

## NAG Fortran Library, Mark 19 Library Contents

### Chapter A00 – Library Identification

A00AAF Prints details of the NAG Fortran Library implementation

### Chapter A02 – Complex Arithmetic

A02AAF Square root of complex number  
A02ABF Modulus of complex number  
A02ACF Quotient of two complex numbers

### Chapter C02 – Zeros of Polynomials

C02AFF All zeros of complex polynomial, modified Laguerre method  
C02AGF All zeros of real polynomial, modified Laguerre method  
C02AHF All zeros of complex quadratic  
C02AJF All zeros of real quadratic

### Chapter C05 – Roots of One or More Transcendental Equations

C05ADF Zero of continuous function in given interval, Bus and Dekker algorithm  
C05AGF 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  
C05AVF Binary search for interval containing zero of continuous function (reverse communication)  
C05AXF Zero of continuous function by continuation method, from given starting value (reverse communication)  
C05AZF Zero in given interval of continuous function by Bus and Dekker algorithm (reverse communication)  
C05NBF Solution of system of nonlinear equations using function values only (easy-to-use)  
C05NCF Solution of system of nonlinear equations using function values only (comprehensive)  
C05NDF Solution of system of nonlinear equations using function values only (reverse communication)  
C05PBF Solution of system of nonlinear equations using first derivatives (easy-to-use)  
C05PCF Solution of system of nonlinear equations using first derivatives (comprehensive)  
C05PDF Solution of system of nonlinear equations using first derivatives (reverse communication)  
C05ZAF Check user's routine for calculating first derivatives

### Chapter C06 – Summation of Series

C06BAF Acceleration of convergence of sequence, Shanks' transformation and epsilon algorithm  
C06DBF Sum of a Chebyshev series  
C06EAF Single one-dimensional real discrete Fourier transform, no extra workspace  
C06EBF Single one-dimensional Hermitian discrete Fourier transform, no extra workspace  
C06ECF Single one-dimensional complex discrete Fourier transform, no extra workspace  
C06EKF Circular convolution or correlation of two real vectors, no extra workspace  
C06FAF Single one-dimensional real discrete Fourier transform, extra workspace for greater speed  
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  
C06FFF One-dimensional complex discrete Fourier transform of multi-dimensional data  
C06FJF Multi-dimensional complex discrete Fourier transform of multi-dimensional data  
C06FKF Circular convolution or correlation of two real vectors, extra workspace for greater speed  
C06FPF Multiple one-dimensional real discrete Fourier transforms  
C06FQF Multiple one-dimensional Hermitian discrete Fourier transforms  
C06FRF Multiple one-dimensional complex discrete Fourier transforms  
C06FUF Two-dimensional complex discrete Fourier transform  
C06FXF Three-dimensional complex discrete Fourier transform  
C06GBF Complex conjugate of Hermitian sequence

C06GCF	Complex conjugate of complex sequence
C06GQF	Complex conjugate of multiple Hermitian sequences
C06GSF	Convert Hermitian sequences to general complex sequences
C06HAF	Discrete sine transform
C06HBF	Discrete cosine transform
C06HCF	Discrete quarter-wave sine transform
C06HDF	Discrete quarter-wave cosine transform
C06LAF	Inverse Laplace transform, Crump's method
C06LBF	Inverse Laplace transform, modified Weeks' method
C06LCF	Evaluate inverse Laplace transform as computed by C06LBF
C06PAF	Single one-dimensional real and Hermitian complex discrete Fourier transform, using complex data format for Hermitian sequences
C06PCF	Single one-dimensional complex discrete Fourier transform, complex data format
C06PFF	One-dimensional complex discrete Fourier transform of multi-dimensional data (using complex data type)
C06PJF	Multi-dimensional complex discrete Fourier transform of multi-dimensional data (using complex data type)
C06PKF	Circular convolution or correlation of two complex vectors
C06PPF	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex data format for Hermitian sequences
C06PQF	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex data format for Hermitian sequences and sequences stored as columns
C06PRF	Multiple one-dimensional complex discrete Fourier transforms using complex data format
C06PSF	Multiple one-dimensional complex discrete Fourier transforms using complex data format and sequences stored as columns
C06PUF	Two-dimensional complex discrete Fourier transform, complex data format
C06PXF	Three-dimensional complex discrete Fourier transform, complex data format
C06RAF	Discrete sine transform (easy-to-use)
C06RBF	Discrete cosine transform (easy-to-use)
C06RCF	Discrete quarter-wave sine transform (easy-to-use)
C06RDF	Discrete quarter-wave cosine transform (easy-to-use)

## Chapter D01 – Quadrature

D01AHF	One-dimensional quadrature, adaptive, finite interval, strategy due to Patterson, suitable for well-behaved integrands
D01AJF	One-dimensional quadrature, adaptive, finite interval, strategy due to Piessens and de Doncker, allowing for badly-behaved integrands
D01AKF	One-dimensional quadrature, adaptive, finite interval, method suitable for oscillating functions
D01ALF	One-dimensional quadrature, adaptive, finite interval, allowing for singularities at user-specified break-points
D01AMF	One-dimensional quadrature, adaptive, infinite or semi-infinite interval
D01ANF	One-dimensional quadrature, adaptive, finite interval, weight function $\cos(\omega x)$ or $\sin(\omega x)$
D01APF	One-dimensional quadrature, adaptive, finite interval, weight function with end-point singularities of algebraico-logarithmic type
D01AQF	One-dimensional quadrature, adaptive, finite interval, weight function $1/(x - c)$ , Cauchy principal value (Hilbert transform)
D01ARF	One-dimensional quadrature, non-adaptive, finite interval with provision for indefinite integrals
D01ASF	One-dimensional quadrature, adaptive, semi-infinite interval, weight function $\cos(\omega x)$ or $\sin(\omega x)$
D01ATF	One-dimensional quadrature, adaptive, finite interval, variant of D01AJF efficient on vector machines
D01AUF	One-dimensional quadrature, adaptive, finite interval, variant of D01AKF efficient on vector machines
D01BAF	One-dimensional Gaussian quadrature
D01BBF	Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule
D01BCF	Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule
D01BDF	One-dimensional quadrature, non-adaptive, finite interval
D01DAF	Two-dimensional quadrature, finite region
D01EAF	Multi-dimensional adaptive quadrature over hyper-rectangle, multiple integrands

D01FBF	Multi-dimensional Gaussian quadrature over hyper-rectangle
D01FCF	Multi-dimensional adaptive quadrature over hyper-rectangle
D01FDF	Multi-dimensional quadrature, Sag–Szekeres method, general product region or $n$ -sphere
D01GAF	One-dimensional quadrature, integration of function defined by data values, Gill–Miller method
D01GBF	Multi-dimensional quadrature over hyper-rectangle, Monte Carlo method
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
D01GYF	Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime
D01GZF	Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes
D01JAF	Multi-dimensional quadrature over an $n$ -sphere, allowing for badly-behaved integrands
D01PAF	Multi-dimensional quadrature over an $n$ -simplex

## Chapter D02 – Ordinary Differential Equations

D02AGF	ODEs, boundary value problem, shooting and matching technique, allowing interior matching point, general parameters to be determined
D02BGF	ODEs, IVP, Runge–Kutta–Merson method, until a component attains given value (simple driver)
D02BHF	ODEs, IVP, Runge–Kutta–Merson method, until function of solution is zero (simple driver)
D02BJF	ODEs, IVP, Runge–Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)
D02CJF	ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver)
D02EJF	ODEs, stiff IVP, BDF method, until function of solution is zero, intermediate output (simple driver)
D02GAF	ODEs, boundary value problem, finite difference technique with deferred correction, simple nonlinear problem
D02GBF	ODEs, boundary value problem, finite difference technique with deferred correction, general linear problem
D02HAF	ODEs, boundary value problem, shooting and matching, boundary values to be determined
D02HBF	ODEs, boundary value problem, shooting and matching, general parameters to be determined
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
D02KAF	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
D02LAF	Second-order ODEs, IVP, Runge–Kutta–Nystrom method
D02LXF	Second-order ODEs, IVP, set-up for D02LAF
D02LYF	Second-order ODEs, IVP, diagnostics for D02LAF
D02LZF	Second-order ODEs, IVP, interpolation for D02LAF
D02MVF	ODEs, IVP, DASSL method, set-up for D02M–N routines
D02MZF	ODEs, IVP, interpolation for D02M–N routines, natural interpolant
D02NBF	Explicit ODEs, stiff IVP, full Jacobian (comprehensive)
D02NCF	Explicit ODEs, stiff IVP, banded Jacobian (comprehensive)
D02NDF	Explicit ODEs, stiff IVP, sparse Jacobian (comprehensive)
D02NGF	Implicit/algebraic ODEs, stiff IVP, full Jacobian (comprehensive)
D02NHF	Implicit/algebraic ODEs, stiff IVP, banded Jacobian (comprehensive)
D02NJF	Implicit/algebraic ODEs, stiff IVP, sparse Jacobian (comprehensive)
D02NMF	Explicit ODEs, stiff IVP (reverse communication, comprehensive)
D02NNF	Implicit/algebraic ODEs, stiff IVP (reverse communication, comprehensive)
D02NRF	ODEs, IVP, for use with D02M–N routines, sparse Jacobian, enquiry routine
D02NSF	ODEs, IVP, for use with D02M–N routines, full Jacobian, linear algebra set-up
D02NTF	ODEs, IVP, for use with D02M–N routines, banded Jacobian, linear algebra set-up
D02NUF	ODEs, IVP, for use with D02M–N routines, sparse Jacobian, linear algebra set-up

