NAG Fortran Library

Mark 21 Library Contents

A00 – Library Identification

Routine Name	Mark of Introduction	Purpose
A00AAF	18	Library identification, details of implementation and mark
A00ACF	21	Check availability of a valid licence key

A02 – Complex Arithmetic

Routine Name	Mark of Introduction	Purpose
A02AAF	2	Square root of complex number
A02ABF	2	Modulus of complex number
A02ACF	2	Quotient of two complex numbers

C02 – Zeros of Polynomials

Routine Name	Mark of Introduction	Purpose
C02AFF	14	All zeros of complex polynomial, modified Laguerre method
C02AGF	13	All zeros of real polynomial, modified Laguerre method
C02AHF	14	All zeros of complex quadratic equation
C02AJF	14	All zeros of real quadratic equation
C02AKF	20	All zeros of real cubic equation
C02ALF	20	All zeros of real quartic equation
C02AMF	20	All zeros of complex cubic equation
C02ANF	20	All zeros of complex quartic equation

C05 – Roots of One or More Transcendental Equations

Routine Name	Mark of Introduction	Purpose
C05ADF	8	Zero of continuous function in given interval, Bus and Dekker algorithm
C05AGF	8	Zero of continuous function, Bus and Dekker algorithm, from given starting value, binary search for interval
C05AJF	8	Zero of continuous function, continuation method, from a given starting value
C05AVF	8	Binary search for interval containing zero of continuous function (reverse communication)
C05AXF	8	Zero of continuous function by continuation method, from given starting value (reverse communication)
C05AZF	7	Zero in given interval of continuous function by Bus and Dekker algorithm (reverse communication)
C05NBF	9	Solution of system of nonlinear equations using function values only (easy-to-use)
C05NCF	9	Solution of system of nonlinear equations using function values only (comprehensive)
C05NDF	14	Solution of system of nonlinear equations using function values only (reverse communication)

C05PBF	9	Solution of system of nonlinear equations using first derivatives (easy-to-use)
C05PCF	9	Solution of system of nonlinear equations using first derivatives (comprehensive)
C05PDF/C05PDA	14	Solution of system of nonlinear equations using first derivatives (reverse communication)
C05ZAF	9	Check user's routine for calculating first derivatives

C06 – Summation of Series

Routine Name	Mark of Introduction	Purpose
C06BAF	10	Acceleration of convergence of sequence, Shanks' transformation and epsilon algorithm
C06DBF	6	Sum of a Chebyshev series
C06EAF	8	Single one-dimensional real discrete Fourier transform, no extra workspace
C06EBF	8	Single one-dimensional Hermitian discrete Fourier transform, no extra workspace
C06ECF	8	Single one-dimensional complex discrete Fourier transform, no extra workspace
C06EKF	11	Circular convolution or correlation of two real vectors, no extra workspace
C06FAF	8	Single one-dimensional real discrete Fourier transform, extra workspace for greater speed
C06FBF	8	Single one-dimensional Hermitian discrete Fourier transform, extra workspace for greater speed
C06FCF	8	Single one-dimensional complex discrete Fourier transform, extra workspace for greater speed
C06FFF	11	One-dimensional complex discrete Fourier transform of multi-dimensional data
C06FJF	11	Multi-dimensional complex discrete Fourier transform of multi-dimensional data
C06FKF	11	Circular convolution or correlation of two real vectors, extra workspace for greater speed
C06FPF	12	Multiple one-dimensional real discrete Fourier transforms
C06FQF	12	Multiple one-dimensional Hermitian discrete Fourier transforms
C06FRF	12	Multiple one-dimensional complex discrete Fourier transforms
C06FUF	13	Two-dimensional complex discrete Fourier transform
C06FXF	17	Three-dimensional complex discrete Fourier transform
C06GBF	8	Complex conjugate of Hermitian sequence
C06GCF	8	Complex conjugate of complex sequence
C06GQF	12	Complex conjugate of multiple Hermitian sequences
C06GSF	12	Convert Hermitian sequences to general complex sequences
C06HAF	13	Discrete sine transform
C06HBF	13	Discrete cosine transform
C06HCF	13	Discrete quarter-wave sine transform
C06HDF	13	Discrete quarter-wave cosine transform
C06LAF	12	Inverse Laplace transform, Crump's method
C06LBF	14	Inverse Laplace transform, modified Weeks' method
C06LCF	14	Evaluate inverse Laplace transform as computed by C06LBF
C06PAF	19	Single one-dimensional real and Hermitian complex discrete Fourier transform, using complex data format for Hermitian sequences
C06PCF	19	Single one-dimensional complex discrete Fourier transform, complex data format

C06PFF	19	One-dimensional complex discrete Fourier transform of multi-dimensional data (using complex data type)
C06PJF	19	Multi-dimensional complex discrete Fourier transform of multi-dimensional data (using complex data type)
C06PKF	19	Circular convolution or correlation of two complex vectors
C06PPF	19	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex data format for Hermitian sequences
C06PQF	19	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex data format for Hermitian sequences
C06PRF	19	Multiple one-dimensional complex discrete Fourier transforms using complex data format
C06PSF	19	Multiple one-dimensional complex discrete Fourier transforms using complex data format and sequences stored as columns
C06PUF	19	Two-dimensional complex discrete Fourier transform, complex data format
C06PXF	19	Three-dimensional complex discrete Fourier transform, complex data format
C06RAF	19	Discrete sine transform (easy-to-use)
C06RBF	19	Discrete cosine transform (easy-to-use)
C06RCF	19	Discrete quarter-wave sine transform (easy-to-use)
C06RDF	19	Discrete quarter-wave cosine transform (easy-to-use)

D01 – Quadrature

Routine Name	Mark of Introduction	Purpose
D01AHF	8	One-dimensional quadrature, adaptive, finite interval, strategy due to Patterson, suitable for well-behaved integrands
D01AJF	8	One-dimensional quadrature, adaptive, finite interval, strategy due to Piessens and de Doncker, allowing for badly behaved integrands
D01AKF	8	One-dimensional quadrature, adaptive, finite interval, method suitable for oscillating functions
D01ALF	8	One-dimensional quadrature, adaptive, finite interval, allowing for singularities at user-specified break-points
D01AMF	2	One-dimensional quadrature, adaptive, infinite or semi-infinite interval
D01ANF	8	One-dimensional quadrature, adaptive, finite interval, weight function $\cos(\omega x)$ or $\sin(\omega x)$
D01APF	8	One-dimensional quadrature, adaptive, finite interval, weight function with end-point singularities of algebraico-logarithmic type
D01AQF	8	One-dimensional quadrature, adaptive, finite interval, weight function $1/(x-c)$, Cauchy principal value (Hilbert transform)
D01ARF	10	One-dimensional quadrature, non-adaptive, finite interval with provision for indefinite integrals
D01ASF	13	One-dimensional quadrature, adaptive, semi-infinite interval, weight function $\cos(\omega x)$ or $\sin(\omega x)$
D01ATF	13	One-dimensional quadrature, adaptive, finite interval, variant of D01AJF efficient on vector machines
D01AUF	13	One-dimensional quadrature, adaptive, finite interval, variant of D01AKF efficient on vector machines
D01BAF	7	One-dimensional Gaussian quadrature
D01BBF	7	Pre-computed weights and abscissae for Gaussian quadrature rules, restricted choice of rule

D01BCF	8	Calculation of weights and abscissae for Gaussian quadrature rules, general choice of rule
D01BDF	8	One-dimensional quadrature, non-adaptive, finite interval
D01DAF	5	Two-dimensional quadrature, finite region
D01EAF	12	Multi-dimensional adaptive quadrature over hyper-rectangle, multiple integrands
D01FBF	8	Multi-dimensional Gaussian quadrature over hyper-rectangle
D01FCF	8	Multi-dimensional adaptive quadrature over hyper-rectangle
D01FDF	10	Multi-dimensional quadrature, Sag–Szekeres method, general product region or *n*-sphere
D01GAF	5	One-dimensional quadrature, integration of function defined by data values, Gill–Miller method
D01GBF	10	Multi-dimensional quadrature over hyper-rectangle, Monte Carlo method
D01GCF	10	Multi-dimensional quadrature, general product region, number-theoretic method
D01GDF	14	Multi-dimensional quadrature, general product region, number-theoretic method, variant of D01GCF efficient on vector machines
D01GYF	10	Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is prime
D01GZF	10	Korobov optimal coefficients for use in D01GCF or D01GDF, when number of points is product of two primes
D01JAF	10	Multi-dimensional quadrature over an *n*-sphere, allowing for badly behaved integrands
D01PAF	10	Multi-dimensional quadrature over an *n*-simplex

D02 – Ordinary Differential Equations

Routine Name	Mark of Introduction	Purpose
D02AGF	2	ODEs, boundary value problem, shooting and matching technique, allowing interior matching point, general parameters to be determined
D02BGF	7	ODEs, IVP, Runge–Kutta–Merson method, until a component attains given value (simple driver)
D02BHF	7	ODEs, IVP, Runge–Kutta–Merson method, until function of solution is zero (simple driver)
D02BJF	18	ODEs, IVP, Runge–Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)
D02CJF	13	ODEs, IVP, Adams method, until function of solution is zero, intermediate output (simple driver)
D02EJF	12	ODEs, stiff IVP, BDF method, until function of solution is zero, intermediate output (simple driver)
D02GAF	8	ODEs, boundary value problem, finite difference technique with deferred correction, simple nonlinear problem
D02GBF	8	ODEs, boundary value problem, finite difference technique with deferred correction, general linear problem
D02HAF	8	ODEs, boundary value problem, shooting and matching, boundary values to be determined
D02HBF	8	ODEs, boundary value problem, shooting and matching, general parameters to be determined
D02JAF	8	ODEs, boundary value problem, collocation and least-squares, single *n*th-order linear equation
D02JBF	8	ODEs, boundary value problem, collocation and least-squares, system of first-order linear equations

D02KAF	7	Second-order Sturm–Liouville problem, regular system, finite range, eigenvalue only
D02KDF	7	Second-order Sturm–Liouville problem, regular/singular system, finite/infinite range, eigenvalue only, user-specified break-points
D02KEF	8	Second-order Sturm–Liouville problem, regular/singular system, finite/infinite range, eigenvalue and eigenfunction, user-specified break-points
D02LAF	13	Second-order ODEs, IVP, Runge–Kutta–Nystrom method
D02LXF	13	Second-order ODEs, IVP, setup for D02LAF
D02LYF	13	Second-order ODEs, IVP, diagnostics for D02LAF
D02LZF	13	Second-order ODEs, IVP, interpolation for D02LAF
D02MVF	14	ODEs, IVP, DASSL method, setup for D02M–N routines
D02MZF	14	ODEs, IVP, interpolation for D02M–N routines, natural interpolant
D02NBF	12	Explicit ODEs, stiff IVP, full Jacobian (comprehensive)
D02NCF	12	Explicit ODEs, stiff IVP, banded Jacobian (comprehensive)
D02NDF	12	Explicit ODEs, stiff IVP, sparse Jacobian (comprehensive)
D02NGF	12	Implicit/algebraic ODEs, stiff IVP, full Jacobian (comprehensive)
D02NHF	12	Implicit/algebraic ODEs, stiff IVP, banded Jacobian (comprehensive)
D02NJF	12	Implicit/algebraic ODEs, stiff IVP, sparse Jacobian (comprehensive)
D02NMF	12	Explicit ODEs, stiff IVP (reverse communication, comprehensive)
D02NNF	12	Implicit/algebraic ODEs, stiff IVP (reverse communication, comprehensive)
D02NRF	12	ODEs, IVP, for use with D02M–N routines, sparse Jacobian, enquiry routine
D02NSF	12	ODEs, IVP, for use with D02M–N routines, full Jacobian, linear algebra set up
D02NTF	12	ODEs, IVP, for use with D02M–N routines, banded Jacobian, linear algebra set up
D02NUF	12	ODEs, IVP, for use with D02M–N routines, sparse Jacobian, linear algebra set up
D02NVF	12	ODEs, IVP, BDF method, setup for D02M–N routines
D02NWF	12	ODEs, IVP, Blend method, setup for D02M–N routines
D02NXF	12	ODEs, IVP, sparse Jacobian, linear algebra diagnostics, for use with D02M–N routines
D02NYF	12	ODEs, IVP, integrator diagnostics, for use with D02M–N routines
D02NZF	12	ODEs, IVP, setup for continuation calls to integrator, for use with D02M–N routines
D02PCF	16	ODEs, IVP, Runge–Kutta method, integration over range with output
D02PDF	16	ODEs, IVP, Runge–Kutta method, integration over one step
D02PVF	16	ODEs, IVP, setup for D02PCF and D02PDF
D02PWF	16	ODEs, IVP, resets end of range for D02PDF
D02PXF	16	ODEs, IVP, interpolation for D02PDF
D02PYF	16	ODEs, IVP, integration diagnostics for D02PCF and D02PDF
D02PZF	16	ODEs, IVP, error assessment diagnostics for D02PCF and D02PDF
D02QFF	13	ODEs, IVP, Adams method with root-finding (forward communication, comprehensive)
D02QGF	13	ODEs, IVP, Adams method with root-finding (reverse communication, comprehensive)
D02QWF	13	ODEs, IVP, setup for D02QFF and D02QGF
D02QXF	13	ODEs, IVP, diagnostics for D02QFF and D02QGF

D02QYF	13	ODEs, IVP, root-finding diagnostics for D02QFF and D02QGF
D02QZF	13	ODEs, IVP, interpolation for D02QFF or D02QGF
D02RAF	8	ODEs, general nonlinear boundary value problem, finite difference technique with deferred correction, continuation facility
D02SAF	8	ODEs, boundary value problem, shooting and matching technique, subject to extra algebraic equations, general parameters to be determined
D02TGF	8	*n*th-order linear ODEs, boundary value problem, collocation and least-squares
D02TKF	17	ODEs, general nonlinear boundary value problem, collocation technique
D02TVF	17	ODEs, general nonlinear boundary value problem, setup for D02TKF
D02TXF	17	ODEs, general nonlinear boundary value problem, continuation facility for D02TKF
D02TYF	17	ODEs, general nonlinear boundary value problem, interpolation for D02TKF
D02TZF	17	ODEs, general nonlinear boundary value problem, diagnostics for D02TKF
D02XJF	12	ODEs, IVP, interpolation for D02M–N routines, natural interpolant
D02XKF	12	ODEs, IVP, interpolation for D02M–N routines, C_1 interpolant
D02ZAF	12	ODEs, IVP, weighted norm of local error estimate for D02M–N routines

D03 – Partial Differential Equations

Routine Name	Mark of Introduction	Purpose
D03EAF	7	Elliptic PDE, Laplace's equation, two-dimensional arbitrary domain
D03EBF	7	Elliptic PDE, solution of finite difference equations by SIP, five-point two-dimensional molecule, iterate to convergence
D03ECF	8	Elliptic PDE, solution of finite difference equations by SIP for seven-point three-dimensional molecule, iterate to convergence
D03EDF	12	Elliptic PDE, solution of finite difference equations by a multigrid technique
D03EEF	13	Discretize a second-order elliptic PDE on a rectangle
D03FAF	14	Elliptic PDE, Helmholtz equation, three-dimensional Cartesian co-ordinates
D03MAF	7	Triangulation of plane region
D03NCF	20	Finite difference solution of the Black–Scholes equations
D03NDF	20	Analytic solution of the Black–Scholes equations
D03NEF	20	Compute average values for D03NDF
D03PCF/D03PCA	15	General system of parabolic PDEs, method of lines, finite differences, one space variable
D03PDF/D03PDA	15	General system of parabolic PDEs, method of lines, Chebyshev C^0 collocation, one space variable
D03PEF	16	General system of first-order PDEs, method of lines, Keller box discretisation, one space variable
D03PFF	17	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/D03PHA	15	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, one space variable

D03PJF/D03PJA	15	General system of parabolic PDEs, coupled DAEs, method of lines, Chebyshev C^0 collocation, one space variable
D03PKF	16	General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, one space variable
D03PLF	17	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/D03PPA	16	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, remeshing, one space variable
D03PRF	16	General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, remeshing, one space variable
D03PSF	17	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	17	Roe's approximate Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF
D03PVF	17	Osher's approximate Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF
D03PWF	18	Modified HLL Riemann solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF
D03PXF	18	Exact Riemann Solver for Euler equations in conservative form, for use with D03PFF, D03PLF and D03PSF
D03PYF	15	PDEs, spatial interpolation with D03PDF/D03PDA or D03PJF/D03PJA
D03PZF	15	PDEs, spatial interpolation with D03PCF/D03PCA, D03PEF, D03PFF, D03PHF/D03PHA, D03PKF, D03PLF, D03PPF/D03PPA, D03PRF or D03PSF
D03RAF	18	General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectangular region
D03RBF	18	General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectilinear region
D03RYF	18	Check initial grid data in D03RBF
D03RZF	18	Extract grid data from D03RBF
D03UAF	7	Elliptic PDE, solution of finite difference equations by SIP, five-point two-dimensional molecule, one iteration
D03UBF	8	Elliptic PDE, solution of finite difference equations by SIP, seven-point three-dimensional molecule, one iteration

