

NAG Library

Mark 22 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
A00ADF	22	Library identification, details of implementation, major and minor marks

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's method
C02AGF	13	All zeros of real polynomial, modified Laguerre's 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, Brent algorithm
C05AGF	8	Zero of continuous function, Brent 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 Brent algorithm (reverse communication)

C05BAF	22	Real values of Lambert's W function, $W(x)$
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)
C05PBA	22	Solution of system of nonlinear equations using first derivatives (easy-to-use)
C05PBF	9	Solution of system of nonlinear equations using first derivatives (easy-to-use)
C05PCA	22	Solution of system of nonlinear equations using first derivatives (comprehensive)
C05PCF	9	Solution of system of nonlinear equations using first derivatives (comprehensive)
C05PDA	20	Solution of system of nonlinear equations using first derivatives (reverse communication)
C05PDF	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 storage format for Hermitian sequences
C06PCF	19	Single one-dimensional complex discrete Fourier transform, complex data type
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 storage format for Hermitian sequences
C06PQF	19	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex storage format for Hermitian sequences
C06PRF	19	Multiple one-dimensional complex discrete Fourier transforms using complex data type
C06PSF	19	Multiple one-dimensional complex discrete Fourier transforms using complex data type and sequences stored as columns
C06PUF	19	Two-dimensional complex discrete Fourier transform, complex data type
C06PXF	19	Three-dimensional complex discrete Fourier transform, Complex data type
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)

C09 – Wavelet Transforms

Routine Name	Mark of Introduction	Purpose
C09AAF	22	Wavelet filter initialization
C09CAF	22	one-dimensional discrete wavelet transform
C09CBF	22	one-dimensional inverse discrete wavelet transform

C09CCF	22	one-dimensional multi-level discrete wavelet transform
C09CDF	22	one-dimensional inverse multi-level discrete wavelet transform

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	8	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	Ordinary differential equations, boundary value problem, shooting and matching technique, allowing interior matching point, general parameters to be determined
D02BGF	7	Ordinary differential equations, initial value problem, Runge–Kutta–Merson method, until a component attains given value (simple driver)
D02BHF	7	Ordinary differential equations, initial value problem, Runge–Kutta–Merson method, until function of solution is zero (simple driver)
D02BJF	18	Ordinary differential equations, initial value problem, Runge–Kutta method, until function of solution is zero, integration over range with intermediate output (simple driver)
D02CJF	13	Ordinary differential equations, initial value problem, Adams method, until function of solution is zero, intermediate output (simple driver)
D02EJF	12	Ordinary differential equations, stiff initial value problem, backward diffential formulae method, until function of solution is zero, intermediate output (simple driver)
D02GAF	8	Ordinary differential equations, boundary value problem, finite difference technique with deferred correction, simple nonlinear problem
D02GBF	8	Ordinary differential equations, boundary value problem, finite difference technique with deferred correction, general linear problem
D02HAF	8	Ordinary differential equations, boundary value problem, shooting and matching, boundary values to be determined
D02HBF	8	Ordinary differential equations, boundary value problem, shooting and matching, general parameters to be determined
D02JAF	8	Ordinary differential equations, boundary value problem, collocation and least-squares, single n th-order linear equation
D02JBF	8	Ordinary differential equations, 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 ordinary differential equations, initial value problem, Runge–Kutta–Nystrom method
D02LXF	13	Second-order ordinary differential equations, initial value problem, setup for D02LAF
D02LYF	13	Second-order ordinary differential equations, initial value problem, diagnostics for D02LAF
D02LZF	13	Second-order ordinary differential equations, initial value problem, interpolation for D02LAF
D02MCF	22	Implicit ordinary differential equations/DAEs, initial value problem, DASSL method continuation for D02NEF
D02MVF	14	Ordinary differential equations, initial value problem, DASSL method, setup for D02M–N routines
D02MWF	22	Implicit ordinary differential equations/DAEs, initial value problem, setup for D02NEF
D02MZF	14	Ordinary differential equations, initial value problem, interpolation for D02M–N routines, natural interpolant
D02NBF	12	Explicit ordinary differential equations, stiff initial value problem, full Jacobian (comprehensive)
D02NCF	12	Explicit ordinary differential equations, stiff initial value problem, banded Jacobian (comprehensive)
D02NDF	12	Explicit ordinary differential equations, stiff initial value problem, sparse Jacobian (comprehensive)
D02NEF	22	Implicit ordinary differential equations/DAEs, initial value problem, DASSL method integrator
D02NGF	12	Implicit/algebraic ordinary differential equations, stiff initial value problem, full Jacobian (comprehensive)
D02NHF	12	Implicit/algebraic ordinary differential equations, stiff initial value problem, banded Jacobian (comprehensive)
D02NJF	12	Implicit/algebraic ordinary differential equations, stiff initial value problem, sparse Jacobian (comprehensive)
D02NMF	12	Explicit ordinary differential equations, stiff initial value problem (reverse communication, comprehensive)
D02NNF	12	Implicit/algebraic ordinary differential equations, stiff initial value problem (reverse communication, comprehensive)
D02NPF	22	Implicit ordinary differential equations/DAEs, initial value problem linear algebra setup routine for D02NEF
D02NRF	12	Ordinary differential equations, initial value problem, for use with D02M–N routines, sparse Jacobian, enquiry routine
D02NSF	12	Ordinary differential equations, initial value problem, for use with D02M–N routines, full Jacobian, linear algebra set up
D02NTF	12	Ordinary differential equations, initial value problem, for use with D02M–N routines, banded Jacobian, linear algebra set up
D02NUF	12	Ordinary differential equations, initial value problem, for use with D02M–N routines, sparse Jacobian, linear algebra set up

D02NVF	12	Ordinary differential equations, initial value problem, backward differential formulae method, setup for D02M–N routines
D02NWF	12	Ordinary differential equations, initial value problem, Blend method, setup for D02M–N routines
D02NXF	12	Ordinary differential equations, initial value problem, sparse Jacobian, linear algebra diagnostics, for use with D02M–N routines
D02NYF	12	Ordinary differential equations, initial value problem, integrator diagnostics, for use with D02M–N routines
D02NZF	12	Ordinary differential equations, initial value problem, setup for continuation calls to integrator, for use with D02M–N routines
D02PCF	16	Ordinary differential equations, initial value problem, Runge–Kutta method, integration over range with output
D02PDF	16	Ordinary differential equations, initial value problem, Runge–Kutta method, integration over one step
D02PVF	16	Ordinary differential equations, initial value problem, setup for D02PCF and D02PDF
D02PWF	16	Ordinary differential equations, initial value problem, resets end of range for D02PDF
D02PXF	16	Ordinary differential equations, initial value problem, interpolation for D02PDF
D02PYF	16	Ordinary differential equations, initial value problem, integration diagnostics for D02PCF and D02PDF
D02PZF	16	Ordinary differential equations, initial value problem, error assessment diagnostics for D02PCF and D02PDF
D02QFF	13	Ordinary differential equations, initial value problem, Adams method with root-finding (forward communication, comprehensive)
D02QGF	13	Ordinary differential equations, initial value problem, Adams method with root-finding (reverse communication, comprehensive)
D02QWF	13	Ordinary differential equations, initial value problem, setup for D02QFF and D02QGF
D02QXF	13	Ordinary differential equations, initial value problem, diagnostics for D02QFF and D02QGF
D02QYF	13	Ordinary differential equations, initial value problem, root-finding diagnostics for D02QFF and D02QGF
D02QZF	13	Ordinary differential equations, initial value problem, interpolation for D02QFF or D02QGF
D02RAF	8	Ordinary differential equations, general nonlinear boundary value problem, finite difference technique with deferred correction, continuation facility
D02SAF	8	Ordinary differential equations, boundary value problem, shooting and matching technique, subject to extra algebraic equations, general parameters to be determined
D02TGF	8	n th-order linear ordinary differential equations, boundary value problem, collocation and least-squares
D02TKF	17	Ordinary differential equations, general nonlinear boundary value problem, collocation technique
D02TVF	17	Ordinary differential equations, general nonlinear boundary value problem, setup for D02TKF