D02NVF	ODEs, IVP, BDF method, set-up for D02M–N routines
D02NWF	ODEs, IVP, Blend method, set-up for D02M–N routines
D02NXF	ODEs, IVP, sparse Jacobian, linear algebra diagnostics, for use with D02M–N routines
D02NYF	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
D02PCF	ODEs, IVP, Runge–Kutta method, integration over range with output
D02PDF	ODEs, IVP, Runge–Kutta method, integration over one step
D02PVF	ODEs, IVP, set-up for D02PCF and D02PDF
D02PWF	ODEs, IVP, resets end of range for D02PDF
D02PXF	ODEs, IVP, interpolation for D02PDF
D02PYF	ODEs, IVP, integration diagnostics for D02PCF and D02PDF
D02PZF	ODEs, IVP, error assessment diagnostics for D02PCF and D02PDF
D02QFF	ODEs, IVP, Adams method with root-finding (forward communication, comprehensive)
D02QGF	ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive)
D02QWF	ODEs, IVP, set-up for D02QFF and D02QGF
D02QXF	ODEs, IVP, diagnostics for D02QFF and D02QGF
D02QYF	ODEs, IVP, root-finding diagnostics for D02QFF and D02QGF
D02QZF	ODEs, IVP, interpolation for D02QFF or D02QGF
D02RAF	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
D02TGF	$n$ th-order linear ODEs, boundary value problem, collocation and least-squares
D02TKF	ODEs, general nonlinear boundary value problem, collocation technique
D02TVF	ODEs, general nonlinear boundary value problem, set-up for D02TKF
D02TXF	ODEs, general nonlinear boundary value problem, continuation facility for D02TKF
D02TYF	ODEs, general nonlinear boundary value problem, interpolation for D02TKF
D02TZF	ODEs, general nonlinear boundary value problem, diagnostics for D02TKF
D02XJF	ODEs, IVP, interpolation for D02M–N routines, natural interpolant
D02XKF	ODEs, IVP, interpolation for D02M–N routines, $C_1$ interpolant
D02ZAF	ODEs, IVP, weighted norm of local error estimate for D02M–N routines

## Chapter D03 – Partial Differential Equations

D03EAF	Elliptic PDE, Laplace’s equation, two-dimensional arbitrary domain
D03EBF	Elliptic PDE, solution of finite difference equations by SIP, five-point two-dimensional molecule, iterate to convergence
D03ECF	Elliptic PDE, solution of finite difference equations by SIP for seven-point three-dimensional molecule, iterate to convergence
D03EDF	Elliptic PDE, solution of finite difference equations by a multigrid technique
D03EEF	Discretize a second-order elliptic PDE on a rectangle
D03FAF	Elliptic PDE, Helmholtz equation, three-dimensional Cartesian co-ordinates
D03MAF	Triangulation of plane region
D03PCF	General system of parabolic PDEs, method of lines, finite differences, one space variable
D03PDF	General system of parabolic PDEs, method of lines, Chebyshev $C^0$ collocation, one space variable
D03PEF	General system of first-order PDEs, method of lines, Keller box discretisation, one space variable
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
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
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

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
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
D03PWF	Modified HLL Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF
D03PXF	Exact Riemann Solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF
D03PYF	PDEs, spatial interpolation with D03PDF or D03PJF
D03PZF	PDEs, spatial interpolation with D03PCF, D03PEF, D03PFF, D03PHF, D03PKF, D03PLF, D03PPF, D03PRF or D03PSF
D03RAF	General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectangular region
D03RBF	General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectilinear region
D03RYF	Check initial grid data in D03RBF
D03RZF	Extract grid data from D03RBF
D03UAF	Elliptic PDE, solution of finite difference equations by SIP, five-point two-dimensional molecule, one iteration
D03UBF	Elliptic PDE, solution of finite difference equations by SIP, seven-point three-dimensional molecule, one iteration

## Chapter D04 – Numerical Differentiation

D04AAF	Numerical differentiation, derivatives up to order 14, function of one real variable
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## Chapter D05 – Integral Equations

D05AAF	Linear non-singular Fredholm integral equation, second kind, split kernel
D05ABF	Linear non-singular Fredholm integral equation, second kind, smooth kernel
D05BAF	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
D05BWF	Generate weights for use in solving Volterra equations
D05BYF	Generate weights for use in solving weakly singular Abel-type equations

## Chapter E01 – Interpolation

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
E01BAF	Interpolating functions, cubic spline interpolant, one variable
E01BEF	Interpolating functions, monotonicity-preserving, piecewise cubic Hermite, one variable
E01BFF	Interpolated values, interpolant computed by E01BEF, function only, one variable
E01BGF	Interpolated values, interpolant computed by E01BEF, function and first derivative, one variable
E01BHF	Interpolated values, interpolant computed by E01BEF, definite integral, one variable
E01DAF	Interpolating functions, fitting bicubic spline, data on rectangular grid
E01RAF	Interpolating functions, rational interpolant, one variable
E01RBF	Interpolated values, evaluate rational interpolant computed by E01RAF, one variable
E01SAF	Interpolating functions, method of Renka and Cline, two variables
E01SBF	Interpolated values, evaluate interpolant computed by E01SAF, two variables
E01SEF	Interpolating functions, modified Shepard's method, two variables

E01SFF	Interpolated values, evaluate interpolant computed by E01SEF, two variables
E01SGF	Interpolating functions, modified Shepard's method, two variables
E01SHF	Interpolated values, evaluate interpolant computed by E01SGF, function and first derivatives, two variables
E01TGF	Interpolating functions, modified Shepard's method, three variables
E01THF	Interpolated values, evaluate interpolant computed by E01TGF, function and first derivatives, three variables

## Chapter E02 – Curve and Surface Fitting

E02ACF	Minimax curve fit by polynomials
E02ADF	Least-squares curve fit, by polynomials, arbitrary data points
E02AEF	Evaluation of fitted polynomial in one variable from Chebyshev series form (simplified parameter list)
E02AFF	Least-squares polynomial fit, special data points (including interpolation)
E02AGF	Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points
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
E02BAF	Least-squares curve cubic spline fit (including interpolation)
E02BBF	Evaluation of fitted cubic spline, function only
E02BCF	Evaluation of fitted cubic spline, function and derivatives
E02BDF	Evaluation of fitted cubic spline, definite integral
E02BEF	Least-squares cubic spline curve fit, automatic knot placement
E02CAF	Least-squares surface fit by polynomials, data on lines
E02CBF	Evaluation of fitted polynomial in two variables
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
E02DEF	Evaluation of fitted bicubic spline at a vector of points
E02DFF	Evaluation of fitted bicubic spline at a mesh of points
E02GAF	$L_1$ -approximation by general linear function
E02GBF	$L_1$ -approximation by general linear function subject to linear inequality constraints
E02GCF	$L_\infty$ -approximation by general linear function
E02RAF	Padé-approximants
E02RBF	Evaluation of fitted rational function as computed by E02RAF
E02ZAF	Sort two-dimensional data into panels for fitting bicubic splines

## Chapter E04 – Minimizing or Maximizing a Function

E04ABF	Minimum, function of one variable using function values only
E04BBF	Minimum, function of one variable, using first derivative
E04CCF	Unconstrained minimum, simplex algorithm, function of several variables using function values only (comprehensive)
E04DGF	Unconstrained minimum, preconditioned conjugate gradient algorithm, function of several variables using first derivatives (comprehensive)
E04DJF	Read optional parameter values for E04DGF from external file
E04DKF	Supply optional parameter values to E04DGF
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)
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)
E04HCF	Check user’s routine for calculating first derivatives of function
E04HDF	Check user’s routine for calculating second derivatives of function
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)
E04JYF	Minimum, function of several variables, quasi-Newton algorithm, simple bounds, using function values only (easy-to-use)
E04KDF	Minimum, function of several variables, modified Newton algorithm, simple bounds, using first derivatives (comprehensive)
E04KYF	Minimum, function of several variables, quasi-Newton algorithm, simple bounds, using first derivatives (easy-to-use)
E04KZF	Minimum, function of several variables, modified Newton algorithm, simple bounds, using first derivatives (easy-to-use)
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, using first and second derivatives (easy-to-use)
E04MFF	LP problem (dense)
E04MGF	Read optional parameter values for E04MFF from external file
E04MHF	Supply optional parameter values to E04MFF
E04MZF	Converts MPSX data file defining LP or QP problem to format required by E04NKF
E04NCF	Convex QP problem or linearly-constrained linear least-squares problem (dense)
E04NDF	Read optional parameter values for E04NCF from external file
E04NEF	Supply optional parameter values to E04NCF
E04NFF	QP problem (dense)
E04NGF	Read optional parameter values for E04NFF from external file
E04NHF	Supply optional parameter values to E04NFF
E04NKF	LP or QP problem (sparse)
E04NLF	Read optional parameter values for E04NKF from external file
E04NMF	Supply optional parameter values to E04NKF
E04UCF	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (forward communication, comprehensive)
E04UDF	Read optional parameter values for E04UCF or E04UFF from external file
E04UEF	Supply optional parameter values to E04UCF or E04UFF
E04UFF	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (reverse communication, comprehensive)
E04UGF	NLP problem (sparse)
E04UHF	Read optional parameter values for E04UGF from external file
E04UJF	Supply optional parameter values to E04UGF
E04UNF	Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive)
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
E04YAF	Check user’s routine for calculating Jacobian of first derivatives
E04YBF	Check user’s routine for calculating Hessian of a sum of squares
E04YCF	Covariance matrix for nonlinear least-squares problem (unconstrained)
E04ZCF	Check user’s routines for calculating first derivatives of function and constraints

## Chapter F01 – Matrix Factorizations

F01ABF	Inverse of real symmetric positive-definite matrix using iterative refinement
F01ADF	Inverse of real symmetric positive-definite matrix
F01BLF	Pseudo-inverse and rank of real $m$ by $n$ matrix ( $m \geq n$ )
F01BRF	$LU$ factorization of real sparse matrix
F01BSF	$LU$ factorization of real sparse matrix with known sparsity pattern