D04 – Numerical Differentiation

Routine Name	Mark of Introduction	Purpose
D04AAF	5	Numerical differentiation, derivatives up to order 14, function of one real variable

D05 – Integral Equations

Routine Name	Mark of Introduction	Purpose
D05AAF	5	Linear non-singular Fredholm integral equation, second kind, split kernel

D05ABF	6	Linear non-singular Fredholm integral equation, second kind, smooth kernel
D05BAF	14	Nonlinear Volterra convolution equation, second kind
D05BDF	16	Nonlinear convolution Volterra–Abel equation, second kind, weakly singular
D05BEF	16	Nonlinear convolution Volterra–Abel equation, first kind, weakly singular
D05BWF	16	Generate weights for use in solving Volterra equations
D05BYF	16	Generate weights for use in solving weakly singular Abel-type equations

D06 – Mesh Generation

Routine Name	Mark of Introduction	Purpose
D06AAF	20	Generates a two-dimensional mesh using a simple incremental method
D06ABF	20	Generates a two-dimensional mesh using a Delaunay–Voronoi process
D06ACF	20	Generates a two-dimensional mesh using an Advancing-front method
D06BAF	20	Generates a boundary mesh
D06CAF	20	Uses a barycentering technique to smooth a given mesh
D06CBF	20	Generates a sparsity pattern of a Finite Element matrix associated with a given mesh
D06CCF	20	Renumbers a given mesh using Gibbs method
D06DAF	20	Generates a mesh resulting from an affine transformation of a given mesh
D06DBF	20	Joins together two given adjacent (possibly overlapping) meshes

E01 – Interpolation

Routine Name	Mark of Introduction	Purpose
E01AAF	1	Interpolated values, Aitken's technique, unequally spaced data, one variable
E01ABF	1	Interpolated values, Everett's formula, equally spaced data, one variable
E01AEF	8	Interpolating functions, polynomial interpolant, data may include derivative values, one variable
E01BAF	8	Interpolating functions, cubic spline interpolant, one variable
E01BEF	13	Interpolating functions, monotonicity-preserving, piecewise cubic Hermite, one variable
E01BFF	13	Interpolated values, interpolant computed by E01BEF, function only, one variable
E01BGF	13	Interpolated values, interpolant computed by E01BEF, function and first derivative, one variable
E01BHF	13	Interpolated values, interpolant computed by E01BEF, definite integral, one variable
E01DAF	14	Interpolating functions, fitting bicubic spline, data on rectangular grid
E01RAF	9	Interpolating functions, rational interpolant, one variable
E01RBF	9	Interpolated values, evaluate rational interpolant computed by E01RAF, one variable
E01SAF	13	Interpolating functions, method of Renka and Cline, two variables

E01SBF	13	Interpolated values, evaluate interpolant computed by E01SAF, two variables
E01SGF	18	Interpolating functions, modified Shepard's method, two variables
E01SHF	18	Interpolated values, evaluate interpolant computed by E01SGF, function and first derivatives, two variables
E01TGF	18	Interpolating functions, modified Shepard's method, three variables
E01THF	18	Interpolated values, evaluate interpolant computed by E01TGF, function and first derivatives, three variables

E02 – Curve and Surface Fitting

Routine Name	Mark of Introduction	Purpose
E02ACF	1	Minimax curve fit by polynomials
E02ADF	5	Least-squares curve fit, by polynomials, arbitrary data points
E02AEF	5	Evaluation of fitted polynomial in one variable from Chebyshev series form (simplified parameter list)
E02AFF	5	Least-squares polynomial fit, special data points (including interpolation)
E02AGF	8	Least-squares polynomial fit, values and derivatives may be constrained, arbitrary data points
E02AHF	8	Derivative of fitted polynomial in Chebyshev series form
E02AJF	8	Integral of fitted polynomial in Chebyshev series form
E02AKF	8	Evaluation of fitted polynomial in one variable from Chebyshev series form
E02BAF	5	Least-squares curve cubic spline fit (including interpolation)
E02BBF	5	Evaluation of fitted cubic spline, function only
E02BCF	7	Evaluation of fitted cubic spline, function and derivatives
E02BDF	7	Evaluation of fitted cubic spline, definite integral
E02BEF	13	Least-squares cubic spline curve fit, automatic knot placement
E02CAF	7	Least-squares surface fit by polynomials, data on lines
E02CBF	7	Evaluation of fitted polynomial in two variables
E02DAF	6	Least-squares surface fit, bicubic splines
E02DCF	13	Least-squares surface fit by bicubic splines with automatic knot placement, data on rectangular grid
E02DDF	13	Least-squares surface fit by bicubic splines with automatic knot placement, scattered data
E02DEF	14	Evaluation of fitted bicubic spline at a vector of points
E02DFF	14	Evaluation of fitted bicubic spline at a mesh of points
E02GAF	7	L_1-approximation by general linear function
E02GBF	7	L_1-approximation by general linear function subject to linear inequality constraints
E02GCF	8	L_∞-approximation by general linear function
E02RAF	7	Padé approximants
E02RBF	7	Evaluation of fitted rational function as computed by E02RAF
E02ZAF	6	Sort two-dimensional data into panels for fitting bicubic splines

E04 – Minimizing or Maximizing a Function

Routine Name	Mark of Introduction	Purpose
E04ABF/E04ABA	6	Minimum, function of one variable using function values only
E04BBF/E04BBA	6	Minimum, function of one variable, using first derivative

E04CCF/E04CCA	1	Unconstrained minimum, simplex algorithm, function of several variables using function values only (comprehensive)
E04DGF/E04DGA	12	Unconstrained minimum, preconditioned conjugate gradient algorithm, function of several variables using first derivatives (comprehensive)
E04DJF/E04DJA	12	Supply optional parameter values for E04DGF/E04DGA from external file
E04DKF/E04DKA	12	Supply optional parameter values to E04DGF/E04DGA
E04FCF	7	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using function values only (comprehensive)
E04FYF	18	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using function values only (easy-to-use)
E04GBF	7	Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-Newton algorithm using first derivatives (comprehensive)
E04GDF	7	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using first derivatives (comprehensive)
E04GYF	18	Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)
E04GZF	18	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using first derivatives (easy-to-use)
E04HCF	6	Check user's routine for calculating first derivatives of function
E04HDF	6	Check user's routine for calculating second derivatives of function
E04HEF	7	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm, using second derivatives (comprehensive)
E04HYF	18	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm, using second derivatives (easy-to-use)
E04JYF	18	Minimum, function of several variables, quasi-Newton algorithm, simple bounds, using function values only (easy-to-use)
E04KDF	6	Minimum, function of several variables, modified Newton algorithm, simple bounds, using first derivatives (comprehensive)
E04KYF	18	Minimum, function of several variables, quasi-Newton algorithm, simple bounds, using first derivatives (easy-to-use)
E04KZF	18	Minimum, function of several variables, modified Newton algorithm, simple bounds, using first derivatives (easy-to-use)
E04LBF	6	Minimum, function of several variables, modified Newton algorithm, simple bounds, using first and second derivatives (comprehensive)
E04LYF	18	Minimum, function of several variables, modified Newton algorithm, simple bounds, using first and second derivatives (easy-to-use)
E04MFF/E04MFA	16	LP problem (dense)
E04MGF/E04MGA	16	Supply optional parameter values for E04MFF/E04MFA from external file
E04MHF/E04MHA	16	Supply optional parameter values to E04MFF/E04MFA
E04MZF	18	Converts MPSX data file defining LP or QP problem to format required by E04NQF

E04NCF/E04NCA	12	Convex QP problem or linearly-constrained linear least-squares problem (dense)
E04NDF/E04NDA	12	Supply optional parameter values for E04NCF/E04NCA from external file
E04NEF/E04NEA	12	Supply optional parameter values to E04NCF/E04NCA
E04NFF/E04NFA	16	QP problem (dense)
E04NGF/E04NGA	16	Supply optional parameter values for E04NFF/E04NFA from external file
E04NHF/E04NHA	16	Supply optional parameter values to E04NFF/E04NFA
E04NPF	21	Initialization routine for E04NQF
E04NQF	21	LP or QP problem (suitable for sparse problems)
E04NRF	21	Supply optional parameter values for E04NQF from external file
E04NSF	21	Set a single option for E04NQF from a character string
E04NTF	21	Set a single option for E04NQF from an INTEGER argument
E04NUF	21	Set a single option for E04NQF from a ***double precision*** argument
E04NXF	21	Get the setting of an INTEGER valued option of E04NQF
E04NYF	21	Get the setting of a ***double precision*** valued option of E04NQF
E04UDF/E04UDA	12	Supply optional parameter values for E04UCF/E04UCA or E04UFF/E04UFA from external file
E04UEF/E04UEA	12	Supply optional parameter values to E04UCF/E04UCA or E04UFF/E04UFA
E04UFF/E04UFA	18	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (reverse communication, comprehensive)
E04UGF/E04UGA	19	NLP problem (sparse)
E04UHF/E04UHA	19	Supply optional parameter values for E04UGF/E04UGA from external file
E04UJF/E04UJA	19	Supply optional parameter values to E04UGF/E04UGA
E04UQF/E04UQA	14	Supply optional parameter values for E04USF/E04USA from external file
E04URF/E04URA	14	Supply optional parameter values to E04USF/E04USA
E04USF/E04USA	20	Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive)
E04VGF	21	Initialization routine for E04VHF
E04VHF	21	General sparse nonlinear optimizer
E04VJF	21	Determine the pattern of nonzeros in the Jacobian matrix for E04VHF
E04VKF	21	Supply optional parameter values for E04VHF from external file
E04VLF	21	Set a single option for E04VHF from a character string
E04VMF	21	Set a single option for E04VHF from an INTEGER argument
E04VNF	21	Set a single option for E04VHF from a ***double precision*** argument
E04VRF	21	Get the setting of an INTEGER valued option of E04VHF
E04VSF	21	Get the setting of a ***double precision*** valued option of E04VHF
E04WBF	20	Initialization routine for E04DGA E04MFA E04NCA E04NFA E04UFA E04UGA E04USA
E04WCF	21	Initialization routine for E04WDF
E04WDF	21	Solves the nonlinear programming (NP) problem
E04WEF	21	Supply optional parameter values for E04WDF from external file
E04WFF	21	Set a single option for E04WDF from a character string
E04WGF	21	Set a single option for E04WDF from an INTEGER argument

E04WHF	21	Set a single option for E04WDF from a ***double precision*** argument
E04WJF	21	Determine whether an E04WDF option has been set or not
E04WKF	21	Get the setting of an INTEGER valued option of E04WDF
E04WLF	21	Get the setting of a ***double precision*** valued option of E04WDF
E04XAF/E04XAA	12	Estimate (using numerical differentiation) gradient and/or Hessian of a function
E04YAF	7	Check user's routine for calculating Jacobian of first derivatives
E04YBF	7	Check user's routine for calculating Hessian of a sum of squares
E04YCF	11	Covariance matrix for nonlinear least-squares problem (unconstrained)
E04ZCF/E04ZCA	11	Check user's routines for calculating first derivatives of function and constraints

F01 – Matrix Operations, Including Inversion

Routine Name	Mark of Introduction	Purpose
F01ABF	1	Inverse of real symmetric positive-definite matrix using iterative refinement
F01ADF	2	Inverse of real symmetric positive-definite matrix
F01BLF	5	Pseudo-inverse and rank of real m by n matrix $(m \geq n)$
F01BRF	7	LU factorization of real sparse matrix
F01BSF	7	LU factorization of real sparse matrix with known sparsity pattern
F01BUF	7	$ULDL^{\mathrm{T}}U^{\mathrm{T}}$ factorization of real symmetric positive-definite band matrix
F01BVF	7	Reduction to standard form, generalized real symmetric-definite banded eigenproblem
F01CKF	2	Matrix multiplication
F01CRF	7	Matrix transposition
F01CTF	14	Sum or difference of two real matrices, optional scaling and transposition
F01CWF	14	Sum or difference of two complex matrices, optional scaling and transposition
F01LEF	11	LU factorization of real tridiagonal matrix
F01LHF	13	LU factorization of real almost block diagonal matrix
F01MCF	8	LDL^{T} factorization of real symmetric positive-definite variable-bandwidth matrix
F01QGF	14	RQ factorization of real m by n upper trapezoidal matrix $(m \leq n)$
F01QJF	14	RQ factorization of real m by n matrix $(m \leq n)$
F01QKF	14	Operations with orthogonal matrices, form rows of Q, after RQ factorization by F01QJF
F01RGF	14	RQ factorization of complex m by n upper trapezoidal matrix $(m \leq n)$
F01RJF	14	RQ factorization of complex m by n matrix $(m \leq n)$
F01RKF	14	Operations with unitary matrices, form rows of Q, after RQ factorization by F01RJF
F01ZAF	14	Convert real matrix between packed triangular and square storage schemes
F01ZBF	14	Convert complex matrix between packed triangular and square storage schemes

F01ZCF	14	Convert real matrix between packed banded and rectangular storage schemes
F01ZDF	14	Convert complex matrix between packed banded and rectangular storage schemes

F02 – Eigenvalues and Eigenvectors

Routine Name	Mark of Introduction	Purpose
F02ECF	17	Selected eigenvalues and eigenvectors of real nonsymmetric matrix (Black Box)
F02FJF	11	Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)
F02GCF	17	Selected eigenvalues and eigenvectors of complex nonsymmetric matrix (Black Box)
F02SDF	8	Eigenvector of generalized real banded eigenproblem by inverse iteration
F02WDF	8	*QR* factorization, possibly followed by SVD
F02WUF	14	SVD of real upper triangular matrix (Black Box)
F02XUF	13	SVD of complex upper triangular matrix (Black Box)

F03 – Determinants

Routine Name	Mark of Introduction	Purpose
F03AAF	1	Determinant of real matrix (Black Box)
F03ABF	1	Determinant of real symmetric positive-definite matrix (Black Box)
F03ACF	1	Determinant of real symmetric positive-definite band matrix (Black Box)
F03ADF	1	Determinant of complex matrix (Black Box)
F03AEF	2	LL^{T} factorization and determinant of real symmetric positive-definite matrix
F03AFF	2	LU factorization and determinant of real matrix

F04 – Simultaneous Linear Equations

Routine Name	Mark of Introduction	Purpose
F04ABF	2	Solution of real symmetric positive-definite simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04AEF	2	Solution of real simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04AFF	2	Solution of real symmetric positive-definite simultaneous linear equations using iterative refinement (coefficient matrix already factorized by F03AEF)
F04AGF	2	Solution of real symmetric positive-definite simultaneous linear equations (coefficient matrix already factorized by F03AEF)
F04AHF	2	Solution of real simultaneous linear equations using iterative refinement (coefficient matrix already factorized by F03AFF)
F04AJF	2	Solution of real simultaneous linear equations (coefficient matrix already factorized by F03AFF)
F04AMF	2	Least-squares solution of m real equations in n unknowns, rank $= n$, $m \geq n$ using iterative refinement (Black Box)