D02TXF	17	Ordinary differential equations, general nonlinear boundary value problem, continuation facility for D02TKF
D02TYF	17	Ordinary differential equations, general nonlinear boundary value problem, interpolation for D02TKF
D02TZF	17	Ordinary differential equations, general nonlinear boundary value problem, diagnostics for D02TKF
D02XJF	12	Ordinary differential equations, initial value problem, interpolation for D02M–N routines, natural interpolant
D02XKF	12	Ordinary differential equations, initial value problem, interpolation for D02M–N routines, C_1 interpolant
D02ZAF	12	Ordinary differential equations, initial value problem, 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 coordinates
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
D03PCA	20	General system of parabolic PDEs, method of lines, finite differences, one space variable
D03PCF	15	General system of parabolic PDEs, method of lines, finite differences, one space variable
D03PDA	20	General system of parabolic PDEs, method of lines, Chebyshev C^0 collocation, one space variable
D03PDF	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
D03PHA	20	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, one space variable
D03PHF	15	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, one space variable

D03PJA	20	General system of parabolic PDEs, coupled DAEs, method of lines, Chebyshev C^0 collocation, one space variable
D03PJF	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
D03PPA	20	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, remeshing, one space variable
D03PPF	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 parallel to one independent coordinate axis
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
E04ABA	20	Minimum, function of one variable using function values only
E04ABF	6	Minimum, function of one variable using function values only
E04BBA	20	Minimum, function of one variable, using first derivative
E04BBF	6	Minimum, function of one variable, using first derivative
E04CBF	22	Unconstrained minimization using simplex algorithm, function of several variables using function values only
E04CCA	20	Unconstrained minimum, simplex algorithm, function of several variables using function values only (comprehensive)
E04CCF	1	Unconstrained minimum, simplex algorithm, function of several variables using function values only (comprehensive)
E04DGA	20	Unconstrained minimum, preconditioned conjugate gradient algorithm, function of several variables using first derivatives (comprehensive)
E04DGF	12	Unconstrained minimum, preconditioned conjugate gradient algorithm, function of several variables using first derivatives (comprehensive)
E04DJA	20	Supply optional parameter values for E04DGF/E04DGA from external file
E04DJF	12	Supply optional parameter values for E04DGF/E04DGA from external file
E04DKA	20	Supply optional parameter values to E04DGF/E04DGA
E04DKF	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)
E04MFA	20	LP problem (dense)
E04MFF	16	LP problem (dense)
E04MGA	20	Supply optional parameter values for E04MFF/E04MFA from external file
E04MGF	16	Supply optional parameter values for E04MFF/E04MFA from external file
E04MHA	20	Supply optional parameter values to E04MFF/E04MFA
E04MHF	16	Supply optional parameter values to E04MFF/E04MFA
E04MZF	18	Converts MPSX data file defining LP or QP problem to format required by E04NKF/E04NKA
E04NCA	20	Convex QP problem or linearly-constrained linear least-squares problem (dense)
E04NCF	12	Convex QP problem or linearly-constrained linear least-squares problem (dense)
E04NDA	20	Supply optional parameter values for E04NCF/E04NCA from external file
E04NDF	12	Supply optional parameter values for E04NCF/E04NCA from external file
E04NEA	20	Supply optional parameter values to E04NCF/E04NCA
E04NEF	12	Supply optional parameter values to E04NCF/E04NCA
E04NFA	20	QP problem (dense)
E04NFF	16	QP problem (dense)
E04NGA	20	Supply optional parameter values for E04NFF/E04NFA from external file
E04NGF	16	Supply optional parameter values for E04NFF/E04NFA from external file
E04NHA	20	Supply optional parameter values to E04NFF/E04NFA
E04NHF	16	Supply optional parameter values to E04NFF/E04NFA
E04NKA	20	LP or QP problem (sparse)
E04NKF	18	LP or QP problem (sparse)
E04NLA	20	Supply optional parameter values for E04NKF/E04NKA from external file
E04NLF	18	Supply optional parameter values for E04NKF/E04NKA from external file
E04NMA	20	Supply optional parameter values to E04NKF/E04NKA
E04NMF	18	Supply optional parameter values to E04NKF/E04NKA
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 real argument
E04NXF	21	Get the setting of an integer valued option of E04NQF
E04NYF	21	Get the setting of a real valued option of E04NQF
E04UCA	20	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (comprehensive)
E04UCF	12	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (comprehensive)
E04UDA	20	Supply optional parameter values for E04UCF/E04UCA or E04UFF/E04UFA from external file
E04UDF	12	Supply optional parameter values for E04UCF/E04UCA or E04UFF/E04UFA from external file
E04UEA	20	Supply optional parameter values to E04UCF/E04UCA or E04UFF/E04UFA
E04UEF	12	Supply optional parameter values to E04UCF/E04UCA or E04UFF/E04UFA
E04UFA	20	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (reverse communication, comprehensive)
E04UFF	18	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (reverse communication, comprehensive)
E04UGA	20	NLP problem (sparse)
E04UGF	19	NLP problem (sparse)
E04UHA	20	Supply optional parameter values for E04UGF/E04UGA from external file
E04UHF	19	Supply optional parameter values for E04UGF/E04UGA from external file
E04UJA	20	Supply optional parameter values to E04UGF/E04UGA
E04UJF	19	Supply optional parameter values to E04UGF/E04UGA
E04UQA	20	Supply optional parameter values for E04USF/E04USA from external file
E04UQF	14	Supply optional parameter values for E04USF/E04USA from external file
E04URA	20	Supply optional parameter values to E04USF/E04USA
E04URF	14	Supply optional parameter values to E04USF/E04USA
E04USA	20	Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive)
E04USF	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 real argument
E04VRF	21	Get the setting of an integer valued option of E04VHF
E04VSF	21	Get the setting of a real valued option of E04VHF
E04WBF	20	Initialization routine for E04DGA, E04MFA, E04NCA, E04NFA, E04UFA, E04UGA and 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 real argument
E04WKF	21	Get the setting of an integer valued option of E04WDF
E04WLF	21	Get the setting of a real valued option of E04WDF
E04XAA	20	Estimate (using numerical differentiation) gradient and/or Hessian of a function
E04XAF	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)
E04ZCA	20	Check user's routines for calculating first derivatives of function and constraints
E04ZCF	11	Check user's routines for calculating first derivatives of function and constraints

E05 – Global Optimization of a Function

Routine Name	Mark of Introduction	Purpose
E05JAF	22	Initialization routine for E05JBF
E05JBF	22	Global optimization by multi-level coordinate search, simple bounds, using function values only
E05JCF	22	Supply optional parameter values for E05JBF from external file
E05JDF	22	Set a single optional parameter for E05JBF from a character string
E05JEF	22	Set a single optional parameter for E05JBF from an 'ON'/'OFF'-valued character argument
E05JFF	22	Set a single optional parameter for E05JBF from an integer argument
E05JGF	22	Set a single optional parameter for E05JBF from a real argument
E05JHF	22	Determine whether an optional parameter for E05JBF has been set by you or not
E05JJF	22	Get the setting of an 'ON'/'OFF'-valued character optional parameter of E05JBF
E05JKF	22	Get the setting of an Integer valued optional parameter of E05JBF

E05JLF 22 Get the setting of a real valued optional parameter of E05JBF

F – Linear Algebra

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	$ULDL^T U^T$ 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
F01ECF	22	Real matrix exponential
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
F02BJF	6	Computes all eigenvalues and, optionally, eigenvectors of generalized eigenproblem by QZ algorithm, real matrices (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02EAF	16	All eigenvalues and Schur factorization of real general matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02EBF	16	All eigenvalues and eigenvectors of real general matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02ECF	17	Selected eigenvalues and eigenvectors of real nonsymmetric matrix (Black Box)
F02FAF	16	Computes all eigenvalues and, optionally, eigenvectors of real symmetric matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02FCF	17	Selected eigenvalues and optionally eigenvectors of real symmetric matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02FDF	16	All eigenvalues and eigenvectors of real symmetric-definite generalized problem (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02FHF	11	All eigenvalues of generalized banded real symmetric-definite eigenproblem (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02FJF	11	Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)
F02GAF	16	All eigenvalues and Schur factorization of complex general matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02GBF	16	Computes all eigenvalues and, optionally, eigenvectors of complex general matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02GCF	17	Selected eigenvalues and eigenvectors of complex nonsymmetric matrix (Black Box)

