) Unitary reduction of complex Hermitian band matrix to real symmetric tridiagonal form   (SORGHR/DORGHR) Orthogonal reduction of real general matrix to upper Hessenberg form determined by F08NEF   (SGEHRD/DGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by F08NEF   (CGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form determined by F08NSF   (CUNGHR/ZUNGHR) Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NSF   (CUNGHR/ZUNGHR) Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   (CONGHR/ZUNGHR) Generate unitary transformation matrix to upper hessenberg form determined by F08NSF   |         | F08FTF           | (CUNGTR/ZUNGTR) Generate unitary transformation matrix from reduction to   |
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| F08GFF   CUPGTR/ZUPGTR) Generate unitary transformation matrix from reduction to tridiagonal form determined by F08GSF   |         | F08GSF           | (CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real  |
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| F08LEF (SGBBRD/DGBBRD) Reduction of real rectangular band matrix to upper bidiagonal form  F08LSF (CGBBRD/ZGBBRD) Reduction of complex rectangular band matrix to upper bidiagonal form  D4c1c Standardize problem  F01BVF Reduction to standard form, generalized real symmetric-definite banded eigenproblem  F08SEF (SSYGST/DSYGST) Reduction to standard form of real symmetric-definite generalized real symmetric-definite generaliz | D4c1b3  | Other            | ressencerg form determined by POONSE   |
| F08LSF (CGBBRD/ZGBBRD) Reduction of complex rectangular band matrix to upper bidiagonal form  Standardize problem F01BVF Reduction to standard form, generalized real symmetric-definite banded eigenproblem F08SEF (SSYGST/DSYGST) Reduction to standard form of real symmetric-definite generalized real symmetric-definite  | 210150  |                  | , , ,  |
| D4c1c Standardize problem  F01BVF Reduction to standard form, generalized real symmetric-definite banded eigenproblem  F08SEF (SSYGST/DSYGST) Reduction to standard form of real symmetric-definite gener-   |         | F08LSF           | (CGBBRD/ZGBBRD) Reduction of complex rectangular band matrix to upper  |
| F01BVF Reduction to standard form, generalized real symmetric-definite banded eigenproblem  F08SEF (SSYGST/DSYGST) Reduction to standard form of real symmetric-definite gener-  | D4c1c   | Standardize prob |  |
| FOSSEF (SSYGST/DSYGST) Reduction to standard form of real symmetric-definite gener-  |         | -                | Reduction to standard form, generalized real symmetric-definite banded   |
|  |         | F08SEF           | (SSYGST/DSYGST) Reduction to standard form of real symmetric-definite gener-   |

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| FOSQXF (CTREVC/ZTREVC) Left and right eigenvectors of complex up matrix  |  |
| D4c4 Back transform eigenvectors   | quasi-triangular   |
| F08FGF (SORMTR/DORMTR) Apply orthogonal transformation determine   | quasi-triangular   |
| F08FUF (CUNMTR/ZUNMTR) Apply unitary transformation matrix of F08FSF   | quasi-triangular oper triangular ed by F08FEF  |
| F08GGF (SOPMTR/DOPMTR) Apply orthogonal transformation determine<br>F08GUF (CUPMTR/ZUPMTR) Apply unitary transformation matrix of<br>F08GSF  | quasi-triangular<br>oper triangular<br>ed by F08FEF<br>determined by   |
| FO8NGF (SORMHR/DORMHR) Apply orthogonal transformation matrix from   | quasi-triangular oper triangular ed by F08FEF determined by ed by F08GEF   |
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| F08NUF (CUNMHR/ZUNMHR) Apply unitary transformation matrix from Hessenberg form determined by F08NSF   | quasi-triangular oper triangular ed by F08FEF determined by ed by F08GEF determined by om reduction to   |
| FO8NWF (CGEBAK/ZGEBAK) Transform eigenvectors of complex balanced of original matrix supplied to F08NVF  | quasi-triangular oper triangular ed by F08FEF determined by ed by F08GEF determined by om reduction to trix to those of  |