F04ASF	4	Solution of real symmetric positive-definite simultaneous linear equations, one right-hand side using iterative refinement (Black Box)
F04ATF	4	Solution of real simultaneous linear equations, one right-hand side using iterative refinement (Black Box)
F04AXF	7	Solution of real sparse simultaneous linear equations (coefficient matrix already factorized)
F04BAF	21	Computes the solution and error-bound to a real system of linear equations
F04BBF	21	Computes the solution and error-bound to a real banded system of linear equations
F04BCF	21	Computes the solution and error-bound to a real tridiagonal system of linear equations
F04BDF	21	Computes the solution and error-bound to a real symmetric positive-definite system of linear equations
F04BEF	21	Computes the solution and error-bound to a real symmetric positive-definite system of linear equations, packed storage
F04BFF	21	Computes the solution and error-bound to a real symmetric positive-definite banded system of linear equations
F04BGF	21	Computes the solution and error-bound to a real symmetric positive-definite tridiagonal system of linear equations
F04BHF	21	Computes the solution and error-bound to a real symmetric system of linear equations
F04BJF	21	Computes the solution and error-bound to a real symmetric system of linear equations, packed storage
F04CAF	21	Computes the solution and error-bound to a complex system of linear equations
F04CBF	21	Computes the solution and error-bound to a complex banded system of linear equations
F04CCF	21	Computes the solution and error-bound to a complex tridiagonal system of linear equations
F04CDF	21	Computes the solution and error-bound to a complex Hermitian positive-definite system of linear equations
F04CEF	21	Computes the solution and error-bound to a complex Hermitian positive-definite system of linear equations, packed storage
F04CFF	21	Computes the solution and error-bound to a complex Hermitian positive-definite banded system of linear equations
F04CGF	21	Computes the solution and error-bound to a complex Hermitian positive-definite tridiagonal system of linear equations
F04CHF	21	Computes the solution and error-bound to a complex Hermitian system of linear equations
F04CJF	21	Computes the solution and error-bound to a complex Hermitian system of linear equations, packed storage
F04DHF	21	Computes the solution and error-bound to a complex symmetric system of linear equations
F04DJF	21	Computes the solution and error-bound to a complex symmetric system of linear equations, packed storage.
F04FEF	15	Solution of the Yule–Walker equations for real symmetric positive-definite Toeplitz matrix, one right-hand side
F04FFF	15	Solution of real symmetric positive-definite Toeplitz system, one right-hand side
F04JGF	8	Least-squares (if rank $= n$) or minimal least-squares (if rank $< n$) solution of m real equations in n unknowns, rank $\leq n$, $m \geq n$
F04LEF	11	Solution of real tridiagonal simultaneous linear equations (coefficient matrix already factorized by F01LEF)

F04LHF	13	Solution of real almost block diagonal simultaneous linear equations (coefficient matrix already factorized by F01LHF)
F04MCF	8	Solution of real symmetric positive-definite variable-bandwidth simultaneous linear equations (coefficient matrix already factorized by F01MCF)
F04MEF	15	Update solution of the Yule–Walker equations for real symmetric positive-definite Toeplitz matrix
F04MFF	15	Update solution of real symmetric positive-definite Toeplitz system
F04QAF	11	Sparse linear least-squares problem, m real equations in n unknowns
F04YAF	11	Covariance matrix for linear least-squares problems, m real equations in n unknowns
F04YCF	13	Norm estimation (for use in condition estimation), real matrix
F04ZCF	13	Norm estimation (for use in condition estimation), complex matrix

F05 – Orthogonalisation

Routine Name	Mark of Introduction	Purpose
F05AAF	5	Gram–Schmidt orthogonalisation of n vectors of order m

F06 – Linear Algebra Support Routines

Routine Name	Mark of Introduction	Purpose
F06AAF (DROTG)	12	Generate real plane rotation
F06BAF	12	Generate real plane rotation, storing tangent
F06BCF	12	Recover cosine and sine from given real tangent
F06BEF	12	Generate real Jacobi plane rotation
F06BHF	12	Apply real similarity rotation to 2 by 2 symmetric matrix
F06BLF	12	Compute quotient of two real scalars, with overflow flag
F06BMF	12	Compute Euclidean norm from scaled form
F06BNF	12	Compute square root of $\left(a^2+b^2\right)$, real a and b
F06BPF	12	Compute eigenvalue of 2 by 2 real symmetric matrix
F06CAF	12	Generate complex plane rotation, storing tangent, real cosine
F06CBF	12	Generate complex plane rotation, storing tangent, real sine
F06CCF	12	Recover cosine and sine from given complex tangent, real cosine
F06CDF	12	Recover cosine and sine from given complex tangent, real sine
F06CHF	12	Apply complex similarity rotation to 2 by 2 Hermitian matrix
F06CLF	12	Compute quotient of two complex scalars, with overflow flag
F06DBF	12	Broadcast scalar into integer vector
F06DFF	12	Copy integer vector
F06EAF (DDOT)	12	Dot product of two real vectors
F06ECF (DAXPY)	12	Add scalar times real vector to real vector
F06EDF (DSCAL)	12	Multiply real vector by scalar
F06EFF (DCOPY)	12	Copy real vector
F06EGF (DSWAP)	12	Swap two real vectors
F06EJF (DNRM2)	12	Compute Euclidean norm of real vector
F06EKF (DASUM)	12	Sum absolute values of real vector elements
F06EPF (DROT)	12	Apply real plane rotation
F06ERF (DDOTI)	14	Dot product of two real sparse vectors
F06ETF (DAXPYI)	14	Add scalar times real sparse vector to real sparse vector
F06EUF (DGTHR)	14	Gather real sparse vector
F06EVF (DGTHRZ)	14	Gather and set to zero real sparse vector

F06EWF (DSCTR)	14	Scatter real sparse vector
F06EXF (DROTI)	14	Apply plane rotation to two real sparse vectors
F06FAF	12	Compute cosine of angle between two real vectors
F06FBF	12	Broadcast scalar into real vector
F06FCF	12	Multiply real vector by diagonal matrix
F06FDF	12	Multiply real vector by scalar, preserving input vector
F06FEF (DRSCL)	21	Multiply real vector by reciprocal of scalar
F06FGF	12	Negate real vector
F06FJF	12	Update Euclidean norm of real vector in scaled form
F06FKF	12	Compute weighted Euclidean norm of real vector
F06FLF	12	Elements of real vector with largest and smallest absolute value
F06FPF	12	Apply real symmetric plane rotation to two vectors
F06FQF	12	Generate sequence of real plane rotations
F06FRF	12	Generate real elementary reflection, NAG style
F06FSF	12	Generate real elementary reflection, LINPACK style
F06FTF	12	Apply real elementary reflection, NAG style
F06FUF	12	Apply real elementary reflection, LINPACK style
F06GAF (ZDOTU)	12	Dot product of two complex vectors, unconjugated
F06GBF (ZDOTC)	12	Dot product of two complex vectors, conjugated
F06GCF (ZAXPY)	12	Add scalar times complex vector to complex vector
F06GDF (ZSCAL)	12	Multiply complex vector by complex scalar
F06GFF (ZCOPY)	12	Copy complex vector
F06GGF (ZSWAP)	12	Swap two complex vectors
F06GRF (ZDOTUI)	14	Dot product of two complex sparse vector, unconjugated
F06GSF (ZDOTCI)	14	Dot product of two complex sparse vector, conjugated
F06GTF (ZAXPYI)	14	Add scalar times complex sparse vector to complex sparse vector
F06GUF (ZGTHR)	14	Gather complex sparse vector
F06GVF (ZGTHRZ)	14	Gather and set to zero complex sparse vector
F06GWF (ZSCTR)	14	Scatter complex sparse vector
F06HBF	12	Broadcast scalar into complex vector
F06HCF	12	Multiply complex vector by complex diagonal matrix
F06HDF	12	Multiply complex vector by complex scalar, preserving input vector
F06HGF	12	Negate complex vector
F06HPF	12	Apply complex plane rotation
F06HQF	12	Generate sequence of complex plane rotations
F06HRF	12	Generate complex elementary reflection
F06HTF	12	Apply complex elementary reflection
F06JDF (ZDSCAL)	12	Multiply complex vector by real scalar
F06JJF (DZNRM2)	12	Compute Euclidean norm of complex vector
F06JKF (DZASUM)	12	Sum absolute values of complex vector elements
F06JLF (IDAMAX)	12	Index, real vector element with largest absolute value
F06JMF (IZAMAX)	12	Index, complex vector element with largest absolute value
F06KCF	12	Multiply complex vector by real diagonal matrix
F06KDF	12	Multiply complex vector by real scalar, preserving input vector
F06KEF (ZDRSCL)	21	Multiply complex vector by reciprocal of real scalar
F06KFF	12	Copy real vector to complex vector
F06KJF	12	Update Euclidean norm of complex vector in scaled form
F06KLF	12	Last non-negligible element of real vector
F06KPF	12	Apply real plane rotation to two complex vectors
F06PAF (DGEMV)	12	Matrix-vector product, real rectangular matrix
F06PBF (DGBMV)	12	Matrix-vector product, real rectangular band matrix
F06PCF (DSYMV)	12	Matrix-vector product, real symmetric matrix
F06PDF (DSBMV)	12	Matrix-vector product, real symmetric band matrix
F06PEF (DSPMV)	12	Matrix-vector product, real symmetric packed matrix
F06PFF (DTRMV)	12	Matrix-vector product, real triangular matrix
F06PGF (DTBMV)	12	Matrix-vector product, real triangular band matrix

F06PHF (DTPMV)	12	Matrix-vector product, real triangular packed matrix
F06PJF (DTRSV)	12	System of equations, real triangular matrix
F06PKF (DTBSV)	12	System of equations, real triangular band matrix
F06PLF (DTPSV)	12	System of equations, real triangular packed matrix
F06PMF (DGER)	12	Rank-1 update, real rectangular matrix
F06PPF (DSYR)	12	Rank-1 update, real symmetric matrix
F06PQF (DSPR)	12	Rank-1 update, real symmetric packed matrix
F06PRF (DSYR2)	12	Rank-2 update, real symmetric matrix
F06PSF (DSPR2)	12	Rank-2 update, real symmetric packed matrix
F06QFF	13	Matrix copy, real rectangular or trapezoidal matrix
F06QHF	13	Matrix initialization, real rectangular matrix
F06QJF	13	Permute rows or columns, real rectangular matrix, permutations represented by an integer array
F06QKF	13	Permute rows or columns, real rectangular matrix, permutations represented by a real array
F06QMF	13	Orthogonal similarity transformation of real symmetric matrix as a sequence of plane rotations
F06QPF	13	*QR* factorization by sequence of plane rotations, rank-1 update of real upper triangular matrix
F06QQF	13	*QR* factorization by sequence of plane rotations, real upper triangular matrix augmented by a full row
F06QRF	13	*QR* or *RQ* factorization by sequence of plane rotations, real upper Hessenberg matrix
F06QSF	13	*QR* or *RQ* factorization by sequence of plane rotations, real upper spiked matrix
F06QTF	13	*QR* factorization of UZ or *RQ* factorization of ZU, U real upper triangular, Z a sequence of plane rotations
F06QVF	13	Compute upper Hessenberg matrix by sequence of plane rotations, real upper triangular matrix
F06QWF	13	Compute upper spiked matrix by sequence of plane rotations, real upper triangular matrix
F06QXF	13	Apply sequence of plane rotations, real rectangular matrix
F06RAF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real general matrix
F06RBF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real band matrix
F06RCF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric matrix
F06RDF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric matrix, packed storage
F06REF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric band matrix
F06RJF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real trapezoidal/triangular matrix
F06RKF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real triangular matrix, packed storage
F06RLF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real triangular band matrix
F06RMF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, real Hessenberg matrix
F06RNF	21	1-norm, ∞-norm, Frobenius norm, largest absolute element, real tridiagonal matrix
F06RPF	21	1-norm, ∞-norm, Frobenius norm, largest absolute element, real symmetric tridiagonal matrix
F06SAF (ZGEMV)	12	Matrix-vector product, complex rectangular matrix
F06SBF (ZGBMV)	12	Matrix-vector product, complex rectangular band matrix
F06SCF (ZHEMV)	12	Matrix-vector product, complex Hermitian matrix
F06SDF (ZHBMV)	12	Matrix-vector product, complex Hermitian band matrix
F06SEF (ZHPMV)	12	Matrix-vector product, complex Hermitian packed matrix

F06SFF (ZTRMV)	12	Matrix-vector product, complex triangular matrix
F06SGF (ZTBMV)	12	Matrix-vector product, complex triangular band matrix
F06SHF (ZTPMV)	12	Matrix-vector product, complex triangular packed matrix
F06SJF (ZTRSV)	12	System of equations, complex triangular matrix
F06SKF (ZTBSV)	12	System of equations, complex triangular band matrix
F06SLF (ZTPSV)	12	System of equations, complex triangular packed matrix
F06SMF (ZGERU)	12	Rank-1 update, complex rectangular matrix, unconjugated vector
F06SNF (ZGERC)	12	Rank-1 update, complex rectangular matrix, conjugated vector
F06SPF (ZHER)	12	Rank-1 update, complex Hermitian matrix
F06SQF (ZHPR)	12	Rank-1 update, complex Hermitian packed matrix
F06SRF (ZHER2)	12	Rank-2 update, complex Hermitian matrix
F06SSF (ZHPR2)	12	Rank-2 update, complex Hermitian packed matrix
F06TAF (ZSYMV)	21	Matrix-vector product, complex symmetric matrix
F06TBF (ZSYR)	21	Rank-1 update, complex symetric matrix
F06TCF (ZSPMV)	21	Matrix-vector product, complex symmetric packed matrix
F06TDF (ZSPR)	21	Rank-1 update, complex symetric packed matrix
F06TFF	13	Matrix copy, complex rectangular or trapezoidal matrix
F06THF	13	Matrix initialization, complex rectangular matrix
F06TMF	13	Unitary similarity transformation of Hermitian matrix as a sequence of plane rotations
F06TPF	13	QR factorization by sequence of plane rotations, rank-1 update of complex upper triangular matrix
F06TQF	13	$QR \times k$ factorization by sequence of plane rotations, complex upper triangular matrix augmented by a full row
F06TRF	13	QR or RQ factorization by sequence of plane rotations, complex upper Hessenberg matrix
F06TSF	13	QR or RQ factorization by sequence of plane rotations, complex upper spiked matrix
F06TTF	13	QR factorization of UZ or RQ factorization of ZU, U complex upper triangular, Z a sequence of plane rotations
F06TVF	13	Compute upper Hessenberg matrix by sequence of plane rotations, complex upper triangular matrix
F06TWF	13	Compute upper spiked matrix by sequence of plane rotations, complex upper triangular matrix
F06TXF	13	Apply sequence of plane rotations, complex rectangular matrix, real cosine and complex sine
F06TYF	13	Apply sequence of plane rotations, complex rectangular matrix, complex cosine and real sine
F06UAF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex general matrix
F06UBF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex band matrix
F06UCF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian matrix
F06UDF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian matrix, packed storage
F06UEF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian band matrix
F06UFF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex symmetric matrix
F06UGF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex symmetric matrix, packed storage
F06UHF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex symmetric band matrix
F06UJF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex trapezoidal/triangular matrix
F06UKF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex triangular matrix, packed storage

F06ULF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex triangular band matrix
F06UMF	15	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hessenberg matrix
F06UNF	21	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex tridiagonal matrix
F06UPF	21	1-norm, ∞-norm, Frobenius norm, largest absolute element, complex Hermitian tridiagonal matrix
F06VJF	13	Permute rows or columns, complex rectangular matrix, permutations represented by an integer array
F06VKF	13	Permute rows or columns, complex rectangular matrix, permutations represented by a real array
F06VXF	13	Apply sequence of plane rotations, complex rectangular matrix, real cosine and sine
F06YAF (DGEMM)	14	Matrix-matrix product, two real rectangular matrices
F06YCF (DSYMM)	14	Matrix-matrix product, one real symmetric matrix, one real rectangular matrix
F06YFF (DTRMM)	14	Matrix-matrix product, one real triangular matrix, one real rectangular matrix
F06YJF (DTRSM)	14	Solves a system of equations with multiple right-hand sides, real triangular coefficient matrix
F06YPF (DSYRK)	14	Rank-k update of a real symmetric matrix
F06YRF (DSYR2K)	14	Rank-2k update of a real symmetric matrix
F06ZAF (ZGEMM)	14	Matrix-matrix product, two complex rectangular matrices
F06ZCF (ZHEMM)	14	Matrix-matrix product, one complex Hermitian matrix, one complex rectangular matrix
F06ZFF (ZTRMM)	14	Matrix-matrix product, one complex triangular matrix, one complex rectangular matrix
F06ZJF (ZTRSM)	14	Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix
F06ZPF (ZHERK)	14	Rank-k update of a complex Hermitian matrix
F06ZRF (ZHER2K)	14	Rank-2k update of a complex Hermitian matrix
F06ZTF (ZSYMM)	14	Matrix-matrix product, one complex symmetric matrix, one complex rectangular matrix
F06ZUF (ZSYRK)	14	Rank-k update of a complex symmetric matrix
F06ZWF (ZSYR2K)	14	Rank-2k update of a complex symmetric matrix

F07 – Linear Equations (LAPACK)

A list of the LAPACK equivalent names is included in the F07 Chapter Introduction.