F01BUF	$ULDL^T U^T$ factorization of real symmetric positive-definite band matrix
F01BVF	Reduction to standard form, generalized real symmetric-definite banded eigenproblem
F01CKF	Matrix multiplication
F01CRF	Matrix transposition
F01CTF	Sum or difference of two real matrices, optional scaling and transposition
F01CWF	Sum or difference of two complex matrices, optional scaling and transposition
F01LEF	$LU$ factorization of real tridiagonal matrix
F01LHF	$LU$ factorization of real almost block diagonal matrix
F01MCF	$LDL^T$ factorization of real symmetric positive-definite variable-bandwidth matrix
F01QGF	$RQ$ factorization of real $m$ by $n$ upper trapezoidal matrix ( $m \leq n$ )
F01QJF	$RQ$ factorization of real $m$ by $n$ matrix ( $m \leq n$ )
F01QKF	Operations with orthogonal matrices, form rows of $Q$ , after $RQ$ factorization by F01QJF
F01RGF	$RQ$ factorization of complex $m$ by $n$ upper trapezoidal matrix ( $m \leq n$ )
F01RJF	$RQ$ factorization of complex $m$ by $n$ matrix ( $m \leq n$ )
F01RKF	Operations with unitary matrices, form rows of $Q$ , after $RQ$ factorization by F01RJF
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

## Chapter F02 – Eigenvalues and Eigenvectors

F02BJF	All eigenvalues and optionally eigenvectors of generalized eigenproblem by $QZ$ algorithm, real matrices (Black Box)
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)
F02FAF	All eigenvalues and eigenvectors of real symmetric matrix (Black Box)
F02FCF	Selected eigenvalues and eigenvectors of real symmetric matrix (Black Box)
F02FDF	All eigenvalues and eigenvectors of real symmetric-definite generalized problem (Black Box)
F02FHF	All eigenvalues of generalized banded real symmetric-definite eigenproblem (Black Box)
F02FJF	Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)
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)
F02GJF	All eigenvalues and optionally eigenvectors of generalized complex eigenproblem by $QZ$ algorithm (Black Box)
F02HAF	All eigenvalues and eigenvectors of complex Hermitian matrix (Black Box)
F02HCF	Selected eigenvalues and eigenvectors of complex Hermitian matrix (Black Box)
F02HDF	All eigenvalues and eigenvectors of complex Hermitian-definite generalized problem (Black Box)
F02SDF	Eigenvector of generalized real banded eigenproblem by inverse iteration
F02WDF	$QR$ factorization, possibly followed by SVD
F02WEF	SVD of real matrix (Black Box)
F02WUF	SVD of real upper triangular matrix (Black Box)
F02XEF	SVD of complex matrix (Black Box)
F02XUF	SVD of complex upper triangular matrix (Black Box)

## Chapter F03 – Determinants

F03AAF	Determinant of real matrix (Black Box)
F03ABF	Determinant of real symmetric positive-definite matrix (Black Box)
F03ACF	Determinant of real symmetric positive-definite band matrix (Black Box)
F03ADF	Determinant of complex matrix (Black Box)
F03AEF	$LL^T$ factorization and determinant of real symmetric positive-definite matrix
F03AFF	$LU$ factorization and determinant of real matrix



**Chapter F04 – Simultaneous Linear Equations**

F04AAF	Solution of real simultaneous linear equations with multiple right-hand sides (Black Box)
F04ABF	Solution of real symmetric positive-definite simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04ACF	Solution of real symmetric positive-definite banded simultaneous linear equations with multiple right-hand sides (Black Box)
F04ADF	Solution of complex 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)
F04AFF	Solution of real symmetric positive-definite simultaneous linear equations using iterative refinement (coefficient matrix already factorized by F03AEF)
F04AGF	Solution of real symmetric positive-definite simultaneous linear equations (coefficient matrix already factorized by F03AEF)
F04AHF	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 by F03AFF)
F04AMF	Least-squares solution of $m$ real equations in $n$ unknowns, rank = $n$ , $m \geq n$ using iterative refinement (Black Box)
F04ARF	Solution of real simultaneous linear equations, one right-hand side (Black Box)
F04ASF	Solution of real symmetric positive-definite simultaneous linear equations, one right-hand side using iterative refinement (Black Box)
F04ATF	Solution of real simultaneous linear equations, one right-hand side using iterative refinement (Black Box)
F04AXF	Solution of real sparse simultaneous linear equations (coefficient matrix already factorized)
F04EAF	Solution of real tridiagonal simultaneous linear equations, one right-hand side (Black Box)
F04FAF	Solution of real symmetric positive-definite tridiagonal simultaneous linear equations, one right-hand side (Black Box)
F04FEF	Solution of the Yule–Walker equations for real symmetric positive-definite Toeplitz matrix, one right-hand side
F04FFF	Solution of real symmetric positive-definite Toeplitz system, one right-hand side
F04JAF	Minimal least-squares solution of $m$ real equations in $n$ unknowns, rank $\leq n$ , $m \geq n$
F04JDF	Minimal least-squares solution of $m$ real equations in $n$ unknowns, rank $\leq n$ , $m \geq n$
F04JGF	Least-squares (if rank = $n$ ) or minimal least-squares (if rank < $n$ ) solution of $m$ real equations in $n$ unknowns, rank $\leq n$ , $m \geq n$
F04JLF	Real general Gauss–Markov linear model (including weighted least-squares)
F04JMF	Equality-constrained real linear least-squares problem
F04KLF	Complex general Gauss–Markov linear model (including weighted least-squares)
F04KMF	Equality-constrained complex linear least-squares problem
F04LEF	Solution of real tridiagonal simultaneous linear equations (coefficient matrix already factorized by F01LEF)
F04LHF	Solution of real almost block diagonal simultaneous linear equations (coefficient matrix already factorized by F01LHF)
F04MCF	Solution of real symmetric positive-definite variable-bandwidth simultaneous linear equations (coefficient matrix already factorized by F01MCF)
F04MEF	Update solution of the Yule–Walker equations for real symmetric positive-definite Toeplitz matrix
F04MFF	Update solution of real symmetric positive-definite Toeplitz system
F04QAF	Sparse linear least-squares problem, $m$ real equations in $n$ unknowns
F04YAF	Covariance matrix for linear least-squares problems, $m$ real equations in $n$ unknowns
F04YCF	Norm estimation (for use in condition estimation), real matrix
F04ZCF	Norm estimation (for use in condition estimation), complex matrix

**Chapter F05 – Orthogonalisation**

F05AAF	Gram–Schmidt orthogonalisation of $n$ vectors of order $m$
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## Chapter F06 – Linear Algebra Support Routines

F06AAF	(SROTG/DROTG) Generate real plane rotation
F06BAF	Generate real plane rotation, storing tangent
F06BCF	Recover cosine and sine from given real tangent
F06BEF	Generate real Jacobi plane rotation
F06BHF	Apply real similarity rotation to 2 by 2 symmetric matrix
F06BLF	Compute quotient of two real scalars, with overflow flag
F06BMF	Compute Euclidean norm from scaled form
F06BNF	Compute square root of $(a^2 + b^2)$ , real $a$ and $b$
F06BPF	Compute eigenvalue of 2 by 2 real symmetric matrix
F06CAF	Generate complex plane rotation, storing tangent, real cosine
F06CBF	Generate complex plane rotation, storing tangent, real sine
F06CCF	Recover cosine and sine from given complex tangent, real cosine
F06CDF	Recover cosine and sine from given complex tangent, real sine
F06CHF	Apply complex similarity rotation to 2 by 2 Hermitian matrix
F06CLF	Compute quotient of two complex scalars, with overflow flag
F06DBF	Broadcast scalar into integer vector
F06DFF	Copy integer vector
F06EAF	(SDOT/DDOT) Dot product of two real vectors
F06ECF	(SAXPY/DAXPY) Add scalar times real vector to real vector
F06EDF	(SSCAL/DSCAL) Multiply real vector by scalar
F06EFF	(SCOPY/DCOPY) Copy real vector
F06EGF	(SSWAP/DSWAP) Swap two real vectors
F06EJF	(SNRM2/DNRM2) Compute Euclidean norm of real vector
F06EKF	(SASUM/DASUM) Sum absolute values of real vector elements
F06EPF	(SROT/DROT) Apply real plane rotation
F06ERF	(SDOTI/DDOTI) Dot product of two real sparse vectors
F06ETF	(SAXPYI/DAXPYI) Add scalar times real sparse vector to real sparse vector
F06EUF	(SGTHR/DGTHR) Gather real sparse vector
F06EVF	(SGTHRZ/DGTHRZ) Gather and set to zero real sparse vector
F06EWF	(SSCTR/DSCTR) Scatter real sparse vector
F06EXF	(SROTI/DROTI) Apply plane rotation to two real sparse vectors
F06FAF	Compute cosine of angle between two real vectors
F06FBF	Broadcast scalar into real vector
F06FCF	Multiply real vector by diagonal matrix
F06FDF	Multiply real vector by scalar, preserving input vector
F06FGF	Negate real vector
F06FJF	Update Euclidean norm of real vector in scaled form
F06FKF	Compute weighted Euclidean norm of real vector
F06FLF	Elements of real vector with largest and smallest absolute value
F06FPF	Apply real symmetric plane rotation to two vectors
F06FQF	Generate sequence of real plane rotations
F06FRF	Generate real elementary reflection, NAG style
F06FSF	Generate real elementary reflection, LINPACK style
F06FTF	Apply real elementary reflection, NAG style
F06FUF	Apply real elementary reflection, LINPACK style
F06GAF	(CDOTU/ZDOTU) Dot product of two complex vectors, unconjugated
F06GBF	(CDOTC/ZDOTC) Dot product of two complex vectors, conjugated
F06GCF	(CAXPY/ZAXPY) Add scalar times complex vector to complex vector
F06GDF	(CSCAL/ZSCAL) Multiply complex vector by complex scalar
F06GFF	(CCOPY/ZCOPY) Copy complex vector
F06GGF	(CSWAP/ZSWAP) Swap two complex vectors
F06GRF	(CDOTUI/ZDOTUI) Dot product of two complex sparse vector, unconjugated
F06GSF	(CDOTCI/ZDOTCI) Dot product of two complex sparse vector, conjugated
F06GTF	(CAXPYI/ZAXPYI) Add scalar times complex sparse vector to complex sparse vector
F06GUF	(CGTHR/ZGTHR) Gather complex sparse vector
F06GVF	(CGTHRZ/ZGTHRZ) Gather and set to zero complex sparse vector
F06GWF	(CSCTR/ZSCTR) Scatter complex sparse vector