F02GJF	8	Computes all eigenvalues and, optionally, eigenvectors of generalized complex eigenproblem by QZ algorithm (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02HAF	16	All eigenvalues and eigenvectors of complex Hermitian matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02HCF	17	Selected eigenvalues and eigenvectors of complex Hermitian matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02HDF	16	All eigenvalues and eigenvectors of complex Hermitian-definite generalized problem (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02SDF	8	Eigenvector of generalized real banded eigenproblem by inverse iteration
F02WDF	8	QR factorization, possibly followed by SVD
F02WEF	13	SVD of real matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F02WGF	22	Computes leading terms in the singular value decomposition of a real general matrix; also computes corresponding left and right singular vectors
F02WUF	14	SVD of real upper triangular matrix (Black Box)
F02XEF	13	SVD of complex matrix (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
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
F04AAF	2	Solution of real simultaneous linear equations with multiple right-hand sides (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04ABF	2	Solution of real symmetric positive-definite simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04ACF	2	Solution of real symmetric positive-definite banded simultaneous linear equations with multiple right-hand sides (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04ADF	2	Solution of complex simultaneous linear equations with multiple right-hand sides (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
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, $\text{rank} = n$, $m \geq n$ using iterative refinement (Black Box)
F04ARF	4	Solution of real simultaneous linear equations, one right-hand side (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
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.
F04EAF	11	Solution of real tridiagonal simultaneous linear equations, one right-hand side (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04FAF	11	Solution of real symmetric positive-definite tridiagonal simultaneous linear equations, one right-hand side (Black Box) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
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
F04JAF	8	Minimal least-squares solution of m real equations in n unknowns, rank $\leq n$, $m \geq n$ Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

F04JDF	8	Minimal least-squares solution of m real equations in n unknowns, $\text{rank} \leq m$, $m \leq n$ Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04JGF	8	Least-squares (if $\text{rank} = n$) or minimal least-squares (if $\text{rank} < n$) solution of m real equations in n unknowns, $m \geq n$
F04JLF	17	Real general Gauss–Markov linear model (including weighted least-squares) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04JMF	17	Equality-constrained real linear least-squares problem Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04KLF	17	Complex general Gauss–Markov linear model (including weighted least-squares) Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
F04KMF	17	Equality-constrained complex linear least-squares problem Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
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	12	DROTG 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 $(a^2 + b^2)$, 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
F06DFE	12	Copy integer vector
F06EAF	12	DDOT Dot product of two real vectors
F06ECF	12	DAXPY Add scalar times real vector to real vector
F06EDF	12	DSCAL Multiply real vector by scalar
F06EFF	12	DCOPY Copy real vector
F06EGF	12	DSWAP Swap two real vectors
F06EJF	12	DNRM2 Compute Euclidean norm of real vector
F06EKF	12	DASUM Sum absolute values of real vector elements
F06EPF	12	DROT Apply real plane rotation
F06ERF	14	DDOTI Dot product of two real sparse vectors
F06ETF	14	DAXPYI Add scalar times real sparse vector to real sparse vector
F06EUF	14	DGTHR Gather real sparse vector
F06EVF	14	DGTHRZ Gather and set to zero real sparse vector
F06EWF	14	DSCTR Scatter real sparse vector
F06EXF	14	DROTI 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	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	12	ZDOTU Dot product of two complex vectors, unconjugated
F06GBF	12	ZDOTC Dot product of two complex vectors, conjugated
F06GCF	12	ZAXPY Add scalar times complex vector to complex vector
F06GDF	12	ZSCAL Multiply complex vector by complex scalar
F06GFF	12	ZCOPY Copy complex vector
F06GGF	12	ZSWAP Swap two complex vectors
F06GRF	14	ZDOTUI Dot product of two complex sparse vector, unconjugated
F06GSF	14	ZDOTCI Dot product of two complex sparse vector, conjugated
F06GTF	14	ZAXPYI Add scalar times complex sparse vector to complex sparse vector
F06GUF	14	ZGTHR Gather complex sparse vector
F06GVF	14	ZGTHRZ Gather and set to zero complex sparse vector
F06GWF	14	ZSCTR 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
F06HMF	21	ZROT Apply plane rotation with real cosine and complex sine
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	12	ZDSCAL Multiply complex vector by real scalar
F06JJF	12	DZNRM2 Compute Euclidean norm of complex vector
F06JKF	12	DZASUM Sum absolute values of complex vector elements
F06JLF	12	IDAMAX Index, real vector element with largest absolute value
F06JMF	12	IZAMAX 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	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	12	DGEMV Matrix-vector product, real rectangular matrix
F06PBF	12	DGBMV Matrix-vector product, real rectangular band matrix
F06PCF	12	DSYMV Matrix-vector product, real symmetric matrix
F06PDF	12	DSBMV Matrix-vector product, real symmetric band matrix
F06PEF	12	DSPMV Matrix-vector product, real symmetric packed matrix
F06PFF	12	DTRMV Matrix-vector product, real triangular matrix
F06PGF	12	DTBMV Matrix-vector product, real triangular band matrix
F06PHF	12	DTPMV Matrix-vector product, real triangular packed matrix
F06PJF	12	DTRSV System of equations, real triangular matrix
F06PKF	12	DTBSV System of equations, real triangular band matrix
F06PLF	12	DTPSV System of equations, real triangular packed matrix
F06PMF	12	DGER Rank-1 update, real rectangular matrix
F06PPF	12	DSYR Rank-1 update, real symmetric matrix

F06PQF	12	DSPR Rank-1 update, real symmetric packed matrix
F06PRF	12	DSYR2 Rank-2 update, real symmetric matrix
F06PSF	12	DSPR2 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 UP or RQ factorization of PU , U real upper triangular, P 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	12	ZGEMV Matrix-vector product, complex rectangular matrix
F06SBF	12	ZGBMV Matrix-vector product, complex rectangular band matrix
F06SCF	12	ZHEMV Matrix-vector product, complex Hermitian matrix
F06SDF	12	ZHBMV Matrix-vector product, complex Hermitian band matrix
F06SEF	12	ZHPMV Matrix-vector product, complex Hermitian packed matrix
F06SFF	12	ZTRMV Matrix-vector product, complex triangular matrix
F06SGF	12	ZTBMV Matrix-vector product, complex triangular band matrix
F06SHF	12	ZTPMV Matrix-vector product, complex triangular packed matrix
F06SJF	12	ZTRSV System of equations, complex triangular matrix
F06SKF	12	ZTBSV System of equations, complex triangular band matrix
F06SLF	12	ZTPSV System of equations, complex triangular packed matrix
F06SMF	12	ZGERU Rank-1 update, complex rectangular matrix, unconjugated vector
F06SNF	12	ZGERC Rank-1 update, complex rectangular matrix, conjugated vector
F06SPF	12	ZHER Rank-1 update, complex Hermitian matrix
F06SQF	12	ZHPR Rank-1 update, complex Hermitian packed matrix
F06SRF	12	ZHER2 Rank-2 update, complex Hermitian matrix
F06SSF	12	ZHPR2 Rank-2 update, complex Hermitian packed matrix
F06TAF	21	Matrix-vector product, complex symmetric matrix
F06TBF	21	Rank-1 update, complex symmetric matrix
F06TCF	21	Matrix-vector product, complex symmetric packed matrix
F06TDF	21	Rank-1 update, complex symmetric 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 UP or RQ factorization of PU , U complex upper triangular, P 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	14	DGEMM Matrix-matrix product, two real rectangular matrices
F06YCF	14	DSYMM Matrix-matrix product, one real symmetric matrix, one real rectangular matrix
F06YFF	14	DTRMM Matrix-matrix product, one real triangular matrix, one real rectangular matrix
F06YJF	14	DTRSM Solves a system of equations with multiple right-hand sides, real triangular coefficient matrix
F06YPF	14	DSYRK Rank- k update of a real symmetric matrix
F06YRF	14	DSYR2K Rank- $2k$ update of a real symmetric matrix
F06ZAF	14	ZGEMM Matrix-matrix product, two complex rectangular matrices
F06ZCF	14	ZHEMM Matrix-matrix product, one complex Hermitian matrix, one complex rectangular matrix
F06ZFF	14	ZTRMM Matrix-matrix product, one complex triangular matrix, one complex rectangular matrix
F06ZJF	14	ZTRSM Solves system of equations with multiple right-hand sides, complex triangular coefficient matrix
F06ZPF	14	ZHERK Rank- k update of a complex Hermitian matrix
F06ZRF	14	ZHER2K Rank- $2k$ update of a complex Hermitian matrix
F06ZTF	14	ZSYMM Matrix-matrix product, one complex symmetric matrix, one complex rectangular matrix
F06ZUF	14	ZSYRK Rank- k update of a complex symmetric matrix
F06ZWF	14	ZSYR2K Rank- $2k$ update of a complex symmetric matrix