| PORTS  OR disconposition, Gram—Schmidt orthogonalization FOLOGY RO [actorization of real m by n upper trapezoidal matrix (m ≤ n) POLOGY RO [actorization of real m by n upper trapezoidal matrix (m ≤ n) Operations with orthogonal matrices, form rows of Q, after RQ factorization by POLOGY POLOGY RO [actorization of complex m by n upper trapezoidal matrix (m ≤ n) FOLOGY POLOGY RO [actorization of complex m by n upper trapezoidal matrix (m ≤ n) FOLOGY RO [actorization with unitary matrices, form rows of Q, after RQ factorization by FURDF FORDER F  | D5 | OR decomposition Cr    | am-Schmidt orthogonalization   |
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| FORSE PORSE RQ factorization of complex m by n upper trapezoidal matrix (m ≤ n) FORSE RQ factorization of complex m by n matrix (m ≤ n) PORSE RQ factorization of complex m by n matrix (m ≤ n) Operations with unitary matrices, form rows of Q, after RQ factorization by FORSE FORSE ROWS of the RD (matrix forms of the Matrix forms of the RD) FORSE RG factorization by sequence of plane rotations, real upper triangular matrix augmented by a full row FORSE RG factorization by sequence of plane rotations, real upper Hessenberg RD (RD (factorization by sequence of plane rotations, real upper Hessenberg RD (RD (factorization by sequence of plane rotations, real upper triangular matrix profits RQ factorization by sequence of plane rotations, real upper triangular rotations RD (RD (factorization by sequence of plane rotations, real upper triangular, Z a sequence of plane rotations and RD (RD (factorization)) and real plane rotations, real upper triangular matrix RD (RD (factorization)) and real plane rotations, complex upper triangular matrix augmented by a full row FORSE QR (factorization) by sequence of plane rotations, complex upper Hessenberg matrix FORSE QR or RQ (factorization) by sequence of plane rotations, complex upper plane for RQ (RD (RD (RQ RD)) and RD (RD (RD (RD RD)) and RD (RD (RD  |    |                        | •                                    |
| FORBLE RQ factorization of complex m by n matrixs (for < n) FORBRE Operations with unitary matrices, form rows of Q, after RQ factorization by FORLE FORBLE Cram-Schmidt orthogonalisation of n vectors of order m FORGE QR factorization by sequence of plane rotations, real upper triangular matrix augmented by a full row FORGE RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FORGE QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FORGE QR or RQ factorization by sequence of plane rotations, real upper spiked matrix FORGE QR or RQ factorization by sequence of plane rotations, real upper triangular. Z a cyclence of plane rotations of ZU, U real upper triangular. Z a cyclence of plane rotations of ZU, U real upper triangular. Z a form of the plane rotations of ZU, U real upper triangular matrix FORGE QR factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row FORGE QR factorization by sequence of plane rotations, complex upper Hessenberg matrix FORGE QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix FORGE QR or RQ factorization by sequence of plane rotations, complex upper triangular, Z a sequence of plane rotations of UZ U. U complex upper triangular, Z a sequence of plane rotations FORGE QR PGCRP (DGCRP) QR factorization of real general rectangular matrix FORGE FORGE (SGNGMC) DGRAGE) Form all or part of orthogonal Q from QR factorization determined by FORAEF FORGE (SGNGMC) DGRAGE) Form all or part of orthogonal Q from QR factorization determined by FORAEF FORGE (SGNGMC) DGRAGE) Form all or part of orthogonal Qr from LQ factorization determined by FORAEF FORGE (SGNGMC) DGRAGE) Form all or part of orthogonal Qr from LQ factorization determined by FORAEF FORGE (SGNGMC) DGRAGE) Form all or part of orthogonal Qr from LQ factorization determined by FORAEF FORGE |    | F01QKF                 |  |
| FOREY FOSAF Gram-Schmidt orthogonalisation of n vectors of order to update of real upper triangular matrix FOSQUF QR factorization by sequence of plane rotations, rank-1 update of real upper triangular matrix augmented by a full row FOSQUF QR or RQ factorization by sequence of plane rotations, real upper triangular matrix augmented by a full row FOSQUF QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FOSQUF FOSQUF QR or RQ factorization by sequence of plane rotations, real upper spiked matrix FOSQUF QR or RQ factorization of UZ or RQ factorization of ZU, U real upper triangular, Z a sequence of plane rotations, rank-1 update of complex upper triangular matrix FOSTGF QR factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row FOSTGF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row FOSTGF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix FOSTGF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix FOSTGF QR or RQ factorization by sequence of plane rotations, complex upper triangular, Z a sequence of plane rotations of the proper triangular are sequence of plane rotations. FOSAFF FOSAF |    |                        |  |
| FOSAF Cram Schmidt orthogonalisation of a vectors of order m FOSGUF QR factorization by sequence of plane rotations, real-update of real upper triangular matrix augmented by a full row FOGGUF QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FOGGUF QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FOGGUF QR actorization of UZ or RQ factorizations, real-upper triangular, Z a sequence of plane rotations, real-upper triangular, Z a sequence of plane rotations, real-upper triangular matrix FOGGUF QR factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix augmented by a full row FOGGUF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row FOGGUF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix POGGUF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix FOGGUF (Ractorization of UZ or RQ factorizations, complex upper triangular, Z Ractorization of UZ or RQ factorization of telemined by FOSAFF (SORGAP) DORGAP) PORGAPF or FOSAFF FOSAFF FOSAFF (SORGAP) PORGAPF PORGAPF or FOSAFF FOSAFF (SORGAP) PORGAPF PORGAPF OR FOSAFF FOSA |    |                        | •                                    |
| POGGFF QR factorization by sequence of plane rotations, rank-1 update of real upper triangular matrix augmented by a full row augmented by a full row augmented by a full row part of the property of the prop |    |                        | - · · · · · · · · · · · · · · · · · · ·                                    |
| FORQUE FORQUE OF Reatorization by sequence of plane rotations, real upper triangular matrix augmented by a full row FORGER OR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FORGER OR or RQ factorization by sequence of plane rotations, real upper piled matrix FORGER OR or RQ factorization by sequence of plane rotations, real upper spiked matrix FORGER OR or RQ factorization by sequence of plane rotations, rank-1 update of complex sequence of plane rotations, rank-1 update of complex upper triangular matrix augmented by a full row FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization by sequence of plane rotations, complex upper spiked matrix FORTER OR RQ factorization of Plane Rotations, complex upper spiked matrix FORTER OR RQ factorization of Plane Rotations, complex upper spiked matrix FORTER OR RQ factorization of Plane Rotations, complex upper spiked matrix FORTER OR RQ factorization of Plane Rotations, complex upper spiked matrix FORTER FORTER FORTER OR RATE OR Rate RQ   |    |                        |  |
| FORERF QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix  FORETF QR or RQ factorization by sequence of plane rotations, real upper piked matrix  FORETF QR factorization of UZ or RQ factorization of ZU, U real upper triangular, Z a sequence of plane rotations and the property of the p |    | •                      |  |
| FORGRE QR or RQ factorization by sequence of plane rotations, real upper Hessenberg matrix FORGRE QR for RQ factorization of VZ or RQ factorization of UZ or RQ factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix FORTIF QR factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row FORTIF QR for RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix FORTIF QR for RQ factorization by sequence of plane rotations, complex upper triangular matrix FORTIF QR for RQ factorization of VZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations or possible description of the possible value of the VZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations or possible description of the possible value of the VZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations or for largerial rectangular matrix FORTIF QR factorization of UZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations or for largerial rectangular matrix FORTIF FORTIF FORTIF PORTIF QR factorization of real general rectangular matrix (SORGR) FORTIF PORTIF PORTIF PORTIF PORTIF PORTIF FORTIF  |    | F06QQF                 | •                                    |
| P668BF QR or RQ factorization by sequence of plane rotations, real upper spiked matrix QR factorization of UZ or RQ factorization of ZU, U real upper triangular, Z a sequence of plane rotations QR factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix augmented by a full row  F668BF QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row  F668BF QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix  F668BF QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix  F668BF QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix  F668BF (SGGRQR/DGRQR) Form all or part of cortage upper triangular, Z a sequence of plane rotations  F68BF (SGGRQR/DGRQR) Form all or part of orthogonal Q from QR factorization determined by F68ABF or F68BBF  F68BBF (SGGRQR/DGRQR) Form all or part of orthogonal Q from QR factorization determined by F68ABF (SGGRQR/DGRQR) Form all or part of orthogonal Q from QR factorization determined by F68ABF (SGGRQR/DGRQR) Form all or part of orthogonal Q from QR factorization determined by F68ABF (SGGRQR/DGRQR) Form all or part of orthogonal Q from QR factorization determined by F68ABF (CGEQRF/ZGEQRF) QR factorization of complex general rectangular matrix F68ABF (CGEQRF/ZGEQRF) QR factorization of complex general rectangular matrix f68ABF (CGEQRF/ZGEQRF) QR factorization of complex general rectangular matrix f68ABF (CGEQFF/ZGEQFF) QR factorization of complex general rectangular matrix f68ABF (CUMCQR/ZUNGQR) Apply unitary transformation determined by F68ABF (CUMCQR/ZUNGQR) Apply unitary transformation dete |    | EOCODE                 |  |
| FOGGES   QR or RQ factorization by sequence of plane rotations, real upper spiked matrix FOGGTF   QR factorization of UZ or RQ factorization of UZ or RQ factorization of UZ or RQ factorization of EV or RQ factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix augmented by a full row   FOGTEF   QR or RQ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row   FOGTEF   QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix   FOGTEF   QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix   FOGTEF   QR or RQ factorization by sequence of plane rotations, complex upper triangular, Z a sequence of plane rotations   FOGLEG   CREATER   CRE |    | гооциг                 |  |
| FOSTPF QR factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix FOSTPF QR factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row FOSTRF QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix FOSTSF QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix FOSTSF QR factorization of UZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations FOSAFF (SCEQRF/DGRQRP) QR factorization of real general rectangular matrix FOSAFF (SCEQRF/DGRQRP) QR factorization of real general rectangular matrix FOSAFF (SCEQRF/DGRQRP) QR factorization of real general rectangular matrix FOSAFF (SCEQRF/DGRQR) Apply orthogonal transformation determined by FOSAFF or FOSAFF (SCEQRF) QR factorization of real general rectangular matrix FOSAFF (SCELQF/DGELQF) LQ factorization of real general rectangular matrix FOSAFF (SCEQRF) QR factorization of real general rectangular matrix FOSAFF (SCEQRF) QR factorization of complex general rectangular matrix FOSAFF (CGEQRF) QR factorization of complex general rectangular matrix FOSAFF (CGEQRF) QR factorization of complex general rectangular matrix FOSAFF (CGEQRF/QGRQR) For RosaFF or FOSAFF FOSAFF (CUMCQR/ZUNGQR) Form all or part of unitary Q from LQ factorization determined by FOSAFF or FOSAFF FOSAFF FOSAFF FOSAFF (CUMCQR/ZUNGQR) Form all or part of unitary Q from LQ factorization determined by FOSAFF or FOSAFF FOSAFF FOSAFF FOSAFF (CUNGQR/ZUNGQR) Form all or part of unitary Q from LQ factorization determined by FOSAFF or FOSAFF FOSAFF (CUNGQR/ZUNGQR) Form all or part of unitary Q from LQ factorization determined by FOSAFF OSAFF FOSAFF FOSAFF (SCEQFF) QR factorization of complex general rectangular matrix with column pivoting  CUNGQR/ZUNGQR Form all or part of unitary Q from LQ factorization determined by FOSAFF FOSAFF (SCEQFF) QR factorization of complex general rectangular matrix to bidiagonal form determined by FOSAFF FOSAFF ( |    | F06QSF                 |  |
| FOGTIF QRek factorization by sequence of plane rotations, complex upper triangular matrix angmented by a full row  FOGTIF QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix  FOGTIF QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix POGTIF QR or RQ factorization of VZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations  FORAEF (SGEQRF/DGEQRP) QR factorization of real general rectangular matrix (SORCQR/DGRACQR) Form all or part of orthogonal Qr from QR factorization determined by FOSAEF or FOSBEF  FOSAEF (SGEQRF/DGEQRP) LQ factorization of real general rectangular matrix FOSAEF or FOSBEF (SGELQF) LQ factorization of real general rectangular matrix FOSAEF (SGELQF) LQ factorization of real general rectangular matrix FOSAEF (SGELQF) LQ factorization of real general rectangular matrix FOSAEF (SGEMG, JORNALQR) Apply orthogonal transformation determined by FOSAEF (SGEMM, JORNALQR) Form all or part of orthogonal Q from LQ factorization determined by FOSAEF (CUNGR/ZUNGQR) Form all or part of orthogonal Q from LQ factorization determined by FOSAEF (CUNGR/ZUNGQR) Form all or part of unitary Q from QR factorization determined by FOSAEF or FOSBEF (CUNGR/ZUNMQR) Apply unitary transformation determined by FOSAEF or FOSBEF (CGELQF/ZGELQF) LQ factorization of complex general rectangular matrix (CUNGLQ/ZUNGLQ) Form all or part of unitary Q from LQ factorization determined by FOSAEF (SGEQPF/DGEQPE) QR factorization of complex general rectangular matrix (CUNGLQ/ZUNGLQ) Form all or part of unitary Q from LQ factorization determined by FOSAEF (SGEQPF/DGEQPE) QR factorization of complex general rectangular matrix with column pivoting  FOSSEF (CGEQFF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting produced produce |    | F06QTF                 | sequence of plane rotations  |
| ### POSTRF   QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix   FOSTSF   QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix  |    |                        | triangular matrix  |
| POGTSF QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix FOGTF QR factorization of UZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations (SCEQRF/DCEQRF) QR factorization of real general rectangular matrix (SCEQRF/DCEQRF) QR factorization of real general rectangular matrix (SCEQRF/DCEQRF) QR factorization of real general rectangular matrix (SCEQRF) DCEQRF) QR factorization of real general rectangular matrix (SCEQRF) FOSAFF (SCENDAR), DORGIQA) porthogonal transformation determined by FOSAFF or FOSBEF (SCENDAR), DORGIQA) prom all or part of orthogonal Q from LQ factorization determined by FOSAFF (SCENDAR), Apply orthogonal transformation determined by FOSAFF (SCENDAR), DORGIQA) prom all or part of orthogonal Q from LQ factorization determined by FOSAFF or FOSBEF (CUNQR/ZUNQGR) Form all or part of unitary Q from QR factorization determined by FOSAFF or FOSBEF (CUNQR/ZUNNQGR) Apply unitary transformation determined by FOSAFF or FOSBEF FOSAFF (CUNGLQ), ZUUNGLQ) Form all or part of unitary Q from LQ factorization determined by FOSAFF or FOSBEF (SCEQFF/ZCEQFF) QR factorization of complex general rectangular matrix (CUNGLQ), ZUUNGLQ) Apply unitary transformation determined by FOSAFF or FOSBEF (SCEQFF/DCEQFF) QR factorization of real general rectangular matrix with column pivoting  POSBEF (SCEQFF/ZCEQFF) QR factorization of real general rectangular matrix with column pivoting  Singular value decomposition  FOSZEF SVD of complex upper triangular matrix (Black Box)  FOZZEF SVD of complex upper triangular matrix (Black Box)  FOZZEF SVD of complex matrix (Black Box)  FOZZEF SVD of compl |    | •                      | augmented by a full row  |
| POSTE  |    |                        | matrix   |
| Sequence of plane rotations  FO8AFF (SGEGRF,DGEQRF) QR factorization of real general rectangular matrix  FO8AFF (SGEGRF,DGEGRF) QR factorization of real general rectangular matrix  FO8AFF (SGRMQR,DORNGQR) Form all or part of orthogonal Q from QR factorization determined by F08AFF or F08BEF  FO8AFF (SGRMQR,DORNGQR) Apply orthogonal transformation determined by F08AFF or F08BFF  FO8AFF (SGELQF,DGELQF) LQ factorization of real general rectangular matrix  FO8AFF (SGRLQ,DORNLQ) Form all or part of orthogonal Q from LQ factorization determined by F08AHF  FO8AFF (SGRMLQ,DORNLQ) Apply orthogonal transformation determined by F08AHF  FO8AFF (CUNCQR,ZUNCQR) Form all or part of unitary Q from QR factorization determined by F08ASF or F08BSF  FO8AFF (CUNNQR,ZUNNQR) Apply unitary transformation determined by F08ASF or F08BSF  FO8AFF (CUNNLQ,ZUNNQR) Form all or part of unitary Q from LQ factorization determined by F08AVF  FO8AFF (CUNNLQ,ZUNNQR) Apply unitary transformation determined by F08AVF  FO8BFF (SGEQPF,ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  FO8BSF (CGEQFF,ZGEQPF) QR factorization of real general rectangular matrix with column pivoting  FO8BSF (CGEQFF,ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  FO8BSF (SGEQPF,ZGEQPF) QR factorization of real general rectangular matrix with column pivoting  FO8BSF (SGEQPF,ZGEQPF) QR factorization of real general rectangular matrix with column pivoting  FO8BSF (SGEQPF,ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  FO8BSF (SGEQPF,ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  FO8BSF (SGEGRM) GROBBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by FO8KEF  FO8KSF (SGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form determined by FO8KEF  FO8KSF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form determined by FO8KE |    |                        |  |
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| FORALF FORAKF FORAUF FORAKF FO |    | F08AHF                 |  |
| FO8ASF   CCBEQRF/ZGEQRF) QR factorization of complex general rectangular matrix (CUNGQR/ZUNGQR) Form all or part of unitary Q from QR factorization determined by F08ASF or F08BSF   |    |                        | (SORGLQ/DORGLQ) Form all or part of orthogonal $Q$ from $LQ$ factorization |
| F08AFF   CUNĞQR/ZUNĞQR) Form all or part of unitary Q from QR factorization determined by F08ASF or F08BSF   |    | F08AKF                 | · · · · · · · · · · · · · · · · · · ·                                      |
| determined by F08ASF or F08BSF  F08AUF  F08AUF  F08AVF  F08BSF  F08AVF  F08BSF  F08AVF  F08BSF  F08BSS  F08BSS  F08BSS  F08BSS  F08BSS  F08BSS  CCBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  CCBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general rectangular matrix  |    |                        |  |
| FO8BSF FO8AWF FO8AWF FO8AWF FO8AWF FO8AWF FO8AWF FO8AWF FO8AWF FO8AWF FO8BSF FO8AWF FO8BSF FO8AWF FO8BSF FO8AWF FO8BSF FO8AWF FO8BEF FO8BEF FO8BEF FO8BEF FO8BEF FO8BEF FO8BEF GOBORPF/DGEQPF) QR factorization of real general rectangular matrix with column pivoting FO8BSF FO8BEF FO8BEF GOBORPF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting FO2BOF FO2WDF FO2WDF FO2WDF FO2WDF FO2WDF SVD of real upper triangular matrix (Black Box) FO2XUF FO2XUF FO2XUF SVD of complex upper triangular matrix (Black Box) FO2XUF FO8KEF GOBORBR/DORGBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF FO8KGF FO8KGF GORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form FO8KFF GORMBR/ZUNMBR) Generate unitary transformation matrices from reduction form determined by F08KEF FO8KGF GORMBR/ZUNMBR) Generate unitary transformation matrices from reduction to bidiagonal form FO8KFF GORMBR/ZUNMBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KEF FO8KGF GORMBR/ZUNMBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KEF FO8KUF GUNMBR/ZUNMBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF GORMBR/ZUNMBR) Apply unitary transformation matrices from reduction to bidiagonal form determined by F08KSF GUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF GUNMBR/ZUNMBR) SVD of real bidiagonal matrix reduced from real general matrix  GUNDSQR/ZBDSQR/SBDSQR) SVD of real bidiagonal matrix reduced from complex general  |    |                        | determined by F08ASF or F08BSF   |
| FO8AWF (CUNGLQ/ZUNGLQ) Form all or part of unitary Q from LQ factorization determined by F08AVF  FO8AXF (CUNMLQ/ZUNMLQ) Apply unitary transformation determined by F08AVF  FO8BEF (SGEQPF/DGEQPF) QR factorization of real general rectangular matrix with column pivoting  FO8BSF (CGEQPF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  FO2WDF QR factorization, possibly followed by SVD  FO2WDF SVD of real matrix (Black Box)  FO2WDF SVD of real upper triangular matrix (Black Box)  FO2XEF SVD of complex matrix (Black Box)  FO2XEF SVD of complex upper triangular matrix (Black Box)  FO3XDF (SGEBRD/DGEBRD) Orthogonal reduction of real general rectangular matrix to bidiagonal form  FO8KFF (SORGBR/DORGBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF  FO8KGF (SORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form  FO8KFF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form  FO8KFF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KEF  FO8KSF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form determined by F08KSF  (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF  FO8KUF (CUNGBR/ZUNGBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF  (SBSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    |                        | F08BSF   |
| determined by F08AVF (CUNMLQ/ZUNMLQ) Apply unitary transformation determined by F08AVF F08BFF (SGEQPF/DGEQPF) QR factorization of real general rectangular matrix with column pivoting F08BFF (CGEQPF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  F02WFF QR factorization, possibly followed by SVD F02WFF SVD of real matrix (Black Box) F02WFF SVD of real upper triangular matrix (Black Box) F02XFF SVD of complex upper triangular matrix (Black Box) F02XFF SVD of complex upper triangular matrix (Black Box) F02XFF (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 (SORGBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form  F08KFF (CGEBRD/ZGEBRD) Unitary transformation matrices from reduction to bidiagonal form determined by F08KEF (CGEBRD/ZGEBRD) Unitary transformation matrices from reduction to bidiagonal form determined by F08KSF (CUNMBR/ZUNMBR) Apply unitary transformation from reduction to bidiagonal form determined by F08KSF (SBSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general  |    |                        |  |
| 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  F02WDF (CGEQPF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  F02WDF (SVD of column pivoting)  SVD of real matrix (Black Box)  F02WDF (SVD of real upper triangular matrix (Black Box)  F02XDF (SVD of complex matrix (Black Box)  F02XDF (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 transformation from reduction to bidiagonal form determined by F08KSF  F08KUF (SDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    |                        | · · · · · · · · · · · · · · · · · · ·                                      |
| column pivoting (CGEQPF/ZGEQPF) QR factorization of complex general rectangular matrix with column pivoting  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) F02XUF SVD of complex matrix (Black Box) F02XUF SVD of complex upper triangular 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 F08KSF (SORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form (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 (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  F08MSF (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    |                        |  |
| Column pivoting  Singular value decomposition  F02WDF QR factorization, possibly followed by SVD  F02WDF SVD of real matrix (Black Box)  F02WDF SVD of real upper triangular matrix (Black Box)  F02WDF SVD of complex matrix (Black Box)  F02XDF SVD of complex upper triangular 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  (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form  F08KFF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF  (CUNGBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF  (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general  |    |                        | column pivoting  |
| 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)  F02XUF SVD of complex matrix (Black Box)  F02XUF SVD of complex upper triangular 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  (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form  F08KFF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF  (CUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF  (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    | FU8BSF                 |  |
| FOZWEF SVD of real matrix (Black Box)  FOZWEF SVD of real upper triangular matrix (Black Box)  FOZXEF SVD of complex matrix (Black Box)  FOZXUF SVD of complex upper triangular matrix (Black Box)  FOZXUF SVD of complex upper triangular matrix (Black Box)  FOZXUF SVD of complex upper triangular matrix (Black Box)  FOZZUF SVD of complex upper triangular matrix (Black Box)  FOZZUF SVD of complex upper triangular matrix (Black Box)  FOZZUF SVD of complex upper triangular matrix (Black Box)  FOZZUF SVD of complex upper triangular matrix to bidiagonal form  FOZZEF (SORGBR/DORGBR) OF SOZEE | D6 | Singular value decompo |  |
| F02WF SVD of real upper triangular matrix (Black Box) F02XF SVD of complex matrix (Black Box) F02XF SVD of complex upper triangular matrix (Black Box) F03KFF SVD of complex upper triangular matrix (Black Box) F03KFF (SGEBRD/DGEBRD) Orthogonal reduction of real general rectangular matrix to bidiagonal form F03KFF (SORGBR/DORGBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F03KEF F03KGF (SORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form determined by F03KEF F03KFF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form F03KFF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F03KSF F03KFF (CUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F03KSF F03KFF (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix F03KFF (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    |                        |  |
| F02XFF 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   |    |                        | · /  |
| FOZUF FORKEF SVD of complex upper triangular matrix (Black Box) (SGEBRD/DGEBRD) Orthogonal reduction of real general rectangular matrix to bidiagonal form FORKEF (SORGBR/DORGBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF FORKEF (SORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form FORKEF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF (CUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF FORMEF (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general  |    |                        | ,  |
| FORKEF (SGEBRD/DGEBRD) Orthogonal reduction of real general rectangular matrix to bidiagonal form  FORKEF (SORGBR/DORGBR) Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF  FORKGF (SORMBR/DORMBR) Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF  FORKSF (CGEBRD/ZGEBRD) Unitary reduction of complex general rectangular matrix to bidiagonal form  FORKEF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF  FORKUF (CUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF  FORMEF (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  FORMEF (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    |                        | - ,  |
| tion 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   |    |                        | (SGEBRD/DGEBRD) Orthogonal reduction of real general rectangular matrix to |
| agonal 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   |    |                        | tion to bidiagonal form determined by F08KEF                               |
| bidiagonal form  FORKTF (CUNGBR/ZUNGBR) Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF  FORKUF (CUNMBR/ZUNMBR) Apply unitary transformations from reduction to bidiagonal form determined by F08KSF  FORMEF (SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix  FORMSF (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general   |    |                        | agonal form determined by F08KEF   |
| 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   |    |                        | bidiagonal form  |
| 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  |    |                        | to bidiagonal form determined by F08KSF                                    |
| matrix (CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general  |    |                        | form determined by F08KSF  |
|  |    | 1 001.11               |  |
|  |    | F08MSF                 |  |

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| D8          | Other matrix equations              | $(a \circ AY + YR - C)$  |
|-------------|-------------------------------------|--|
| Do          | F08QHF                              | (STRSYL/DTRSYL) Solve real Sylvester matrix equation $AX + XB = C$ , A and   |
|             | FOODE                               | B are upper quasi-triangular or transposes  (CTDSVI /TTDSVI ) Salva complex Salvactor matrix equation AY + VB = C. A.  |
|             | F08QVF                              | (CTRSYL/ZTRSYL) Solve complex Sylvester matrix equation $AX + XB = C$ , A and B are upper triangular or conjugate-transposes   |
| D9          | -                                   | ed or underdetermined systems of linear equations, generalized inverses  |
| D9a<br>D9a1 | Unconstrained Least squares $(L_2)$ | solution   |
| Daar        | FO4AMF                              | Least-squares solution of m real equations in n unknowns, rank = $n, m \ge n$ using  |
|             |                                     | iterative refinement (Black Box)   |
|             | F04JAF<br>F04JDF                    | Minimal least-squares solution of $m$ real equations in $n$ unknowns, rank $\leq n, m \geq n$<br>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<br>F04KLF                    | Real general Gauss—Markov linear model (including weighted least-squares)  Complex general Gauss—Markov linear model (including weighted least-squares)  |
|             | FO4QAF                              | 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 $(L_{\infty})$ s E02GCF   | olution $L_{\infty}$ -approximation by general linear function   |
| D9a3        | Least absolute valu                 |  |
|             | E02GAF                              | $\hat{L}_1$ -approximation by general linear function  |
| D9b<br>D9b1 | Constrained Least squares $(L_2)$   | colution   |
| Danı        | E04NCF                              | Convex QP problem or linearly-constrained linear least-squares problem (dense)   |
|             | F04JMF                              | Equality-constrained real linear least-squares problem   |
| D9b3        | F04KMF                              | Equality-constrained complex linear least-squares problem  |
| Dans        | Least absolute valu<br>E02GBF       | $L_1$ -approximation by general linear function subject to linear inequality constraints   |
| D9c         | Generalized inverses                |  |
| ${f E}$     | F01BLF<br>Interpolation             | Pseudo-inverse and rank of real $m$ by $n$ matrix $(m \ge n)$  |
| E1          | Univariate data (curve              | fitting)   |
| E1a         | *                                   | piecewise polynomials)   |
|             | E01BAF<br>E01BEF                    | Interpolating functions, cubic spline interpolant, one variable Interpolating functions, monotonicity-preserving, piecewise cubic Hermite, one   |
|             | 101201                              | variable   |
|             | E02BAF                              | Least-squares curve cubic spline fit (including interpolation)   |
| E1b         | Polynomials<br>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         | , ,                                 | , rational, trigonometric)   |
| EO          | E01RAF<br>Multivariate data (surf   | Interpolating functions, rational interpolant, one variable  |
| E2<br>E2a   | Gridded Gridded                     | ace numg)  |
|             | E01DAF                              | Interpolating functions, fitting bicubic spline, data on rectangular grid  |
| E2b         | Scattered<br>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   |
| E3          | Service routines for inte           | derivatives, three variables expolation  |
| E3a         | Evaluation of fitted f              | unctions, including quadrature   |
| E3a1        | Function evaluation E01BFF          | n Interpolated values, interpolant computed by E01BEF, function only, one variable   |
|             | E01RBF                              | Interpolated values, evaluate rational interpolant computed by E01RAF, one   |
|             |                                     | variable   |
|             | E01SBF<br>E01SFF                    | Interpolated values, evaluate interpolant computed by E01SAF, two variables Interpolated values, evaluate interpolant computed by E01SEF, two variables  |
|             | E02AEF                              | Evaluation of fitted polynomial in one variable from Chebyshev series form   |
|             | 700117                              | (simplified parameter list)  |
|             | E02AKF<br>E02BBF                    | Evaluation of fitted polynomial in one variable from Chebyshev series form<br>Evaluation of fitted cubic spline, function only   |
|             | E02BCF                              | Evaluation of fitted cubic spline, function and derivatives  |
|             | E02CBF                              | Evaluation of fitted polynomial in two variables   |