F06HBF	Broadcast scalar into complex vector
F06HCF	Multiply complex vector by complex diagonal matrix
F06HDF	Multiply complex vector by complex scalar, preserving input vector
F06HGF	Negate complex vector
F06HPF	Apply complex plane rotation
F06HQF	Generate sequence of complex plane rotations
F06HRF	Generate complex elementary reflection
F06HTF	Apply complex elementary reflection
F06JDF	(CSSCAL/ZDSCAL) Multiply complex vector by real scalar
F06JJF	(SCNRM2/DZNRM2) Compute Euclidean norm of complex vector
F06JKF	(SCASUM/DZASUM) Sum absolute values of complex vector elements
F06JLF	(ISAMAX/IDAMAX) Index, real vector element with largest absolute value
F06JMF	(ICAMAX/IZAMAX) Index, complex vector element with largest absolute value
F06KCF	Multiply complex vector by real diagonal matrix
F06KDF	Multiply complex vector by real scalar, preserving input vector
F06KFF	Copy real vector to complex vector
F06KJF	Update Euclidean norm of complex vector in scaled form
F06KLF	Last non-negligible element of real vector
F06KPF	Apply real plane rotation to two complex vectors
F06PAF	(SGEMV/DGEMV) Matrix-vector product, real rectangular matrix
F06PBF	(SGBMV/DGBMV) Matrix-vector product, real rectangular band matrix
F06PCF	(SSYMV/DSYMV) Matrix-vector product, real symmetric matrix
F06PDF	(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
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
F06PMF	(SGER/DGER) Rank-1 update, real rectangular matrix
F06PPF	(SSYR/DSYR) Rank-1 update, real symmetric matrix
F06PQF	(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
F06QFF	Matrix copy, real rectangular or trapezoidal matrix
F06QHF	Matrix initialisation, real rectangular matrix
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 real array
F06QMF	Orthogonal similarity transformation of real symmetric matrix as a sequence of plane rotations
F06QPF	$QR$ factorization by sequence of plane rotations, rank-1 update of real upper triangular matrix
F06QQF	$QR$ factorization by sequence of plane rotations, real upper triangular matrix augmented by a full row
F06QRF	$QR$ or $RQ$ factorization by sequence of plane rotations, real upper Hessenberg matrix
F06QSF	$QR$ or $RQ$ factorization by sequence of plane rotations, real upper spiked matrix
F06QTF	$QR$ factorization of $UZ$ or $RQ$ factorization of $ZU$ , $U$ real upper triangular, $Z$ a sequence of plane rotations
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
F06RAF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real general matrix
F06RBF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real band matrix
F06RCF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real symmetric matrix
F06RDF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real symmetric matrix, packed storage
F06REF	1-norm, $\infty$ -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, $\infty$ -norm, Frobenius norm, largest absolute element, real triangular matrix, packed storage
F06RLF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real triangular band matrix
F06RMF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, real Hessenberg matrix
F06SAF	(CGEMV/ZGEMV) Matrix-vector product, complex rectangular matrix
F06SBF	(CGBMV/ZGBMV) Matrix-vector product, complex rectangular band matrix
F06SCF	(CHEMV/ZHEMV) Matrix-vector product, complex Hermitian matrix
F06SDF	(CHBMV/ZHBMV) Matrix-vector product, complex Hermitian band matrix
F06SEF	(CHPMV/ZHPMV) Matrix-vector product, complex Hermitian packed matrix
F06SFF	(CTRMV/ZTRMV) Matrix-vector product, complex triangular matrix
F06SGF	(CTBMV/ZTBMV) Matrix-vector product, complex triangular band matrix
F06SHF	(CTPMV/ZTPMV) Matrix-vector product, complex triangular packed matrix
F06SJF	(CTRSV/ZTRSV) System of equations, complex triangular matrix
F06SKF	(CTBSV/ZTBSV) System of equations, complex triangular band matrix
F06SLF	(CTPSV/ZTPSV) System of equations, complex triangular packed matrix
F06SMF	(CGERU/ZGERU) Rank-1 update, complex rectangular matrix, unconjugated vector
F06SNF	(CGERC/ZGERC) Rank-1 update, complex rectangular matrix, conjugated vector
F06SPF	(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
F06TFF	Matrix copy, complex rectangular or trapezoidal matrix
F06THF	Matrix initialisation, complex rectangular matrix
F06TMF	Unitary similarity transformation of Hermitian matrix as a sequence of plane rotations
F06TPF	$QR$ factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix
F06TQF	$QRxk$ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row
F06TRF	$QR$ or $RQ$ factorization by sequence of plane rotations, complex upper Hessenberg matrix
F06TSF	$QR$ or $RQ$ factorization by sequence of plane rotations, complex upper spiked matrix
F06TTF	$QR$ factorization of $UZ$ or $RQ$ factorization of $ZU$ , $U$ complex upper triangular, $Z$ a sequence of plane rotations
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
F06UAF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex general matrix
F06UBF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex band matrix
F06UCF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex Hermitian matrix
F06UDF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex Hermitian matrix, packed storage
F06UEF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex Hermitian band matrix
F06UFF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex symmetric matrix
F06UGF	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, $\infty$ -norm, Frobenius norm, largest absolute element, complex triangular matrix, packed storage
F06ULF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex triangular band matrix
F06UMF	1-norm, $\infty$ -norm, Frobenius norm, largest absolute element, complex Hessenberg matrix
F06VJF	Permute rows or columns, complex rectangular matrix, permutations represented by an integer array
F06VKF	Permute rows or columns, complex rectangular matrix, permutations represented by a real array
F06VXF	Apply sequence of plane rotations, complex rectangular matrix, real cosine and sine

F06YAF	(SGEMM/DGEMM) Matrix-matrix product, two real rectangular matrices
F06YCF	(SSYMM/DSYMM) Matrix-matrix product, one real symmetric matrix, one real rectangular matrix
F06YFF	(STRMM/DTRMM) Matrix-matrix product, one real triangular matrix, one real rectangular matrix
F06YJF	(STRSM/DTRSM) Solves system of equations with multiple right-hand sides, real triangular coefficient matrix
F06YPF	(SSYRK/DSYRK) Rank- $k$ update of real symmetric 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 complex rectangular matrix
F06ZFF	(CTRMM/ZTRMM) Matrix-matrix product, one complex triangular matrix, one complex rectangular matrix
F06ZJF	(CTRSM/ZTRSM) Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix
F06ZPF	(CHERK/ZHERK) Rank- $k$ update of complex Hermitian matrix
F06ZRF	(CHER2K/ZHER2K) Rank- $2k$ update of complex Hermitian matrix
F06ZTF	(CSYMM/ZSYMM) Matrix-matrix product, one complex symmetric matrix, one complex rectangular matrix
F06ZUF	(CSYRK/ZSYRK) Rank- $k$ update of complex symmetric matrix
F06ZWF	(CSYR2K/ZHER2K) Rank- $2k$ update of complex symmetric matrix

## Chapter F07 – Linear Equations (LAPACK)

F07ADF	(SGETRF/DGETRF) $LU$ factorization of real $m$ by $n$ matrix
F07AEF	(SGETRS/DGETRS) Solution of real system of linear equations, multiple right-hand sides, matrix already factorized by F07ADF
F07AGF	(SGECON/DGECON) Estimate condition number of real matrix, matrix already factorized by F07ADF
F07AHF	(SGERFS/DGERFS) Refined solution with error bounds of real system of linear equations, multiple right-hand sides
F07AJF	(SGETRI/DGETRI) Inverse of real matrix, matrix already factorized by F07ADF
F07ARF	(CGETRF/ZGETRF) $LU$ factorization of complex $m$ by $n$ matrix
F07ASF	(CGETRS/ZGETRS) Solution of complex system of linear equations, multiple right-hand sides, matrix already factorized by F07ARF
F07AUF	(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
F07AWF	(CGETRI/ZGETRI) Inverse of complex matrix, matrix already factorized by F07ARF
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
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
F07FDF	(SPOTRF/DPOTRF) Cholesky factorization of real symmetric positive-definite matrix
F07FEF	(SPOTRS/DPOTRS) Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FDF

F07FGF	(SPOCON/DPOCON) Estimate condition number of real symmetric positive-definite matrix, matrix already factorized by F07FDF
F07FHF	(SPORFS/DPORFS) Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides
F07FJF	(SPOTRI/DPOTRI) Inverse of real symmetric positive-definite matrix, matrix already factorized by F07FDF
F07FRF	(CPOTRF/ZPOTRF) Cholesky factorization of complex Hermitian positive-definite matrix
F07FSF	(CPOTRS/ZPOTRS) Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FRF
F07FUF	(CPOCON/ZPOCON) Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF
F07FVF	(CPORFS/ZPORFS) Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides
F07FWF	(CPOTRI/ZPOTRI) Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF
F07GDF	(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
F07GRF	(CPPTRF/ZPPTRF) Cholesky factorization of complex Hermitian positive-definite matrix, packed storage
F07GSF	(CPPTRS/ZPPTRS) Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GRF, packed storage
F07GUF	(CPPCON/ZPPCON) Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF, packed storage
F07GVF	(CPPRFS/ZPPRFS) Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, packed storage
F07GWF	(CPPTRI/ZPPTRI) Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF, packed storage
F07HDF	(SPBTRF/DPBTRF) Cholesky factorization of real symmetric positive-definite band matrix
F07HEF	(SPBTRS/DPBTRS) Solution of real symmetric positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HDF
F07HGF	(SPBCON/DPBCON) Estimate condition number of real symmetric positive-definite band matrix, matrix already factorized by F07HDF
F07HHF	(SPBRFS/DPBRFS) Refined solution with error bounds of real symmetric positive-definite band system of linear equations, multiple right-hand sides
F07HRF	(CPBTRF/ZPBTRF) Cholesky factorization of complex Hermitian positive-definite band matrix
F07HSF	(CPBTRS/ZPBTRS) Solution of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HRF
F07HUF	(CPBCON/ZPBCON) Estimate condition number of complex Hermitian positive-definite band matrix, matrix already factorized by F07HRF
F07HVF	(CPBRFS/ZPBRFS) Refined solution with error bounds of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides
F07MDF	(SSYTRF/DSYTRF) Bunch–Kaufman factorization of real symmetric indefinite matrix
F07MEF	(SSYTRS/DSYTRS) Solution of real symmetric indefinite system of linear equations, 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 system of linear equations, multiple right-hand sides