Routine Name	Mark of Introduction	Purpose
F07AAF (DGESV)	21	Computes the solution to a real system of linear equations
F07ABF (DGESVX)	21	Uses the LU factorization to compute the solution, error-bound and condition estimate for a real system of linear equations
F07ADF (DGETRF)	15	LU factorization of real m by n matrix
F07AEF (DGETRS)	15	Solution of real system of linear equations, multiple right-hand sides, matrix already factorized by F07ADF (DGETRF)
F07AFF (DGEEQU)	21	Computes row and column scalings intended to equilibrate a general real matrix and reduce its condition number
F07AGF (DGECON)	15	Estimate condition number of real matrix, matrix already factorized by F07ADF (DGETRF)
F07AHF (DGERFS)	15	Refined solution with error bounds of real system of linear equations, multiple right-hand sides
F07AJF (DGETRI)	15	Inverse of real matrix, matrix already factorized by F07ADF (DGETRF)

F07ANF (ZGESV)	21	Computes the solution to a complex system of linear equations
F07APF (ZGESVX)	21	Uses the *LU* factorization to compute the solution, error-bound and condition estimate for a complex system of linear equations
F07ARF (ZGETRF)	15	*LU* factorization of complex *m* by *n* matrix
F07ASF (ZGETRS)	15	Solution of complex system of linear equations, multiple right-hand sides, matrix already factorized by F07ARF (ZGETRF)
F07ATF (ZGEEQU)	21	Computes row and column scalings intended to equilibrate a general complex matrix and reduce its condition number
F07AUF (ZGECON)	15	Estimate condition number of complex matrix, matrix already factorized by F07ARF (ZGETRF)
F07AVF (ZGERFS)	15	Refined solution with error bounds of complex system of linear equations, multiple right-hand sides
F07AWF (ZGETRI)	15	Inverse of complex matrix, matrix already factorized by F07ARF (ZGETRF)
F07BAF (DGBSV)	21	Computes the solution to a real banded system of linear equations
F07BBF (DGBSVX)	21	Uses the *LU* factorization to compute the solution, error-bound and condition estimate for a real banded system of linear equations
F07BDF (DGBTRF)	15	*LU* factorization of real *m* by *n* band matrix
F07BEF (DGBTRS)	15	Solution of real band system of linear equations, multiple right-hand sides, matrix already factorized by F07BDF (DGBTRF)
F07BFF (DGBEQU)	21	Computes row and column scalings intended to equilibrate a real banded matrix and reduce its condition number
F07BGF (DGBCON)	15	Estimate condition number of real band matrix, matrix already factorized by F07BDF (DGBTRF)
F07BHF (DGBRFS)	15	Refined solution with error bounds of real band system of linear equations, multiple right-hand sides
F07BNF (ZGBSV)	21	Computes the solution to a complex banded system of linear equations
F07BPF (ZGBSVX)	21	Uses the *LU* factorization to compute the solution, error-bound and condition estimate for a complex banded system of linear equations
F07BRF (ZGBTRF)	15	*LU* factorization of complex *m* by *n* band matrix
F07BSF (ZGBTRS)	15	Solution of complex band system of linear equations, multiple right-hand sides, matrix already factorized by F07BRF (ZGBTRF)
F07BTF (ZGBEQU)	21	Computes row and column scalings intended to equilibrate a complex banded matrix and reduce its condition number
F07BUF (ZGBCON)	15	Estimate condition number of complex band matrix, matrix already factorized by F07BRF (ZGBTRF)
F07BVF (ZGBRFS)	15	Refined solution with error bounds of complex band system of linear equations, multiple right-hand sides
F07CAF (DGTSV)	21	Computes the solution to a real tridiagonal system of linear equations
F07CBF (DGTSVX)	21	Uses the *LU* factorization to compute the solution, error-bound and condition estimate for a real tridiagonal system of linear equations
F07CDF (DGTTRF)	21	*LU* factorization of real tridiagonal matrix
F07CEF (DGTTRS)	21	Solves a real tridiagonal system of linear equations using the *LU* factorization computed by F07CDF (DGTTRF)
F07CGF (DGTCON)	21	Estimates the reciprocal of the condition number of a real tridiagonal matrix using the *LU* factorization computed by F07CDF (DGTTRF)
F07CHF (DGTRFS)	21	Refined solution with error bounds of real tridiagonal system of linear equations, multiple right-hand sides

F07CNF (ZGTSV)	21	Computes the solution to a complex tridiagonal system of linear equations
F07CPF (ZGTSVX)	21	Uses the *LU* factorization to compute the solution, error-bound and condition estimate for a complex tridiagonal system of linear equations
F07CRF (ZGTTRF)	21	*LU* factorization of complex tridiagonal matrix
F07CSF (ZGTTRS)	21	Solves a complex tridiagonal system of linear equations using the *LU* factorization computed by F07CDF (DGTTRF)
F07CUF (ZGTCON)	21	Estimates the reciprocal of the condition number of a complex tridiagonal matrix using the *LU* factorization computed by F07CDF (DGTTRF)
F07CVF (ZGTRFS)	21	Refined solution with error bounds of complex tridiagonal system of linear equations, multiple right-hand sides
F07FAF (DPOSV)	21	Computes the solution to a real symmetric positive-definite system of linear equations
F07FBF (DPOSVX)	21	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a real symmetric positive-definite system of linear equations
F07FDF (DPOTRF)	15	Cholesky factorization of real symmetric positive-definite matrix
F07FEF (DPOTRS)	15	Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FDF (DPOTRF)
F07FFF (DPOEQU)	21	Computes row and column scalings intended to equilibrate a real symmetric positive-definite matrix and reduce its condition number
F07FGF (DPOCON)	15	Estimate condition number of real symmetric positive-definite matrix, matrix already factorized by F07FDF (DPOTRF)
F07FHF (DPORFS)	15	Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides
F07FJF (DPOTRI)	15	Inverse of real symmetric positive-definite matrix, matrix already factorized by F07FDF (DPOTRF)
F07FNF (ZPOSV)	21	Computes the solution to a complex Hermitian positive-definite system of linear equations
F07FPF (ZPOSVX)	21	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a complex Hermitian positive-definite system of linear equations
F07FRF (ZPOTRF)	15	Cholesky factorization of complex Hermitian positive-definite matrix
F07FSF (ZPOTRS)	15	Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FRF (ZPOTRF)
F07FTF (ZPOEQU)	21	Computes row and column scalings intended to equilibrate a complex Hermitian positive-definite matrix and reduce its condition number
F07FUF (ZPOCON)	15	Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF (ZPOTRF)
F07FVF (ZPORFS)	15	Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides
F07FWF (ZPOTRI)	15	Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF (ZPOTRF)
F07GAF (DPPSV)	21	Computes the solution to a real symmetric positive-definite system of linear equations, packed storage
F07GBF (DPPSVX)	21	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a real symmetric positive-definite system of linear equations, packed storage

F07GDF (DPPTRF)	15	Cholesky factorization of real symmetric positive-definite matrix, packed storage
F07GEF (DPPTRS)	15	Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GFF (DPPEQU)	21	Computes row and column scalings intended to equilibrate a real symmetric positive-definite matrix and reduce its condition number, packed storage
F07GGF (DPPCON)	15	Estimate condition number of real symmetric positive-definite matrix, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GHF (DPPRFS)	15	Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides, packed storage
F07GJF (DPPTRI)	15	Inverse of real symmetric positive-definite matrix, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GNF (ZPPSV)	21	Computes the solution to a complex Hermitian positive-definite system of linear equations, packed storage
F07GPF (ZPPSVX)	21	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a complex Hermitian positive-definite system of linear equations, packed storage
F07GRF (ZPPTRF)	15	Cholesky factorization of complex Hermitian positive-definite matrix, packed storage
F07GSF (ZPPTRS)	15	Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07GTF (ZPPEQU)	21	Computes row and column scalings intended to equilibrate a complex Hermitian positive-definite matrix and reduce its condition number, packed storage
F07GUF (ZPPCON)	15	Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07GVF (ZPPRFS)	15	Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, packed storage
F07GWF (ZPPTRI)	15	Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07HAF (DPBSV)	21	Computes the solution to a real symmetric positive-definite banded system of linear equations
F07HBF (DPBSVX)	21	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a real symmetric positive-definite banded system of linear equations
F07HDF (DPBTRF)	15	Cholesky factorization of real symmetric positive-definite band matrix
F07HEF (DPBTRS)	15	Solution of real symmetric positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HDF (DPBTRF)
F07HFF (DPBEQU)	21	Computes row and column scalings intended to equilibrate a real symmetric positive-definite banded matrix and reduce its condition number
F07HGF (DPBCON)	15	Estimate condition number of real symmetric positive-definite band matrix, matrix already factorized by F07HDF (DPBTRF)
F07HHF (DPBRFS)	15	Refined solution with error bounds of real symmetric positive-definite band system of linear equations, multiple right-hand sides
F07HNF (ZPBSV)	21	Computes the solution to a complex Hermitian positive-definite banded system of linear equations

F07HPF (ZPBSVX)	21	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a complex Hermitian positive-definite banded system of linear equations
F07HRF (ZPBTRF)	15	Cholesky factorization of complex Hermitian positive-definite band matrix
F07HSF (ZPBTRS)	15	Solution of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HRF (ZPBTRF)
F07HTF (ZPBEQU)	21	Computes row and column scalings intended to equilibrate a complex Hermitian positive-definite banded matrix and reduce its condition number
F07HUF (ZPBCON)	15	Estimate condition number of complex Hermitian positive-definite band matrix, matrix already factorized by F07HRF (ZPBTRF)
F07HVF (ZPBRFS)	15	Refined solution with error bounds of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides
F07JAF (DPTSV)	21	Computes the solution to a real symmetric positive-definite tridiagonal system of linear equations
F07JBF (DPTSVX)	21	Uses the modified Cholesky factorization to compute the solution, error-bound and condition estimate for a real symmetric positive-definite tridiagonal system of linear equations
F07JDF (DPTTRF)	21	Computes the modified Cholesky factorization of a real symmetric positive-definite tridiagonal matrix
F07JEF (DPTTRS)	21	Solves a real symmetric positive-definite tridiagonal system using the modified Cholesky factorization computed by F07JDF (DPTTRF)
F07JGF (DPTCON)	21	Computes the reciprocal of the condition number of a real symmetric positive-definite tridiagonal system using the modified Cholesky factorization computed by F07JDF (DPTTRF)
F07JHF (DPTRFS)	21	Refined solution with error bounds of real symmetric positive-definite tridiagonal system of linear equations, multiple right-hand sides
F07JNF (ZPTSV)	21	Computes the solution to a complex Hermitian positive-definite tridiagonal system of linear equations
F07JPF (ZPTSVX)	21	Uses the modified Cholesky factorization to compute the solution, error-bound and condition estimate for a complex Hermitian positive-definite tridiagonal system of linear equations
F07JRF (ZPTTRF)	21	Computes the modified Cholesky factorization of a complex Hermitian positive-definite tridiagonal matrix
F07JSF (ZPTTRS)	21	Solves a complex Hermitian positive-definite tridiagonal system using the modified Cholesky factorization computed by F07JRF (ZPTTRF)
F07JUF (ZPTCON)	21	Computes the reciprocal of the condition number of a complex Hermitian positive-definite tridiagonal system using the modified Cholesky factorization computed by F07JRF (ZPTTRF)
F07JVF (ZPTRFS)	21	Refined solution with error bounds of complex Hermitian positive-definite tridiagonal system of linear equations, multiple right-hand sides
F07MAF (DSYSV)	21	Computes the solution to a real symmetric system of linear equations
F07MBF (DSYSVX)	21	Uses the diagonal pivoting factorization to compute the solution to a real symmetric system of linear equations
F07MDF (DSYTRF)	15	Bunch–Kaufman factorization of real symmetric indefinite matrix

F07MEF (DSYTRS)	15	Solution of real symmetric indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07MDF (DSYTRF)
F07MGF (DSYCON)	15	Estimate condition number of real symmetric indefinite matrix, matrix already factorized by F07MDF (DSYTRF)
F07MHF (DSYRFS)	15	Refined solution with error bounds of real symmetric indefinite system of linear equations, multiple right-hand sides
F07MJF (DSYTRI)	15	Inverse of real symmetric indefinite matrix, matrix already factorized by F07MDF (DSYTRF)
F07MNF (ZHESV)	21	Computes the solution to a complex Hermitian system of linear equations
F07MPF (ZHESVX)	21	Uses the diagonal pivoting factorization to compute the solution to a complex Hermitian system of linear equations
F07MRF (ZHETRF)	15	Bunch–Kaufman factorization of complex Hermitian indefinite matrix
F07MSF (ZHETRS)	15	Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07MRF (ZHETRF)
F07MUF (ZHECON)	15	Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07MRF (ZHETRF)
F07MVF (ZHERFS)	15	Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides
F07MWF (ZHETRI)	15	Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07MRF (ZHETRF)
F07NNF (ZSYSV)	21	Computes the solution to a complex symmetric system of linear equations
F07NPF (ZSYSVX)	21	Uses the diagonal pivoting factorization to compute the solution to a complex symmetric system of linear equations
F07NRF (ZSYTRF)	15	Bunch–Kaufman factorization of complex symmetric matrix
F07NSF (ZSYTRS)	15	Solution of complex symmetric system of linear equations, multiple right-hand sides, matrix already factorized by F07NRF (ZSYTRF)
F07NUF (ZSYCON)	15	Estimate condition number of complex symmetric matrix, matrix already factorized by F07NRF (ZSYTRF)
F07NVF (ZSYRFS)	15	Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides
F07NWF (ZSYTRI)	15	Inverse of complex symmetric matrix, matrix already factorized by F07NRF (ZSYTRF)
F07PAF (DSPSV)	21	Computes the solution to a real symmetric system of linear equations, packed storage
F07PBF (DSPSVX)	21	Uses the diagonal pivoting factorization to compute the solution to a real symmetric system of linear equations, packed storage
F07PDF (DSPTRF)	15	Bunch–Kaufman factorization of real symmetric indefinite matrix, packed storage
F07PEF (DSPTRS)	15	Solution of real symmetric indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07PDF (DSPTRF), packed storage
F07PGF (DSPCON)	15	Estimate condition number of real symmetric indefinite matrix, matrix already factorized by F07PDF (DSPTRF), packed storage
F07PHF (DSPRFS)	15	Refined solution with error bounds of real symmetric indefinite system of linear equations, multiple right-hand sides, packed storage
F07PJF (DSPTRI)	15	Inverse of real symmetric indefinite matrix, matrix already factorized by F07PDF (DSPTRF), packed storage
F07PNF (ZHPSV)	21	Computes the solution to a complex Hermitian system of linear equations, packed storage

F07PPF (ZHPSVX)	21	Uses the diagonal pivoting factorization to compute the solution to a complex Hermitian system of linear equations, packed storage
F07PRF (ZHPTRF)	15	Bunch–Kaufman factorization of complex Hermitian indefinite matrix, packed storage
F07PSF (ZHPTRS)	15	Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07PRF (ZHPTRF), packed storage
F07PUF (ZHPCON)	15	Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07PRF (ZHPTRF), packed storage
F07PVF (ZHPRFS)	15	Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides, packed storage
F07PWF (ZHPTRI)	15	Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07PRF (ZHPTRF), packed storage
F07QNF (ZSPSV)	21	Computes the solution to a complex symmetric system of linear equations, packed storage
F07QPF (ZSPSVX)	21	Uses the diagonal pivoting factorization to compute the solution to a complex symmetric system of linear equations, packed storage
F07QRF (ZSPTRF)	15	Bunch–Kaufman factorization of complex symmetric matrix, packed storage
F07QSF (ZSPTRS)	15	Solution of complex symmetric system of linear equations, multiple right-hand sides, matrix already factorized by F07QRF (ZSPTRF), packed storage
F07QUF (ZSPCON)	15	Estimate condition number of complex symmetric matrix, matrix already factorized by F07QRF (ZSPTRF), packed storage
F07QVF (ZSPRFS)	15	Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides, packed storage
F07QWF (ZSPTRI)	15	Inverse of complex symmetric matrix, matrix already factorized by F07QRF (ZSPTRF), packed storage
F07TEF (DTRTRS)	15	Solution of real triangular system of linear equations, multiple right-hand sides
F07TGF (DTRCON)	15	Estimate condition number of real triangular matrix
F07THF (DTRRFS)	15	Error bounds for solution of real triangular system of linear equations, multiple right-hand sides
F07TJF (DTRTRI)	15	Inverse of real triangular matrix
F07TSF (ZTRTRS)	15	Solution of complex triangular system of linear equations, multiple right-hand sides
F07TUF (ZTRCON)	15	Estimate condition number of complex triangular matrix
F07TVF (ZTRRFS)	15	Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides
F07TWF (ZTRTRI)	15	Inverse of complex triangular matrix
F07UEF (DTPTRS)	15	Solution of real triangular system of linear equations, multiple right-hand sides, packed storage
F07UGF (DTPCON)	15	Estimate condition number of real triangular matrix, packed storage
F07UHF (DTPRFS)	15	Error bounds for solution of real triangular system of linear equations, multiple right-hand sides, packed storage
F07UJF (DTPTRI)	15	Inverse of real triangular matrix, packed storage
F07USF (ZTPTRS)	15	Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07UUF (ZTPCON)	15	Estimate condition number of complex triangular matrix, packed storage
F07UVF (ZTPRFS)	15	Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage

F07UWF (ZTPTRI)	15	Inverse of complex triangular matrix, packed storage
F07VEF (DTBTRS)	15	Solution of real band triangular system of linear equations, multiple right-hand sides
F07VGF (DTBCON)	15	Estimate condition number of real band triangular matrix
F07VHF (DTBRFS)	15	Error bounds for solution of real band triangular system of linear equations, multiple right-hand sides
F07VSF (ZTBTRS)	15	Solution of complex band triangular system of linear equations, multiple right-hand sides
F07VUF (ZTBCON)	15	Estimate condition number of complex band triangular matrix
F07VVF (ZTBRFS)	15	Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides

F08 – Least-squares and Eigenvalue Problems (LAPACK)

A list of the LAPACK equivalent names is included in the F08 Chapter Introduction.