|               | E02DEF<br>E02DFF                     | Evaluation of fitted bicubic spline at a vector of points<br>Evaluation of fitted bicubic spline at a mesh of points  |
|---------------|--------------------------------------|---|
| E3a2          | Derivative evaluation E01BGF         | Interpolated values, interpolant computed by E01BEF, function and first derivative, one variable  |
|               | EO2AHF<br>EO2BCF                     | Derivative of fitted polynomial in Chebyshev series form Evaluation of fitted cubic spline, function and derivatives  |
| E3a3          | Quadrature<br>E01BHF                 | Interpolated values, interpolant computed by E01BEF, definite integral, one variable  |
|               | EO2AJF<br>EO2BDF                     | Integral of fitted polynomial in Chebyshev series form<br>Evaluation of fitted cubic spline, definite integral  |
| E3d           | Other                                | Cont two dimensional data into namela for fitting bisplies onlines  |
| $\mathbf{F}$  | E02ZAF<br>Solution of nonlinear equa | Sort two-dimensional data into panels for fitting bicubic splines tions   |
| <b>F1</b>     | Single equation                      |   |
| F1a           | Polynomial                           |   |
| F1a1          | Real coefficients C02AGF             | All zeros of real polynomial, modified Laguerre method  |
|               | CO2AJF                               | All zeros of real quadratic   |
| F1a2          | Complex coefficient                  |   |
|               | CO2AFF                               | All zeros of complex polynomial, modified Laguerre method   |
|               | CO2AHF                               | All zeros of complex quadratic  |
| F1b           | Nonpolynomial                        |   |
|               | CO5ADF<br>CO5AGF                     | Zero of continuous function in given interval, Bus and Dekker algorithm Zero of continuous function, Bus and Dekker algorithm, from given starting value, binary search for interval      |
|               | C05AJF                               | Zero of continuous function, continuation method, from a given starting value   |
|               | CO5AVF                               | Binary search for interval containing zero of continuous function (reverse communication)   |
|               | CO5AXF<br>CO5AZF                     | Zero of continuous function by continuation method, from given starting value (reverse communication)  Zero in given interval of continuous function by Bus and Dekker algorithm (reverse |
| T-0           |                                      | communication)  |
| $\mathbf{F2}$ | System of equations<br>C05NBF        | Solution of system of nonlinear equations using function values only (easy-to-use)  |
|               | COSNDF<br>COSNCF<br>COSNDF           | Solution of system of nonlinear equations using function values only (comprehensive) Solution of system of nonlinear equations using function values only (reverse                        |
|               | C05PBF                               | communication) Solution of system of nonlinear equations using first derivatives (easy-to-use)  |
|               | CO5PCF<br>CO5PDF                     | Solution of system of nonlinear equations using first derivatives (comprehensive)<br>Solution of system of nonlinear equations using first derivatives (reverse communication)            |
| <b>F3</b>     | Service routines (e.g., ch           | neck user-supplied derivatives)   |
|               | CO5ZAF                               | Check user's routine for calculating first derivatives  |
|               | E04HCF                               | Check user's routine for calculating first derivatives of function  |
| $\mathbf{G}$  | E04HDF<br>Optimization (search also  | Check user's routine for calculating second derivatives of function   |
| G<br>G1       | Unconstrained                        | clusses A, Lo)  |
| G1a           | Univariate                           |   |
| G1a1          | Smooth function                      |   |
| G1a1a         | User provides no                     |   |
| · •           | E04ABF                               | Minimum, function of one variable using function values only  |
| G1a1b         | User provides firs<br>E04BBF         | Minimum, function of one variable, using first derivative   |
| G1b           | Multivariate                         | withinfulli, function of one variable, using first derivative   |
| G1b1          | Smooth function                      |   |
| G1b1b         | User provides firs                   | t derivatives   |
|               | E04DGF                               | Unconstrained minimum, preconditioned conjugate gradient algorithm, function of several variables using first derivatives (comprehensive)   |
| G1b2          | General function (n<br>E04CCF        | o smoothness assumed) Unconstrained minimum, simplex algorithm, function of several variables using function values only (comprehensive)  |
| G2            | Constrained                          | , , , , , , , , , , , , , , , , , , ,   |
| G2a           | Linear programming                   |   |
| G2a1          | Dense matrix of cor                  |   |
|               | E04MFF                               | LP problem (dense)  |
|               | E04NCF                               | Convex QP problem or linearly-constrained linear least-squares problem (dense)  |
|               | E04NFF<br>H02BFF                     | QP problem (dense) Interpret MPSX data file defining IP or LP problem, optimize and print solution  |
|               | HO2CBF                               | Integer QP problem (dense)  |

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| G2a2                                    | Sparse matrix of co                            |  |
|---|--|--|
|   | E04NKF   | LP or QP problem (sparse)  |
|   | E04UGF   | NLP problem (sparse)   |
| G2b                                     | H02CEF<br>Transportation and a                 | Integer LP or QP problem (sparse)  |
| G20                                     | HO3ABF   | Transportation problem, modified 'stepping stone' method   |
| G2c                                     | Integer programming                            |  |
| G2c1                                    | Zero/one                                       |  |
| G201                                    | HO2BBF   | Integer LP problem (dense)   |
| G2c6                                    | Pure integer progra                            |  |
|   | H02BBF   | Integer LP problem (dense)   |
| G2c7                                    | Mixed integer prog                             |  |
|   | H02BBF   | Integer LP problem (dense)   |
|   | H02BFF   | Interpret MPSX data file defining IP or LP problem, optimize and print solution  |
| G2d                                     | **   | reliability search class M)  |
| G2d1                                    | Shortest path                                  | Chartest noth muchlane Dilletter's almosithms  |
| CO-                                     | HO3ADF   | Shortest path problem, Dijkstra's algorithm  |
| $egin{array}{c} G2e \ G2e1 \end{array}$ | Quadratic programm                             | essian (i.e., convex problem)  |
| G2e1                                    | E04NCF   | Convex QP problem or linearly-constrained linear least-squares problem (dense)   |
|   | E04NFF   | QP problem (dense)   |
|   | E04NKF   | LP or QP problem (sparse)  |
|   | E04UGF   | NLP problem (sparse)   |
|   | H02CBF   | Integer QP problem (dense)   |
|   | H02CEF   | Integer LP or QP problem (sparse)  |
| G2e2                                    | Indefinite Hessian                             |  |
|   | E04NFF   | QP problem (dense)   |
|   | E04NKF   | LP or QP problem (sparse)  |
|   | E04UGF   | NLP problem (sparse)   |
|   | HO2CBF<br>HO2CEF                               | Integer QP problem (dense) Integer LP or QP problem (sparse)   |
| G2h                                     | General nonlinear pro                          | - , , ,  |
| G2h1                                    | Simple bounds                                  | 261 camming  |
| G2h1a                                   | Smooth function                                |  |
| G2h1a1                                  | User provides                                  |  |
|   | E04JYF   | Minimum, function of several variables, quasi-Newton algorithm, simple bounds,   |
|   |  | using function values only (easy-to-use)   |
|   | E04UCF   | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|   |  | straints, using function values and optionally first derivatives (forward communica-   |
|   | E04UFF   | tion, comprehensive) Minimum, function of several variables, sequential QP method, nonlinear con-  |
|   | E040FF   | straints, using function values and optionally first derivatives (reverse communi-   |
|   |  | cation, comprehensive)   |
|   | E04UNF   | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
|   |  | function values and optionally first derivatives (comprehensive)   |
| G2h1a2                                  |  | first derivatives  |
|   | E04KDF   | Minimum, function of several variables, modified Newton algorithm, simple bounds,  |
|   | TO 4177T                                       | using first derivatives (comprehensive)  |
|   | E04KYF   | Minimum, function of several variables, quasi-Newton algorithm, simple bounds,   |
|   | E04KZF   | using first derivatives (easy-to-use) Minimum, function of several variables, modified Newton algorithm, simple bounds,                          |
|   | БОЧКЫ  | using first derivatives (easy-to-use)  |
|   | E04UCF   | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|   |  | straints, using function values and optionally first derivatives (forward communica-   |
|   |  | tion, comprehensive)   |
|   | E04UFF   | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|   |  | straints, using function values and optionally first derivatives (reverse communi-   |
|   | EOAINE   | cation, comprehensive)   |
|   | E04UNF   | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive) |
| G2h1a3                                  | User provides                                  | first and second derivatives   |
|   | E04LBF   | Minimum, function of several variables, modified Newton algorithm, simple bounds,  |
|   |  | using first and second derivatives (comprehensive)   |
|   | E04LYF   | Minimum, function of several variables, modified Newton algorithm, simple bounds,  |
|   | <b>T</b> • • • • • • • • • • • • • • • • • • • | using first and second derivatives (easy-to-use)   |
| G2h2                                    |  | inequality constraints   |
| G2h2a                                   | Smooth function                                |  |
| G2h2a1                                  | User provides<br>E04UCF                        | no derivatives  Minimum, function of several variables, sequential QP method, nonlinear con-   |
|   | T0400L   | straints, using function values and optionally first derivatives (forward communica-   |
|   |  | tion, comprehensive)   |
|   |  | ,  |

|           | E04UFF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|-----------|----------------------|--|
|           |                      | straints, using function values and optionally first derivatives (reverse communi-   |
|           |                      | cation, comprehensive)   |
|           | E04UNF               | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
|           |                      | function values and optionally first derivatives (comprehensive)   |
| G2h2a2    | •                    | first derivatives  |
|           | E04UCF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (forward communica-   |
|           |                      | tion, comprehensive)   |
|           | E04UFF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (reverse communi-   |
|           |                      | cation, comprehensive)   |
|           | E04UNF               | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
| COL O     | NI 1:                | function values and optionally first derivatives (comprehensive)   |
| G2h3      | Nonlinear constrai   |  |
| G2h3a     | Equality constra     | ion and constraints  |
| G2h3a1    | E04UCF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           | E040CF               | straints, using function values and optionally first derivatives (forward communica-   |
|           |                      | tion, comprehensive)   |
|           | E04UFF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           | L04011               | straints, using function values and optionally first derivatives (reverse communi-   |
|           |                      | cation, comprehensive)   |
|           | E04UNF               | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
|           | 20 10111             | function values and optionally first derivatives (comprehensive)   |
| G2h3b     | Equality and ine     | equality constraints   |
| G2h3b1    | - •                  | ion and constraints  |
| G2h3b1a   | User provid          | es no derivatives  |
|           | E04UCF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (forward communica-   |
|           |                      | tion, comprehensive)   |
|           | E04UFF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (reverse communi-   |
|           |                      | cation, comprehensive)   |
|           | E04UNF               | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
|           |                      | function values and optionally first derivatives (comprehensive)   |
| G2h3b1b   | •                    | es first derivatives of function and constraints   |
|           | E04UCF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (forward communica-   |
|           |                      | tion, comprehensive)   |
|           | E04UFF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (reverse communi-   |
|           | EQ AIDIE             | cation, comprehensive)   |
|           | E04UNF               | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive) |
| G4        | Service routines     | function values and optionally first derivatives (comprehensive)   |
| G4<br>G4a | Problem input (e.g., | matrix generation)   |
| G4a       | E04MZF               | Converts MPSX data file defining LP or QP problem to format required by E04NKF   |
|           | E04UQF               | Read optional parameter values for E04UNF from external file   |
|           | HO2BUF               | Convert MPSX data file defining IP or LP problem to format required by H02BBF  |
|           | 1102.001             | or E04MFF  |
| G4c       | Check user-supplied  |  |
| -         | E04HCF               | Check user's routine for calculating first derivatives of function   |
|           | E04HDF               | Check user's routine for calculating second derivatives of function  |
|           | E04YAF               | Check user's routine for calculating Jacobian of first derivatives   |
|           | E04YBF               | Check user's routine for calculating Hessian of a sum of squares   |
|           | E04ZCF               | Check user's routines for calculating first derivatives of function and constraints  |
| G4d       | Find feasible point  | · ·  |
|           | E04MFF               | LP problem (dense)   |
|           | E04NCF               | Convex QP problem or linearly-constrained linear least-squares problem (dense)   |
|           | EO4NFF               | QP problem (dense)   |
|           | EO4NKF               | LP or QP problem (sparse)  |
|           | E04UCF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (forward communica-   |
|           |                      | tion, comprehensive)   |
|           | E04UFF               | Minimum, function of several variables, sequential QP method, nonlinear con-   |
|           |                      | straints, using function values and optionally first derivatives (reverse communi-   |
|           |                      | cation, comprehensive)   |
|           | E04UGF               | NLP problem (sparse)   |
|           | E04UNF               | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
|           | *** * ** =           | function values and optionally first derivatives (comprehensive)   |
|           | H02CBF               | Integer QP problem (dense)   |
|           | H02CEF               | Integer LP or QP problem (sparse)  |
|           |                      |  |

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| G4f             | Other  |   |
|-----------------|--|---|
| 041             | 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<br>E04NEF                                   | Read optional parameter values for E04NCF from external file<br>Supply optional parameter values to E04NCF  |
|                 | E04NGF   | Read optional parameter values for E04NFF from external file  |
|                 | E04NHF   | Supply optional parameter values to E04NFF  |
|                 | EO4NLF   | 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<br>E04UHF                                   | Supply optional parameter values to E04UCF or E04UFF 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  |
|                 | HO2BVF<br>HO2BZF                                   | Print IP or LP solutions with user specified names for rows and columns<br>Integer programming solution, supplies further information on solution obtained by |
|                 | IIOZBZI  | 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<br>Supply optional parameter values to H02CEF  |
| Н               | H02CGF Differentiation, integration                |   |
| H1              | Numerical differentiation                          |   |
|                 | DO4AAF   | 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 of One-dimensional integral) | evaluation of definite integrals)   |
| H2a<br>H2a1     | Finite interval (gen-                              |   |
| H2a1a           |  | ble via user-defined procedure  |
| H2a1a1          | Automatic (use                                     | er need only specify required accuracy)   |
|                 | DO1AHF   | 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   |
|                 | DOLARE   | 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<br>D01BAF                             | One-dimensional Gaussian quadrature   |
| H2a1b           | Integrand availab                                  |   |
| H2a1b2          | Nonautomatic                                       |   |
|                 | D01GAF   | One-dimensional quadrature, integration of function defined by data values, Gill-   |
| H2a2            | Finite interval (spe                               | Miller method ecific or special type integrand including weight functions, oscillating and singular   |
|                 | integrands, principa                               | al value integrals, splines, etc.)  |
| H2a2a           | _  | ele via user-defined procedure  |
| H2a2a1          | D01AKF   | er need only specify required accuracy)  One-dimensional quadrature, adaptive, finite interval, method suitable for oscillat-                                 |
|                 | Domin  | ing functions   |
|                 | D01ALF   | One-dimensional quadrature, adaptive, finite interval, allowing for singularities at user-specified break-points  |
|                 | DO1ANF   | 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-<br>point singularities of algebraico-logarithmic type                        |
|                 | DO1AQF   | One-dimensional quadrature, adaptive, finite interval, weight function $1/(x-c)$ , Cauchy principal value (Hilbert transform)                                 |
|                 | DO1AUF   | One-dimensional quadrature, adaptive, finite interval, variant of D01AKF efficient  |
| H2a2b           | Integrand availab                                  | on vector machines  |
| н2а2b<br>H2a2b1 | _  | er need only specify required accuracy)   |
|                 | E02AJF   | Integral of fitted polynomial in Chebyshev series form  |
|                 | E02BDF   | Evaluation of fitted cubic spline, definite integral  |