F07 – Linear Equations (LAPACK)

Routine Name	Mark of Introduction	Purpose
F07AAF	21	DGESV Computes the solution to a real system of linear equations

F07ABF	21	DGESVX Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a real system of linear equations
F07ACF	22	DSGESV Mixed precision real system solver
F07ADF	15	DGETRF <i>LU</i> factorization of real m by n matrix
F07AEF	15	DGETRS Solution of real system of linear equations, multiple right-hand sides, matrix already factorized by F07ADF (DGETRF)
F07AFF	21	DGEEQU Computes row and column scalings intended to equilibrate a general real matrix and reduce its condition number
F07AGF	15	DGECON Estimate condition number of real matrix, matrix already factorized by F07ADF (DGETRF)
F07AHF	15	DGERFS Refined solution with error bounds of real system of linear equations, multiple right-hand sides
F07AJF	15	DGETRI Inverse of real matrix, matrix already factorized by F07ADF (DGETRF)
F07ANF	21	ZGESV Computes the solution to a complex system of linear equations
F07APF	21	ZGESVX Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a complex system of linear equations
F07AQF	22	ZCGESV Mixed precision complex system solver
F07ARF	15	ZGETRF <i>LU</i> factorization of complex m by n matrix
F07ASF	15	ZGETRS Solution of complex system of linear equations, multiple right-hand sides, matrix already factorized by F07ARF (ZGETRF)
F07ATF	21	ZGEEQU Computes row and column scalings intended to equilibrate a general complex matrix and reduce its condition number
F07AUF	15	ZGECON Estimate condition number of complex matrix, matrix already factorized by F07ARF (ZGETRF)
F07AVF	15	ZGERFS Refined solution with error bounds of complex system of linear equations, multiple right-hand sides
F07AWF	15	ZGETRI Inverse of complex matrix, matrix already factorized by F07ARF (ZGETRF)
F07BAF	21	DGBSV Computes the solution to a real banded system of linear equations
F07BBF	21	DGBSVX Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a real banded system of linear equations

F07BDF	15	DGBTRF <i>LU</i> factorization of real m by n band matrix
F07BEF	15	DGBTRS Solution of real band system of linear equations, multiple right-hand sides, matrix already factorized by F07BDF (DGBTRF)
F07BFF	21	DGBEQU Computes row and column scalings intended to equilibrate a real banded matrix and reduce its condition number
F07BGF	15	DGBCON Estimate condition number of real band matrix, matrix already factorized by F07BDF (DGBTRF)
F07BHF	15	DGBRFS Refined solution with error bounds of real band system of linear equations, multiple right-hand sides
F07BNF	21	ZGBSV Computes the solution to a complex banded system of linear equations
F07BPF	21	ZGBSVX Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a complex banded system of linear equations
F07BRF	15	ZGBTRF <i>LU</i> factorization of complex m by n band matrix
F07BSF	15	ZGBTRS Solution of complex band system of linear equations, multiple right-hand sides, matrix already factorized by F07BRF (ZGBTRF)
F07BTF	21	ZGBEQU Computes row and column scalings intended to equilibrate a complex banded matrix and reduce its condition number
F07BUF	15	ZGBCON Estimate condition number of complex band matrix, matrix already factorized by F07BRF (ZGBTRF)
F07BVF	15	ZGBRFS Refined solution with error bounds of complex band system of linear equations, multiple right-hand sides
F07CAF	21	DGTSV Computes the solution to a real tridiagonal system of linear equations
F07CBF	21	DGTSVX Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a real tridiagonal system of linear equations
F07CDF	21	DGTTRF <i>LU</i> factorization of real tridiagonal matrix
F07CEF	21	DGTTRS Solves a real tridiagonal system of linear equations using the <i>LU</i> factorization computed by F07CDF (DGTTRF)
F07CGF	21	DGTCON Estimates the reciprocal of the condition number of a real tridiagonal matrix using the <i>LU</i> factorization computed by F07CDF (DGTTRF)
F07CHF	21	DGTRFS Refined solution with error bounds of real tridiagonal system of linear equations, multiple right-hand sides

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

F07FSF	15	ZPOTRS Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FRF (ZPOTRF)
F07FTF	21	ZPOEQU Computes row and column scalings intended to equilibrate a complex Hermitian positive-definite matrix and reduce its condition number
F07FUF	15	ZPOCON Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF (ZPOTRF)
F07FVF	15	ZPORFS Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides
F07FWF	15	ZPOTRI Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07FRF (ZPOTRF)
F07GAF	21	DPPSV Computes the solution to a real symmetric positive-definite system of linear equations, packed storage
F07GBF	21	DPPSVX 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	15	DPPTRF Cholesky factorization of real symmetric positive-definite matrix, packed storage
F07GEF	15	DPPTRS Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GFF	21	DPPEQU Computes row and column scalings intended to equilibrate a real symmetric positive-definite matrix and reduce its condition number, packed storage
F07GGF	15	DPPCON Estimate condition number of real symmetric positive-definite matrix, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GHF	15	DPPRFS Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides, packed storage
F07GJF	15	DPPTRI Inverse of real symmetric positive-definite matrix, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GNF	21	ZPPSV Computes the solution to a complex Hermitian positive-definite system of linear equations, packed storage
F07GPF	21	ZPPSVX 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	15	ZPPTRF Cholesky factorization of complex Hermitian positive-definite matrix, packed storage

F07GSF	15	ZPPTRS Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07GTF	21	ZPPEQU Computes row and column scalings intended to equilibrate a complex Hermitian positive-definite matrix and reduce its condition number, packed storage
F07GUF	15	ZPPCON Estimate condition number of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07GVF	15	ZPPRFS Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, packed storage
F07GWF	15	ZPPTRI Inverse of complex Hermitian positive-definite matrix, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07HAF	21	DPBSV Computes the solution to a real symmetric positive-definite banded system of linear equations
F07HBF	21	DPBSVX 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	15	DPBTRF Cholesky factorization of real symmetric positive-definite band matrix
F07HEF	15	DPBTRS Solution of real symmetric positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HDF (DPBTRF)
F07HFF	21	DPBEQU Computes row and column scalings intended to equilibrate a real symmetric positive-definite banded matrix and reduce its condition number
F07HGF	15	DPBCON Estimate condition number of real symmetric positive-definite band matrix, matrix already factorized by F07HDF (DPBTRF)
F07HHF	15	DPBRFS Refined solution with error bounds of real symmetric positive-definite band system of linear equations, multiple right-hand sides
F07HNF	21	ZPBSV Computes the solution to a complex Hermitian positive-definite banded system of linear equations
F07HPF	21	ZPBSVX 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	15	ZPBTRF Cholesky factorization of complex Hermitian positive-definite band matrix
F07HSF	15	ZPBTRS Solution of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HRF (ZPBTRF)

F07HTF	21	ZPBEQU Computes row and column scalings intended to equilibrate a complex Hermitian positive-definite banded matrix and reduce its condition number
F07HUF	15	ZPBCON Estimate condition number of complex Hermitian positive-definite band matrix, matrix already factorized by F07HRF (ZPBTRF)
F07HVF	15	ZPBRFS Refined solution with error bounds of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides
F07JAF	21	DPTSV Computes the solution to a real symmetric positive-definite tridiagonal system of linear equations
F07JBF	21	DPTSVX 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	21	DPTTRF Computes the modified Cholesky factorization of a real symmetric positive-definite tridiagonal matrix
F07JEF	21	DPTTRS Solves a real symmetric positive-definite tridiagonal system using the modified Cholesky factorization computed by F07JDF (DPTTRF)
F07JGF	21	DPTCON 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	21	DPTRFS Refined solution with error bounds of real symmetric positive-definite tridiagonal system of linear equations, multiple right-hand sides
F07JNF	21	ZPTSV Computes the solution to a complex Hermitian positive-definite tridiagonal system of linear equations
F07JPF	21	ZPTSVX 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	21	ZPTTRF Computes the modified Cholesky factorization of a complex Hermitian positive-definite tridiagonal matrix
F07JSF	21	ZPTTRS Solves a complex Hermitian positive-definite tridiagonal system using the modified Cholesky factorization computed by F07JRF (ZPTTRF)
F07JUF	21	ZPTCON 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	21	ZPTRFS Refined solution with error bounds of complex Hermitian positive-definite tridiagonal system of linear equations, multiple right-hand sides
F07MAF	21	DSYSV Computes the solution to a real symmetric system of linear equations