F07MJF	(SSYTRI/DSYTRI) Inverse of real symmetric indefinite matrix, matrix already factorized by F07MDF
F07MRF	(CHETRF/ZHETRF) Bunch–Kaufman factorization of complex Hermitian indefinite matrix
F07MSF	(CHETRS/ZHETRS) Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07MRF
F07MUF	(CHECON/ZHECON) Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07MRF
F07MVF	(CHERFS/ZHERFS) Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides
F07MWF	(CHETRI/ZHETRI) Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07MRF
F07NRF	(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, matrix already factorized by F07NRF
F07NVF	(CSYRFS/ZSYRFS) Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides
F07NWF	(CSYTRI/ZSYTRI) Inverse of complex symmetric matrix, matrix already factorized by F07NRF
F07PDF	(SSPTRF/DSPTRF) Bunch–Kaufman factorization of real symmetric indefinite matrix, packed storage
F07PEF	(SSPTRS/DSPTRS) Solution of real symmetric indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07PDF, packed storage
F07PGF	(SSPCON/DSPCON) Estimate condition number of real symmetric indefinite 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 factorized by F07PDF, packed storage
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
F07QRF	(CSPTRF/ZSPTRF) Bunch–Kaufman factorization of complex symmetric matrix, packed storage
F07QSF	(CSPTRS/ZSPTRS) Solution of complex symmetric system of linear equations, multiple right-hand sides, matrix already factorized by F07QRF, packed storage
F07QUF	(CSPCON/ZSPCON) Estimate condition number of complex symmetric matrix, matrix already factorized by F07QRF, packed storage
F07QVF	(CSPRFS/ZSPRFS) Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides, packed storage
F07QWF	(CSPTRI/ZSPTRI) Inverse of complex symmetric matrix, matrix already factorized by F07QRF, packed storage
F07TEF	(STRTRS/DTRTRS) Solution of real triangular system of linear equations, multiple right-hand sides
F07TGF	(STRCON/DTRCON) Estimate condition number of real triangular matrix
F07THF	(STRRFS/DTRRFS) Error bounds for solution of real triangular system of linear equations, multiple right-hand sides
F07TJF	(STRTRI/DTRTRI) Inverse of real triangular matrix
F07TSF	(CTRTRS/ZTRTRS) Solution of complex triangular system of linear equations, multiple right-hand sides

F07TUF	(CTRCON/ZTRCON) Estimate condition number of complex triangular matrix
F07TVF	(CTRRFS/ZTRRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides
F07TWF	(CTRTRI/ZTRTRI) Inverse of complex 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
F07USF	(CTPTRS/ZTPTRS) Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07UUF	(CTPCON/ZTPCON) Estimate condition number of complex triangular matrix, packed storage
F07UVF	(CTPRFS/ZTPRFS) Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07UWF	(CTPTRI/ZTPTRI) Inverse of complex triangular matrix, packed storage
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 linear equations, multiple right-hand sides
F07VSF	(CTBTRS/ZTBTRS) Solution of complex band triangular system of linear equations, 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 of linear equations, multiple right-hand sides

## Chapter F08 – Least-squares and Eigenvalue Problems (LAPACK)

F08AEF	(SGEQRF/DGEQRF) $QR$ factorization of real general rectangular matrix
F08AFF	(SORGQR/DORGQR) Form all or part of orthogonal $Q$ from $QR$ factorization determined by F08AEF or F08BEF
F08AGF	(SORMQR/DORMQR) Apply orthogonal transformation determined by F08AEF or F08BEF
F08AHF	(SGELQF/DGELQF) $LQ$ factorization of real general rectangular matrix
F08AJF	(SORGLQ/DORGLQ) Form all or part of orthogonal $Q$ from $LQ$ factorization determined by F08AHF
F08AKF	(SORMLQ/DORMLQ) Apply orthogonal transformation determined by F08AHF
F08ASF	(CGEQRF/ZGEQRF) $QR$ factorization of complex general rectangular matrix
F08ATF	(CUNGQR/ZUNGQR) Form all or part of unitary $Q$ from $QR$ factorization determined by F08ASF or F08BSF
F08AUF	(CUNMQR/ZUNMQR) Apply unitary transformation determined by F08ASF or F08BSF
F08AVF	(CGELQF/ZGELQF) $LQ$ factorization of complex general rectangular matrix
F08AWF	(CUNGLQ/ZUNGLQ) Form all or part of unitary $Q$ from $LQ$ factorization determined by F08AVF
F08AXF	(CUNMLQ/ZUNMLQ) Apply unitary transformation determined by F08AVF
F08BEF	(SGEQPF/DGEQPF) $QR$ factorization of real general rectangular matrix with column pivoting
F08BSF	(CGEQPF/ZGEQPF) $QR$ factorization of complex general rectangular matrix with column pivoting
F08FCF	(SSYEVD/DSYEVD) All eigenvalues and optionally all eigenvectors of real symmetric matrix, using divide and conquer
F08FEF	(SSYTRD/DSYTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form
F08FFF	(SORGTR/DORGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08FEF
F08FGF	(SORMTR/DORMTR) Apply orthogonal transformation determined by F08FEF
F08FQF	(CHEEVD/ZHEEVD) All eigenvalues and optionally all eigenvectors of complex Hermitian matrix, using divide and conquer
F08FSF	(CHETRD/ZHETRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form



F08FTF	(CUNGTR/ZUNGTR) Generate unitary transformation matrix from reduction to tridiagonal form determined by F08FSF
F08FUF	(CUNMTR/ZUNMTR) Apply unitary transformation matrix determined by F08FSF
F08GCF	(SSPEVD/DSPEVD) All eigenvalues and optionally all eigenvectors of real symmetric matrix, packed storage, using divide and conquer
F08GEF	(SSPTRD/DSPTRD) Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form, packed storage
F08GFF	(SOPGTR/DOPGTR) Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08GEF
F08GGF	(SOPMTR/DOPMTR) Apply orthogonal transformation determined by F08GEF
F08GQF	(CHPEVD/ZHPEVD) All eigenvalues and optionally all eigenvectors of complex Hermitian matrix, packed storage, using divide and conquer
F08GSF	(CHPTRD/ZHPTRD) Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form, packed storage
F08GTF	(CUPGTR/ZUPGTR) Generate unitary transformation matrix from reduction to tridiagonal form determined by F08GSF
F08GUF	(CUPMTR/ZUPMTR) Apply unitary transformation matrix determined by F08GSF
F08HCF	(SSBEVD/DSBEVD) All eigenvalues and optionally all eigenvectors of real symmetric band matrix, using divide and conquer
F08HEF	(SSBTRD/DSBTRD) Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form
F08HQF	(CHBEVD/ZHBEVD) All eigenvalues and optionally all eigenvectors of complex Hermitian band matrix, using divide and conquer
F08HSF	(CHBTRD/ZHBTRD) Unitary reduction of complex Hermitian band matrix to real symmetric tridiagonal form
F08JCF	(SSTEVD/DSTEVD) All eigenvalues and optionally all eigenvectors of real symmetric tridiagonal matrix, using divide and conquer
F08JEF	(SSTEQR/DSTEQR) All eigenvalues and eigenvectors of real symmetric tridiagonal 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-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 inverse iteration, storing eigenvectors in real array
F08JSF	(CSTEQR/ZSTEQR) All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from complex Hermitian matrix, using implicit $QL$ or $QR$
F08JUF	(CPTEQR/ZPTEQR) All eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from complex Hermitian positive-definite matrix
F08JXF	(CSTEIN/ZSTEIN) Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in complex array
F08KEF	(SGBBRD/DGBBRD) 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
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
F08MEF	(SBDSQR/DBDSQR) SVD of real bidiagonal matrix reduced from real general matrix
F08MSF	(CBDSQR/ZBDSQR) SVD of real bidiagonal matrix reduced from complex general matrix