| H2a3                            |  | al (including $e^{-x}$ weight function)   |
|---------------------------------|--|---|
| H2a3a                           | Integrand available via user-defined procedure Automatic (user need only specify required accuracy)  |   |
| H2a3a1                          | DO1AMF   | One-dimensional quadrature, adaptive, infinite or semi-infinite interval  |
|                                 | DO1ASF   | One-dimensional quadrature, adaptive, semi-infinite interval, weight function $\cos(\omega x)$ or $\sin(\omega x)$  |
| H2a3a2                          | Nonautomatic D01BAF  | One-dimensional Gaussian quadrature   |
| H2a4                            |  | cluding $e^{-x^2}$ weight function)   |
| H2a4a                           | 9  | le via user-defined procedure   |
| H2a4a1                          | Automatic (use<br>DO1AMF   | er need only specify required accuracy) One-dimensional quadrature, adaptive, infinite or semi-infinite interval  |
| H2a4a2                          | Nonautomatic D01BAF  | One-dimensional Gaussian quadrature   |
| H2b                             | Multidimensional inte  | 9   |
| H2b1                            | · -  | rectangular regions (includes iterated integrals)   |
| H2b1a<br>H2b1a1                 | _  | le via user-defined procedure er need only specify required accuracy)   |
| 1120141                         | DO1DAF   | Two-dimensional quadrature, finite region   |
|                                 | DO1EAF   | Multi-dimensional adaptive quadrature over hyper-rectangle, multiple integrands   |
|                                 | D01FCF   | Multi-dimensional adaptive quadrature over hyper-rectangle  |
| TT01 1 0                        | D01GBF<br>Nonautomatic   | Multi-dimensional quadrature over hyper-rectangle, Monte Carlo method   |
| H2b1a2                          | D01FBF   | Multi-dimensional Gaussian quadrature over hyper-rectangle  |
|                                 | D01FDF   | Multi-dimensional quadrature, Sag–Szekeres method, general product region or $n$ -  |
|                                 |  | sphere  |
|                                 | D01GCF   | Multi-dimensional quadrature, general product region, number-theoretic method   |
|                                 | D01GDF   | Multi-dimensional quadrature, general product region, number-theoretic method, variant of D01GCF efficient on vector machines   |
| H2b2                            | n-dimensional quad   | rature on a nonrectangular region   |
| H2b2a                           | _  | le via user-defined procedure   |
| H2b2a1                          | Automatic (use<br>D01JAF   | er need only specify required accuracy)  Multi-dimensional quadrature over an $n$ -sphere, allowing for badly-behaved   |
|                                 | DOIJAF   | integrands  |
| H2b2a2                          | Nonautomatic   |   |
| TTO                             | DO1PAF   | Multi-dimensional quadrature over an <i>n</i> -simplex  |
|                                 |  |   |
| H2c                             | ,  | compute weights and nodes for quadrature formulas)  Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice   |
| H2C                             | D01BBF   | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule   |
| H2C                             | ,  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice  |
| H2C                             | DO1BBF<br>DO1BCF   | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  |
| H2c                             | D01BBF   | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice  |
| H2C                             | DO1BBF<br>DO1BCF   | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points   |
| H2c                             | D01BBF D01BCF D01GYF   | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes  |
| I<br>I1                         | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equal to the control of | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations  |
| I<br>I1<br>I1a                  | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equal of the control of | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations  autions (ODE's)   |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equivalential value problems General, nonstiff or  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations  autions (ODE's)  mildly stiff   |
| I<br>I1<br>I1a                  | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equivalential value problems General, nonstiff or  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations  tations (ODE's)  mildly stiff s (e.g., Runge–Kutta)  ODEs, IVP, Runge–Kutta—Merson method, until a component attains given value  |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  DO1BCF  DO1GYF  DO1GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method DO2BGF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations eations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)   |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equivalent of the control of the contr | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations eations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple   |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  DO1BCF  DO1GYF  DO1GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method DO2BGF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations eations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)   |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BJF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)   |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BHF  D02BJF  D02LAF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)  Second-order ODEs, IVP, Runge-Kutta-Nystrom method  |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BJF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)  Second-order ODEs, IVP, Runge-Kutta method, integration over range with output   |
| I<br>I1<br>I1a<br>I1a1          | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equation of the problems of the prob | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations  (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)  Second-order ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector)  |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equation of the policy of th | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)  Second-order ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector)  ODEs, IVP, Adams method, until function of solution is zero, intermediate output   |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equation of the problems of the prob | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) Second-order ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver)  |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equation of the problems of the prob | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule  Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime  Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta)  ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver)  ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver)  ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)  Second-order ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector)  ODEs, IVP, Adams method, until function of solution is zero, intermediate output   |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral equation of the problems of the prob | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) Second-order ODEs, IVP, Runge-Kutta-Nystrom method ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver) ODEs, IVP, Adams method with root-finding (forward communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication,  |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BHF  D02BJF  D02LAF D02PCF D02PDF Multistep method D02CJF  D02QFF  D02QGF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) Second-order ODEs, IVP, Runge-Kutta-Nystrom method ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step ls (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver) ODEs, IVP, Adams method with root-finding (forward communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive)  |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BHF  D02BJF  D02LAF D02PCF D02PDF Multistep method D02CJF  D02QFF  D02QGF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta-Merson method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) Second-order ODEs, IVP, Runge-Kutta-Nystrom method ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function is zero, intermediate output (simple driver) ODEs, IVP, Adams method with root-finding (forward communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive)                          |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BHF  D02BJF  D02LAF D02POF D02PDF Multistep method D02CJF  D02QFF  D02QFF  D02QGF  Stiff and mixed alge  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver) ODEs, IVP, Adams method with root-finding (forward communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive) ODEs, Stiff IVP, BDF method, until function of solution is zero, intermediate output (simple driver)  |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BHF  D02BJF  D02LAF D02PCF D02PDF  Multistep method D02CJF  D02QFF  D02QFF  D02QFF  D02QFF  D02DF  Stiff and mixed alge D02EJF  D02NBF   | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) Second-order ODEs, IVP, Runge-Kutta-Nystrom method ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step Is (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver) ODEs, IVP, Adams method with root-finding (forward communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive) ODEs, stiff IVP, BDF method, until function of solution is zero, intermediate output (simple driver) |
| I<br>I1<br>I1a<br>I1a1<br>I1a1a | DO1BBF  D01BCF  D01GYF  D01GZF  Differential and integral eq Ordinary differential equ Initial value problems General, nonstiff or One-step method D02BGF  D02BJF  D02LAF D02PCF D02PDF Multistep method D02CJF  D02QFF  D02QFF  D02QFF  D02QFF  D02QFF  D02QFF  D02CJF  | Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes quations (ODE's)  mildly stiff s (e.g., Runge-Kutta) ODEs, IVP, Runge-Kutta-Merson method, until a component attains given value (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero (simple driver) ODEs, IVP, Runge-Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver) ODEs, IVP, Runge-Kutta method, integration over range with output ODEs, IVP, Runge-Kutta method, integration over one step is (e.g., Adams predictor-corrector) ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver) ODEs, IVP, Adams method with root-finding (forward communication, comprehensive) ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive) ODEs, Stiff IVP, BDF method, until function of solution is zero, intermediate output (simple driver)  |

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|             | DO2NGF<br>DO2NHF              | Implicit/algebraic ODEs, stiff IVP, full Jacobian (comprehensive) Implicit/algebraic ODEs, stiff IVP, banded Jacobian (comprehensive)                           |
|-------------|-------------------------------|---|
|             | DO2NJF                        | Implicit/algebraic ODEs, stiff IVP, sparse Jacobian (comprehensive)   |
|             | DO2NMF                        | Explicit ODEs, stiff IVP (reverse communication, comprehensive)   |
|             | DO2NNF                        | Implicit/algebraic ODEs, stiff IVP (reverse communication, comprehensive)   |
|             | D03PKF                        | General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, one space variable  |
|             | D03PPF                        | General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, remeshing, one space variable  |
|             | D03PRF                        | General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, remeshing, one space variable                                     |
| I1b<br>I1b1 | Multipoint boundary<br>Linear | · · · · · · · · · · · · · · · · · · ·   |
|             | D02GBF                        | ODEs, boundary value problem, finite difference technique with deferred correction, general linear problem  |
|             | D02JAF                        | ODEs, boundary value problem, collocation and least-squares, single $n$ th-order linear equation  |
|             | D02JBF                        | ODEs, boundary value problem, collocation and least-squares, system of first-order linear equations   |
|             | D02TGF                        | $n{ m th}{ m -order}$ linear ODEs, boundary value problem, collocation and least-squares  |
| I1b2        | Nonlinear                     |   |
|             | D02AGF                        | ODEs, boundary value problem, shooting and matching technique, allowing interior matching point, general parameters to be determined                            |
|             | DO2GAF                        | ODEs, boundary value problem, finite difference technique with deferred correction,   |
|             | DO2HAF                        | simple nonlinear problem ODEs, boundary value problem, shooting and matching, boundary values to be determined  |
|             | DO2HBF                        | ODEs, boundary value problem, shooting and matching, general parameters to be determined  |
|             | DO2RAF                        | ODEs, general nonlinear boundary value problem, finite difference technique with deferred correction, continuation facility                                     |
|             | D02SAF                        | ODEs, boundary value problem, shooting and matching technique, subject to extra algebraic equations, general parameters to be determined                        |
|             | D02TKF                        | ODEs, general nonlinear boundary value problem, collocation technique   |
| I1b3        | Eigenvalue (e.g., St          |   |
|             | D02AGF                        | ODEs, boundary value problem, shooting and matching technique, allowing interior matching point, general parameters to be determined                            |
|             | DO2HBF                        | ODEs, boundary value problem, shooting and matching, general parameters to be determined  |
|             | DO2KAF                        | Second-order Sturm-Liouville problem, regular system, finite range, eigenvalue only   |
|             | D02KDF                        | Second-order Sturm-Liouville problem, regular/singular system, finite/infinite range, eigenvalue only, user-specified break-points                              |
|             | D02KEF                        | Second-order Sturm-Liouville problem, regular/singular system, finite/infinite range, eigenvalue and eigenfunction, user-specified break-points                 |
| I1c         | Service routines (e g         | interpolation of solutions, error handling, test programs)  |
| 110         | DO2LXF                        | Second-order ODEs, IVP, set-up for D02LAF   |
|             | D02LYF                        | Second-order ODEs, IVP, diagnostics for D02LAF  |
|             | D02LZF                        | Second-order ODEs, IVP, interpolation for D02LAF  |
|             | DO2MVF                        | ODEs, IVP, DASSL method, set-up for D02M–N routines   |
|             | D02MZF                        | ODEs, IVP, interpolation for D02M–N routines, natural interpolant   |
|             | DO2NRF                        | ODEs, IVP, for use with D02M-N routines, sparse Jacobian, enquiry routine   |
|             | DO2NSF                        | ODEs, IVP, for use with D02M–N routines, full Jacobian, linear algebra set-up   |
|             | DO2NTF                        | ODEs, IVP, for use with D02M-N routines, banded Jacobian, linear algebra set-up ODEs, IVP, for use with D02M-N routines, sparse Jacobian, linear algebra set-up |
|             | DO2NUF<br>DO2NVF              | ODEs, IVP, for use with Dozin-in routines, sparse Jacobian, linear algebra set-up ODEs, IVP, BDF method, set-up for Do2M-N routines                             |
|             | DO2NWF                        | ODEs, IVP, Blend method, set-up for D02M-N routines   |
|             | DO2NXF                        | ODEs, IVP, sparse Jacobian, linear algebra diagnostics, for use with D02M–N routines  |
|             | DO2NYF                        | ODEs, IVP, integrator diagnostics, for use with D02M–N routines   |
|             | D02NZF                        | ODEs, IVP, set-up for continuation calls to integrator, for use with D02M–N routines  |
|             | D02PVF                        | ODEs, IVP, set-up for D02PCF and D02PDF   |
|             | DO2PWF                        | ODEs, IVP, resets end of range for D02PDF   |
|             | DO2PXF                        | ODEs, IVP, interpolation for D02PDF   |
|             | DO2PYF                        | ODEs, IVP, integration diagnostics for D02PCF and D02PDF  |
|             | DO2PZF                        | ODEs, IVP, error assessment diagnostics for D02PCF and D02PDF   |
|             | DO2QWF<br>DO2QXF              | ODEs, IVP, set-up for D02QFF and D02QGF<br>ODEs, IVP, diagnostics for D02QFF and D02QGF   |
|             | DO2QXF<br>DO2QYF              | ODEs, IVI, diagnostics for D02QFF and D02QGF  ODEs, IVP, root-finding diagnostics for D02QFF and D02QGF   |
|             | D02QZF                        | ODEs, IVP, interpolation for D02QFF or D02QGF   |
|             | D02TVF                        | ODEs, general nonlinear boundary value problem, set-up for D02TKF   |
|             | DO2TXF                        | ODEs, general nonlinear boundary value problem, continuation facility for D02TKF  |

|               | DO2TYF                             | ODEs, general nonlinear boundary value problem, interpolation for D02TKF  |
|---------------|------------------------------------|---|
|               | DO2TZF<br>DO2XJF                   | ODEs, general nonlinear boundary value problem, diagnostics for D02TKF<br>ODEs, IVP, interpolation for D02M-N routines, natural interpolant   |
|               | DO2XKF                             | ODEs, IVP, interpolation for D02M-N routines, $C_1$ interpolation   |
|               | DO2ZAF                             | ODEs, IVP, weighted norm of local error estimate for D02M-N routines  |
| I2            | Partial differential equa          |   |
| I2a<br>I2a1   | Initial boundary valu<br>Parabolic | e problems  |
| 12a1<br>12a1a | One spatial dime                   | ension  |
|               | D03PCF                             | General system of parabolic PDEs, method of lines, finite differences, one space variable   |
|               | DO3PDF                             | General system of parabolic PDEs, method of lines, Chebyshev $\mathbb{C}^0$ collocation, one space variable   |
|               | D03PEF                             | General system of first-order PDEs, method of lines, Keller box discretisation, one space variable  |
|               | D03PHF                             | General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, one space variable   |
|               | D03PJF                             | General system of parabolic PDEs, coupled DAEs, method of lines, Chebyshev $C^0$ collocation, one space variable  |
|               | D03PKF                             | General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, one space variable  |
|               | D03PPF                             | General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, remeshing, one space variable  |
|               | D03PRF                             | General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, remeshing, one space variable   |
|               | DO3PYF<br>DO3PZF                   | PDEs, spatial interpolation with D03PDF or D03PJF<br>PDEs, spatial interpolation with D03PCF, D03PEF, D03PFF, D03PHF, D03PKF,   |
|               | 2001 21                            | D03PLF, D03PPF, D03PRF or D03PSF  |
| I2a1b         | Two or more spa                    |   |
|               | DOSRAF                             | General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectangular region  |
|               | DOORBF                             | General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectilinear region  |
|               | DO3RYF<br>DO3RZF                   | Check initial grid data in D03RBF<br>Extract grid data from D03RBF  |
| I2a2          | Hyperbolic                         |   |
|               | D03PFF                             | General system of convection-diffusion PDEs with source terms in conservative form, method of lines, upwind scheme using numerical flux function based on Riemann solver, one space variable  |
|               | D03PLF                             | General system of convection-diffusion PDEs with source terms in conservative form, coupled DAEs, method of lines, upwind scheme using numerical flux function based on Riemann solver, one space variable  |
|               | D03PSF                             | General system of convection-diffusion PDEs with source terms in conservative form, coupled DAEs, method of lines, upwind scheme using numerical flux function based on Riemann solver, remeshing, one space variable   |
|               | D03PUF                             | Roe's approximate Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF   |
|               | D03PVF                             | Osher's approximate Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF   |
|               | DO3PWF                             | Modified HLL Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF  |
| TO.           | D03PXF                             | Exact Riemann Solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF   |
| I2b<br>I2b1   | Elliptic boundary val<br>Linear    | nue problems  |
| 12b1<br>12b1a | Second order                       |   |
| I2b1a1        |                                    | ace) or Helmholtz equation  |
| I2b1a1a       | Rectangular<br>DO3FAF              | domain (or topologically rectangular in the coordinate system) Elliptic PDE, Helmholtz equation, three-dimensional Cartesian co-ordinates   |
| I2b1a1b       |                                    | ular domain   |
|               | DOSEAF                             | Elliptic PDE, Laplace's equation, two-dimensional arbitrary domain  |
| I2b1a3        | Nonseparable<br>D03EEF             | problems Discretize a second-order elliptic PDE on a rectangle  |
| I2b4          | Service routines                   | Discretization and a discretization DDE and the discretization of |
|               | DO3EEF<br>DO3PYF                   | Discretize a second-order elliptic PDE on a rectangle<br>PDEs, spatial interpolation with D03PDF or D03PJF  |
|               | DOSPZF                             | PDEs, spatial interpolation with D031 BF of D031 SF<br>PDEs, spatial interpolation with D03PCF, D03PEF, D03PFF, D03PHF, D03PKF,<br>D03PLF, D03PPF, D03PRF or D03PSF   |
| I2b4a         | Domain triangul<br>DO3MAF          | Triangulation of plane region   |
|               |                                    |   |