F07MBF	21	DSYSVX Uses the diagonal pivoting factorization to compute the solution to a real symmetric system of linear equations
F07MDF	15	DSYTRF Bunch–Kaufman factorization of real symmetric indefinite matrix
F07MEF	15	DSYTRS Solution of real symmetric indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07MDF (DSYTRF)
F07MGF	15	DSYCON Estimate condition number of real symmetric indefinite matrix, matrix already factorized by F07MDF (DSYTRF)
F07MHF	15	DSYRFS Refined solution with error bounds of real symmetric indefinite system of linear equations, multiple right-hand sides
F07MJF	15	DSYTRI Inverse of real symmetric indefinite matrix, matrix already factorized by F07MDF (DSYTRF)
F07MNF	21	ZHESV Computes the solution to a complex Hermitian system of linear equations
F07MPF	21	ZHESVX Uses the diagonal pivoting factorization to compute the solution to a complex Hermitian system of linear equations
F07MRF	15	ZHETRF Bunch–Kaufman factorization of complex Hermitian indefinite matrix
F07MSF	15	ZHETRS Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07MRF (ZHETRF)
F07MUF	15	ZHECON Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07MRF (ZHETRF)
F07MVF	15	ZHERFS Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides
F07MWF	15	ZHETRI Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07MRF (ZHETRF)
F07NNF	21	ZSYSV Computes the solution to a complex symmetric system of linear equations
F07NPF	21	ZSYSVX Uses the diagonal pivoting factorization to compute the solution to a complex symmetric system of linear equations
F07NRF	15	ZSYTRF Bunch–Kaufman factorization of complex symmetric matrix
F07NSF	15	ZSYTRS Solution of complex symmetric system of linear equations, multiple right-hand sides, matrix already factorized by F07NRF (ZSYTRF)
F07NUF	15	ZSYCON Estimate condition number of complex symmetric matrix, matrix already factorized by F07NRF (ZSYTRF)

F07NVF	15	ZSYRFS Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides
F07NWF	15	ZSYTRI Inverse of complex symmetric matrix, matrix already factorized by F07NRF (ZSYTRF)
F07PAF	21	DSPSV Computes the solution to a real symmetric system of linear equations, packed storage
F07PBF	21	DSPSVX Uses the diagonal pivoting factorization to compute the solution to a real symmetric system of linear equations, packed storage
F07PDF	15	DSPTRF Bunch–Kaufman factorization of real symmetric indefinite matrix, packed storage
F07PEF	15	DSPTRS Solution of real symmetric indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07PDF (DSPTRF), packed storage
F07PGF	15	DSPCON Estimate condition number of real symmetric indefinite matrix, matrix already factorized by F07PDF (DSPTRF), packed storage
F07PHF	15	DSPRFS Refined solution with error bounds of real symmetric indefinite system of linear equations, multiple right-hand sides, packed storage
F07PJF	15	DSPTRI Inverse of real symmetric indefinite matrix, matrix already factorized by F07PDF (DSPTRF), packed storage
F07PNF	21	ZHPSV Computes the solution to a complex Hermitian system of linear equations, packed storage
F07PPF	21	ZHPSVX Uses the diagonal pivoting factorization to compute the solution to a complex Hermitian system of linear equations, packed storage
F07PRF	15	ZHPTRF Bunch–Kaufman factorization of complex Hermitian indefinite matrix, packed storage
F07PSF	15	ZHPTRS Solution of complex Hermitian indefinite system of linear equations, multiple right-hand sides, matrix already factorized by F07PRF (ZHPTRF), packed storage
F07PUF	15	ZHPCON Estimate condition number of complex Hermitian indefinite matrix, matrix already factorized by F07PRF (ZHPTRF), packed storage
F07PVF	15	ZHPRFS Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides, packed storage
F07PWF	15	ZHPTRI Inverse of complex Hermitian indefinite matrix, matrix already factorized by F07PRF (ZHPTRF), packed storage

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

F07USF	15	ZTPTRS Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07UUF	15	ZTPCON Estimate condition number of complex triangular matrix, packed storage
F07UVF	15	ZTPRFS Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07UWF	15	ZTPTRI Inverse of complex triangular matrix, packed storage
F07VEF	15	DTBTRS Solution of real band triangular system of linear equations, multiple right-hand sides
F07VGF	15	DTBCON Estimate condition number of real band triangular matrix
F07VHF	15	DTBRFS Error bounds for solution of real band triangular system of linear equations, multiple right-hand sides
F07VSF	15	ZTBTRS Solution of complex band triangular system of linear equations, multiple right-hand sides
F07VUF	15	ZTBCON Estimate condition number of complex band triangular matrix
F07VVF	15	ZTBRFS Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides

F08 – Least-squares and Eigenvalue Problems (LAPACK)

Routine Name	Mark of Introduction	Purpose
F08AAF	21	DGELS Solves an overdetermined or underdetermined real linear system
F08AEF	16	DGEQRF QR factorization of real general rectangular matrix
F08AFF	16	DORGQR Form all or part of orthogonal Q from QR factorization determined by F08AEF (DGEQRF) or F08BEF (DGEQPF)
F08AGF	16	DORMQR Apply orthogonal transformation determined by F08AEF (DGEQRF) or F08BEF (DGEQPF)
F08AHF	16	DGELQF LQ factorization of real general rectangular matrix
F08AJF	16	DORGLQ Form all or part of orthogonal Q from LQ factorization determined by F08AHF (DGELQF)
F08AKF	16	DORMLQ Apply orthogonal transformation determined by F08AHF (DGELQF)
F08ANF	21	ZGELS Solves an overdetermined or underdetermined complex linear system

F08ASF	16	ZGEQRF <i>QR</i> factorization of complex general rectangular matrix
F08ATF	16	ZUNGQR Form all or part of unitary Q from <i>QR</i> factorization determined by F08ASF (ZGEQRF) or F08BSF (ZGEQPF)
F08AUF	16	ZUNMQR Apply unitary transformation determined by F08ASF (ZGEQRF) or F08BSF (ZGEQPF)
F08AVF	16	ZGELQF <i>LQ</i> factorization of complex general rectangular matrix
F08AWF	16	ZUNGLQ Form all or part of unitary Q from <i>LQ</i> factorization determined by F08AVF (ZGELQF)
F08AXF	16	ZUNMLQ Apply unitary transformation determined by F08AVF (ZGELQF)
F08BAF	21	DGELSY Computes the minimum-norm solution to a real linear least-squares problem
F08BEF	16	DGEQPF <i>QR</i> factorization of real general rectangular matrix with column pivoting
F08BFF	21	DGEQP3 <i>QR</i> factorization of real general rectangular matrix with column pivoting, using BLAS-3
F08BHF	21	DTZRZF Reduces a real upper trapezoidal matrix to upper triangular form
F08BKF	21	DORMRZ Apply orthogonal transformation determined by F08BHF (DTZRZF)
F08BNF	21	ZGELSY Computes the minimum-norm solution to a complex linear least-squares problem
F08BSF	16	ZGEQPF <i>QR</i> factorization of complex general rectangular matrix with column pivoting
F08BTF	21	ZGEQP3 <i>QR</i> factorization of complex general rectangular matrix with column pivoting, using BLAS-3
F08BVF	21	ZTZRZF Reduces a complex upper trapezoidal matrix to upper triangular form
F08BXF	21	ZUNMRZ Apply unitary transformation determined by F08BVF (ZTZRZF)
F08CEF	21	DGEQLF <i>QL</i> factorization of real general rectangular matrix
F08CFF	21	DORGQL Form all or part of orthogonal Q from <i>QL</i> factorization determined by F08CEF (DGEQLF)
F08CGF	21	DORMQL Apply orthogonal transformation determined by F08CEF (DGEQLF)
F08CHF	21	DGERQF <i>RQ</i> factorization of real general rectangular matrix