F08NEF	(SGEHRD/DGEHRD) Orthogonal reduction of real general matrix to upper Hessenberg form
F08NFF	(SORGHR/DORGHR) Generate orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF
F08NGF	(SORMHR/DORMHR) Apply orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF
F08NHF	(SGEBAL/DGEBAL) Balance real general matrix
F08NJF	(SGEBAK/DGEBAK) Transform eigenvectors of real balanced matrix to those of original matrix supplied to F08NHF
F08NSF	(CGEHRD/ZGEHRD) Unitary reduction of complex general matrix to upper Hessenberg form
F08NTF	(CUNGHR/ZUNGHR) Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NSF
F08NUF	(CUNMHR/ZUNMHR) Apply unitary transformation matrix from reduction to Hessenberg form determined by F08NSF
F08NVF	(CGEBAL/ZGEBAL) Balance complex general matrix
F08NWF	(CGEBAK/ZGEBAK) Transform eigenvectors of complex balanced matrix to those of original matrix supplied to F08NVF
F08PEF	(SHSEQR/DHSEQR) Eigenvalues and Schur factorization of real upper Hessenberg matrix reduced from real general matrix
F08PKF	(SHSEIN/DHSEIN) Selected right and/or left eigenvectors of real upper Hessenberg matrix by inverse iteration
F08PSF	(CHSEQR/ZHSEQR) Eigenvalues and Schur factorization of complex upper Hessenberg matrix reduced from complex general matrix
F08PXF	(CHSEIN/ZHSEIN) Selected right and/or left eigenvectors of complex upper Hessenberg matrix by inverse iteration
F08QFF	(STREXC/DTREXC) Reorder Schur factorization of real matrix using orthogonal similarity transformation
F08QGF	(STRSEN/DTRSEN) Reorder Schur factorization of real matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities
F08QHF	(STRSYL/DTRSYL) Solve real Sylvester matrix equation $AX + XB = C$ , $A$ and $B$ are upper quasi-triangular or transposes
F08QKF	(STREVC/DTREVC) Left and right eigenvectors of real upper quasi-triangular matrix
F08QLF	(STRSNA/DTRSNA) Estimates of sensitivities of selected eigenvalues and eigenvectors of real upper quasi-triangular matrix
F08QTF	(CTREXC/ZTREXC) Reorder Schur factorization of complex matrix using unitary similarity transformation
F08QUF	(CTRSEN/ZTRSEN) Reorder Schur factorization of complex matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities
F08QVF	(CTRSYL/ZTRSYL) Solve complex Sylvester matrix equation $AX + XB = C$ , $A$ and $B$ are upper triangular or conjugate-transposes
F08QXF	(CTREVC/ZTREVC) Left and right eigenvectors of complex upper triangular matrix
F08QYF	(CTRSNA/ZTRSNA) Estimates of sensitivities of selected eigenvalues and eigenvectors of complex upper triangular matrix
F08SEF	(SSYGST/DSYGST) Reduction to standard form of real symmetric-definite generalized eigenproblem $Ax = \lambda Bx$ , $ABx = \lambda x$ or $BAx = \lambda x$ , $B$ factorized by F07FDF
F08SSF	(CHEGST/ZHEGST) Reduction to standard form of complex Hermitian-definite generalized eigenproblem $Ax = \lambda Bx$ , $ABx = \lambda x$ or $BAx = \lambda x$ , $B$ factorized by F07FRF
F08TEF	(SSPGST/DSPGST) Reduction to standard form of real symmetric-definite generalized eigenproblem $Ax = \lambda Bx$ , $ABx = \lambda x$ or $BAx = \lambda x$ , packed storage, $B$ factorized by F07GDF
F08TSF	(CHPGST/ZHPGST) Reduction to standard form of complex Hermitian-definite generalized eigenproblem $Ax = \lambda Bx$ , $ABx = \lambda x$ or $BAx = \lambda x$ , packed storage, $B$ factorized by F07GRF
F08UEF	(SSBGST/DSBGST) Reduction of real symmetric-definite banded generalized eigenproblem $Ax = \lambda Bx$ to standard form $Cy = \lambda y$ , such that $C$ has the same bandwidth as $A$
F08UFF	(SPBSTF/DPBSTF) Computes a split Cholesky factorization of real symmetric positive-definite band matrix $A$
F08USF	(CHBGST/ZHBGST) Reduction of complex Hermitian-definite banded generalized eigenproblem $Ax = \lambda Bx$ to standard form $Cy = \lambda y$ , such that $C$ has the same bandwidth as $A$
F08UTF	(CPBSTF/ZPBSTF) Computes a split Cholesky factorization of complex Hermitian positive-definite band matrix $A$

## Chapter F11 – Sparse Linear Algebra

F11BAF	Real sparse nonsymmetric linear systems, set-up for F11BBF
F11BBF	Real sparse nonsymmetric linear systems, preconditioned RGMRES, CGS or Bi-CGSTAB
F11BCF	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-CGSTAB or TFQMR method
F11BTF	Complex sparse non-Hermitian linear systems, diagnostic for F11BSF
F11DAF	Real sparse nonsymmetric linear systems, incomplete $LU$ factorization
F11DBF	Solution of linear system involving incomplete $LU$ preconditioning matrix generated 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 SSOR to real sparse nonsymmetric matrix
F11DEF	Solution of real sparse nonsymmetric linear system, RGMRES, CGS or Bi-CGSTAB method, Jacobi or SSOR preconditioner (Black Box)
F11DNF	Complex sparse non-Hermitian linear systems, incomplete $LU$ factorization
F11DPF	Solution of complex linear system involving incomplete $LU$ preconditioning matrix generated by F11DNF
F11DQF	Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DNF (Black Box)
F11DRF	Solution of linear system involving preconditioning matrix generated by applying SSOR to complex sparse non-Hermitian matrix
F11DSF	Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, Jacobi or SSOR preconditioner (Black Box)
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
F11JAF	Real sparse symmetric matrix, incomplete Cholesky factorization
F11JBF	Solution of linear system involving incomplete Cholesky preconditioning matrix generated by F11JAF
F11JCF	Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JAF (Black Box)
F11JDF	Solution of linear system involving preconditioning matrix generated by applying SSOR to real sparse symmetric matrix
F11JEF	Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)
F11JNF	Complex sparse Hermitian matrix, incomplete Cholesky factorization
F11JPF	Solution of complex linear system involving incomplete Cholesky preconditioning matrix generated by F11JNF
F11JQF	Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JNF (Black Box)
F11JRF	Solution of linear system involving preconditioning matrix generated by applying SSOR to complex sparse Hermitian matrix
F11JSF	Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)
F11XAF	Real sparse nonsymmetric matrix vector multiply
F11XEF	Real sparse symmetric matrix vector multiply
F11XNF	Complex sparse non-Hermitian matrix vector multiply
F11XSF	Complex sparse Hermitian matrix vector multiply
F11ZAF	Real sparse nonsymmetric matrix reorder routine
F11ZBF	Real sparse symmetric matrix reorder routine
F11ZNF	Complex sparse non-Hermitian matrix reorder routine
F11ZPF	Complex sparse Hermitian matrix reorder routine

**Chapter G01 – Simple Calculations and Statistical Data**

G01AAF	Mean, variance, skewness, kurtosis, etc, one variable, from raw data
G01ABF	Mean, variance, skewness, kurtosis, etc, two variables, from raw data
G01ADF	Mean, variance, skewness, kurtosis, etc, one variable, from frequency table
G01AEF	Frequency table from raw data
G01AFF	Two-way contingency table analysis, with $\chi^2$ /Fisher's exact test
G01AGF	Lineprinter scatterplot of two variables
G01AHF	Lineprinter scatterplot of one variable against Normal scores
G01AJF	Lineprinter histogram of one variable
G01ALF	Computes a five-point summary (median, hinges and extremes)
G01ARF	Constructs a stem and leaf plot
G01ASF	Constructs a box and whisker plot
G01BJF	Binomial distribution function
G01BKF	Poisson distribution function
G01BLF	Hypergeometric distribution function
G01DAF	Normal scores, accurate values
G01DBF	Normal scores, approximate values
G01DCF	Normal scores, approximate variance-covariance matrix
G01DDF	Shapiro and Wilk's $W$ test for Normality
G01DHF	Ranks, Normal scores, approximate Normal scores or exponential (Savage) scores
G01EAF	Computes probabilities for the standard Normal distribution
G01EBF	Computes probabilities for Student's $t$ -distribution
G01ECF	Computes probabilities for $\chi^2$ distribution
G01EDF	Computes probabilities for $F$ -distribution
G01EEF	Computes upper and lower tail probabilities and probability density function for the beta distribution
G01EFF	Computes probabilities for the gamma distribution
G01EMF	Computes probability for the Studentized range statistic
G01EPF	Computes bounds for the significance of a Durbin–Watson statistic
G01ERF	Computes probability for von Mises distribution
G01EYF	Computes probabilities for the one-sample Kolmogorov–Smirnov distribution
G01EZF	Computes probabilities for the two-sample Kolmogorov–Smirnov distribution
G01FAF	Computes deviates for the standard Normal distribution
G01FBF	Computes deviates for Student's $t$ -distribution
G01FCF	Computes deviates for the $\chi^2$ distribution
G01FDF	Computes deviates for the $F$ -distribution
G01FEF	Computes deviates for the beta distribution
G01FFF	Computes deviates for the gamma distribution
G01FMF	Computes deviates for the Studentized range statistic
G01GBF	Computes probabilities for the non-central Student's $t$ -distribution
G01GCF	Computes probabilities for the non-central $\chi^2$ distribution
G01GDF	Computes probabilities for the non-central $F$ -distribution
G01GEF	Computes probabilities for the non-central beta distribution
G01HAF	Computes probability for the bivariate Normal distribution
G01HBF	Computes probabilities for the multivariate Normal distribution
G01JCF	Computes probability for a positive linear combination of $\chi^2$ variables
G01JDF	Computes lower tail probability for a linear combination of (central) $\chi^2$ variables
G01MBF	Computes reciprocal of Mills' Ratio
G01NAF	Cumulants and moments of quadratic forms in Normal variables
G01NBF	Moments of ratios of quadratic forms in Normal variables, and related statistics

**Chapter G02 – Correlation and Regression Analysis**

G02BAF	Pearson product-moment correlation coefficients, all variables, no missing values
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