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| I2b4b       | Solution of discre      | etized elliptic equations  |
|-------------|-------------------------|--|
|             | DO3EBF                  | Elliptic PDE, solution of finite difference equations by SIP, five-point two-  |
|             | D03ECF                  | dimensional molecule, iterate to convergence<br>Elliptic PDE, solution of finite difference equations by SIP for seven-point three-  |
|             | 500201                  | dimensional molecule, iterate to convergence   |
|             | DO3EDF                  | Elliptic PDE, solution of finite difference equations by a multigrid technique   |
|             | DOSUAF                  | Elliptic PDE, solution of finite difference equations by SIP, five-point two-<br>dimensional molecule, one iteration   |
|             | DOSUBF                  | Elliptic PDE, solution of finite difference equations by SIP, seven-point three-dimensional molecule, one iteration  |
| <b>I</b> 3  | Integral equations      |  |
|             | DO5AAF<br>DO5ABF        | Linear non-singular Fredholm integral equation, second kind, split kernel<br>Linear non-singular Fredholm integral equation, second kind, smooth kernel  |
|             | DO5BAF                  | Nonlinear Volterra convolution equation, second kind   |
|             | D05BDF                  | Nonlinear convolution Volterra–Abel equation, second kind, weakly singular   |
|             | D05BEF                  | Nonlinear convolution Volterra—Abel equation, first kind, weakly singular  |
|             | DO5BWF<br>DO5BYF        | Generate weights for use in solving Volterra equations Generate weights for use in solving weakly singular Abel-type equations   |
| J           | Integral transforms     |  |
| J1          | ~                       | ns including fast Fourier transforms   |
| J1a<br>J1a1 | One-dimensional<br>Real |  |
| JIAI        | C06EAF                  | Single one-dimensional real discrete Fourier transform, no extra workspace   |
|             | CO6FAF                  | Single one-dimensional real discrete Fourier transform, extra workspace for greater speed  |
|             | C06FPF                  | Multiple one-dimensional real discrete Fourier transforms  |
|             | CO6PAF                  | Single 1D real and Hermitian complex discrete Fourier transform, using complex   |
|             | CO6PAF                  | data format for Hermitian sequences Single one-dimensional real and Hermitian complex discrete Fourier transform, using  |
|             | COOPAP                  | complex data format for Hermitian sequences  |
|             | C06PPF                  | Multiple 1D real and Hermitian complex discrete Fourier transforms, using complex data format for Hermitian sequences  |
|             | C06PPF                  | Multiple one-dimensional real and Hermitian complex discrete Fourier transforms,   |
|             | C06PQF                  | using complex data format for Hermitian sequences  Multiple one-dimensional real and Hermitian complex discrete Fourier transforms,  |
| 74 0        | G1                      | using complex data format for Hermitian sequences and sequences stored as columns $% \left( 1\right) =\left( 1\right) \left( 1\right)$ |
| J1a2        | Complex<br>C06EBF       | Single one-dimensional Hermitian discrete Fourier transform, no extra workspace  |
|             | C06ECF                  | Single one-dimensional complex discrete Fourier transform, no extra workspace  |
|             | C06FBF                  | Single one-dimensional Hermitian discrete Fourier transform, extra workspace for greater speed   |
|             | C06FCF                  | Single one-dimensional complex discrete Fourier transform, extra workspace for   |
|             |                         | greater speed  |
|             | CO6FFF<br>CO6FQF        | One-dimensional complex discrete Fourier transform of multi-dimensional data<br>Multiple one-dimensional Hermitian discrete Fourier transforms   |
|             | CO6FRF                  | Multiple one-dimensional complex discrete Fourier transforms   |
|             | C06GBF                  | Complex conjugate of Hermitian sequence  |
|             | CO6GCF<br>CO6GQF        | Complex conjugate of complex sequence Complex conjugate of multiple Hermitian sequences  |
|             | COGGSF                  | Convert Hermitian sequences to general complex sequences   |
|             | C06PCF                  | Single 1D complex discrete Fourier transform, complex data format  |
|             | CO6PCF<br>CO6PFF        | Single one-dimensional complex discrete Fourier transform, complex data format 1D complex discrete Fourier transform of multi-dimensional data (using the complex  |
|             | COOFFF                  | data type)   |
|             | CO6PFF                  | One-dimensional complex discrete Fourier transform of multi-dimensional data   |
|             | CO6PRF                  | (using complex data type) Multiple 1D complex discrete Fourier transforms using complex data format  |
|             | CO6PRF                  | Multiple one-dimensional complex discrete Fourier transforms using complex data format   |
|             | C06PSF                  | Multiple one-dimensional complex discrete Fourier transforms using complex data  |
| 71 0        | Cine and assine to      | format and sequences stored as columns   |
| J1a3        | Sine and cosine tra     | Discrete sine transform  |
|             | C06HBF                  | Discrete cosine transform  |
|             | CO6HCF<br>CO6HDF        | Discrete quarter-wave sine transform Discrete quarter-wave cosine transform  |
|             | COGRAF                  | Discrete quarter-wave cosine transform  Discrete sine transform (easy-to-use)  |
|             | CO6RAF                  | Discrete sine transform (easy-to-use)  |
|             | CO6RBF<br>CO6RBF        | Discrete cosine transform (easy-to-use) Discrete cosine transform (easy-to-use)  |
|             | COGRCF                  | Discrete cosine transform (easy-to-use)  Discrete quarter-wave sine transform (easy-to-use)  |
|             | C06RCF                  | Discrete quarter-wave sine transform (easy-to-use)   |

| Discrete quartor-wave cosine transform (cosy-to-use)   |             |               |   |
|--|-------------|---------------|---|
| Multi-dimensional Complex discrete Fourier transform of multi-dimensional data   Construction    |             | CO6RDF        | Discrete quarter-wave cosine transform (easy-to-use)                                |
| Multi-dimensional complex discrete Fourier transform of multi-dimensional data   |             |               | Discrete quarter-wave cosine transform (easy-to-use)                                |
| COSPUT   C   | $_{ m J1b}$ |               |   |
| Company  |             |               |   |
| Multi-dimensional complex discrete Fourier transform of multi-dimensional data (uning complex data type)   (uning complex data format complex data f   |             |               | •   |
| Using complex data type  |             |               | *   |
| Multi-dimensional complex discrete Fourier transform of multi-dimensional data   Using complex data   Using complex data   C   |             | 000101        | • .   |
| CORPUT   COMPUT   C   |             | CO6PJF        | \ · · · · · · · · · · · · · · · · ·   |
| CORPUT   Two-dimensional complex discrete Fourier transform, complex data format CORPUT   CORPUT   Three-dimensional complex discrete Fourier transform, complex data format Three-dimensional complex discrete Fourier transform, complex data format Three-dimensional complex discrete Fourier transform, complex data format CORPUT   Corputation of two real vectors, no extra workspace for greater speed   CORPUT   Circular convolution or correlation of two real vectors, extra workspace for greater speed   CORPUT   Circular convolution or correlation of two complex vectors   CORPUT   Circular convolution or correlation of two complex vectors   CORPUT   Circular convolution or correlation of two complex vectors   CORPUT   Corputation   CORPUT   Corputation   Corputatio   |             |               | \ · · · · · · · · · · · · · · · · ·   |
| CORPET   Three-dimensional complex discrete Fourier transform, complex data format   CORPET   Three-dimensional complex discrete Fourier transform, complex data format   CORPET   Corellar convolution or correlation of two real vectors, extra workspace   Circular convolution or correlation of two complex vectors   CORPET   Circular convolution or correlation of two complex vectors   CORPET   Circular convolution or correlation of two complex vectors   CORPET   Circular convolution or correlation of two complex vectors   CORPET   CORLES   Inverse Laplace transform or correlation of two complex vectors   CORPET   CORLES   Inverse Laplace transform, Crump's method   Inverse Laplace transform as computed by CORLES      |             |               |   |
| Convolutions   |             |               |   |
| Convolutions  CORERF CORERF Circular convolution or correlation of two real vectors, no extra workspace for greater speed Corelation of two complex vectors (CORERF Circular convolution or correlation of two complex vectors (CORERF Circular convolution or correlation of two complex vectors (CORERF CIRCUlar convolution or correlation of two complex vectors (CORERF CIRCUlar convolution or correlation of two complex vectors (CORERF CIRCUlar convolution or correlation of two complex vectors (CORERF CIRCUlar convolution or correlation of two complex vectors (CORERF CIRCUlar convolution or correlation of two complex vectors  Jay Italian (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution or correlation of two complex vectors  MIA (CORERF CIRCUlar convolution)  MIA (MIA) |             |               | •   |
| COSEKE   COSEKE   Circular convolution or correlation of two real vectors, extra workspace for greater speed   COSEKE   COSEKE   COSEKE   COSEKE   COSEKE   COSEKE   COSEKE   Coverage   Circular convolution or correlation of two complex vectors  | 10          |               | Three-dimensional complex discrete Fourier transform, complex data format           |
|  | J Z         |               | Circular convolution or correlation of two real vectors, no extra workspace         |
| COPFECT   Circular convolution or correlation of two complex vectors   Corontarion     |             |               | •   |
| CORPER   CORPER   Cornelation of two complex vectors   |             |               |   |
| Laplace transforms   |             | CO6PKF        | <del>-</del>  |
| COGLES   Country principal value (Hilbert transform as computed by COGLES   Country principal value (Hilbert transform)   Country principal value (Hilbert transform)   Country principal value (Hilbert transform)   |             |               | Circular convolution or correlation of two complex vectors                          |
| COGEST   COGEST   COGEST   COGEST   Coultain timerse Laplace transform, modified Weeks' method (COGEST   Coultain timerse Laplace transforms as computed by COGEST   Coultain timerse Laplace transforms as computed by COGEST   Coultain timerse   Coultain timer   | J3          |               |   |
| Milbert transforms   |             |               | 1 , 1   |
| Hilbert transforms   |             |               | 1   |
|  | .14         |               | Evaluate inverse Eaplace transform as computed by Coolds                            |
| Cauchy principal value (Hilbert transform)   | 01          |               | One-dimensional quadrature, adaptive, finite interval, weight function $1/(x-c)$ ,  |
| K1   |             |               |   |
| Klala   Unconstrained   Unconstrained   Unconstrained   Unconstrained   Unconstrained   Unconstrained   Unconstrained   Unconstrained   East-squares curve cubic spline flit (including interpolation)   Least-squares curve cubic spline curve fit, automatic knot placement   Least-squares curve cubic spline curve fit, automatic knot placement   Least-squares curve fit, by polynomials, arbitrary data points   Least-squares curve fit, by polynomials, arbitrary data points   Least-squares polynomial fit, special data points (including interpolation)   |             |               | , , , , , , , , , , , , , , , , , , ,   |
| Klala   Unconstrained   Klala   Univariate data (curve fitting)  |             | - , ,         |   |
| Klala   Univariate data \( curve fitting )   |             | - ,           | search also classes D5, D6, D9)   |
| Polynomial splines (piecewise polynomials)   E028BF   Least-squares curve cubic spline fit (including interpolation)   E028BF   Least-squares curve fit, automatic knot placement   Polynomials   E024BF   Least-squares curve fit, by polynomials, arbitrary data points   E024BF   Least-squares surface fit by polynomials, arbitrary data points   E024BF   Least-squares surface fit by polynomials, data on lines   E020BF   Least-squares surface fit by polynomials, data on lines   E020BF   Least-squares surface fit by bicubic splines   E020BF   Least-squares surface fit by bicubic splines with automatic knot placement, data on rectangular grid   E020BF   Least-squares surface fit by bicubic splines with automatic knot placement, scattered data   |             |               | (curve fitting)   |
| K1a1a2 Polynomials E02ADF Least-squares curve cubic spline curve fit, automatic knot placement F02ADF Least-squares curve fit, by polynomials, arbitrary data points E02ADF Least-squares polynomial fit, special data points (including interpolation)  K1a1b Multivariate data (surface fitting) E02CAF Least-squares surface fit by polynomials, data on lines E02DAF Least-squares surface fit, bicubic splines E02DAF Least-squares surface fit by bicubic splines E02DAF Least-squares surface fit by bicubic splines with automatic knot placement, data on rectangular grid E02DAF Least-squares surface fit by bicubic splines with automatic knot placement, data on rectangular grid Least-squares surface fit by bicubic splines with automatic knot placement, data on rectangular grid Linear constraints  K1a2 Constrained K1a2 Linear constraints K1b1a Unconstrained K1b1a Simooth functions K1b1a Unconstrained K1b1a Simooth functions K1b1a Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  E04FFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using first derivatives (comprehensive)  Wewton algorithm, using first derivatives (comprehensive)  Wewton algorithm, using first derivatives (comprehensive)  Wewton algorithm, using second derivatives (comprehensive)  Wewton algorithm, using second derivatives (com |             |               | ·   |
| Polynomials  |             | * -           | Least-squares curve cubic spline fit (including interpolation)                      |
| E02AFF   Least-squares polynomial fit, special data points (including interpolation)   |             |               | Least-squares cubic spline curve fit, automatic knot placement                      |
| Klab   Multivariate data (surface fitting)   | K1a1a2      | -             |   |
| Multivariate data   (surface fitting)  |             |               |   |
| E02CAF   Least-squares surface fit by polynomials, data on lines   | W1o1b       |               |   |
| E02DAF   Least-squares surface fit, bicubic splines   E02DCF   Least-squares surface fit by bicubic splines with automatic knot placement, data on rectangular grid   E02DDF   Least-squares surface fit by bicubic splines with automatic knot placement, scattered data  K1a2   Constrained   K1a2a   Linear constraints   E02AGF   Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points  K1b   Nonlinear least squares   K1b1   Unconstrained   K1b1a   Smooth functions   K1b1a   User provides   Deferment of the constrained   K1b1a   User provides   Deferment of the constrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm using function values only (comprehensive)   E04GF   Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)   E04GF   Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm using first derivatives (comprehensive)   Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (casy-to-use)   E04GF   Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm using first derivatives (casy-to-use)   Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm, using first derivatives (comprehensive)   Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm, using second derivatives (comprehensive)   Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm, using second derivatives (comprehensive)   Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified   Newton algorithm,  | Kiaib       |               | (   |
| rectangular grid Least-squares surface fit by bicubic splines with automatic knot placement, scattered data  K1a2 Constrained K1a2a Linear constraints  E02AGF Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points  K1b Nonlinear least squares K1b1 Unconstrained K1b1a Smooth functions  K1b1a1 User provides no derivatives  E04FCF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  K1b1a2 User provides first derivatives  E04FVF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2 User provides first derivatives  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GDF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Newton algorithm, using second derivatives (comprehensive)  |             |               |   |
| K1a2 Constrained K1a2a Linear constraints  E02AGF Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points  K1b Nonlinear least squares K1b1 Unconstrained K1b1a Smooth functions K1b1a1 User provides no derivatives E04FYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  K1b1a2 User provides first derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2 User provides first derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (comprehensive)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using first derivatives (casy-to-use)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)   |             | E02DCF        | Least-squares surface fit by bicubic splines with automatic knot placement, data on |
| K1a2 Constrained K1a2a Constraines  E02AGF Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points  K1b Nonlinear least squares K1b1 Unconstrained K1b1a Smooth functions K1b1a1 User provides no derivatives  E04FCF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  E04FYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2 User provides first derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GDF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using first derivatives (easy-to-use)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using first derivatives (easy-to-use)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)   |             |               |   |
| K1a2a Constrained K1a2a Linear constraints  E02AGF Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points  K1b Nonlinear least squares K1b1 Unconstrained K1b1a Smooth functions  K1b1a1 User provides no derivatives  E04FCF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  E04FYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2 User provides # Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  E04GF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)   |             | E02DDF        |   |
| K1b2   | K102        | Constrained   | data  |
| K1b Nonlinear least squares polynomial fit, values and derivatives may be constrained, arbitrary data points  K1b1 Unconstrained K1b1a Smooth functions K1b1a1 User provides no derivatives  E04FCF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  E04FYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2 User provides first derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)   |             |               | S   |
| K1b1 (Vinconstrained Smooth functions K1b1a (Smooth functions K1b1a1 (User provides no derivatives E04FCF (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using function values only (comprehensive) (E04FYF (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2 (User provides first derivatives E04GBF (Unconstrained minimum of a sum of squares, combined Gauss—Newton and quasi-Newton algorithm using first derivatives (comprehensive) (E04GDF (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using first derivatives (comprehensive) (Unconstrained minimum of a sum of squares, combined Gauss—Newton and quasi-Newton algorithm, using first derivatives (easy-to-use) (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3 (User provides first and second derivatives) (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive) (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive) (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive) (Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive)  | 111424      |               |   |
| K1b1a K1b1a1   |             |               | data points   |
| K1bla   Smooth functions   K1bla1   User provides no derivatives   |             | _             | es  |
| K1b1a1  User provides no derivatives  E04FCF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (comprehensive)  E04FYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a2  User provides first derivatives  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GDF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  E04GZF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3  User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)  |             |               |   |
| K1b1a2 User provides first and second derivatives (casy-to-use)  K1b1a3 User provides first derivatives  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using function values only (easy-to-use)  K1b1a3 User provides first derivatives  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm using first derivatives (comprehensive)  E04GDF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  E04GFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HFF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  |             |               |   |
| Newton algorithm using function values only (comprehensive)   E04FYF   Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using function values only (easy-to-use)   Newton algorithm using function values only (easy-to-use)   User provides first derivatives   | Kibiai      | _             |   |
| K1b1a2  User provides first derivatives  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi- Newton algorithm using first derivatives (comprehensive)  E04GDF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi- Newton algorithm, using first derivatives (easy-to-use)  E04GZF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3  User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Vunconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Vunconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)   |             | 2011 01       |   |
| User provides first derivatives  E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi- Newton algorithm using first derivatives (comprehensive)  E04GDF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi- Newton algorithm, using first derivatives (easy-to-use)  E04GZF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)   |             | E04FYF        | Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified       |
| E04GBF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi- Newton algorithm using first derivatives (comprehensive)  E04GPF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi- Newton algorithm, using first derivatives (easy-to-use)  E04GZF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  K1b1a3 User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)  |             |               |   |
| Newton algorithm using first derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss—Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  E04GZF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using first derivatives (easy-to-use)  Wester provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (easy-to-use)  | K1b1a2      | •             |   |
| E04GDF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using first derivatives (comprehensive)  E04GYF Unconstrained minimum of a sum of squares, combined Gauss—Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  E04GZF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm using first derivatives (easy-to-use)  User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (easy-to-use)  |             | E04GBF        | • '   |
| Newton algorithm using first derivatives (comprehensive)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)  Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)   |             | E04GDF        | ,   |
| Newton algorithm, using first derivatives (easy-to-use) Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  West provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)   |             |               |   |
| E04GZF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm using first derivatives (easy-to-use)  User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)  |             | E04GYF        | Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-         |
| Newton algorithm using first derivatives (easy-to-use)  User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)   |             |               |   |
| User provides first and second derivatives  E04HEF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (comprehensive)  E04HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)   |             | E04GZF        |   |
| EO4HEF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (comprehensive)  EO4HYF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (easy-to-use)   | K1h1a9      | Heer provides |   |
| Newton algorithm, using second derivatives (comprehensive)  EO4HYF Unconstrained minimum of a sum of squares, combined Gauss—Newton and modified Newton algorithm, using second derivatives (easy-to-use)  | 1710199     | _             |   |
| EO4HYF Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified Newton algorithm, using second derivatives (easy-to-use)  |             | 20 24422      |   |
|  |             | E04HYF        | Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified       |
| K1b2 Constrained   | ****        | Q             | Newton algorithm, using second derivatives (easy-to-use)                            |
|  | K1b2        | Constrained   |   |