Routine Name	Mark of Introduction	Purpose
F08AAF (DGELS)	21	Solves an overdetermined or underdetermined real linear system
F08AEF (DGEQRF)	16	*QR* factorization of real general rectangular matrix
F08AFF (DORGQR)	16	Form all or part of orthogonal *Q* from *QR* factorization determined by F08AEF (DGEQRF) or F08BEF (DGEQPF)
F08AGF (DORMQR)	16	Apply orthogonal transformation determined by F08AEF (DGEQRF) or F08BEF (DGEQPF)
F08AHF (DGELQF)	16	*LQ* factorization of real general rectangular matrix
F08AJF (DORGLQ)	16	Form all or part of orthogonal *Q* from *LQ* factorization determined by F08AHF (DGELQF)
F08AKF (DORMLQ)	16	Apply orthogonal transformation determined by F08AHF (DGELQF)
F08ANF (ZGELS)	21	Solves an overdetermined or underdetermined complex linear system
F08ASF (ZGEQRF)	16	*QR* factorization of complex general rectangular matrix
F08ATF (ZUNGQR)	16	Form all or part of unitary *Q* from *QR* factorization determined by F08ASF (ZGEQRF) or F08BSF (ZGEQPF)
F08AUF (ZUNMQR)	16	Apply unitary transformation determined by F08ASF (ZGEQRF) or F08BSF (ZGEQPF)
F08AVF (ZGELQF)	16	*LQ* factorization of complex general rectangular matrix
F08AWF (ZUNGLQ)	16	Form all or part of unitary *Q* from *LQ* factorization determined by F08AVF (ZGELQF)
F08AXF (ZUNMLQ)	16	Apply unitary transformation determined by F08AVF (ZGELQF)
F08BAF (DGELSY)	21	Computes the minimum-norm solution to a real linear least-squares problem
F08BEF (DGEQPF)	16	*QR* factorization of real general rectangular matrix with column pivoting
F08BFF (DGEQP3)	21	*QR* factorization of real general rectangular matrix with column pivoting, using BLAS-3
F08BHF (DTZRZF)	21	Reduces a real upper trapezoidal matrix to upper triangular form
F08BKF (DORMRZ)	21	Apply orthogonal transformation determined by F08BHF (DTZRZF)
F08BNF (ZGELSY)	21	Computes the minimum-norm solution to a complex linear least-squares problem
F08BSF (ZGEQPF)	16	*QR* factorization of complex general rectangular matrix with column pivoting
F08BTF (ZGEQP3)	21	*QR* factorization of complex general rectangular matrix with column pivoting, using BLAS-3

F08BVF (ZTZRZF)	21	Reduces a complex upper trapezoidal matrix to upper triangular form
F08BXF (ZUNMRZ)	21	Apply unitary transformation determined by F08BVF (ZTZRZF)
F08CEF (DGEQLF)	21	*QL* factorization of real general rectangular matrix
F08CFF (DORGQL)	21	Form all or part of orthogonal *Q* from *QL* factorization determined by F08CEF (DGEQLF)
F08CGF (DORMQL)	21	Apply orthogonal transformation determined by F08CEF (DGEQLF)
F08CHF (DGERQF)	21	*RQ* factorization of real general rectangular matrix
F08CJF (DORGRQ)	21	Form all or part of orthogonal *Q* from *RQ* factorization determined by F08CHF (DGERQF)
F08CKF (DORMRQ)	21	Apply orthogonal transformation determined by F08CHF (DGERQF)
F08CSF (ZGEQLF)	21	*QL* factorization of complex general rectangular matrix
F08CTF (ZUNGQL)	21	Form all or part of orthogonal *Q* from *QL* factorization determined by F08CSF (ZGEQLF)
F08CUF (ZUNMQL)	21	Apply unitary transformation determined by F08CSF (ZGEQLF)
F08CVF (ZGERQF)	21	*RQ* factorization of complex general rectangular matrix
F08CWF (ZUNGRQ)	21	Form all or part of orthogonal *Q* from *RQ* factorization determined by F08CVF (ZGERQF)
F08CXF (ZUNMRQ)	21	Apply unitary transformation determined by F08CVF (ZGERQF)
F08FAF (DSYEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric matrix
F08FBF (DSYEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix
F08FCF (DSYEVD)	19	All eigenvalues and optionally all eigenvectors of real symmetric matrix (divide-and-conquer)
F08FDF (DSYEVR)	21	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix (Relatively Robust Representations)
F08FEF (DSYTRD)	16	Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form
F08FFF (DORGTR)	16	Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08FEF (DSYTRD)
F08FGF (DORMTR)	16	Apply orthogonal transformation determined by F08FEF (DSYTRD)
F08FLF (DDISNA)	21	Computes the reciprocal condition numbers for the eigenvectors of a real symmetric or complex Hermitian matrix or for the left or right singular vectors of a general matrix
F08FNF (ZHEEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix
F08FPF (ZHEEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix
F08FQF (ZHEEVD)	19	All eigenvalues and optionally all eigenvectors of complex Hermitian matrix (divide-and-conquer)
F08FRF (ZHEEVR)	21	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix (Relatively Robust Representations)
F08FSF (ZHETRD)	16	Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form
F08FTF (ZUNGTR)	16	Generate unitary transformation matrix from reduction to tridiagonal form determined by F08FSF (ZHETRD)
F08FUF (ZUNMTR)	16	Apply unitary transformation matrix determined by F08FSF (ZHETRD)
F08GAF (DSPEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric matrix, packed storage

F08GBF (DSPEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix, packed storage
F08GCF (DSPEVD)	19	All eigenvalues and optionally all eigenvectors of real symmetric matrix, packed storage (divide-and-conquer)
F08GEF (DSPTRD)	16	Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form, packed storage
F08GFF (DOPGTR)	16	Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08GEF (DSPTRD)
F08GGF (DOPMTR)	16	Apply orthogonal transformation determined by F08GEF (DSPTRD)
F08GNF (ZHPEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix, packed storage
F08GPF (ZHPEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix, packed storage
F08GQF (ZHPEVD)	19	All eigenvalues and optionally all eigenvectors of complex Hermitian matrix, packed storage (divide-and-conquer)
F08GSF (ZHPTRD)	16	Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form, packed storage
F08GTF (ZUPGTR)	16	Generate unitary transformation matrix from reduction to tridiagonal form determined by F08GSF (ZHPTRD)
F08GUF (ZUPMTR)	16	Apply unitary transformation matrix determined by F08GSF (ZHPTRD)
F08HAF (DSBEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric band matrix
F08HBF (DSBEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric band matrix
F08HCF (DSBEVD)	19	All eigenvalues and optionally all eigenvectors of real symmetric band matrix (divide-and-conquer)
F08HEF (DSBTRD)	16	Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form
F08HNF (ZHBEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian band matrix
F08HPF (ZHBEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian band matrix
F08HQF (ZHBEVD)	19	All eigenvalues and optionally all eigenvectors of complex Hermitian band matrix (divide-and-conquer)
F08HSF (ZHBTRD)	16	Unitary reduction of complex Hermitian band matrix to real symmetric tridiagonal form
F08JAF (DSTEV)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix
F08JBF (DSTEVX)	21	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix
F08JCF (DSTEVD)	19	All eigenvalues and optionally all eigenvectors of real symmetric tridiagonal matrix (divide-and-conquer)
F08JDF (DSTEVR)	21	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix (Relatively Robust Representations)
F08JEF (DSTEQR)	16	All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from real symmetric matrix using implicit *QL* or *QR*
F08JFF (DSTERF)	16	All eigenvalues of real symmetric tridiagonal matrix, root-free variant of *QL* or *QR*
F08JGF (DPTEQR)	16	All eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from real symmetric positive-definite matrix
F08JHF (DSTEDC)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a matrix reduced to this form (divide-and-conquer)

F08JJF (DSTEBZ)	16	Selected eigenvalues of real symmetric tridiagonal matrix by bisection
F08JKF (DSTEIN)	16	Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in real array
F08JLF (DSTEGR)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a symmetric matrix reduced to this form (Relatively Robust Representations)
F08JSF (ZSTEQR)	16	All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from complex Hermitian matrix, using implicit *QL* or *QR*
F08JUF (ZPTEQR)	16	All eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from complex Hermitian positive-definite matrix
F08JVF (ZSTEDC)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a complex Hermitian matrix reduced to this form (divide-and-conquer)
F08JXF (ZSTEIN)	16	Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in complex array
F08JYF (ZSTEGR)	21	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a complex Hermitian matrix reduced to this form (Relatively Robust Representations)
F08KAF (DGELSS)	21	Computes the minimum-norm solution to a real linear least-squares problem using singular value decomposition
F08KBF (DGESVD)	21	Computes the singular value decomposition of a real matrix, optionally computing the left and/or right singular vectors
F08KCF (DGELSD)	21	Computes the minimum-norm solution to a real linear least-squares problem using singular value decomposition (divide-and-conquer)
F08KDF (DGESDD)	21	Computes the singular value decomposition of a real matrix, optionally computing the left and/or right singular vectors (divide-and-conquer)
F08KEF (DGEBRD)	16	Orthogonal reduction of real general rectangular matrix to bidiagonal form
F08KFF (DORGBR)	16	Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF (DGEBRD)
F08KGF (DORMBR)	16	Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF (DGEBRD)
F08KNF (ZGELSS)	21	Computes the minimum-norm solution to a complex linear least-squares problem using singular value decomposition
F08KPF (ZGESVD)	21	Computes the singular value decomposition of a complex matrix, optionally computing the left and/or right singular vectors
F08KQF (ZGELSD)	21	Computes the minimum-norm solution to a complex linear least-squares problem using singular value decomposition (divide-and-conquer)
F08KRF (ZGESDD)	21	Computes the singular value decomposition of a complex matrix, optionally computing the left and/or right singular vectors (divide-and-conquer)
F08KSF (ZGEBRD)	16	Unitary reduction of complex general rectangular matrix to bidiagonal form
F08KTF (ZUNGBR)	16	Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF (ZGEBRD)
F08KUF (ZUNMBR)	16	Apply unitary transformations from reduction to bidiagonal form determined by F08KSF (ZGEBRD)
F08LEF (DGBBRD)	19	Reduction of real rectangular band matrix to upper bidiagonal form
F08LSF (ZGBBRD)	19	Reduction of complex rectangular band matrix to upper bidiagonal form

F08MDF (DBDSDC)	21	Computes the singular value decomposition of a real bidiagonal matrix, optionally computing the singular vectors (divide-and-conquer)
F08MEF (DBDSQR)	16	SVD of real bidiagonal matrix reduced from real general matrix
F08MSF (ZBDSQR)	16	SVD of real bidiagonal matrix reduced from complex general matrix
F08NAF (DGEEV)	21	Computes all eigenvalues and, optionally, left and/or right eigenvectors of a real nonsymmetric matrix
F08NBF (DGEEVX)	21	Computes all eigenvalues and, optionally, left and/or right eigenvectors of a real nonsymmetric matrix; also, optionally, the balancing transformation, the reciprocal condition numbers for the eigenvalues and for the right eigenvectors
F08NEF (DGEHRD)	16	Orthogonal reduction of real general matrix to upper Hessenberg form
F08NFF (DORGHR)	16	Generate orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (DGEHRD)
F08NGF (DORMHR)	16	Apply orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (DGEHRD)
F08NHF (DGEBAL)	16	Balance real general matrix
F08NJF (DGEBAK)	16	Transform eigenvectors of real balanced matrix to those of original matrix supplied to F08NHF (DGEBAL)
F08NNF (ZGEEV)	21	Computes all eigenvalues and, optionally, left and/or right eigenvectors of a complex nonsymmetric matrix
F08NPF (ZGEEVX)	21	Computes all eigenvalues and, optionally, left and/or right eigenvectors of a complex nonsymmetric matrix; also, optionally, the balancing transformation, the reciprocal condition numbers for the eigenvalues and for the right eigenvectors
F08NSF (ZGEHRD)	16	Unitary reduction of complex general matrix to upper Hessenberg form
F08NTF (ZUNGHR)	16	Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NSF (ZGEHRD)
F08NUF (ZUNMHR)	16	Apply unitary transformation matrix from reduction to Hessenberg form determined by F08NSF (ZGEHRD)
F08NVF (ZGEBAL)	16	Balance complex general matrix
F08NWF (ZGEBAK)	16	Transform eigenvectors of complex balanced matrix to those of original matrix supplied to F08NVF (ZGEBAL)
F08PAF (DGEES)	21	Computes for real square nonsymmetric matrix, the eigenvalues, the real Schur form, and, optionally, the matrix of Schur vectors
F08PBF (DGEESX)	21	Computes for real square nonsymmetric matrix, the eigenvalues, the real Schur form, and, optionally, the matrix of Schur vectors; also, optionally, computes reciprocal condition numbers for selected eigenvalues
F08PEF (DHSEQR)	16	Eigenvalues and Schur factorization of real upper Hessenberg matrix reduced from real general matrix
F08PKF (DHSEIN)	16	Selected right and/or left eigenvectors of real upper Hessenberg matrix by inverse iteration
F08PNF (ZGEES)	21	Computes for complex square nonsymmetric matrix, the eigenvalues, the Schur form, and, optionally, the matrix of Schur vectors
F08PPF (ZGEESX)	21	Computes for real square nonsymmetric matrix, the eigenvalues, the Schur form, and, optionally, the matrix of Schur vectors; also, optionally, computes reciprocal condition numbers for selected eigenvalues
F08PSF (ZHSEQR)	16	Eigenvalues and Schur factorization of complex upper Hessenberg matrix reduced from complex general matrix

F08PXF (ZHSEIN)	16	Selected right and/or left eigenvectors of complex upper Hessenberg matrix by inverse iteration
F08QFF (DTREXC)	16	Reorder Schur factorization of real matrix using orthogonal similarity transformation
F08QGF (DTRSEN)	16	Reorder Schur factorization of real matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities
F08QHF (DTRSYL)	16	Solve real Sylvester matrix equation $AX + XB = C$, A and B are upper quasi-triangular or transposes
F08QKF (DTREVC)	16	Left and right eigenvectors of real upper quasi-triangular matrix
F08QLF (DTRSNA)	16	Estimates of sensitivities of selected eigenvalues and eigenvectors of real upper quasi-triangular matrix
F08QTF (ZTREXC)	16	Reorder Schur factorization of complex matrix using unitary similarity transformation
F08QUF (ZTRSEN)	16	Reorder Schur factorization of complex matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities
F08QVF (ZTRSYL)	16	Solve complex Sylvester matrix equation $AX + XB = C$, A and B are upper triangular or conjugate-transposes
F08QXF (ZTREVC)	16	Left and right eigenvectors of complex upper triangular matrix
F08QYF (ZTRSNA)	16	Estimates of sensitivities of selected eigenvalues and eigenvectors of complex upper triangular matrix
F08SAF (DSYGV)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem
F08SBF (DSYGVX)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem
F08SCF (DSYGVD)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem (divide-and-conquer)
F08SEF (DSYGST)	16	Reduction to standard form of real symmetric-definite generalized eigenproblem $Ax = \lambda Bx$, $ABx = \lambda x$ or $BAx = \lambda x$, B factorized by F07FDF (DPOTRF)
F08SNF (ZHEGV)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem
F08SPF (ZHEGVX)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem
F08SQF (ZHEGVD)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem (divide-and-conquer)
F08SSF (ZHEGST)	16	Reduction to standard form of complex Hermitian-definite generalized eigenproblem $Ax = \lambda Bx$, $ABx = \lambda x$ or $BAx = \lambda x$, B factorized by F07FRF (ZPOTRF)
F08TAF (DSPGV)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage
F08TBF (DSPGVX)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage
F08TCF (DSPGVD)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage (divide-and-conquer)
F08TEF (DSPGST)	16	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 (DPPTRF)