G02BDF	Correlation-like coefficients (about zero), all variables, no missing values
G02BEF	Correlation-like coefficients (about zero), all variables, casewise treatment of missing values
G02BFF	Correlation-like coefficients (about zero), all variables, pairwise treatment of missing values
G02BGF	Pearson product-moment correlation coefficients, subset of variables, no missing values
G02BHF	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
G02BKF	Correlation-like coefficients (about zero), subset of variables, no 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
G02BNF	Kendall/Spearman non-parametric rank correlation coefficients, no missing values, overwriting input data
G02BPF	Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, overwriting input data
G02BQF	Kendall/Spearman non-parametric rank correlation coefficients, no missing values, preserving input data
G02BRF	Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, preserving input data
G02BSF	Kendall/Spearman non-parametric rank correlation coefficients, pairwise treatment of missing values
G02BTF	Update a weighted sum of squares matrix with a new observation
G02BUF	Computes a weighted sum of squares matrix
G02BWF	Computes a correlation matrix from a sum of squares matrix
G02BXF	Computes (optionally weighted) correlation and covariance matrices
G02BYF	Computes partial correlation/variance-covariance matrix from correlation/variance-covariance matrix computed by G02BXF
G02CAF	Simple linear regression with constant term, no missing values
G02CBF	Simple linear regression without constant term, no missing values
G02CCF	Simple linear regression with constant term, missing values
G02CDF	Simple linear regression without constant term, missing values
G02CEF	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
G02CGF	Multiple linear regression, from correlation coefficients, with constant term
G02CHF	Multiple linear regression, from correlation-like coefficients, without constant term
G02DAF	Fits a general (multiple) linear regression model
G02DCF	Add/delete an observation to/from a general linear regression model
G02DDF	Estimates of linear parameters and general linear regression model from updated model
G02DEF	Add a new variable to a general linear regression model
G02DFE	Delete a variable from a general linear regression model
G02DGF	Fits a general linear regression model for new dependent variable
G02DKF	Estimates and standard errors of parameters of a general linear regression model for given constraints
G02DNF	Computes estimable function of a general linear regression model and its standard error
G02EAF	Computes residual sums of squares for all possible linear regressions for a set of independent variables
G02ECF	Calculates $R^2$ and $C_p$ values from residual sums of squares
G02EEF	Fits a linear regression model by forward selection
G02FAF	Calculates standardized residuals and influence statistics
G02FCF	Computes Durbin-Watson test statistic
G02GAF	Fits a generalized linear model with Normal errors
G02GBF	Fits a generalized linear model with binomial errors
G02GCF	Fits a generalized linear model with Poisson errors
G02GDF	Fits a generalized linear model with gamma errors
G02GKF	Estimates and standard errors of parameters of a general linear model for given constraints
G02GNF	Computes estimable function of a generalized linear model and its standard error

G02HAF	Robust regression, standard $M$ -estimates
G02HBF	Robust regression, compute weights for use with G02HDF
G02HDF	Robust regression, compute regression with user-supplied functions and weights
G02HFF	Robust regression, variance-covariance matrix following G02HDF
G02HKF	Calculates a robust estimation of a correlation matrix, Huber's weight function
G02HLF	Calculates a robust estimation of a correlation matrix, user-supplied weight function plus derivatives
G02HMF	Calculates a robust estimation of a correlation matrix, user-supplied weight function

### Chapter G03 – Multivariate Methods

G03AAF	Performs principal component analysis
G03ACF	Performs canonical variate analysis
G03ADF	Performs canonical correlation analysis
G03BAF	Computes orthogonal rotations for loading matrix, generalized orthomax criterion
G03BCF	Computes Procrustes rotations
G03CAF	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)
G03DAF	Computes test statistic for equality of within-group covariance matrices and matrices for discriminant analysis
G03DBF	Computes Mahalanobis squared distances for group or pooled variance-covariance matrices (for use after G03DAF)
G03DCF	Allocates observations to groups according to selected rules (for use after G03DAF)
G03EAF	Computes distance matrix
G03ECF	Hierarchical cluster analysis
G03EFF	$K$ -means cluster analysis
G03EHF	Constructs dendrogram (for use after G03ECF)
G03EJF	Computes cluster indicator variable (for use after G03ECF)
G03FAF	Performs principal co-ordinate analysis, classical metric scaling
G03FCF	Performs non-metric (ordinal) multidimensional scaling
G03ZAF	Produces standardized values ( $z$ -scores) for a data matrix

### Chapter G04 – Analysis of Variance

G04AGF	Two-way analysis of variance, hierarchical classification, subgroups of unequal size
G04BBF	Analysis of variance, randomized block or completely randomized design, treatment means and standard errors
G04BCF	Analysis of variance, general row and column design, treatment means and standard errors
G04CAF	Analysis of variance, complete factorial design, treatment means and standard errors
G04DAF	Computes sum of squares for contrast between means
G04DBF	Computes confidence intervals for differences between means computed by G04BBF or G04BCF
G04EAF	Computes orthogonal polynomials or dummy variables for factor/classification variable

### Chapter G05 – Random Number Generators

G05CAF	Pseudo-random real numbers, uniform distribution over (0,1)
G05CBF	Initialise random number generating routines to give repeatable sequence
G05CCF	Initialise random number generating routines to give non-repeatable sequence
G05CFF	Save state of random number generating routines
G05CGF	Restore state of random number generating routines
G05DAF	Pseudo-random real numbers, uniform distribution over $(a, b)$
G05DBF	Pseudo-random real numbers, (negative) exponential distribution
G05DCF	Pseudo-random real numbers, logistic distribution
G05DDF	Pseudo-random real numbers, Normal distribution
G05DEF	Pseudo-random real numbers, log-normal distribution
G05DFF	Pseudo-random real numbers, Cauchy distribution
G05DHF	Pseudo-random real numbers, $\chi^2$ distribution
G05DJF	Pseudo-random real numbers, Student's $t$ -distribution

G05DKF	Pseudo-random real numbers, $F$ -distribution
G05DPF	Pseudo-random real numbers, Weibull distribution
G05DRF	Pseudo-random integer, Poisson distribution
G05DYF	Pseudo-random integer from uniform distribution
G05DZF	Pseudo-random logical (boolean) value
G05EAF	Set up reference vector for multivariate Normal distribution
G05EBF	Set up reference vector for generating pseudo-random integers, uniform distribution
G05ECF	Set up reference vector for generating pseudo-random integers, Poisson distribution
G05EDF	Set up reference vector for generating pseudo-random integers, binomial distribution
G05EEF	Set up reference vector for generating pseudo-random integers, negative binomial distribution
G05EFF	Set up reference vector for generating pseudo-random integers, hypergeometric distribution
G05EGF	Set up reference vector for univariate ARMA time series model
G05EHF	Pseudo-random permutation of an integer vector
G05EJF	Pseudo-random sample from an integer vector
G05EWF	Generate next term from reference vector for ARMA time series model
G05EXF	Set up reference vector from supplied cumulative distribution function or probability distribution function
G05EYF	Pseudo-random integer from reference vector
G05EZF	Pseudo-random multivariate Normal vector from reference vector
G05FAF	Generates a vector of random numbers from a uniform distribution
G05FBF	Generates a vector of random numbers from an (negative) exponential distribution
G05FDF	Generates a vector of random numbers from a Normal distribution
G05FEF	Generates a vector of pseudo-random numbers from a beta distribution
G05FFF	Generates a vector of pseudo-random numbers from a gamma distribution
G05FSF	Generates a vector of pseudo-random variates from von Mises distribution
G05GAF	Computes random orthogonal matrix
G05GBF	Computes random correlation matrix
G05HDF	Generates a realisation of a multivariate time series from a VARMA model

## Chapter G07 – Univariate Estimation

G07AAF	Computes confidence interval for the parameter of a binomial distribution
G07ABF	Computes confidence interval for the parameter of a Poisson distribution
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
G07CAF	Computes $t$ -test statistic for a difference in means between two Normal populations, confidence interval
G07DAF	Robust estimation, median, median absolute deviation, robust standard deviation
G07DBF	Robust estimation, $M$ -estimates for location and scale parameters, standard weight functions
G07DCF	Robust estimation, $M$ -estimates for location and scale parameters, user-defined weight functions
G07DDF	Computes a trimmed and winsorized mean of a single sample with estimates of their variance
G07EAF	Robust confidence intervals, one-sample
G07EBF	Robust confidence intervals, two-sample

## Chapter G08 – Nonparametric Statistics

G08AAF	Sign test on two paired samples
G08ACF	Median test on two samples of unequal size
G08AEF	Friedman two-way analysis of variance on $k$ matched samples
G08AFF	Kruskal–Wallis one-way analysis of variance on $k$ samples of unequal size
G08AGF	Performs the Wilcoxon one-sample (matched pairs) signed rank test
G08AHF	Performs the Mann–Whitney $U$ test on two independent samples
G08AJF	Computes the exact probabilities for the Mann–Whitney $U$ statistic, no ties in pooled sample
G08AKF	Computes the exact probabilities for the Mann–Whitney $U$ statistic, ties in pooled sample
G08ALF	Performs the Cochran $Q$ test on cross-classified binary data
G08BAF	Mood's and David's tests on two samples of unequal size
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
G08DAF	Kendall’s coefficient of concordance
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
G08RAF	Regression using ranks, uncensored data
G08RBF	Regression using ranks, right-censored data

## Chapter G10 – Smoothing in Statistics

G10ABF	Fit cubic smoothing spline, smoothing parameter given
G10ACF	Fit cubic smoothing spline, smoothing parameter estimated
G10BAF	Kernel density estimate using Gaussian kernel
G10CAF	Compute smoothed data sequence using running median smoothers
G10ZAF	Reorder data to give ordered distinct observations

## Chapter G11 – Contingency Table Analysis

G11AAF	$\chi^2$ statistics for two-way contingency table
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
G11SAF	Contingency table, latent variable model for binary data
G11SBF	Frequency count for G11SAF

## Chapter G12 – Survival Analysis

G12AAF	Computes Kaplan–Meier (product-limit) estimates of survival probabilities
G12BAF	Fits Cox’s proportional hazard model
G12ZAF	Creates the risk sets associated with the Cox proportional hazards model for fixed covariates