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| T          | N. 1.                                      | . ,  |
|------------|--|--|
| K1b2b      | Nonlinear constra<br>E04UNF                | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
|            | 20 1011                                    | function values and optionally first derivatives (comprehensive)   |
| K2         | Minimax $(L_{\infty})$ approxim            |  |
| T. 4       | E02ACF                                     | Minimax curve fit by polynomials   |
| K4         | Other analytic approxim                    | ations (e.g., Taylor polynomial, Padé) Padé-approximants   |
| <b>K</b> 6 | Service routines for appr                  |  |
| K6a        |  | nctions, including quadrature  |
| K6a1       | Function evaluation                        |  |
|            | 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<br>E02RBF                           | Evaluation of fitted polynomial in two variables<br>Evaluation of fitted rational function as computed by E02RAF   |
| K6a2       | Derivative evaluatio                       | - v  |
| 11042      | E02AHF                                     | Derivative of fitted polynomial in Chebyshev series form   |
|            | E02BCF                                     | Evaluation of fitted cubic spline, function and derivatives  |
| K6a3       | Quadrature                                 | Integral of fitted polynomial in Chebyshev series form   |
|            | EO2AJF<br>EO2BDF                           | Evaluation of fitted cubic spline, definite integral   |
| K6d        | Other                                      |  |
|            | E02ZAF                                     | Sort two-dimensional data into panels for fitting bicubic splines  |
| L          | Statistics, probability Data summarization |  |
| L1<br>L1a  | One-dimensional data                       |  |
| L1a1       | Raw data                                   |  |
|            | GO1AAF                                     | Mean, variance, skewness, kurtosis, etc, one variable, from raw data   |
|            | GO1ALF<br>GO7DAF                           | Computes a five-point summary (median, hinges and extremes) Robust estimation, median, median absolute deviation, robust standard deviation  |
|            | GO7DBF                                     | Robust estimation, $M$ -estimates for location and scale parameters, standard weight   |
|            |  | functions  |
|            | G07DCF                                     | Robust estimation, M-estimates for location and scale parameters, user-defined   |
|            | GO7DDF                                     | weight functions Computes a trimmed and winsorized mean of a single sample with estimates of their   |
|            | GOTDDI                                     | variance   |
| L1a3       | Grouped data                               |  |
| T 1L       | GO1ADF                                     | Mean, variance, skewness, kurtosis, etc, one variable, from frequency table (search also class L1c)  |
| L1b        | GO1ABF                                     | Mean, variance, skewness, kurtosis, etc, two variables, from raw data  |
| L1c        | Multi-dimensional dat                      |  |
| L1c1       | Raw data                                   |  |
|            | GO2BDF<br>GO2BKF                           | Correlation-like coefficients (about zero), all variables, no missing values<br>Correlation-like coefficients (about zero), subset of variables, no missing values   |
|            | G11BAF                                     | Computes multiway table from set of classification factors using selected statistic  |
|            | G11BBF                                     | Computes multiway table from set of classification factors using given   |
| T = =1     | Gi   | percentile/quantile  |
| L1c1b      | Covariance, correl<br>G02BAF               | Pearson product-moment correlation coefficients, all variables, no missing values  |
|            | GO2BGF                                     | Pearson product-moment correlation coefficients, subset of variables, no missing   |
|            |  | values   |
|            | GO2BNF                                     | Kendall/Spearman non-parametric rank correlation coefficients, no missing values, overwriting input data   |
|            | G02BQF                                     | Kendall/Spearman non-parametric rank correlation coefficients, no missing values,  |
|            | •  | preserving input data  |
|            | G02BTF                                     | Update a weighted sum of squares matrix with a new observation   |
|            | GO2BUF<br>GO2BWF                           | Computes a weighted sum of squares matrix<br>Computes a correlation matrix from a sum of squares matrix  |
|            | GO2BXF                                     | Computes (optionally weighted) correlation and covariance matrices   |
|            | G02BYF                                     | $Computes\ partial\ correlation/variance-covariance\ matrix\ from\ correlation/variance-covariance$ |
|            |  | covariance matrix computed by G02BXF   |
|            | GO2HKF<br>GO2HLF                           | Calculates a robust estimation of a correlation matrix, Huber's weight function<br>Calculates a robust estimation of a correlation matrix, user-supplied weight function   |
|            | GOZILF                                     | plus derivatives   |
|            | GO2HMF                                     | Calculates a robust estimation of a correlation matrix, user-supplied weight function  |
| L1c2       | ,  | g missing values (search also class L1c1)  |
|            | G02BBF                                     | Pearson product-moment correlation coefficients, all variables, casewise treatment of missing values   |
|            | G02BCF                                     | Pearson product-moment correlation coefficients, all variables, pairwise treatment   |
|            |  | of missing values  |
|            |  |  |

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|                 | G02BEF                            | Correlation-like coefficients (about zero), all variables, casewise treatment of missing   |
|-----------------|-----------------------------------|--|
|                 | G02BFF                            | values Correlation-like coefficients (about zero), all variables, pairwise treatment of missing  |
|                 | G02BHF                            | values Pearson product-moment correlation coefficients, subset of variables, casewise  |
|                 |                                   | treatment of missing values  |
|                 | G02BJF                            | Pearson product-moment correlation coefficients, subset of variables, pairwise treatment of missing values   |
|                 | G02BLF                            | Correlation-like coefficients (about zero), subset of variables, casewise treatment of missing values  |
|                 | G02BMF                            | Correlation-like coefficients (about zero), subset of variables, pairwise treatment of missing values  |
|                 | G02BPF                            | Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, overwriting input data                                |
|                 | G02BRF                            | Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment  |
|                 | G02BSF                            | of missing values, preserving input data<br>Kendall/Spearman non-parametric rank correlation coefficients, pairwise treatment<br>of missing values         |
| L2              | Data manipulation                 |  |
| L2a             | Transform (search a $GO3ZAF$      | lso classes L10a1, N6, and N8) Produces standardized values (z-scores) for a data matrix   |
| L2b             | Tally                             | 1 Todaess standardized varies (2 sectes) for a data matrix   |
|                 | GO1AEF                            | Frequency table from raw data  |
|                 | G11BAF<br>G11BBF                  | Computes multiway table from set of classification factors using selected statistic Computes multiway table from set of classification factors using given |
|                 |                                   | percentile/quantile  |
|                 | G11BCF<br>G11SBF                  | Computes marginal tables for multiway table computed by G11BAF or G11BBF Frequency count for G11SAF  |
| L2c             | Subset                            |  |
|                 | G02CEF                            | Service routines for multiple linear regression, select elements from vectors and matrices   |
| L3              | *                                 | graphics (search also class $Q$ )  |
| L3a<br>L3a1     | One-dimensional dat<br>Histograms | a  |
| Loai            | G01AJF                            | Lineprinter histogram of one variable  |
| L3a3            | EDA (e.g., box-ple                | ,  |
|                 | GO1ARF<br>GO1ASF                  | Constructs a stem and leaf plot Constructs a box and whisker plot  |
| L3b             |                                   | ta (search also class L3e)   |
| L3b3            | Scatter diagrams                  |  |
| L3b3a           | $Y 	ext{ vs. } X$                 | Lineprinter scatterplot of two variables   |
| L4              | Elementary data analy             |  |
| L4a             | One-dimensional dat               | a  |
| L4a1            | Raw data                          |  |
| L4a1a<br>L4a1a2 | Parametric anal<br>Probability p  | ·  |
| L4a1a2n         | v -                               | nomial, normal   |
|                 | GO1AHF                            | Lineprinter scatterplot of one variable against Normal scores  |
|                 | GO1DCF<br>GO1DHF                  | Normal scores, approximate variance-covariance matrix<br>Ranks, Normal scores, approximate Normal scores or exponential (Savage) scores                    |
| L4a1a4          |                                   | imates and tests   |
| L4a1a4b         | Binomial                          |  |
| L4a1a4n         | G07AAF<br>Normal                  | Computes confidence interval for the parameter of a binomial distribution  |
| 2 101UTII       | G01DDF                            | Shapiro and Wilk's $W$ test for Normality  |
|                 | G07BBF                            | Computes maximum likelihood estimates for parameters of the Normal distribution  |
|                 | GO7CAF                            | from grouped and/or censored data<br>Computes t-test statistic for a difference in means between two Normal populations,<br>confidence interval            |
| L4a1a4p         | Poisson<br>G07ABF                 | Computes confidence interval for the parameter of a Poisson distribution   |
| L4a1a4w         | Weibull                           | Computes confidence interval for the parameter of a roisson distribution   |
|                 | G07BEF                            | Computes maximum likelihood estimates for parameters of the Weibull distribution   |
| L4a1b           | Nonparametric                     | · ·  |
| L4a1b1          | GO7EAF                            | l tests regarding location (e.g., median), dispersion, and shape<br>Robust confidence intervals, one-sample  |
|                 | G07EBF                            | Robust confidence intervals, two-sample  |
|                 | G08AGF                            | Performs the Wilcoxon one-sample (matched pairs) signed rank test  |
|                 | GO8AHF<br>GO8AJF                  | Performs the Mann–Whitney $U$ test on two independent samples<br>Computes the exact probabilities for the Mann–Whitney $U$ statistic, no ties in           |
|                 | GOORST                            | pooled sample  |

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|             | G08AKF  | Computes the exact probabilities for the Mann–Whitney $U$ statistic, ties in pooled sample   |
|-------------|---|--|
| L4a1b2      | Density function  | on estimation  |
| L4a1c       | G10BAF<br>Goodness-of-fit t                             | Kernel density estimate using Gaussian kernel  |
| L4aIC       | G08CBF  | Performs the one-sample Kolmogorov–Smirnov test for standard distributions   |
|             | G08CCF  | Performs the one-sample Kolmogorov–Smirnov test for a user-supplied distribution   |
|             | G08CDF  | Performs the two-sample Kolmogorov–Smirnov test  |
|             | G08CGF  | Performs the $\chi^2$ goodness of fit test, for standard continuous distributions  |
| L4a1d       | Analysis of a seq                                       | uence of numbers (search also class L10a)  |
|             | G08EAF  | Performs the runs up or runs down test for randomness  |
|             | G08EBF  | Performs the pairs (serial) test for randomness  |
|             | G08ECF  | Performs the triplets test for randomness  |
| _           | G08EDF  | Performs the gaps test for randomness  |
| L4a3        | Grouped and/or ce                                       |  |
|             | G07BBF  | Computes maximum likelihood estimates for parameters of the Normal distribution from grouped and/or censored data                                    |
|             | G07BEF  | Computes maximum likelihood estimates for parameters of the Weibull distribution   |
| L4a5        | Categorical data  | Computes maximum intermode estimates for parameters of the welder distribution   |
| L4ao        | G11AAF  | $\chi^2$ statistics for two-way contingency table  |
| L4b         |   | $\alpha$ (search also class $L4c$ )  |
| L4b1        | Pairwise independe                                      | . /  |
| L4b1b       | -   | nalysis (e.g., rank tests)   |
|             | G08ACF  | Median test on two samples of unequal size   |
|             | GO8BAF  | Mood's and David's tests on two samples of unequal size  |
| L4b3        | Pairwise dependent                                      | data   |
|             | GOSAAF  | Sign test on two paired samples  |
| $_{ m L4c}$ |   | ta (search also classes L4b and L7a1)  |
| L4c1        | Independent data  |  |
| L4c1b       | Nonparametric a   |  |
| TE          | GOSDAF Function evaluation (see                         | Kendall's coefficient of concordance   |
| L5<br>L5a   | Function evaluation (search also class $C$ ) Univariate |  |
| L5a1        |   | ution functions, probability density functions   |
| Loui        | GO1EMF  | Computes probability for the Studentized range statistic   |
|             | G01EPF  | Computes bounds for the significance of a Durbin–Watson statistic  |
|             | G01JDF  | Computes lower tail probability for a linear combination of (central) $\chi^2$ variables   |
| L5a1b       | Beta, binomial  |  |
|             | G01BJF  | Binomial distribution function   |
|             | G01EEF  | Computes upper and lower tail probabilities and probability density function for   |
|             |   | the beta distribution  |
|             | GO1GEF  | Computes probabilities for the non-central beta distribution   |
| L5a1c       | Cauchy, $\chi^2$  | Character and difficulty for 2 distribution  |
|             | G01ECF  | Computes probabilities for $\chi^2$ distribution<br>Computes probabilities for the non-central $\chi^2$ distribution                                 |
|             | G01GCF  | Computes probabilities for the non-central $\chi$ distribution.<br>Computes probability for a positive linear combination of $\chi^2$ variables      |
| TEOLO       | G01JCF<br>Error function                                | computes probability for a positive linear combination of $\chi$ variables xponential, extreme value   |
| L5a1e       | S15ADF  | Complement of error function $\operatorname{erfc}(x)$  |
|             | S15AEF  | Error function $erf(x)$  |
| L5a1f       | F distribution  |  |
|             | GO1EDF  | Computes probabilities for $F$ -distribution   |
|             | G01GDF  | Computes probabilities for the non-central $F$ -distribution   |
| L5a1g       | Gamma, general,   | -  |
|             | G01EFF  | Computes probabilities for the gamma distribution  |
| L5a1h       | Halfnormal, hype  |  |
| T = -11     | G01BLF  | Hypergeometric distribution function   |
| L5a1k       |   | cic, Kolmogorov-Smirnov  Computes probabilities for the one-sample Kolmogorov-Smirnov distribution   |
|             | GO1EYF<br>GO1EZF  | Computes probabilities for the one-sample Kolmogorov–Smirnov distribution  Computes probabilities for the two-sample Kolmogorov–Smirnov distribution |
| L5a1n       | Negative binomia  |  |
| Loain       | G01EAF  | Computes probabilities for the standard Normal distribution  |
|             | GO1MBF  | Computes reciprocal of Mills' Ratio  |
|             | S15ABF  | Cumulative normal distribution function $P(x)$   |
|             | S15ACF  | Complement of cumulative normal distribution function $Q(x)$   |
| L5a1p       | Pareto, Poisson   |  |
|             | G01BKF  | Poisson distribution function  |
| L5a1t       | t distribution  |  |
|             | G01EBF  | Computes probabilities for Student's t-distribution  |
| _           | G01GBF  | Computes probabilities for the non-central Student's t-distribution  |
| L5a1v       | Von Mises   |  |
|             | G01ERF  | Computes probability for von Mises distribution  |