F08TNF (ZHPGV)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage
F08TPF (ZHPGVX)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage
F08TQF (ZHPGVD)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage (divide-and-conquer)
F08TSF (ZHPGST)	16	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 (ZPPTRF)
F08UAF (DSBGV)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem
F08UBF (DSBGVX)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem
F08UCF (DSBGVD)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem (divide-and-conquer)
F08UEF (DSBGST)	19	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 (DPBSTF)	19	Computes a split Cholesky factorization of real symmetric positive-definite band matrix A
F08UNF (ZHBGV)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem
F08UPF (ZHBGVX)	21	Computes selected eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem
F08UQF (ZHBGVD)	21	Computes all the eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem (divide-and-conquer)
F08USF (ZHBGST)	19	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 (ZPBSTF)	19	Computes a split Cholesky factorization of complex Hermitian positive-definite band matrix A
F08VAF (DGGSVD)	21	Computes the generalized singular value decomposition of a real matrix pair
F08VEF (DGGSVP)	21	Computes orthogonal matrices as processing steps for computing the generalized singular value decomposition of a real matrix pair
F08VNF (ZGGSVD)	21	Computes the generalized singular value decomposition of a complex matrix pair
F08VSF (ZGGSVP)	21	Computes orthogonal matrices as processing steps for computing the generalized singular value decomposition of a complex matrix pair
F08WAF (DGGEV)	21	Computes, for a real nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors
F08WBF (DGGEVX)	21	Computes, for a real nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors; also, optionally, the balancing transformation, the reciprocal condition numbers for the eigenvalues and for the right eigenvectors
F08WEF (DGGHRD)	20	Orthogonal reduction of a pair of real general matrices to generalized upper Hessenberg form

F08WHF (DGGBAL)	20	Balance a pair of real general matrices
F08WJF (DGGBAK)	20	Transform eigenvectors of a pair of real balanced matrices to those of original matrix pair supplied to F08WHF (DGGBAL)
F08WNF (ZGGEV)	21	Computes, for a complex nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors
F08WPF (ZGGEVX)	21	Computes, for a complex nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors; also, optionally, the balancing transformation, the reciprocal condition numbers for the eigenvalues and for the right eigenvectors
F08WSF (ZGGHRD)	20	Unitary reduction of a pair of complex general matrices to generalized upper Hessenberg form
F08WVF (ZGGBAL)	20	Balance a pair of complex general matrices
F08WWF (ZGGBAK)	20	Transform eigenvectors of a pair of complex balanced matrices to those of original matrix pair supplied to F08WVF (ZGGBAL)
F08XAF (DGGES)	21	Computes, for a real nonsymmetric matrix pair, the generalized eigenvalues, the generalized real Schur form and, optionally, the left and/or right matrices of Schur vectors
F08XBF (DGGESX)	21	Computes, for a real nonsymmetric matrix pair, the generalized eigenvalues, the generalized real Schur form and, optionally, the left and/or right matrices of Schur vectors; also, optionally, computes reciprocal condition numbers for selected eigenvalues
F08XEF (DHGEQZ)	20	Eigenvalues and generalized Schur factorization of real generalized upper Hessenberg form reduced from a pair of real general matrices
F08XNF (ZGGES)	21	Computes, for a complex nonsymmetric matrix pair, the generalized eigenvalues, the generalized complex Schur form and, optionally, the left and/or right matrices of Schur vectors
F08XPF (ZGGESX)	21	Computes, for a complex nonsymmetric matrix pair, the generalized eigenvalues, the generalized complex Schur form and, optionally, the left and/or right matrices of Schur vectors; also, optionally, computes reciprocal condition numbers for selected eigenvalues
F08XSF (ZHGEQZ)	20	Eigenvalues and generalized Schur factorization of complex generalized upper Hessenberg form reduced from a pair of complex general matrices
F08YEF (DTGSJA)	21	Computes the generalized singular value decomposition of a real upper triangular (or trapezoidal) matrix pair
F08YFF (DTGEXC)	21	Reorders the generalized real Schur decomposition of a real matrix pair using an orthogonal equivalence transformation
F08YGF (DTGSEN)	21	Reorders the generalized real Schur decomposition of a real matrix pair using an orthogonal equivalence transformation, computes the generalized eigenvalues of the reordered pair and, optionally, computes the estimates of reciprocal condition numbers for eigenvalues and eigenspaces
F08YHF (DTGSYL)	21	Solves the real-valued generalized Sylvester equation
F08YKF (DTGEVC)	20	Left and right eigenvectors of a pair of real upper quasi-triangular matrices
F08YLF (DTGSNA)	21	Estimates reciprocal condition numbers for specified eigenvalues and/or eigenvectors of a real matrix pair in generalized real Schur canonical form
F08YSF (ZTGSJA)	21	Computes the generalized singular value decomposition of a complex upper triangular (or trapezoidal) matrix pair
F08YTF (ZTGEXC)	21	Reorders the generalized Schur decomposition of a complex matrix pair using an unitary equivalence transformation

F08YUF (ZTGSEN)	21	Reorders the generalized Schur decomposition of a complex matrix pair using an unitary equivalence transformation, computes the generalized eigenvalues of the reordered pair and, optionally, computes the estimates of reciprocal condition numbers for eigenvalues and eigenspaces
F08YVF (ZTGSYL)	21	Solves the complex generalized Sylvester equation
F08YXF (ZTGEVC)	20	Left and right eigenvectors of a pair of complex upper triangular matrices
F08YYF (ZTGSNA)	21	Estimates reciprocal condition numbers for specified eigenvalues and/or eigenvectors of a complex matrix pair in generalized Schur canonical form
F08ZAF (DGGLSE)	21	Solves the real linear equality-constrained least-squares (LSE) problem
F08ZBF (DGGGLM)	21	Solves a real general Gauss–Markov linear model (GLM) problem
F08ZEF (DGGQRF)	21	Computes a generalized *QR* factorization of a real matrix pair
F08ZFF (DGGRQF)	21	Computes a generalized *RQ* factorization of a real matrix pair
F08ZNF (ZGGLSE)	21	Solves the complex linear equality-constrained least-squares (LSE) problem
F08ZPF (ZGGGLM)	21	Solves a complex general Gauss–Markov linear model (GLM) problem
F08ZSF (ZGGQRF)	21	Computes a generalized *QR* factorization of a complex matrix pair
F08ZTF (ZGGRQF)	21	Computes a generalized *RQ* factorization of a complex matrix pair

F11 – Large Scale Linear Systems

Routine Name	Mark of Introduction	Purpose
F11BDF	19	Real sparse nonsymmetric linear systems, setup for F11BEF
F11BEF	19	Real sparse nonsymmetric linear systems, preconditioned RGMRES, CGS, Bi-CGSTAB or TFQMR method
F11BFF	19	Real sparse nonsymmetric linear systems, diagnostic for F11BEF
F11BRF	19	Complex sparse non-Hermitian linear systems, setup for F11BSF
F11BSF	19	Complex sparse non-Hermitian linear systems, preconditioned RGMRES, CGS, Bi-CGSTAB or TFQMR method
F11BTF	19	Complex sparse non-Hermitian linear systems, diagnostic for F11BSF
F11DAF	18	Real sparse nonsymmetric linear systems, incomplete *LU* factorization
F11DBF	18	Solution of linear system involving incomplete *LU* preconditioning matrix generated by F11DAF
F11DCF	18	Solution of real sparse nonsymmetric linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DAF
F11DDF	18	Solution of linear system involving preconditioning matrix generated by applying SSOR to real sparse nonsymmetric matrix
F11DEF	18	Solution of real sparse nonsymmetric linear system, RGMRES, CGS, Bi-CGSTAB, or TFQMR method, Jacobi or SSOR preconditioner (Black Box)
F11DKF	20	Real sparse nonsymmetric linear systems, line Jacobi preconditioner
F11DNF	19	Complex sparse non-Hermitian linear systems, incomplete *LU* factorization

F11DPF	19	Solution of complex linear system involving incomplete *LU* preconditioning matrix generated by F11DNF
F11DQF	19	Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DNF (Black Box)
F11DRF	19	Solution of linear system involving preconditioning matrix generated by applying SSOR to complex sparse non-Hermitian matrix
F11DSF	19	Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, Jacobi or SSOR preconditioner Black Box
F11DXF	20	Complex sparse nonsymmetric linear systems, line Jacobi preconditioner
F11GDF	20	Real sparse symmetric linear systems, setup for F11GEF
F11GEF	20	Real sparse symmetric linear systems, preconditioned conjugate gradient or Lanczos
F11GFF	20	Real sparse symmetric linear systems, diagnostic for F11GEF
F11GRF	20	Complex sparse Hermitian linear systems, setup for F11GSF
F11GSF	20	Complex sparse Hermitian linear systems, preconditioned conjugate gradient or Lanczos
F11GTF	20	Complex sparse Hermitian linear systems, diagnostic for F11GSF
F11JAF	17	Real sparse symmetric matrix, incomplete Cholesky factorization
F11JBF	17	Solution of linear system involving incomplete Cholesky preconditioning matrix generated by F11JAF
F11JCF	17	Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JAF (Black Box)
F11JDF	17	Solution of linear system involving preconditioning matrix generated by applying SSOR to real sparse symmetric matrix
F11JEF	17	Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)
F11JNF	19	Complex sparse Hermitian matrix, incomplete Cholesky factorization
F11JPF	19	Solution of complex linear system involving incomplete Cholesky preconditioning matrix generated by F11JNF
F11JQF	19	Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JNF (Black Box)
F11JRF	19	Solution of linear system involving preconditioning matrix generated by applying SSOR to complex sparse Hermitian matrix
F11JSF	19	Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)
F11MDF	21	Real sparse nonsymmetric linear systems, setup for F11MEF
F11MEF	21	*LU* factorization of real sparse matrix
F11MFF	21	Solution of real sparse simultaneous linear equations (coefficient matrix already factorized)
F11MGF	21	Estimate condition number of real matrix, matrix already factorized by F11MEF
F11MHF	21	Refined solution with error bounds of real system of linear equations, multiple right-hand sides
F11MKF	21	Real sparse nonsymmetric matrix matrix multiply, compressed column storage
F11MLF	21	1-norm, ∞-norm, largest absolute element, real general matrix

F11MMF	21	Real sparse nonsymmetric linear systems, diagnostic for F11MEF
F11XAF	18	Real sparse nonsymmetric matrix vector multiply
F11XEF	17	Real sparse symmetric matrix vector multiply
F11XNF	19	Complex sparse non-Hermitian matrix vector multiply
F11XSF	19	Complex sparse Hermitian matrix vector multiply
F11ZAF	18	Real sparse nonsymmetric matrix reorder routine
F11ZBF	17	Real sparse symmetric matrix reorder routine
F11ZNF	19	Complex sparse non-Hermitian matrix reorder routine
F11ZPF	19	Complex sparse Hermitian matrix reorder routine

F12 – Large Scale Eigenproblems

Routine Name	Mark of Introduction	Purpose
F12AAF	21	Initialization routine for (F12ABF) computing selected eigenvalues and, optionally, eigenvectors of a real nonsymmetric sparse (standard or generalized) eigenproblem
F12ABF	21	Implements a reverse communication interface for the Implicitly Restarted Arnoldi iteration for computing selected eigenvalues and, optionally, eigenvectors of a real nonsymmetric sparse (standard or generalized) eigenproblem
F12ACF	21	Returns the converged approximations (as determined by F12ABF) to eigenvalues of a real nonsymmetric sparse (standard or generalized) eigenproblem and, optionally, the corresponding approximate eigenvectors and/or an orthonormal basis for the associated approximate invariant subspace
F12ADF	21	Set a single option from a string (F12ABF/F12ACF/F12AGF)
F12AEF	21	Provides monitoring information for F12ABF
F12AFF	21	Initialization routine for (F12AGF) computing selected eigenvalues and, optionally, eigenvectors of a real nonsymmetric banded (standard or generalized) eigenproblem
F12AGF	21	Computes approximations to selected eigenvalues of a real nonsymmetric banded (standard or generalized) eigenproblem and, optionally, the corresponding approximate eigenvectors and/or an orthonormal basis for the associated approximate invariant subspace
F12ANF	21	Initialization routine for (F12APF) computing selected eigenvalues and, optionally, eigenvectors of a complex sparse (standard or generalized) eigenproblem
F12APF	21	Implements a reverse communication interface for the Implicitly Restarted Arnoldi iteration for computing selected eigenvalues and, optionally, eigenvectors of a complex sparse (standard or generalized) eigenproblem
F12AQF	21	Returns the converged approximations (as determined by F12ABF) to eigenvalues of a complex sparse (standard or generalized) eigenproblem and, optionally, the corresponding approximate eigenvectors and/or an orthonormal basis for the associated approximate invariant subspace
F12ARF	21	Set a single option from a string (F12APF/F12AQF)
F12ASF	21	Provides monitoring information for F12APF
F12FAF	21	Initialization routine for (F12FBF) computing selected eigenvalues and, optionally, eigenvectors of a real symmetric sparse (standard or generalized) eigenproblem

F12FBF	21	Implements a reverse communication interface for the Implicitly Restarted Arnoldi iteration for computing selected eigenvalues and, optionally, eigenvectors of a real symmetric sparse (standard or generalized) eigenproblem
F12FCF	21	Returns the converged approximations (as determined by F12ABF) to eigenvalues of a real symmetric sparse (standard or generalized) eigenproblem and, optionally, the corresponding approximate eigenvectors and/or an orthonormal basis for the associated approximate invariant subspace
F12FDF	21	Set a single option from a string (F12FBF/F12FCF/F12FGF)
F12FEF	21	Provides monitoring information for F12FBF
F12FFF	21	Initialization routine for (F12FGF) computing selected eigenvalues and, optionally, eigenvectors of a real symmetric banded (standard or generalized) eigenproblem
F12FGF	21	Computes approximations to selected eigenvalues of a real symmetric banded (standard or generalized) eigenproblem and, optionally, the corresponding approximate eigenvectors and/or an orthonormal basis for the associated approximate invariant subspace

G01 – Simple Calculations on Statistical Data

Routine Name	Mark of Introduction	Purpose
G01AAF	4	Mean, variance, skewness, kurtosis, etc., one variable, from raw data
G01ABF	4	Mean, variance, skewness, kurtosis, etc., two variables, from raw data
G01ADF	4	Mean, variance, skewness, kurtosis, etc., one variable, from frequency table
G01AEF	4	Frequency table from raw data
G01AFF	4	Two-way contingency table analysis, with χ^2/Fisher's exact test
G01AGF	8	Lineprinter scatterplot of two variables
G01AHF	8	Lineprinter scatterplot of one variable against Normal scores
G01AJF	10	Lineprinter histogram of one variable
G01ALF	14	Computes a five-point summary (median, hinges and extremes)
G01ARF	14	Constructs a stem and leaf plot
G01ASF	14	Constructs a box and whisker plot
G01BJF	13	Binomial distribution function
G01BKF	13	Poisson distribution function
G01BLF	13	Hypergeometric distribution function
G01DAF	8	Normal scores, accurate values
G01DBF	12	Normal scores, approximate values
G01DCF	12	Normal scores, approximate variance-covariance matrix
G01DDF	12	Shapiro and Wilk's W test for Normality
G01DHF	15	Ranks, Normal scores, approximate Normal scores or exponential (Savage) scores
G01EAF	15	Computes probabilities for the standard Normal distribution
G01EBF	14	Computes probabilities for Student's t-distribution
G01ECF	14	Computes probabilities for χ^2 distribution
G01EDF	14	Computes probabilities for F-distribution
G01EEF	14	Computes upper and lower tail probabilities and probability density function for the beta distribution
G01EFF	14	Computes probabilities for the gamma distribution
G01EMF	15	Computes probability for the Studentized range statistic