F08CJF	21	DORGRQ Form all or part of orthogonal Q from RQ factorization determined by F08CHF (DGERQF)
F08CKF	21	DORMRQ Apply orthogonal transformation determined by F08CHF (DGERQF)
F08CSF	21	ZGEQLF QL factorization of complex general rectangular matrix
F08CTF	21	ZUNGQL Form all or part of orthogonal Q from QL factorization determined by F08CSF (ZGEQLF)
F08CUF	21	ZUNMQL Apply unitary transformation determined by F08CSF (ZGEQLF)
F08CVF	21	ZGERQF RQ factorization of complex general rectangular matrix
F08CWF	21	ZUNGRQ Form all or part of orthogonal Q from RQ factorization determined by F08CVF (ZGERQF)
F08CXF	21	ZUNMRQ Apply unitary transformation determined by F08CVF (ZGERQF)
F08FAF	21	DSYEV Computes all eigenvalues and, optionally, eigenvectors of a real symmetric matrix
F08FBF	21	DSYEVX Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix
F08FCF	19	DSYEVD Computes all eigenvalues and, optionally, all eigenvectors of real symmetric matrix (divide-and-conquer)
F08FDF	21	DSYEV Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix (Relatively Robust Representations)
F08FEF	16	DSYTRD Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form
F08FFF	16	DORGTR Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08FEF (DSYTRD)
F08FGF	16	DORMTR Apply orthogonal transformation determined by F08FEF (DSYTRD)
F08FLF	21	DDISNA 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	21	ZHEEV Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix
F08FPF	21	ZHEEVX Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix

F08FQF	19	ZHEEVD Computes all eigenvalues and, optionally, all eigenvectors of complex Hermitian matrix (divide-and-conquer)
F08FRF	21	ZHEEVR Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix (Relatively Robust Representations)
F08FSF	16	ZHETRD Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form
F08FTF	16	ZUNGTR Generate unitary transformation matrix from reduction to tridiagonal form determined by F08FSF (ZHETRD)
F08FUF	16	ZUNMTR Apply unitary transformation matrix determined by F08FSF (ZHETRD)
F08GAF	21	DSPEV Computes all eigenvalues and, optionally, eigenvectors of a real symmetric matrix, packed storage
F08GBF	21	DSPEVX Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix, packed storage
F08GCF	19	DSPEVD Computes all eigenvalues and, optionally, all eigenvectors of real symmetric matrix, packed storage (divide-and-conquer)
F08GEF	16	DSPTRD Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form, packed storage
F08GFF	16	DOPGTR Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08GEF (DSPTRD)
F08GGF	16	DOPMTR Apply orthogonal transformation determined by F08GEF (DSPTRD)
F08GNF	21	ZHPEV Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix, packed storage
F08GPF	21	ZHPEVX Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix, packed storage
F08GQF	19	ZHPEVD Computes all eigenvalues and, optionally, all eigenvectors of complex Hermitian matrix, packed storage (divide-and-conquer)
F08GSF	16	ZHPTRD Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form, packed storage
F08GTF	16	ZUPGTR Generate unitary transformation matrix from reduction to tridiagonal form determined by F08GSF (ZHPTRD)
F08GUF	16	ZUPMTR Apply unitary transformation matrix determined by F08GSF (ZHPTRD)

F08HAF	21	DSBEV Computes all eigenvalues and, optionally, eigenvectors of a real symmetric band matrix
F08HBF	21	DSBEVX Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric band matrix
F08HCF	19	DSBEVD Computes all eigenvalues and, optionally, all eigenvectors of real symmetric band matrix (divide-and-conquer)
F08HEF	16	DSBTRD Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form
F08HNF	21	ZHBEV Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian band matrix
F08HPF	21	ZHBEVX Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian band matrix
F08HQF	19	ZHBEVD Computes all eigenvalues and, optionally, all eigenvectors of complex Hermitian band matrix (divide-and-conquer)
F08HSF	16	ZHBTRD Unitary reduction of complex Hermitian band matrix to real symmetric tridiagonal form
F08JAF	21	DSTEV Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix
F08JBF	21	DSTEVX Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix
F08JCF	19	DSTEVD Computes all eigenvalues and, optionally, all eigenvectors of real symmetric tridiagonal matrix (divide-and-conquer)
F08JDF	21	DSTEVR Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix (Relatively Robust Representations)
F08JEF	16	DSTEQR All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from real symmetric matrix using the implicit QL or QR algorithm
F08JFF	16	DSTERF All eigenvalues of real symmetric tridiagonal matrix, root-free variant of the QL or QR algorithm
F08JGF	16	DPTEQR Computes all eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from real symmetric positive-definite matrix
F08JHF	21	DSTEDC Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a matrix reduced to this form (divide-and-conquer)
F08JFF	16	DSTEBZ Selected eigenvalues of real symmetric tridiagonal matrix by bisection

F08JKF	16	DSTEIN Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in real array
F08JLF	21	DSTEGR Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a symmetric matrix reduced to this form (Relatively Robust Representations)
F08JSF	16	ZSTEQR All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from complex Hermitian matrix, using the implicit QL or QR algorithm
F08JUF	16	ZPTEQR Computes all eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from complex Hermitian positive-definite matrix
F08JVF	21	ZSTEDC 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	16	ZSTEIN Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in complex array
F08JYF	21	ZSTEGR 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	21	DGELSS Computes the minimum-norm solution to a real linear least-squares problem using singular value decomposition
F08KBF	21	DGESVD Computes the singular value decomposition of a real matrix, optionally computing the left and/or right singular vectors
F08KCF	21	DGELSD Computes the minimum-norm solution to a real linear least-squares problem using singular value decomposition (divide-and-conquer)
F08KDF	21	DGESDD Computes the singular value decomposition of a real matrix, optionally computing the left and/or right singular vectors (divide-and-conquer)
F08KEF	16	DGEBRD Orthogonal reduction of real general rectangular matrix to bidiagonal form
F08KFF	16	DORGBR Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF (DGEBRD)
F08KGF	16	DORMBR Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF (DGEBRD)
F08KNF	21	ZGELSS Computes the minimum-norm solution to a complex linear least-squares problem using singular value decomposition
F08KPF	21	ZGESVD Computes the singular value decomposition of a complex matrix, optionally computing the left and/or right singular vectors

F08KQF	21	ZGELSD Computes the minimum-norm solution to a complex linear least-squares problem using singular value decomposition (divide-and-conquer)
F08KRF	21	ZGESDD Computes the singular value decomposition of a complex matrix, optionally computing the left and/or right singular vectors (divide-and-conquer)
F08KSF	16	ZGEBRD Unitary reduction of complex general rectangular matrix to bidiagonal form
F08KTF	16	ZUNGBR Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF (ZGEBRD)
F08KUF	16	ZUNMBR Apply unitary transformations from reduction to bidiagonal form determined by F08KSF (ZGEBRD)
F08LEF	19	DGBBRD Reduction of real rectangular band matrix to upper bidiagonal form
F08LSF	19	ZGBBRD Reduction of complex rectangular band matrix to upper bidiagonal form
F08MDF	21	DBDSDC Computes the singular value decomposition of a real bidiagonal matrix, optionally computing the singular vectors (divide-and-conquer)
F08MEF	16	DBDSQR SVD of real bidiagonal matrix reduced from real general matrix
F08MSF	16	ZBDSQR SVD of real bidiagonal matrix reduced from complex general matrix
F08NAF	21	DGEEV Computes all eigenvalues and, optionally, left and/or right eigenvectors of a real nonsymmetric matrix
F08NBF	21	DGEEVX 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	16	DGEHRD Orthogonal reduction of real general matrix to upper Hessenberg form
F08NFF	16	DORGHR Generate orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (DGEHRD)
F08NGF	16	DORMHR Apply orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (DGEHRD)
F08NHF	16	DGEBAL Balance real general matrix
F08NJF	16	DGEBAK Transform eigenvectors of real balanced matrix to those of original matrix supplied to F08NHF (DGEBAL)
F08NNF	21	ZGEEV Computes all eigenvalues and, optionally, left and/or right eigenvectors of a complex nonsymmetric matrix