| L5a2   | Inverse distribution functions, sparsity functions  GO1FMF Computes deviates for the Studentized range statistic  |
|--------|---|
| L5a2b  | Beta, binomial  |
|        | G01FEF Computes deviates for the beta distribution  |
| L5a2c  | Cauchy, $\chi^2$ G01FCF Computes deviates for the $\chi^2$ distribution   |
| L5a2f  | F distribution  |
| T. 0   | GO1FDF Computes deviates for the $F$ -distribution  |
| L5a2g  | Gamma, general, geometric  G01FFF Computes deviates for the gamma distribution  |
| L5a2n  | Negative binomial, normal order statistics  |
|        | GO1DAF Normal scores, accurate values   |
|        | G01DBF Normal scores, approximate values G01FAF Computes deviates for the standard Normal distribution  |
| L5a2t  | t distribution  |
|        | G01FBF Computes deviates for Student's t-distribution   |
| L5b    | Multivariate  Converse of manager of manager of production forms in Normal maniphles  |
|        | GO1NAF Cumulants and moments of quadratic forms in Normal variables GO1NBF Moments of ratios of quadratic forms in Normal variables, and related statistics |
| L5b1   | Cumulative multivariate distribution functions, probability density functions   |
| L5b1n  | Normal  |
|        | GO1HAF Computes probability for the bivariate Normal distribution  GO1HBF Computes probabilities for the multivariate Normal distribution                   |
| L6     | GO1HBF Computes probabilities for the multivariate Normal distribution Random number generation   |
| L6a    | Univariate  |
|        | G05EYF Pseudo-random integer from reference vector  |
| L6a2   | Beta, binomial, Boolean G05DZF Pseudo-random logical (boolean) value  |
|        | GOSEDF Set up reference vector for generating pseudo-random integers, binomial distribution   |
|        | GO5FEF Generates a vector of pseudo-random numbers from a beta distribution   |
| L6a3   | Cauchy, $\chi^2$  |
|        | GO5DFF Pseudo-random real numbers, Cauchy distribution  |
| L6a5   | G05DHF Pseudo-random real numbers, $\chi^2$ distribution Exponential, extreme value   |
| Loas   | G05DBF Pseudo-random real numbers, (negative) exponential distribution  |
|        | G05FBF Generates a vector of random numbers from an (negative) exponential distribution   |
| L6a6   | F distribution  G05DKF Pseudo-random real numbers, $F$ -distribution  |
| L6a7   | Gamma, general (continuous, discrete), geometric  |
|        | GO5EXF Set up reference vector from supplied cumulative distribution function or probability  |
|        | distribution function  G05FFF Generates a vector of pseudo-random numbers from a gamma distribution   |
| L6a8   | Halfnormal, hypergeometric  |
| 2000   | G05EFF Set up reference vector for generating pseudo-random integers, hypergeometric  |
|        | distribution  |
| L6a12  | Lambda, logistic, lognormal  GO5DCF Pseudo-random real numbers, logistic distribution   |
|        | G05DEF Pseudo-random real numbers, log-normal distribution  |
| L6a14  | Negative binomial, normal order statistics  |
|        | GO5DDF Pseudo-random real numbers, Normal distribution GO5EEF Set up reference vector for generating pseudo-random integers, negative binomia               |
|        | distribution  |
|        | GO5FDF Generates a vector of random numbers from a Normal distribution  |
| L6a16  | Pareto, Pascal, permutations, Poisson   |
|        | GO5DRF Pseudo-random integer, Poisson distribution GO5ECF Set up reference vector for generating pseudo-random integers, Poisson distribution               |
|        | G05EHF Pseudo-random permutation of an integer vector   |
| L6a19  | Samples, stable distribution  |
| I 6-20 | G05EJF Pseudo-random sample from an integer vector  |
| L6a20  | t distribution, time series, triangular G05DJF Pseudo-random real numbers, Student's $t$ -distribution  |
|        | G05EGF Set up reference vector for univariate ARMA time series model  |
| _      | GO5EWF Generate next term from reference vector for ARMA time series model  |
| L6a21  | Uniform (continuous, discrete), uniform order statistics  G05CAF Pseudo-random real numbers, uniform distribution over (0,1)                                |
|        | GOSDAF Pseudo-random real numbers, uniform distribution over $(0,1)$<br>GOSDAF Pseudo-random real numbers, uniform distribution over $(a,b)$                |
|        | G05DYF Pseudo-random integer from uniform distribution  |
|        | GOSEBF Set up reference vector for generating pseudo-random integers, uniform distribution  |
| I 6522 | G05FAF Generates a vector of random numbers from a uniform distribution Von Mises   |
| L6a22  | G05FSF Generates a vector of pseudo-random variates from von Mises distribution   |
|        | •   |

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| L6a23  | Weibull  |  |
|--|--|--|
|  | G05DPF   | Pseudo-random real numbers, Weibull distribution   |
| L6b  | Multivariate<br>GO5HDF                               | Generates a realisation of a multivariate time series from a VARMA model   |
| L6b3   | Contingency table,<br>G05GBF                         | correlation matrix Computes random correlation matrix  |
| L6b14  | Normal   |  |
|  | GO5EAF<br>GO5EZF                                     | Set up reference vector for multivariate Normal distribution Pseudo-random multivariate Normal vector from reference vector  |
| L6b15  | Orthogonal matrix                                    |  |
| L6c  | G05GAF<br>Service routines (e.g.,                    | Computes random orthogonal matrix<br>, seed)   |
|  | G05CBF<br>G05CCF                                     | Initialise random number generating routines to give repeatable sequence<br>Initialise random number generating routines to give non-repeatable sequence               |
|  | G05CFF   | Save state of random number generating routines  |
|  | GO5CGF<br>GO5ZAF                                     | Restore state of random number generating routines<br>Selection of basic algorithm random number generator or Wichmann–Hill algorithm                                  |
| T =  |  | generators for subsequent calls to G05 routines  |
| L7<br>L7a  | One-way  | cluding analysis of covariance)  |
| L7a1   | Parametric   | Analysis of mainers and desired block on completely and animal desires to other  |
|  | G04BBF   | Analysis of variance, randomized block or completely randomized design, treatment means and standard errors  |
|  | GO4DAF<br>GO4DBF                                     | Computes sum of squares for contrast between means<br>Computes confidence intervals for differences between means computed by G04BBF                                   |
|  |  | or G04BCF  |
| L7a2   | Nonparametric<br>G08AFF                              | Kruskal–Wallis one-way analysis of variance on $k$ samples of unequal size   |
| L7b  | Two-way (search also                                 | · · · · · · · · · · · · · · · · · · ·  |
|  | GO4AGF<br>GO4BBF                                     | Two-way analysis of variance, hierarchical classification, subgroups of unequal size Analysis of variance, randomized block or completely randomized design, treatment |
|  | G08AEF   | means and standard errors  Friedman two-way analysis of variance on $k$ matched samples  |
|  | G08ALF   | Performs the Cochran $Q$ test on cross-classified binary data  |
| L7c  | Three-way (e.g., Lating G04BCF                       | n squares) (search also class L7d)  Analysis of variance, general row and column design, treatment means and standard  |
| T = 1  |  | errors   |
| $egin{array}{c} { m L7d} \\ { m L7d1} \end{array}$ | Multi-way<br>Balanced complete                       | data (e.g., factorial designs)   |
| L7d2   | G04CAF<br>Balanced incomple                          | Analysis of variance, complete factorial design, treatment means and standard errors te data   |
|  | F04JLF   | Real general Gauss–Markov linear model (including weighted least-squares)  |
| L7f  | Generate experiments G02DAF                          | al designs Fits a general (multiple) linear regression model   |
|  | G02DNF   | Computes estimable function of a general linear regression model and its standard  |
| L7g  | Service routines                                     | error  |
|  | GO4EAF   | Computes orthogonal polynomials or dummy variables for factor/classification variable  |
| L8   | ,  | classes $D5$ , $D6$ , $D9$ , $G$ , $K$ )   |
| L8a<br>L8a1  | Simple linear (i.e., $y = 0$ ) Ordinary least square | $=b_0+b_1x$ ) (search also class $L8h$ )   |
| L8a1a  | Parameter estima                                     |  |
| L8a1a1   | Unweighted da  |  |
|  | GO2CAF<br>GO2CBF                                     | Simple linear regression with constant term, no missing values Simple linear regression without constant term, no missing values                                       |
|  | G02CCF   | Simple linear regression with constant term, missing values  |
| T 0 - 0  | GO2CDF   | Simple linear regression without constant term, missing values rom 2 (e.g., least absolute value, minimax)   |
| L8a2   | $L_p$ for $p$ different in E02GAF                    | $L_1$ -approximation by general linear function  |
| L8b  | E02GCF   | $L_{\infty}$ -approximation by general linear function $b_0 + b_1 x + b_2 x^2$ ) (search also class L8c)   |
| L8b1   | Ordinary least squa                                  |  |
| L8b1b  | Parameter estim                                      |  |
| L8b1b2   | Using orthogor<br>E02ADF                             | nal polynomials  Least-squares curve fit, by polynomials, arbitrary data points  |
| L8c  |  | $y = b_0 + b_1 x_1 + + b_p x_p)$   |
|  | F04JLF   | Real general Gauss–Markov linear model (including weighted least-squares)  |
| L8c1   | F04JMF<br>Ordinary least squa                        | Equality-constrained real linear least-squares problem ares  |
| L8c1a  | Variable selection                                   | n  |
|  | G02ECF   | Calculates $\mathbb{R}^2$ and $\mathbb{C}_P$ values from residual sums of squares  |

|          | ***                        |  |
|----------|----------------------------|--|
| L8c1a1   | Using raw data<br>G02DDF   | Estimates of linear parameters and general linear regression model from updated  |
|          | GOZDDF                     | model  |
|          | G02DEF                     | Add a new variable to a general linear regression model  |
|          | G02DFF                     | Delete a variable from a general linear regression model   |
|          | G02EAF                     | Computes residual sums of squares for all possible linear regressions for a set of   |
|          | GO2EEF                     | independent variables Fits a linear regression model by forward selection  |
| L8c1b    |                            | ation (search also class L8c1a)  |
| L8c1b1   | Using raw data             |  |
|          | GO2DAF                     | Fits a general (multiple) linear regression model  |
|          | GO2DCF<br>GO2DDF           | Add/delete an observation to/from a general linear regression model  Estimates of linear parameters and general linear regression model from updated                   |
|          | GOZDDF                     | model  |
|          | G02DEF                     | Add a new variable to a general linear regression model  |
|          | G02DFF                     | Delete a variable from a general linear regression model   |
|          | G02DKF                     | Estimates and standard errors of parameters of a general linear regression model   |
|          | GO2DNF                     | for given constraints  Computes estimable function of a general linear regression model and its standard   |
|          |                            | error  |
| L8c1b2   | Using correlati            |  |
|          | GO2CGF<br>GO2CHF           | Multiple linear regression, from correlation coefficients, with constant term<br>Multiple linear regression, from correlation-like coefficients, without constant term |
| L8c1c    |                            | also classes L8c1a and L8c1b)  |
| Locic    | GO2FAF                     | Calculates standardized residuals and influence statistics   |
| L8c1d    | ,                          | also classes L8c1a and L8c1b)  |
|          | GO2DNF                     | Computes estimable function of a general linear regression model and its standard  |
|          | G02FCF                     | error<br>Computes Durbin–Watson test statistic   |
| L8c2     | Several regressions        |  |
|          | G02DGF                     | Fits a general linear regression model for new dependent variable  |
| L8c4     | Robust                     | Debugt remarries standard Mastimates   |
|          | GO2HAF<br>GO2HBF           | Robust regression, standard M-estimates Robust regression, compute weights for use with G02HDF   |
|          | GO2HDF                     | Robust regression, compute regression with user-supplied functions and weights   |
|          | G02HFF                     | Robust regression, variance-covariance matrix following G02HDF   |
| L8c6     | Models based on ra         |  |
|          | GO8RAF<br>GO8RBF           | Regression using ranks, uncensored data Regression using ranks, right-censored data  |
| L8e      |                            | (X,b)) (search also class L8h)   |
|          | G02GBF                     | Fits a generalized linear model with binomial errors   |
|          | G02GCF                     | Fits a generalized linear model with Poisson errors  |
|          | GO2GDF<br>GO2GKF           | Fits a generalized linear model with gamma errors Estimates and standard errors of parameters of a general linear model for given                                      |
|          | 4024                       | constraints  |
|          | GO2GNF                     | Computes estimable function of a generalized linear model and its standard error   |
| L8e1     | Ordinary least squa        |  |
| L8e1b    | Parameter estima<br>E04YCF | ation (search also class L8e1a)  Covariance matrix for nonlinear least-squares problem (unconstrained)   |
|          | GO2GAF                     | Fits a generalized linear model with Normal errors   |
| L8e1b1   |                            | ta, user provides no derivatives   |
|          | E04FCF                     | Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified  |
|          | E04FYF                     | Newton algorithm using function values only (comprehensive) Unconstrained minimum of a sum of squares, combined Gauss-Newton and modified                              |
|          | LO4I II                    | Newton algorithm using function values only (easy-to-use)  |
|          | E04UNF                     | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using  |
| T 0 11 0 | II                         | function values and optionally first derivatives (comprehensive)   |
| L8e1b2   | Unweighted da<br>E04GBF    | ta, user provides derivatives Unconstrained minimum of a sum of squares, combined Gauss-Newton and quasi-  |
|          | 20 1021                    | Newton algorithm using first derivatives (comprehensive)   |
|          | E04GDF                     | Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified  |
|          | E04GYF                     | Newton algorithm using first derivatives (comprehensive) Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-                                   |
|          | EU4G1f                     | Newton algorithm, using first derivatives (easy-to-use)  |
|          | E04GZF                     | Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified  |
|          |                            | Newton algorithm using first derivatives (easy-to-use)   |
|          | E04UNF                     | Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive)                       |
| L8g      | Spline (i.e., piecewise    |  |
| J        | E02BAF                     | Least-squares curve cubic spline fit (including interpolation)   |
|          | E02BEF                     | Least-squares cubic spline curve fit, automatic knot placement   |
|          | G10ABF                     | Fit cubic smoothing spline, smoothing parameter given  |