G01EPF	15	Computes bounds for the significance of a Durbin–Watson statistic
G01ERF	16	Computes probability for von Mises distribution
G01ETF	21	Landau distribution function $\Phi(\lambda)$
G01EUF	21	Vavilov distribution function $\Phi_V(\lambda;\kappa,\beta^2)$
G01EYF	14	Computes probabilities for the one-sample Kolmogorov–Smirnov distribution
G01EZF	14	Computes probabilities for the two-sample Kolmogorov–Smirnov distribution
G01FAF	15	Computes deviates for the standard Normal distribution
G01FBF	14	Computes deviates for Student's t-distribution
G01FCF	14	Computes deviates for the χ^2 distribution
G01FDF	14	Computes deviates for the F-distribution
G01FEF	14	Computes deviates for the beta distribution
G01FFF	14	Computes deviates for the gamma distribution
G01FMF	15	Computes deviates for the Studentized range statistic
G01FTF	21	Landau inverse function $\Psi(x)$
G01GBF	14	Computes probabilities for the non-central Student's t-distribution
G01GCF	14	Computes probabilities for the non-central χ^2 distribution
G01GDF	14	Computes probabilities for the non-central F-distribution
G01GEF	14	Computes probabilities for the non-central beta distribution
G01HAF	14	Computes probability for the bivariate Normal distribution
G01HBF	15	Computes probabilities for the multivariate Normal distribution
G01JCF	14	Computes probability for a positive linear combination of χ^2 variables
G01JDF	15	Computes lower tail probability for a linear combination of (central) χ^2 variables
G01MBF	15	Computes reciprocal of Mills' Ratio
G01MTF	21	Landau density function $\phi(\lambda)$
G01MUF	21	Vavilov density function $\phi_V(\lambda;\kappa,\beta^2)$
G01NAF	16	Cumulants and moments of quadratic forms in Normal variables
G01NBF	16	Moments of ratios of quadratic forms in Normal variables, and related statistics
G01PTF	21	Landau first moment function $\Phi_1(x)$
G01QTF	21	Landau second moment function $\Phi_2(x)$
G01RTF	21	Landau derivative function $\phi\prime(\lambda)$
G01ZUF	21	Initialization routine for G01MUF and G01EUF

G02 – Correlation and Regression Analysis

Routine Name	Mark of Introduction	Purpose
G02BAF	4	Pearson product-moment correlation coefficients, all variables, no missing values
G02BBF	4	Pearson product-moment correlation coefficients, all variables, casewise treatment of missing values
G02BCF	4	Pearson product-moment correlation coefficients, all variables, pairwise treatment of missing values
G02BDF	4	Correlation-like coefficients (about zero), all variables, no missing values
G02BEF	4	Correlation-like coefficients (about zero), all variables, casewise treatment of missing values
G02BFF	4	Correlation-like coefficients (about zero), all variables, pairwise treatment of missing values

G02BGF	4	Pearson product-moment correlation coefficients, subset of variables, no missing values
G02BHF	4	Pearson product-moment correlation coefficients, subset of variables, casewise treatment of missing values
G02BJF	4	Pearson product-moment correlation coefficients, subset of variables, pairwise treatment of missing values
G02BKF	4	Correlation-like coefficients (about zero), subset of variables, no missing values
G02BLF	4	Correlation-like coefficients (about zero), subset of variables, casewise treatment of missing values
G02BMF	4	Correlation-like coefficients (about zero), subset of variables, pairwise treatment of missing values
G02BNF	4	Kendall/Spearman non-parametric rank correlation coefficients, no missing values, overwriting input data
G02BPF	4	Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, overwriting input data
G02BQF	4	Kendall/Spearman non-parametric rank correlation coefficients, no missing values, preserving input data
G02BRF	4	Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, preserving input data
G02BSF	4	Kendall/Spearman non-parametric rank correlation coefficients, pairwise treatment of missing values
G02BTF	14	Update a weighted sum of squares matrix with a new observation
G02BUF	14	Computes a weighted sum of squares matrix
G02BWF	14	Computes a correlation matrix from a sum of squares matrix
G02BXF	14	Computes (optionally weighted) correlation and covariance matrices
G02BYF	17	Computes partial correlation/variance-covariance matrix from correlation/variance-covariance matrix computed by G02BXF
G02CAF	4	Simple linear regression with constant term, no missing values
G02CBF	4	Simple linear regression without constant term, no missing values
G02CCF	4	Simple linear regression with constant term, missing values
G02CDF	4	Simple linear regression without constant term, missing values
G02CEF	4	Service routines for multiple linear regression, select elements from vectors and matrices
G02CFF	4	Service routines for multiple linear regression, re-order elements of vectors and matrices
G02CGF	4	Multiple linear regression, from correlation coefficients, with constant term
G02CHF	4	Multiple linear regression, from correlation-like coefficients, without constant term
G02DAF	14	Fits a general (multiple) linear regression model
G02DCF	14	Add/delete an observation to/from a general linear regression model
G02DDF	14	Estimates of linear parameters and general linear regression model from updated model
G02DEF	14	Add a new independent variable to a general linear regression model
G02DFF	14	Delete an independent variable from a general linear regression model
G02DGF	14	Fits a general linear regression model to new dependent variable
G02DKF	14	Estimates and standard errors of parameters of a general linear regression model for given constraints
G02DNF	14	Computes estimable function of a general linear regression model and its standard error

G02EAF	14	Computes residual sums of squares for all possible linear regressions for a set of independent variables
G02ECF	14	Calculates R^2 and C_P values from residual sums of squares
G02EEF	14	Fits a linear regression model by forward selection
G02EFF	21	Stepwise linear regression
G02FAF	14	Calculates standardized residuals and influence statistics
G02FCF	15	Computes Durbin–Watson test statistic
G02GAF	14	Fits a generalized linear model with Normal errors
G02GBF	14	Fits a generalized linear model with binomial errors
G02GCF	14	Fits a generalized linear model with Poisson errors
G02GDF	14	Fits a generalized linear model with gamma errors
G02GKF	14	Estimates and standard errors of parameters of a general linear model for given constraints
G02GNF	14	Computes estimable function of a generalized linear model and its standard error
G02HAF	13	Robust regression, standard M-estimates
G02HBF	13	Robust regression, compute weights for use with G02HDF
G02HDF	13	Robust regression, compute regression with user-supplied functions and weights
G02HFF	13	Robust regression, variance-covariance matrix following G02HDF
G02HKF	14	Calculates a robust estimation of a correlation matrix, Huber's weight function
G02HLF	14	Calculates a robust estimation of a correlation matrix, user-supplied weight function plus derivatives
G02HMF	14	Calculates a robust estimation of a correlation matrix, user-supplied weight function
G02JAF	21	Linear mixed effects regression using Restricted Maximum Likelihood (REML)
G02JBF	21	Linear mixed effects regression using Maximum Likelihood (ML)

G03 – Multivariate Methods

Routine Name	Mark of Introduction	Purpose
G03AAF	14	Performs principal component analysis
G03ACF	14	Performs canonical variate analysis
G03ADF	14	Performs canonical correlation analysis
G03BAF	15	Computes orthogonal rotations for loading matrix, generalized orthomax criterion
G03BCF	15	Computes Procrustes rotations
G03CAF	15	Computes maximum likelihood estimates of the parameters of a factor analysis model, factor loadings, communalities and residual correlations
G03CCF	15	Computes factor score coefficients (for use after G03CAF)
G03DAF	15	Computes test statistic for equality of within-group covariance matrices and matrices for discriminant analysis
G03DBF	15	Computes Mahalanobis squared distances for group or pooled variance-covariance matrices (for use after G03DAF)
G03DCF	15	Allocates observations to groups according to selected rules (for use after G03DAF)
G03EAF	16	Computes distance matrix
G03ECF	16	Hierarchical cluster analysis
G03EFF	16	K-means cluster analysis
G03EHF	16	Constructs dendrogram (for use after G03ECF)
G03EJF	16	Computes cluster indicator variable (for use after G03ECF)

G03FAF	17	Performs principal co-ordinate analysis, classical metric scaling
G03FCF	17	Performs non-metric (ordinal) multidimensional scaling
G03ZAF	15	Produces standardized values (z-scores) for a data matrix

G04 – Analysis of Variance

Routine Name	Mark of Introduction	Purpose
G04AGF	8	Two-way analysis of variance, hierarchical classification, subgroups of unequal size
G04BBF	16	Analysis of variance, randomized block or completely randomized design, treatment means and standard errors
G04BCF	17	Analysis of variance, general row and column design, treatment means and standard errors
G04CAF	16	Analysis of variance, complete factorial design, treatment means and standard errors
G04DAF	17	Computes sum of squares for contrast between means
G04DBF	17	Computes confidence intervals for differences between means computed by G04BBF or G04BCF
G04EAF	17	Computes orthogonal polynomials or dummy variables for factor/classification variable

G05 – Random Number Generators

Routine Name	Mark of Introduction	Purpose
G05HKF	20	Univariate time series, generate n terms of either a symmetric GARCH process or a GARCH process with asymmetry of the form $(\epsilon_{t-1}+\gamma)^2$
G05HLF	20	Univariate time series, generate n terms of a GARCH process with asymmetry of the form $(\lvert\epsilon_{t-1}\rvert+\gamma\epsilon_{t-1})^2$
G05HMF	20	Univariate time series, generate n terms of an asymmetric Glosten, Jagannathan and Runkle (GJR) GARCH process
G05HNF	20	Univariate time series, generate n terms of an exponential GARCH (EGARCH) process
G05KAF	20	Pseudo-random real numbers, uniform distribution over (0,1), seeds and generator number passed explicitly
G05KBF	20	Initialize seeds of a given generator for random number generating routines (that pass seeds explicitly) to give a repeatable sequence
G05KCF	20	Initialize seeds of a given generator for random number generating routines (that pass seeds expicitly) to give non-repeatable sequence
G05KEF	20	Pseudo-random logical (boolean) value, seeds and generator number passed explicitly
G05LAF	20	Generates a vector of random numbers from a Normal distribution, seeds and generator number passed explicitly
G05LBF	20	Generates a vector of random numbers from a Student's t-distribution, seeds and generator number passed explicitly
G05LCF	20	Generates a vector of random numbers from a χ^2 distribution, seeds and generator number passed explicitly
G05LDF	20	Generates a vector of random numbers from an F-distribution, seeds and generator number passed explicitly
G05LEF	20	Generates a vector of random numbers from a β distribution, seeds and generator number passed explicitly

G05LFF	20	Generates a vector of random numbers from a γ distribution, seeds and generator number passed explicitly
G05LGF	20	Generates a vector of random numbers from a uniform distribution, seeds and generator number passed explicitly
G05LHF	20	Generates a vector of random numbers from a triangular distribution, seeds and generator number passed explicitly
G05LJF	20	Generates a vector of random numbers from an exponential distribution, seeds and generator number passed explicitly
G05LKF	20	Generates a vector of random numbers from a lognormal distribution, seeds and generator number passed explicitly
G05LLF	20	Generates a vector of random numbers from a Cauchy distribution, seeds and generator number passed explicitly
G05LMF	20	Generates a vector of random numbers from a Weibull distribution, seeds and generator number passed explicitly
G05LNF	20	Generates a vector of random numbers from a logistic distribution, seeds and generator number passed explicitly
G05LPF	20	Generates a vector of random numbers from a von Mises distribution, seeds and generator number passed explicitly
G05LQF	20	Generates a vector of random numbers from an exponential mixture distribution, seeds and generator number passed explicitly
G05LXF	21	Generates a matrix of random numbers from a multivariate Student's *t*-distribution, seeds and generator passed explicitly
G05LYF	21	Generates a matrix of random numbers from a multivariate Normal distribution, seeds and generator passed explicitly
G05LZF	20	Generates a vector of random numbers from a multivariate Normal distribution, seeds and generator number passed explicitly
G05MAF	20	Generates a vector of random integers from a uniform distribution, seeds and generator number passed explicitly
G05MBF	20	Generates a vector of random integers from a geometric distribution, seeds and generator number passed explicitly
G05MCF	20	Generates a vector of random integers from a negative binomial distribution, seeds and generator number passed explicitly
G05MDF	20	Generates a vector of random integers from a logarithmic distribution, seeds and generator number passed explicitly
G05MEF	20	Generates a vector of random integers from a Poisson distribution with varying mean, seeds and generator number passed explicitly
G05MJF	20	Generates a vector of random integers from a binomial distribution, seeds and generator number passed explicitly
G05MKF	20	Generates a vector of random integers from a Poisson distribution, seeds and generator number passed explicitly
G05MLF	20	Generates a vector of random integers from a hypergeometric distribution, seeds and generator number passed explicitly
G05MRF	20	Generates a vector of random integers from a multinomial distribution, seeds and generator number passed explicitly
G05MZF	20	Generates a vector of random integers from a general discrete distribution, seeds and generator number passed explicitly
G05NAF	20	Pseudo-random permutation of an integer vector
G05NBF	20	Pseudo-random sample from an integer vector
G05PAF	20	Generates a realisation of a time series from an ARMA model
G05PCF	20	Generates a realisation of a multivariate time series from a VARMA model
G05QAF	20	Computes a random orthogonal matrix
G05QBF	20	Computes a random correlation matrix
G05QDF	20	Generates a random table matrix

G05RAF	21	Generates a matrix of random numbers from a Gaussian Copula, seeds and generator passed explicitly
G05RBF	21	Generates a matrix of random numbers from a Student's *t*-Copula, seeds and generator passed explicitly
G05YCF	21	Initializes the Faure generator (G05YDF/G05YJF/G05YKF)
G05YDF	21	Generates a sequence of quasi-random numbers using Faure's method
G05YEF	21	Initializes the Sobol generator (G05YFF/G05YJF/G05YKF)
G05YFF	21	Generates a sequence of quasi-random numbers using Sobol's method
G05YGF	21	Initializes the Neiderreiter generator (G05YHF/G05YJF/G05YKF)
G05YHF	21	Generates a sequence of quasi-random numbers using Neiderreiter's method
G05YJF	21	Generates a Normal quasi-random number sequence using Faure's, Sobol's or Neiderreiter's method
G05YKF	21	Generates a log-Normal quasi-random number sequence using Faure's, Sobol's or Neiderreiter's method

G07 – Univariate Estimation

Routine Name	Mark of Introduction	Purpose
G07AAF	15	Computes confidence interval for the parameter of a binomial distribution
G07ABF	15	Computes confidence interval for the parameter of a Poisson distribution
G07BBF	15	Computes maximum likelihood estimates for parameters of the Normal distribution from grouped and/or censored data
G07BEF	15	Computes maximum likelihood estimates for parameters of the Weibull distribution
G07CAF	15	Computes *t*-test statistic for a difference in means between two Normal populations, confidence interval
G07DAF	13	Robust estimation, median, median absolute deviation, robust standard deviation
G07DBF	13	Robust estimation, *M*-estimates for location and scale parameters, standard weight functions
G07DCF	13	Robust estimation, *M*-estimates for location and scale parameters, user-defined weight functions
G07DDF	14	Computes a trimmed and winsorized mean of a single sample with estimates of their variance
G07EAF	16	Robust confidence intervals, one-sample
G07EBF	16	Robust confidence intervals, two-sample

G08 – Nonparametric Statistics

Routine Name	Mark of Introduction	Purpose
G08AAF	8	Sign test on two paired samples
G08ACF	8	Median test on two samples of unequal size
G08AEF	8	Friedman two-way analysis of variance on k matched samples
G08AFF	8	Kruskal–Wallis one-way analysis of variance on k samples of unequal size
G08AGF	14	Performs the Wilcoxon one-sample (matched pairs) signed rank test
G08AHF	14	Performs the Mann–Whitney U test on two independent samples

G08AJF	14	Computes the exact probabilities for the Mann–Whitney U statistic, no ties in pooled sample
G08AKF	14	Computes the exact probabilities for the Mann–Whitney U statistic, ties in pooled sample
G08ALF	15	Performs the Cochran Q test on cross-classified binary data
G08BAF	8	Mood's and David's tests on two samples of unequal size
G08CBF	14	Performs the one-sample Kolmogorov–Smirnov test for standard distributions
G08CCF	14	Performs the one-sample Kolmogorov–Smirnov test for a user-supplied distribution
G08CDF	14	Performs the two-sample Kolmogorov–Smirnov test
G08CGF	14	Performs the χ^2 goodness of fit test, for standard continuous distributions
G08DAF	8	Kendall's coefficient of concordance
G08EAF	14	Performs the runs up or runs down test for randomness
G08EBF	14	Performs the pairs (serial) test for randomness
G08ECF	14	Performs the triplets test for randomness
G08EDF	14	Performs the gaps test for randomness
G08RAF	12	Regression using ranks, uncensored data
G08RBF	12	Regression using ranks, right-censored data