F08NPF	21	ZGEEVX 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	16	ZGEHRD Unitary reduction of complex general matrix to upper Hessenberg form
F08NTF	16	ZUNGHR Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NSF (ZGEHRD)
F08NUF	16	ZUNMHR Apply unitary transformation matrix from reduction to Hessenberg form determined by F08NSF (ZGEHRD)
F08NVF	16	ZGEBAL Balance complex general matrix
F08NWF	16	ZGEBAK Transform eigenvectors of complex balanced matrix to those of original matrix supplied to F08NVF (ZGEBAL)
F08PAF	21	DGEES Computes for real square nonsymmetric matrix, the eigenvalues, the real Schur form, and, optionally, the matrix of Schur vectors
F08PBF	21	DGEESX 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	16	DHSEQR Computes the eigenvalues and Schur factorization of real upper Hessenberg matrix reduced from real general matrix
F08PKF	16	DHSEIN Selected right and/or left eigenvectors of real upper Hessenberg matrix by inverse iteration
F08PNF	21	ZGEES Computes for complex square nonsymmetric matrix, the eigenvalues, the Schur form, and, optionally, the matrix of Schur vectors
F08PPF	21	ZGEESX 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	16	ZHSEQR Computes the eigenvalues and Schur factorization of complex upper Hessenberg matrix reduced from complex general matrix
F08PXF	16	ZHSEIN Selected right and/or left eigenvectors of complex upper Hessenberg matrix by inverse iteration
F08QFF	16	DTREXC Reorder Schur factorization of real matrix using orthogonal similarity transformation
F08QGF	16	DTRSEN Reorder Schur factorization of real matrix, form orthonormal basis of right invariant subspace for selected eigenvalues, with estimates of sensitivities

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

F08TAF	21	DSPGV Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage
F08TBF	21	DSPGVX Computes selected eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage
F08TCF	21	DSPGVD Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage (divide-and-conquer)
F08TEF	16	DSPGST Reduction to standard form of real symmetric-definite generalized eigenproblem $Ax = \lambda Bx$, $ABx = \lambda x$ or $BAx = \lambda x$, packed storage, B factorized by F07GDF (DPPTRF)
F08TNF	21	ZHPGV Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage
F08TPF	21	ZHPGVX Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage
F08TQF	21	ZHPGVD Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage (divide-and-conquer)
F08TSF	16	ZHPGST Reduction to standard form of complex Hermitian-definite generalized eigenproblem $Ax = \lambda Bx$, $ABx = \lambda x$ or $BAx = \lambda x$, packed storage, B factorized by F07GRF (ZPPTRF)
F08UAF	21	DSBGV Computes all the eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem
F08UBF	21	DSBGVX Computes selected eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem
F08UCF	21	DSBGVD Computes all the eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem (divide-and-conquer)
F08UEF	19	DSBGST Reduction of real symmetric-definite banded generalized eigenproblem $Ax = \lambda Bx$ to standard form $Cy = \lambda y$, such that C has the same bandwidth as A
F08UFF	19	DPBSTF Computes a split Cholesky factorization of real symmetric positive-definite band matrix A
F08UNF	21	ZHBGV Computes all the eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem
F08UPF	21	ZHBGVX Computes selected eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem

F08UQF	21	ZHBGVD Computes all the eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem (divide-and-conquer)
F08USF	19	ZHBGST Reduction of complex Hermitian-definite banded generalized eigenproblem $Ax = \lambda Bx$ to standard form $Cy = \lambda y$, such that C has the same bandwidth as A
F08UTF	19	ZPBSTF Computes a split Cholesky factorization of complex Hermitian positive-definite band matrix A
F08VAF	21	DGGSVD Computes the generalized singular value decomposition of a real matrix pair
F08VEF	21	DGGSVP Computes orthogonal matrices as processing steps for computing the generalized singular value decomposition of a real matrix pair
F08VNF	21	ZGGSVD Computes the generalized singular value decomposition of a complex matrix pair
F08VSF	21	ZGGSVP Computes orthogonal matrices as processing steps for computing the generalized singular value decomposition of a complex matrix pair
F08WAF	21	DGGEV Computes, for a real nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors
F08WBF	21	DGGEVX 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	20	DGGHRD Orthogonal reduction of a pair of real general matrices to generalized upper Hessenberg form
F08WHF	20	DGGBAL Balance a pair of real general matrices
F08WJF	20	DGGBAK Transform eigenvectors of a pair of real balanced matrices to those of original matrix pair supplied to F08WHF (DGGBAL)
F08WNF	21	ZGGEV Computes, for a complex nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors
F08WPF	21	ZGGEVX 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	20	ZGGHRD Unitary reduction of a pair of complex general matrices to generalized upper Hessenberg form
F08WVF	20	ZGGBAL Balance a pair of complex general matrices

F08WWF	20	ZGGBAK Transform eigenvectors of a pair of complex balanced matrices to those of original matrix pair supplied to F08WVF (ZGGBAL)
F08XAF	21	DGGES 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	21	DGGESX 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	20	DHGEQZ Eigenvalues and generalized Schur factorization of real generalized upper Hessenberg form reduced from a pair of real general matrices
F08XNF	21	ZGGES 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	21	ZGGESX 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	20	ZHGEQZ Eigenvalues and generalized Schur factorization of complex generalized upper Hessenberg form reduced from a pair of complex general matrices
F08YEF	21	DTGSJA Computes the generalized singular value decomposition of a real upper triangular (or trapezoidal) matrix pair
F08YFF	21	DTGEXC Reorders the generalized real Schur decomposition of a real matrix pair using an orthogonal equivalence transformation
F08YGF	21	DTGSEN 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	21	DTGSYL Solves the real-valued generalized Sylvester equation
F08YKF	20	DTGEVC Left and right eigenvectors of a pair of real upper quasi-triangular matrices
F08YLF	21	DTGSNA Estimates reciprocal condition numbers for specified eigenvalues and/or eigenvectors of a real matrix pair in generalized real Schur canonical form
F08YSF	21	ZTGSJA Computes the generalized singular value decomposition of a complex upper triangular (or trapezoidal) matrix pair
F08YTF	21	ZTGEXC Reorders the generalized Schur decomposition of a complex matrix pair using an unitary equivalence transformation

F08YUF	21	ZTGSEN 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	21	ZTGSYL Solves the complex generalized Sylvester equation
F08YXF	20	ZTGEVC Left and right eigenvectors of a pair of complex upper triangular matrices
F08YYF	21	ZTGSNA Estimates reciprocal condition numbers for specified eigenvalues and/or eigenvectors of a complex matrix pair in generalized Schur canonical form
F08ZAF	21	DGGLSE Solves the real linear equality-constrained least-squares (LSE) problem
F08ZBF	21	DGGGLM Solves a real general Gauss–Markov linear model (GLM) problem
F08ZEF	21	DGGQRF Computes a generalized QR factorization of a real matrix pair
F08ZFF	21	DGGRQF Computes a generalized RQ factorization of a real matrix pair
F08ZNF	21	ZGGLSE Solves the complex linear equality-constrained least-squares (LSE) problem
F08ZPF	21	ZGGGLM Solves a complex general Gauss–Markov linear model (GLM) problem
F08ZSF	21	ZGGQRF Computes a generalized QR factorization of a complex matrix pair
F08ZTF	21	ZGGRQF 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 F12APF) 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 F12FBF) 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

F16 – Further Linear Algebra Support Routines

Routine Name	Mark of Introduction	Purpose
F16DLF	22	Sum elements of integer vector
F16DNF	22	Maximum value and location, integer vector
F16DPF	22	Minimum value and location, integer vector
F16DQF	22	Maximum absolute value and location, integer vector
F16DRF	22	Minimum absolute value and location, integer vector
F16EHF	22	BLAS_DWXPBY Real scaled vector addition preserving input
F16ELF	22	BLAS_DSUM Sum elements of real vector
F16GHF	22	BLAS_ZWXPBY Complex scaled vector addition preserving input
F16GLF	22	BLAS_ZSUM Sum elements of complex vector
F16JNF	22	BLAS_DMAX_VAL Maximum value and location, real vector
F16JPF	22	BLAS_DMIN_VAL Minimum value and location, real vector

F16JQF	22	BLAS_DAMAX_VAL Maximum absolute value and location, real vector
F16JRF	22	BLAS_DAMIN_VAL Minimum absolute value and location, real vector
F16JSF	22	BLAS_ZAMAX_VAL Maximum absolute value and location, complex vector
F16JTF	22	BLAS_ZAMIN_VAL Minimum absolute value and location, complex vector

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)
G01AMF	22	Find quantiles of an unordered vector, real numbers
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 $\phi'(\lambda)$
G01ZUF	21	Initialization routine for G01MUF and G01EUF

G02 – Correlation and Regression Analysis

Routine Name	Mark of Introduction	Purpose
G02AAF	22	Computes the nearest correlation matrix to a real square matrix, using the method of Qi and Sun
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
G02GPF	22	Computes a predicted value and its associated standard error based on a previously fitted generalized linear model.
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)
G02KAF	22	Ridge regression, optimizing a ridge regression parameter
G02KBF	22	Ridge regression using a number of supplied ridge regression parameters
G02LAF	22	Partial least-squares (PLS) regression using singular value decomposition
G02LBF	22	Partial least-squares (PLS) regression using Wold's iterative method
G02LCF	22	PLS parameter estimates following partial least-squares regression by G02LAF or G02LBF
G02LDF	22	PLS predictions based on parameter estimates from G02LCF