## Chapter G13 – Time Series Analysis

G13AAF	Univariate time series, seasonal and non-seasonal differencing
G13ABF	Univariate time series, sample autocorrelation function
G13ACF	Univariate time series, partial autocorrelations from autocorrelations
G13ADF	Univariate time series, preliminary estimation, seasonal ARIMA model
G13AEF	Univariate time series, estimation, seasonal ARIMA model (comprehensive)
G13AFF	Univariate time series, estimation, seasonal ARIMA model (easy-to-use)
G13AGF	Univariate time series, update state set for forecasting
G13AHF	Univariate time series, forecasting from state set
G13AJF	Univariate time series, state set and forecasts, from fully specified seasonal ARIMA model
G13ASF	Univariate time series, diagnostic checking of residuals, following G13AEF or G13AFF
G13AUF	Computes quantities needed for range-mean or standard deviation-mean plot
G13BAF	Multivariate time series, filtering (pre-whitening) by an ARIMA model
G13BBF	Multivariate time series, filtering by a transfer function model
G13BCF	Multivariate time series, cross-correlations
G13BDF	Multivariate time series, preliminary estimation of transfer function model
G13BEF	Multivariate time series, estimation of multi-input model
G13BGF	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
G13CAF	Univariate time series, smoothed sample spectrum using rectangular, Bartlett, Tukey or Parzen lag window
G13CBF	Univariate time series, smoothed sample spectrum using spectral smoothing by the trapezium frequency (Daniell) window



G13CCF	Multivariate time series, smoothed sample cross spectrum using rectangular, Bartlett, Tukey or Parzen lag window
G13CDF	Multivariate time series, smoothed sample cross spectrum using spectral smoothing by the trapezium frequency (Daniell) window
G13CEF	Multivariate time series, cross amplitude spectrum, squared coherency, bounds, univariate and bivariate (cross) spectra
G13CFF	Multivariate time series, gain, phase, bounds, univariate and bivariate (cross) spectra
G13CGF	Multivariate time series, noise spectrum, bounds, impulse response function and its standard error
G13DBF	Multivariate time series, multiple squared partial autocorrelations
G13DCF	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
G13EAF	Combined measurement and time update, one iteration of Kalman filter, time-varying, square root covariance filter
G13EBF	Combined measurement and time update, one iteration of Kalman filter, time-invariant, square root covariance filter

## Chapter H – Operations Research

H02BBF	Integer LP problem (dense)
H02BFF	Interpret MPSX data file defining IP or LP problem, optimize and print solution
H02BUF	Convert MPSX data file defining IP or LP problem to format required by H02BBF or E04MFF
H02BVF	Print IP or LP solutions with user specified names for rows and columns
H02BZF	Integer programming solution, supplies further information on solution obtained by H02BBF
H02CBF	Integer QP problem (dense)
H02CCF	Read optional parameter values for H02CBF from external file
H02CDF	Supply optional parameter values to H02CBF
H02CEF	Integer LP or QP problem (sparse)
H02CFF	Read optional parameter values for H02CEF from external file
H02CGF	Supply optional parameter values to H02CEF
H03ABF	Transportation problem, modified ‘stepping stone’ method
H03ADF	Shortest path problem, Dijkstra’s algorithm

## Chapter M01 – Sorting

M01CAF	Sort a vector, real numbers
M01CBF	Sort a vector, integer numbers
M01CCF	Sort a vector, character data
M01DAF	Rank a vector, real numbers
M01DBF	Rank a vector, integer numbers
M01DCF	Rank a vector, character data
M01DEF	Rank rows of a matrix, real numbers
M01DFE	Rank rows of a matrix, integer numbers
M01DJF	Rank columns of a matrix, real numbers
M01DKF	Rank columns of a matrix, integer numbers
M01DZF	Rank arbitrary data
M01EAF	Rearrange a vector according to given ranks, real numbers
M01EBF	Rearrange a vector according to given ranks, integer numbers
M01ECF	Rearrange a vector according to given ranks, character data
M01EDF	Rearrange a vector according to given ranks, complex numbers
M01ZAF	Invert a permutation

M01ZBF Check validity of a permutation  
 M01ZCF Decompose a permutation into cycles

## Chapter P01 – Error Trapping

P01ABF Return value of error indicator/terminate with error message

## Chapter S – Approximations of Special Functions

S01BAF  $\ln(1+x)$   
 S01EAF Complex exponential,  $e^z$   
 S07AAF  $\tan x$   
 S09AAF  $\arcsin x$   
 S09ABF  $\arccos x$   
 S10AAF  $\tanh x$   
 S10ABF  $\sinh x$   
 S10ACF  $\cosh x$   
 S11AAF  $\operatorname{arctanh} x$   
 S11ABF  $\operatorname{arcsinh} x$   
 S11ACF  $\operatorname{arccosh} x$   
 S13AAF Exponential integral  $E_1(x)$   
 S13ACF Cosine integral  $\operatorname{Ci}(x)$   
 S13ADF Sine integral  $\operatorname{Si}(x)$   
 S14AAF Gamma function  
 S14ABF Log Gamma function  
 S14ACF  $\psi(x) - \ln x$   
 S14ADF Scaled derivatives of  $\psi(x)$   
 S14BAF Incomplete Gamma functions  $P(a, x)$  and  $Q(a, x)$   
 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  $\operatorname{erf}(x)$   
 S15AFF Dawson's integral  
 S15DDF Scaled complex complement of error function,  $\exp(-z^2)\operatorname{erfc}(-iz)$   
 S17ACF Bessel function  $Y_0(x)$   
 S17ADF Bessel function  $Y_1(x)$   
 S17AEF Bessel function  $J_0(x)$   
 S17AFF Bessel function  $J_1(x)$   
 S17AGF Airy function  $\operatorname{Ai}(x)$   
 S17AHF Airy function  $\operatorname{Bi}(x)$   
 S17AJF Airy function  $\operatorname{Ai}'(x)$   
 S17AKF Airy function  $\operatorname{Bi}'(x)$   
 S17DCF Bessel functions  $Y_{\nu+a}(z)$ , real  $a \geq 0$ , complex  $z$ ,  $\nu = 0, 1, 2, \dots$   
 S17DEF Bessel functions  $J_{\nu+a}(z)$ , real  $a \geq 0$ , complex  $z$ ,  $\nu = 0, 1, 2, \dots$   
 S17DGF Airy functions  $\operatorname{Ai}(z)$  and  $\operatorname{Ai}'(z)$ , complex  $z$   
 S17DHF Airy functions  $\operatorname{Bi}(z)$  and  $\operatorname{Bi}'(z)$ , complex  $z$   
 S17DLF Hankel functions  $H_{\nu+a}^{(j)}(z)$ ,  $j = 1, 2$ , real  $a \geq 0$ , complex  $z$ ,  $\nu = 0, 1, 2, \dots$   
 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  $e^x K_0(x)$   
 S18CDF Modified Bessel function  $e^x K_1(x)$   
 S18CEF Modified Bessel function  $e^{-|x|} I_0(x)$   
 S18CFF Modified Bessel function  $e^{-|x|} I_1(x)$   
 S18DCF Modified Bessel functions  $K_{\nu+a}(z)$ , real  $a \geq 0$ , complex  $z$ ,  $\nu = 0, 1, 2, \dots$   
 S18DEF Modified Bessel functions  $I_{\nu+a}(z)$ , real  $a \geq 0$ , complex  $z$ ,  $\nu = 0, 1, 2, \dots$   
 S19AAF Kelvin function  $\operatorname{ber} x$   
 S19ABF Kelvin function  $\operatorname{bei} x$

S19ACF	Kelvin function $\ker x$
S19ADF	Kelvin function $\text{kei } x$
S20ACF	Fresnel integral $S(x)$
S20ADF	Fresnel integral $C(x)$
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 $R_J(x, y, z, r)$
S21CAF	Jacobian elliptic functions $\text{sn}$ , $\text{cn}$ and $\text{dn}$

### Chapter X01 – Mathematical Constants

X01AAF	Provides the mathematical constant $\pi$
X01ABF	Provides the mathematical constant $\gamma$ (Euler's Constant)

### Chapter X02 – Machine Constants

X02AHF	The largest permissible argument for $\sin$ and $\cos$
X02AJF	The machine precision
X02AKF	The smallest positive model number
X02ALF	The largest positive model number
X02AMF	The safe range parameter
X02ANF	The safe range parameter for complex floating-point arithmetic
X02BBF	The largest representable integer
X02BEF	The maximum number of decimal digits that can be represented
X02BHF	The floating-point model parameter, $b$
X02BJF	The floating-point model parameter, $p$
X02BKF	The floating-point model parameter $e_{\min}$
X02BLF	The floating-point model parameter $e_{\max}$
X02DAF	Switch for taking precautions to avoid underflow
X02DJF	The floating-point model parameter ROUNDS

### Chapter X03 – Inner Products

X03AAF	Real inner product added to initial value, basic/additional precision
X03ABF	Complex inner product added to initial value, basic/additional precision

### Chapter X04 – Input/Output Utilities

X04AAF	Return or set unit number for error messages
X04ABF	Return or set unit number for advisory messages
X04ACF	Open unit number for reading, writing or appending, and associate unit with named file
X04ADF	Close file associated with given unit number
X04BAF	Write formatted record to external file
X04BBF	Read formatted record from external file
X04CAF	Print real general matrix (easy-to-use)
X04CBF	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)
X04DAF	Print complex general matrix (easy-to-use)
X04DBF	Print complex general matrix (comprehensive)
X04DCF	Print complex packed triangular matrix (easy-to-use)
X04DDF	Print complex packed triangular matrix (comprehensive)
X04DEF	Print complex packed banded matrix (easy-to-use)
X04DFE	Print complex packed banded matrix (comprehensive)
X04EAF	Print integer matrix (easy-to-use)
X04EBF	Print integer matrix (comprehensive)

## Chapter X05 – Date and Time Utilities

X05AAF	Return date and time as an array of integers
X05ABF	Convert array of integers representing date and time to character string
X05ACF	Compare two character strings representing date and time
X05BAF	Return the CPU time

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