G10 – Smoothing in Statistics

Routine Name	Mark of Introduction	Purpose
G10ABF	16	Fit cubic smoothing spline, smoothing parameter given
G10ACF	16	Fit cubic smoothing spline, smoothing parameter estimated
G10BAF	16	Kernel density estimate using Gaussian kernel
G10CAF	16	Compute smoothed data sequence using running median smoothers
G10ZAF	16	Reorder data to give ordered distinct observations

G11 – Contingency Table Analysis

Routine Name	Mark of Introduction	Purpose
G11AAF	16	χ^2 statistics for two-way contingency table
G11BAF	17	Computes multiway table from set of classification factors using selected statistic
G11BBF	17	Computes multiway table from set of classification factors using given percentile/quantile
G11BCF	17	Computes marginal tables for multiway table computed by G11BAF or G11BBF
G11CAF	19	Returns parameter estimates for the conditional analysis of stratified data
G11SAF	12	Contingency table, latent variable model for binary data
G11SBF	12	Frequency count for G11SAF

G12 – Survival Analysis

Routine Name	Mark of Introduction	Purpose
G12AAF	15	Computes Kaplan–Meier (product-limit) estimates of survival probabilities
G12BAF	17	Fits Cox's proportional hazard model

G12ZAF	19	Creates the risk sets associated with the Cox proportional hazards model for fixed covariates

G13 – Time Series Analysis

Routine Name	Mark of Introduction	Purpose
G13AAF	9	Univariate time series, seasonal and non-seasonal differencing
G13ABF	9	Univariate time series, sample autocorrelation function
G13ACF	9	Univariate time series, partial autocorrelations from autocorrelations
G13ADF	9	Univariate time series, preliminary estimation, seasonal ARIMA model
G13AEF	9	Univariate time series, estimation, seasonal ARIMA model (comprehensive)
G13AFF	9	Univariate time series, estimation, seasonal ARIMA model (easy-to-use)
G13AGF	9	Univariate time series, update state set for forecasting
G13AHF	9	Univariate time series, forecasting from state set
G13AJF	10	Univariate time series, state set and forecasts, from fully specified seasonal ARIMA model
G13ASF	13	Univariate time series, diagnostic checking of residuals, following G13AEF or G13AFF
G13AUF	14	Computes quantities needed for range-mean or standard deviation-mean plot
G13BAF	10	Multivariate time series, filtering (pre-whitening) by an ARIMA model
G13BBF	11	Multivariate time series, filtering by a transfer function model
G13BCF	10	Multivariate time series, cross-correlations
G13BDF	11	Multivariate time series, preliminary estimation of transfer function model
G13BEF	11	Multivariate time series, estimation of multi-input model
G13BGF	11	Multivariate time series, update state set for forecasting from multi-input model
G13BHF	11	Multivariate time series, forecasting from state set of multi-input model
G13BJF	11	Multivariate time series, state set and forecasts from fully specified multi-input model
G13CAF	10	Univariate time series, smoothed sample spectrum using rectangular, Bartlett, Tukey or Parzen lag window
G13CBF	10	Univariate time series, smoothed sample spectrum using spectral smoothing by the trapezium frequency (Daniell) window
G13CCF	10	Multivariate time series, smoothed sample cross spectrum using rectangular, Bartlett, Tukey or Parzen lag window
G13CDF	10	Multivariate time series, smoothed sample cross spectrum using spectral smoothing by the trapezium frequency (Daniell) window
G13CEF	10	Multivariate time series, cross amplitude spectrum, squared coherency, bounds, univariate and bivariate (cross) spectra
G13CFF	10	Multivariate time series, gain, phase, bounds, univariate and bivariate (cross) spectra
G13CGF	10	Multivariate time series, noise spectrum, bounds, impulse response function and its standard error
G13DBF	11	Multivariate time series, multiple squared partial autocorrelations
G13DCF	12	Multivariate time series, estimation of VARMA model
G13DJF	15	Multivariate time series, forecasts and their standard errors

G13DKF	15	Multivariate time series, updates forecasts and their standard errors
G13DLF	15	Multivariate time series, differences and/or transforms
G13DMF	15	Multivariate time series, sample cross-correlation or cross-covariance matrices
G13DNF	15	Multivariate time series, sample partial lag correlation matrices, χ^2 statistics and significance levels
G13DPF	16	Multivariate time series, partial autoregression matrices
G13DSF	13	Multivariate time series, diagnostic checking of residuals, following G13DCF
G13DXF	15	Calculates the zeros of a vector autoregressive (or moving average) operator
G13EAF	17	Combined measurement and time update, one iteration of Kalman filter, time-varying, square root covariance filter
G13EBF	17	Combined measurement and time update, one iteration of Kalman filter, time-invariant, square root covariance filter
G13FAF	20	Univariate time series, parameter estimation for either a symmetric GARCH process or a GARCH process with asymmetry of the form $(\epsilon_{t-1}+\gamma)^2$
G13FBF	20	Univariate time series, forecast function for either a symmetric GARCH process or a GARCH process with asymmetry of the form $(\epsilon_{t-1}+\gamma)^2$
G13FCF	20	Univariate time series, parameter estimation for a GARCH process with asymmetry of the form $(\lvert\epsilon_{t-1}\rvert+\gamma\epsilon_{t-1})^2$
G13FDF	20	Univariate time series, forecast function for a GARCH process with asymmetry of the form $(\lvert\epsilon_{t-1}\rvert+\gamma\epsilon_{t-1})^2$
G13FEF	20	Univariate time series, parameter estimation for an asymmetric Glosten, Jagannathan and Runkle (GJR) GARCH process
G13FFF	20	Univariate time series, forecast function for an asymmetric Glosten, Jagannathan and Runkle (GJR) GARCH process
G13FGF	20	Univariate time series, parameter estimation for an exponential GARCH (EGARCH) process
G13FHF	20	Univariate time series, forecast function for an exponential GARCH (EGARCH) process

H – Operations Research

Routine Name	Mark of Introduction	Purpose
H02BBF	14	Integer LP problem (dense)
H02BFF	16	Interpret MPSX data file defining IP or LP problem, optimize and print solution
H02BUF	16	Convert MPSX data file defining IP or LP problem to format required by H02BBF or E04MFF/E04MFA
H02BVF	16	Print IP or LP solutions with user specified names for rows and columns
H02BZF	15	Integer programming solution, supplies further information on solution obtained by H02BBF
H02CBF	19	Integer QP problem (dense)
H02CCF	19	Read optional parameter values for H02CBF from external file
H02CDF	19	Supply optional parameter values to H02CBF
H02CEF	19	Integer LP or QP problem (sparse)
H02CFF	19	Read optional parameter values for H02CEF from external file
H02CGF	19	Supply optional parameter values to H02CEF
H03ABF	4	Transportation problem, modified ‘stepping stone’ method
H03ADF	18	Shortest path problem, Dijkstra’s algorithm

M01 – Sorting

Routine Name	Mark of Introduction	Purpose
M01CAF	12	Sort a vector, real numbers
M01CBF	12	Sort a vector, integer numbers
M01CCF	12	Sort a vector, character data
M01DAF	12	Rank a vector, real numbers
M01DBF	12	Rank a vector, integer numbers
M01DCF	12	Rank a vector, character data
M01DEF	12	Rank rows of a matrix, real numbers
M01DFF	12	Rank rows of a matrix, integer numbers
M01DJF	12	Rank columns of a matrix, real numbers
M01DKF	12	Rank columns of a matrix, integer numbers
M01DZF	12	Rank arbitrary data
M01EAF	12	Rearrange a vector according to given ranks, real numbers
M01EBF	12	Rearrange a vector according to given ranks, integer numbers
M01ECF	12	Rearrange a vector according to given ranks, character data
M01EDF	19	Rearrange a vector according to given ranks, complex numbers
M01ZAF	12	Invert a permutation
M01ZBF	12	Check validity of a permutation
M01ZCF	12	Decompose a permutation into cycles

P01 – Error Trapping

Routine Name	Mark of Introduction	Purpose
P01ABF	12	Return value of error indicator/terminate with error message

S – Approximations of Special Functions

Routine Name	Mark of Introduction	Purpose
S01BAF	14	$\ln(1+x)$
S01EAF	14	Complex exponential, e^z
S07AAF	1	$\tan x$
S09AAF	1	$\arcsin x$
S09ABF	3	$\arccos x$
S10AAF	3	$\tanh x$
S10ABF	4	$\sinh x$
S10ACF	4	$\cosh x$
S11AAF	4	$\operatorname{arctanh} x$
S11ABF	4	$\operatorname{arcsinh} x$
S11ACF	4	$\operatorname{arccosh} x$
S13AAF	1	Exponential integral $E_1(x)$
S13ACF	2	Cosine integral $\mathrm{Ci}(x)$
S13ADF	5	Sine integral $\mathrm{Si}(x)$
S14AAF	1	Gamma function
S14ABF	8	Log Gamma function
S14ACF	14	$\psi(x) - \ln x$
S14ADF	14	Scaled derivatives of $\psi(x)$
S14AEF	20	Polygamma function $\psi^{(n)}(x)$ for real x
S14AFF	20	Polygamma function $\psi^{(n)}(z)$ for complex z
S14AGF	21	Logarithm of the Gamma function $\ln \Gamma(z)$
S14BAF	14	Incomplete Gamma functions $P(a,x)$ and $Q(a,x)$

S15ABF	3	Cumulative Normal distribution function $P(x)$
S15ACF	4	Complement of cumulative Normal distribution function $Q(x)$
S15ADF	4	Complement of error function $\mathrm{erfc}(x)$
S15AEF	4	Error function $\mathrm{erf}(x)$
S15AFF	7	Dawson's integral
S15DDF	14	Scaled complex complement of error function, $\exp(-z^2)\,\mathrm{erfc}(-iz)$
S17ACF	1	Bessel function $Y_0(x)$
S17ADF	1	Bessel function $Y_1(x)$
S17AEF	5	Bessel function $J_0(x)$
S17AFF	5	Bessel function $J_1(x)$
S17AGF	8	Airy function $\mathrm{Ai}(x)$
S17AHF	8	Airy function $\mathrm{Bi}(x)$
S17AJF	8	Airy function $\mathrm{Ai}'(x)$
S17AKF	8	Airy function $\mathrm{Bi}\prime(x)$
S17ALF	20	Zeros of Bessel functions $J_\alpha(x)$, $J_\alpha\prime(x)$, $Y_\alpha(x)$ or $Y_\alpha\prime(x)$
S17DCF	13	Bessel functions $Y_{\nu+a}(z)$, real $a \geq 0$, complex z, $\nu = 0, 1, 2, \ldots$
S17DEF	13	Bessel functions $J_{\nu+a}(z)$, real $a \geq 0$, complex z, $\nu = 0, 1, 2, \ldots$
S17DGF	13	Airy functions $\mathrm{Ai}(z)$ and $\mathrm{Ai}\prime(z)$, complex z
S17DHF	13	Airy functions $\mathrm{Bi}(z)$ and $\mathrm{Bi}\prime(z)$, complex z
S17DLF	13	Hankel functions $H^{(j)}_{\nu+a}(z)$, $j = 1, 2$, real $a \geq 0$, complex z, ν=0, 1, 2, ...
S18ACF	1	Modified Bessel function $K_0(x)$
S18ADF	1	Modified Bessel function $K_1(x)$
S18AEF	5	Modified Bessel function $I_0(x)$
S18AFF	5	Modified Bessel function $I_1(x)$
S18CCF	10	Scaled modified Bessel function $e^x K_0(x)$
S18CDF	10	Scaled modified Bessel function $e^x K_1(x)$
S18CEF	10	Scaled modified Bessel function $e^{-\lvert x\rvert} I_0(x)$
S18CFF	10	Scaled modified Bessel function $e^{-\lvert x\rvert} I_1(x)$
S18DCF	13	Modified Bessel functions $K_{\nu+a}(z)$, real $a \geq 0$, complex z, $\nu = 0, 1, 2, \ldots$
S18DEF	13	Modified Bessel functions $I_{\nu+a}(z)$, real $a \geq 0$, complex z, $\nu = 0, 1, 2, \ldots$
S18GKF	21	Bessel function of the 1st kind $J_{\alpha\pm n}(z)$
S19AAF	11	Kelvin function $\mathrm{ber}\,x$
S19ABF	11	Kelvin function $\mathrm{bei}\,x$
S19ACF	11	Kelvin function $\mathrm{ker}\,x$
S19ADF	11	Kelvin function $\mathrm{kei}\,x$
S20ACF	5	Fresnel integral $S(x)$
S20ADF	5	Fresnel integral $C(x)$
S21BAF	8	Degenerate symmetrised elliptic integral of 1st kind $R_C(x, y)$
S21BBF	8	Symmetrised elliptic integral of 1st kind $R_F(x, y, z)$
S21BCF	8	Symmetrised elliptic integral of 2nd kind $R_D(x, y, z)$
S21BDF	8	Symmetrised elliptic integral of 3rd kind $R_J(x, y, z, r)$
S21CAF	15	Jacobian elliptic functions sn, cn and dn of real argument
S21CBF	20	Jacobian elliptic functions sn, cn and dn of complex argument
S21CCF	20	Jacobian theta functions $\theta_k(x, q)$ of real argument
S21DAF	20	General elliptic integral of 2nd kind $F(z, k\prime, a, b)$ of complex argument
S22AAF	20	Legendre functions of 1st kind $P^m_n(x)$ or $\overline{P^m_n}(x)$

X01 – Mathematical Constants

Routine Name	Mark of Introduction	Purpose
X01AAF	5	Provides the mathematical constant π
X01ABF	5	Provides the mathematical constant γ (Euler's Constant)

X02 – Machine Constants

Routine Name	Mark of Introduction	Purpose
X02AHF	9	The largest permissible argument for sin and cos
X02AJF	12	The machine precision
X02AKF	12	The smallest positive model number
X02ALF	12	The largest positive model number
X02AMF	12	The safe range parameter
X02ANF	15	The safe range parameter for complex floating-point arithmetic
X02BBF	5	The largest representable integer
X02BEF	5	The maximum number of decimal digits that can be represented
X02BHF	12	The floating-point model parameter, b
X02BJF	12	The floating-point model parameter, p
X02BKF	12	The floating-point model parameter $e_{\min}$
X02BLF	12	The floating-point model parameter $e_{\max}$
X02DAF	8	Switch for taking precautions to avoid underflow
X02DJF	12	The floating-point model parameter ROUNDS

X03 – Inner Products

Routine Name	Mark of Introduction	Purpose
X03AAF	5	Real inner product added to initial value, basic/additional precision
X03ABF	5	Complex inner product added to initial value, basic/additional precision

X04 – Input/Output Utilities

Routine Name	Mark of Introduction	Purpose
X04AAF	7	Return or set unit number for error messages
X04ABF	7	Return or set unit number for advisory messages
X04ACF	19	Open unit number for reading, writing or appending, and associate unit with named file
X04ADF	19	Close file associated with given unit number
X04BAF	12	Write formatted record to external file
X04BBF	12	Read formatted record from external file
X04CAF	14	Print real general matrix (easy-to-use)
X04CBF	14	Print real general matrix (comprehensive)
X04CCF	14	Print real packed triangular matrix (easy-to-use)
X04CDF	14	Print real packed triangular matrix (comprehensive)
X04CEF	14	Print real packed banded matrix (easy-to-use)
X04CFF	14	Print real packed banded matrix (comprehensive)
X04DAF	14	Print complex general matrix (easy-to-use)
X04DBF	14	Print complex general matrix (comprehensive)
X04DCF	14	Print complex packed triangular matrix (easy-to-use)

X04DDF	14	Print complex packed triangular matrix (comprehensive)
X04DEF	14	Print complex packed banded matrix (easy-to-use)
X04DFF	14	Print complex packed banded matrix (comprehensive)
X04EAF	14	Print integer matrix (easy-to-use)
X04EBF	14	Print integer matrix (comprehensive)

X05 – Date and Time Utilities

Routine Name	Mark of Introduction	Purpose
X05AAF	14	Return date and time as an array of integers
X05ABF	14	Convert array of integers representing date and time to character string
X05ACF	14	Compare two character strings representing date and time
X05BAF	14	Return the CPU time