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| T.O.                  | G10ACF                           | Fit cubic smoothing spline, smoothing parameter estimated  |
|-----------------------|----------------------------------|--|
| L8h                   | EDA (e.g., smoothing G10CAF      | Compute smoothed data sequence using running median smoothers  |
| L8i                   | Service routines (e.g.<br>G02CEF | , matrix manipulation for variable selection)  Service routines for multiple linear regression, select elements from vectors and matrices            |
|                       | G02CFF                           | Service routines for multiple linear regression, re-order elements of vectors and matrices   |
|                       | GO4EAF                           | Computes orthogonal polynomials or dummy variables for factor/classification variable  |
| T.0                   | G10ZAF                           | Reorder data to give ordered distinct observations   |
| L9                    | Categorical data analys G11BAF   | Computes multiway table from set of classification factors using selected statistic  |
|                       | G11BBF                           | Computes multiway table from set of classification factors using given percentile/quantile   |
|                       | G11BCF                           | Computes marginal tables for multiway table computed by G11BAF or G11BBF   |
|                       | G11CAF                           | Returns parameter estimates for the conditional analysis of stratified data  |
| T 0.1                 | G12ZAF                           | Creates the risk sets associated with the Cox proportional hazards model for fixed covariates  |
| L9b                   | Two-way tables (sear G01AFF      | Two-way contingency table analysis, with $\chi^2$ /Fisher's exact test   |
|                       | G11AAF                           | $\chi^2$ statistics for two-way contingency table  |
| L9c                   | Log-linear model                 | a statistics for two may contained tubic   |
|                       | GO2GCF<br>GO2GKF                 | Fits a generalized linear model with Poisson errors<br>Estimates and standard errors of parameters of a general linear model for given               |
|                       |                                  | constraints  |
|                       | GO2GNF                           | Computes estimable function of a generalized linear model and its standard error   |
| L10                   | Time series analysis (se         | ·  |
| L10a<br>L10a1         | Transformations                  | so classes $L3a6$ and $L3a7$ )   |
| L10a1<br>L10a1c       | Filters (search a                | lso class K5)  |
| L10a1c1               | Difference                       | ,  |
|                       | G13AAF                           | Univariate time series, seasonal and non-seasonal differencing   |
| L10a1c4               | Other<br>G13BBF                  | Multivariate time series, filtering by a transfer function model   |
| L10a2                 | Time domain analy                |  |
| L10a2a                | Summary statist                  |  |
| T 10 0 1              | G13AUF                           | Computes quantities needed for range-mean or standard deviation-mean plot<br>ons and autocovariances   |
| L10a2a1               | G13ABF                           | Univariate time series, sample autocorrelation function  |
| L10a2a2               | Partial autoco<br>G13ACF         |  |
| L10a2b                |                                  | Univariate time series, partial autocorrelations from autocorrelations lysis (search also class L10a2a)  |
| L10a2b                | G13AUF                           | Computes quantities needed for range-mean or standard deviation-mean plot  |
| L10a2c                | Autoregressive m                 | nodels   |
| L10a2c1               | Model identifie                  |  |
| T 10 0 1              | G13ACF                           | Univariate time series, partial autocorrelations from autocorrelations   |
| m L10a2d $ m L10a2d1$ | Model identific                  | MA models (including Box–Jenkins methods)  |
| 2100201               | G13ADF                           | Univariate time series, preliminary estimation, seasonal ARIMA model   |
| L10a2d2               | Parameter esti                   | mation   |
|                       | G13AEF                           | Univariate time series, estimation, seasonal ARIMA model (comprehensive)   |
|                       | G13AFF<br>G13ASF                 | Univariate time series, estimation, seasonal ARIMA model (easy-to-use) Univariate time series, diagnostic checking of residuals, following G13AEF or |
|                       | GISAST                           | G13AFF   |
|                       | G13BEF                           | Multivariate time series, estimation of multi-input model  |
| L10a2d3               | Forecasting G13AGF               | University time series undete state set for forecasting  |
|                       | G13AHF                           | Univariate time series, update state set for forecasting Univariate time series, forecasting from state set  |
|                       | G13AJF                           | Univariate time series, state set and forecasts, from fully specified seasonal ARIMA   |
|                       | ~ .                              | model  |
| L10a2e                | - '                              | ysis (e.g., Kalman filtering)  |
|                       | G13EAF                           | Combined measurement and time update, one iteration of Kalman filter, time-<br>varying, square root covariance filter                                |
|                       | G13EBF                           | Combined measurement and time update, one iteration of Kalman filter, time-  |
|                       |                                  | invariant, square root covariance filter   |
| L10a2f                | -                                | ally stationary series   |
|                       | G13DXF                           | Calculates the zeros of a vector autoregressive (or moving average) operator   |

| L10a3             | - "                             | analysis (search also class J1)  |
|-------------------|---------------------------------|--|
| L10a3a<br>L10a3a3 | Spectral analysis Spectrum esti | mation using the periodogram   |
| LIUdodo           | G13CBF                          | Univariate time series, smoothed sample spectrum using spectral smoothing by the   |
|                   |                                 | trapezium frequency (Daniell) window   |
| L10a3a4           | _                               | mation using the Fourier transform of the autocorrelation function   |
|                   | G13CAF                          | Univariate time series, smoothed sample spectrum using rectangular, Bartlett,  |
| L10b              | Two time series (sear           | Tukey or Parzen lag window rch also classes L3b3c, L10c, and L10d)   |
| L10b<br>L10b2     | Time domain analy               | ,  |
| L10b2a            | •                               | ics (e.g., cross-correlations)   |
|                   | G13BCF                          | Multivariate time series, cross-correlations   |
| L10b2b            | Transfer function               |  |
|                   | G13BAF                          | Multivariate time series, filtering (pre-whitening) by an ARIMA model  |
|                   | G13BDF<br>G13BEF                | Multivariate time series, preliminary estimation of transfer function model<br>Multivariate time series, estimation of multi-input model     |
|                   | G13BGF                          | Multivariate time series, estimation of multi-input model  Multivariate time series, update state set for forecasting from multi-input model |
|                   | G13BHF                          | Multivariate time series, forecasting from state set of multi-input model  |
|                   | G13BJF                          | Multivariate time series, state set and forecasts from fully specified multi-input   |
|                   |                                 | model  |
| L10b3             |                                 | analysis (search also class J1)  |
| L10b3a<br>L10b3a3 | Cross-spectral ar               | naiysis n estimation using the cross-periodogram   |
| LIUDJaj           | G13CDF                          | Multivariate time series, smoothed sample cross spectrum using spectral smoothing  |
|                   |                                 | by the trapezium frequency (Daniell) window  |
| L10b3a4           | _                               | m estimation using the Fourier transform of the cross-correlation or cross-covariance  |
|                   | function<br>G13CCF              | Multivariate time series, smoothed sample cross spectrum using rectangular,  |
|                   |                                 | Bartlett, Tukey or Parzen lag window   |
| L10b3a6           | Spectral funct                  |  |
|                   | G13CEF                          | Multivariate time series, cross amplitude spectrum, squared coherency, bounds,   |
|                   | G13CFF                          | univariate and bivariate (cross) spectra  Multivariate time series, gain, phase, bounds, univariate and bivariate (cross)                    |
|                   | 410011                          | spectra  |
|                   | G13CGF                          | Multivariate time series, noise spectrum, bounds, impulse response function and its  |
| _                 | 3.6.3.4                         | standard error   |
| L10c              | Multivariate time ser<br>G13DBF | ies (search also classes J1, L3e3 and L10b)  Multivariate time series, multiple squared partial autocorrelations                             |
|                   | G13DCF                          | Multivariate time series, multiple squared partial autocorrelations  Multivariate time series, estimation of VARMA model                     |
|                   | G13DJF                          | Multivariate time series, forecasts and their standard errors  |
|                   | G13DKF                          | Multivariate time series, updates forecasts and their standard errors  |
|                   | G13DLF                          | Multivariate time series, differences and/or transforms (for use before G13DCF)  |
|                   | G13DMF                          | Multivariate time series, sample cross-correlation or cross-covariance matrices  |
|                   | G13DNF                          | Multivariate time series, sample partial lag correlation matrices, $\chi^2$ statistics and significance levels                               |
|                   | G13DPF                          | Multivariate time series, partial autoregression matrices  |
|                   | G13DSF                          | Multivariate time series, diagnostic checking of residuals, following G13DCF   |
|                   | G13DXF                          | Calculates the zeros of a vector autoregressive (or moving average) operator   |
| L12               | Discriminant analysis           |  |
|                   | GO3ACF<br>GO3DAF                | Performs canonical variate analysis  Computes test statistic for equality of within-group covariance matrices and                            |
|                   | GOSDAF                          | matrices for discriminant analysis   |
|                   | GO3DBF                          | Computes Mahalanobis squared distances for group or pooled variance-covariance   |
|                   |                                 | matrices (for use after G03DAF)  |
| _                 | GO3DCF                          | Allocates observations to groups according to selected rules (for use after G03DAF)  |
| L13               | Covariance structure m          | odels  |
| L13a              | Factor analysis<br>GO3BAF       | Computes orthogonal rotations for loading matrix, generalized orthomax criterion   |
|                   | GO3BCF                          | Computes Procrustes rotations  |
|                   | GO3CAF                          | Computes maximum likelihood estimates of the parameters of a factor analysis   |
|                   |                                 | model, factor loadings, communalities and residual correlations  |
|                   | G03CCF                          | Computes factor score coefficients (for use after G03CAF)  |
| L13b              | G11SAF Principal components     | Contingency table, latent variable model for binary data   |
| L130              | GO3AAF                          | Performs principal component analysis  |
| L13c              | Canonical correlation           |  |
|                   | GOSACF                          | Performs canonical variate analysis  |
| T 4 4             | GOSADF                          | Performs canonical correlation analysis  |
| L14               | Cluster analysis<br>One-way     |  |
| L14a<br>L14a1     | Unconstrained                   |  |
| 211111            | 2 2 01 011100                   |  |

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| L14a1a            | Nested                            |   |
|-------------------|-----------------------------------|---|
| L14a1a<br>L14a1a1 | Joining (e.g., s                  | single link)  |
| Litaiai           | GO3ECF                            | Hierarchical cluster analysis   |
|                   | GO3EHF                            | Constructs dendrogram (for use after G03ECF)  |
|                   | G03EJF                            | Computes cluster indicator variable (for use after G03ECF)  |
| L14a1b            | Non-nested (e.g.,                 |   |
| T 1 4 1           | GO3EFF                            | K-means cluster analysis  |
| L14d              | GO3EAF                            | compute distance matrix) Computes distance matrix   |
| L15               | Life testing, survival an         | Ÿ   |
|                   | G11CAF<br>G12AAF                  | Returns parameter estimates for the conditional analysis of stratified data Computes Kaplan–Meier (product-limit) estimates of survival probabilities |
| T - 0             | G12BAF                            | Fits Cox's proportional hazard model  |
| L16               | Multidimensional scalin<br>GO3FAF | Performs principal co-ordinate analysis, classical metric scaling   |
|                   | GOSFCF                            | Performs non-metric (ordinal) multidimensional scaling  |
| $\mathbf{M}$      |                                   | delling (search also classes L6 and L10)  |
| N                 | Data handling (search als         |   |
| N1                | Input, output                     |   |
|                   | XO4ACF                            | Open unit number for reading, writing or appending, and associate unit with named file  |
|                   | XO4ADF                            | Close file associated with given unit number  |
|                   | XO4BAF                            | Write formatted record to external file   |
|                   | X04BBF                            | Read formatted record from external file  |
|                   | XO4CAF<br>XO4CBF                  | Print real general matrix (easy-to-use) Print real general matrix (comprehensive)   |
|                   | X04CCF                            | Print real packed triangular matrix (easy-to-use)   |
|                   | X04CDF                            | Print real packed triangular matrix (comprehensive)   |
|                   | X04CEF                            | Print real packed banded matrix (easy-to-use)   |
|                   | X04CFF                            | Print real packed banded matrix (comprehensive)   |
|                   | XO4DAF                            | Print complex general matrix (easy-to-use)  |
|                   | XO4DBF                            | Print complex general matrix (comprehensive)  |
|                   | X04DCF                            | Print complex packed triangular matrix (easy-to-use)  |
|                   | XO4DDF<br>XO4DEF                  | Print complex packed triangular matrix (comprehensive) Print complex packed banded matrix (easy-to-use)   |
|                   | X04DEF<br>X04DFF                  | Print complex packed banded matrix (easy-to-use)  Print complex packed banded matrix (comprehensive)  |
|                   | XO4EAF                            | Print integer matrix (easy-to-use)  |
|                   | XO4EBF                            | Print integer matrix (comprehensive)  |
| N4                | Storage management (e             |   |
|                   | F06EUF                            | (SGTHR/DGTHR) Gather real sparse vector   |
|                   | F06EVF                            | (SGTHRZ/DGTHRZ) Gather and set to zero real sparse vector   |
|                   | F06EWF<br>F06GUF                  | (SSCTR/DSCTR) Scatter real sparse vector<br>(CGTHR/ZGTHR) Gather complex sparse vector  |
|                   | F06GVF                            | (CGTHRZ/ZGTHRZ) Gather and set to zero complex sparse vector  |
|                   | F06GWF                            | (CSCTR/ZSCTR) Scatter complex sparse vector   |
| N5                | Searching                         |   |
| N5a               | Extreme value                     |   |
|                   | F06FLF                            | Elements of real vector with largest and smallest absolute value  |
|                   | F06JLF                            | (ISAMAX/IDAMAX) Index, real vector element with largest absolute value  |
|                   | F06JMF<br>F06KLF                  | (ICAMAX/IZAMAX) Index, complex vector element with largest absolute value<br>Last non-negligible element of real vector                               |
| N6                | Sorting                           | Last non-negligible element of real vector  |
| N6a               | Internal                          |   |
| N6a1              | Passive (i.e., constr             | ruct pointer array, rank)   |
|                   | MO1DZF                            | Rank arbitrary data   |
| N6a1a             | Integer                           | Dank a wasten interna numbera   |
|                   | MO1DBF<br>MO1DFF                  | Rank a vector, integer numbers Rank rows of a matrix, integer numbers   |
|                   | MO1DKF                            | Rank columns of a matrix, integer numbers   |
| N6a1b             | Real                              | ,   |
|                   | GO1DHF                            | Ranks, Normal scores, approximate Normal scores or exponential (Savage) scores  |
|                   | MO1DAF                            | Rank a vector, real numbers   |
|                   | MO1DEF                            | Rank rows of a matrix, real numbers   |
| NIG 1             | MO1DJF                            | Rank columns of a matrix, real numbers  |
| N6a1c             | Character<br>M01DCF               | Rank a vector, character data   |
| N6a2              | Active                            | Towns a record, character data  |
| N6a2a             | Integer                           |   |
| -                 | MO1CBF                            | Sort a vector, integer numbers  |
| N6a2b             | Real                              |   |
|                   | MO1CAF                            | Sort a vector, real numbers   |

| N6a2c         | Character                 |  |
|---------------|---------------------------|--|
|               | MO1CCF                    | Sort a vector, character data  |
| N8            | Permuting                 |  |
|               | F06QJF                    | Permute rows or columns, real rectangular matrix, permutations represented by an integer array |
|               | F06QKF                    |  |
|               | F06VJF                    | v  |
|               | F06VKF                    |  |
|               | MO1EAF                    | · ·  |
|               | MO1EBF                    |  |
|               | MO1ECE                    |  |
|               | MO1EDF                    |  |
|               | MO1ZAF                    |  |
|               | MO1ZBF                    | 1  |
|               | MO1ZCF                    | · -  |
| Р             |                           | ry (search also classes $G$ and $Q$ )  |
| •             | DO3MAF                    | -/   |
| $\mathbf{Q}$  | Graphics (search also     |  |
| ••            | GO1ARF                    | ,  |
|               | G01ASF                    |  |
| $\mathbf{R}$  | Service routines          |  |
|               | AOOAAF                    | Prints details of the NAG Fortran Library implementation                                       |
|               | XO5AAF                    | Return date and time as an array of integers   |
|               | X05ABF                    | Convert array of integers representing date and time to character string                       |
|               | XO5ACE                    | Compare two character strings representing date and time                                       |
|               | X05BAF                    | Return the CPU time  |
| $\mathbf{R}1$ | Machine-dependent         | constants  |
|               | XO1AAF                    | Provides the mathematical constant $\pi$   |
|               | XO1ABF                    | Provides the mathematical constant $\gamma$ (Euler's Constant)                                 |
|               | XO2AHF                    | The largest permissible argument for sin and cos   |
|               | XO2AJF                    | The machine precision  |
|               | XO2AKF                    |  |
|               | XO2ALF                    |  |
|               | XO2AMF                    | 0 1  |
|               | XO2ANF                    | 0.1  |
|               | X02BBF                    |  |
|               | X02BEF                    | 0 1  |
|               | X02BHF                    | ST. T. T  |
|               | X02BJF                    | 01 1 /1  |
|               | XO2BKF                    | 01 1   |
|               | XO2BLF                    | 01 1   |
|               | XO2DAF                    | 01   |
| <b>D</b> 0    | X02DJF                    | The floating-point model parameter ROUNDS  |
| R3            | Error handling            |  |
| R3b           | Set unit number f         |  |
|               | XO4AAF                    | 8  |
| De            | XO4ABF                    | Return or set unit number for advisory messages  |
| R3c           | Other utilities<br>P01ABF | Return value of error indicator/terminate with error message                                   |
|               |                           |  |

## References

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