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
G03BDF	22	ProMax 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 coordinate 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 $(\epsilon_{t-1} + \gamma)^2$ Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05HLF	20	Univariate time series, generate n terms of a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma\epsilon_{t-1})^2$ Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05HMF	20	Univariate time series, generate n terms of an asymmetric Glosen, Jagannathan and Runkle (GJR) GARCH process Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05HNF	20	Univariate time series, generate n terms of an exponential GARCH (EGARCH) process Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05KAF	20	Pseudorandom real numbers, uniform distribution over (0,1), seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05KBF	20	Initialize seeds of a given generator for random number generating routines (that pass seeds explicitly) to give a repeatable sequence Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05KCF	20	Initialize seeds of a given generator for random number generating routines (that pass seeds explicitly) to give non-repeatable sequence Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

G05KEF	20	Pseudorandom logical (boolean) value, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05KFF	22	Initializes a pseudorandom number generator to give a repeatable sequence
G05KGF	22	Initializes a pseudorandom number generator to give a non-repeatable sequence
G05KHF	22	Primes a pseudorandom number generator for generating multiple streams using leap-frog
G05KJF	22	Primes a pseudorandom number generator for generating multiple streams using skip-ahead
G05LAF	20	Generates a vector of random numbers from a Normal distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LBF	20	Generates a vector of random numbers from a Student's t -distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LCF	20	Generates a vector of random numbers from a χ^2 distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LDF	20	Generates a vector of random numbers from an F -distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LEF	20	Generates a vector of random numbers from a β distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LFF	20	Generates a vector of random numbers from a γ distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LGF	20	Generates a vector of random numbers from a uniform distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LHF	20	Generates a vector of random numbers from a triangular distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

G05LJF	20	Generates a vector of random numbers from an exponential distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LKF	20	Generates a vector of random numbers from a log-normal distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LLF	20	Generates a vector of random numbers from a Cauchy distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LMF	20	Generates a vector of random numbers from a Weibull distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LNF	20	Generates a vector of random numbers from a logistic distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LPF	20	Generates a vector of random numbers from a von Mises distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LQF	20	Generates a vector of random numbers from an exponential mixture distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LXF	21	Generates a matrix of random numbers from a multivariate Student's t -distribution, seeds and generator passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LYF	21	Generates a matrix of random numbers from a multivariate Normal distribution, seeds and generator passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05LZF	20	Generates a vector of random numbers from a multivariate Normal distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

G05MAF	20	Generates a vector of random integers from a uniform distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MBF	20	Generates a vector of random integers from a geometric distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MCF	20	Generates a vector of random integers from a negative binomial distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MDF	20	Generates a vector of random integers from a logarithmic distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MEF	20	Generates a vector of random integers from a Poisson distribution with varying mean, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MJF	20	Generates a vector of random integers from a binomial distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MKF	20	Generates a vector of random integers from a Poisson distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MLF	20	Generates a vector of random integers from a hypergeometric distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MRF	20	Generates a vector of random integers from a multinomial distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05MZF	20	Generates a vector of random integers from a general discrete distribution, seeds and generator number passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05NAF	20	Pseudorandom permutation of an integer vector Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

G05NBF	20	Pseudorandom sample from an integer vector Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05NCF	22	Pseudorandom permutation of an integer vector
G05NDF	22	Pseudorandom sample from an integer vector
G05PAF	20	Generates a realization of a time series from an ARMA model Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05PCF	20	Generates a realization of a multivariate time series from a VARMA model Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05PDF	22	Generates a realization of a time series from a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma)^2$
G05PEF	22	Generates a realization of a time series from a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma\epsilon_{t-1})^2$
G05PFF	22	Generates a realization of a time series from an asymmetric Glosten, Jagannathan and Runkle (GJR) GARCH process
G05PGF	22	Generates a realization of a time series from an exponential GARCH (EGARCH) process
G05PHF	22	Generates a realization of a time series from an ARMA model
G05PJF	22	Generates a realization of a multivariate time series from a VARMA model
G05PMF	22	Generates a realization of a time series from an exponential smoothing model
G05PXF	22	Generates a random orthogonal matrix
G05PYF	22	Generates a random correlation matrix
G05PZF	22	Generates a random two-way table
G05QAF	20	Computes a random orthogonal matrix Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05QBF	20	Computes a random correlation matrix Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05QDF	20	Generates a random table matrix Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05RAF	21	Generates a matrix of random numbers from a Gaussian copula, seeds and generator passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

G05RBF	21	Generates a matrix of random numbers from a Student's t -copula, seeds and generator passed explicitly Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05RCF	22	Generates a matrix of pseudorandom numbers from a Student's t -copula
G05RDF	22	Generates a matrix of pseudorandom numbers from a Gaussian copula
G05RYF	22	Generates a matrix of pseudorandom numbers from a multivariate Student's t -distribution
G05RZF	22	Generates a matrix of pseudorandom numbers from a multivariate Normal distribution
G05SAF	22	Generates a vector of pseudorandom numbers from a uniform distribution over $(0, 1]$
G05SBF	22	Generates a vector of pseudorandom numbers from a beta distribution
G05SCF	22	Generates a vector of pseudorandom numbers from a Cauchy distribution
G05SDF	22	Generates a vector of pseudorandom numbers from a χ^2 distribution
G05SEF	22	Generates a vector of pseudorandom numbers from a Dirichlet distribution
G05SFF	22	Generates a vector of pseudorandom numbers from an exponential distribution
G05SGF	22	Generates a vector of pseudorandom numbers from an exponential mix distribution
G05SHF	22	Generates a vector of pseudorandom numbers from an F -distribution
G05SJF	22	Generates a vector of pseudorandom numbers from a gamma distribution
G05SKF	22	Generates a vector of pseudorandom numbers from a Normal distribution
G05SLF	22	Generates a vector of pseudorandom numbers from a logistic distribution
G05SMF	22	Generates a vector of pseudorandom numbers from a log-normal distribution
G05SNF	22	Generates a vector of pseudorandom numbers from a Student's t -distribution
G05SPF	22	Generates a vector of pseudorandom numbers from a triangular distribution
G05SQF	22	Generates a vector of pseudorandom numbers from a uniform distribution over $[a, b]$
G05SRF	22	Generates a vector of pseudorandom numbers from a von Mises distribution
G05SSF	22	Generates a vector of pseudorandom numbers from a Weibull distribution
G05TAF	22	Generates a vector of pseudorandom integers from a binomial distribution
G05TBF	22	Generates a vector of pseudorandom logical values
G05TCF	22	Generates a vector of pseudorandom integers from a geometric distribution
G05TDF	22	Generates a vector of pseudorandom integers from a general discrete distribution
G05TEF	22	Generates a vector of pseudorandom integers from a hypergeometric distribution
G05TFF	22	Generates a vector of pseudorandom integers from a logarithmic distribution
G05TGF	22	Generates a vector of pseudorandom integers from a multinomial distribution
G05THF	22	Generates a vector of pseudorandom integers from a negative binomial distribution
G05TJF	22	Generates a vector of pseudorandom integers from a Poisson distribution

G05TKF	22	Generates a vector of pseudorandom integers from a Poisson distribution with varying mean
G05TLF	22	Generates a vector of pseudorandom integers from a uniform distribution
G05YAF	20	Multi-dimensional quasi-random number generator with a uniform probability distribution Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YBF	20	Multi-dimensional quasi-random number generator with a Gaussian or log-normal probability distribution Note: this routine is scheduled for withdrawal at Mark 23, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YCF	21	Initializes the Faure generator (G05YDF/G05YJF/G05YKF) Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YDF	21	Generates a sequence of quasi-random numbers using Faure's method Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YEF	21	Initializes the Sobol generator (G05YFF/G05YJF/G05YKF) Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YFF	21	Generates a sequence of quasi-random numbers using Sobol's method Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YGF	21	Initializes the Niederreiter generator (G05YHF/G05YJF/G05YKF) Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YHF	21	Generates a sequence of quasi-random numbers using Niederreiter's method Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G05YJF	21	Generates a Normal quasi-random number sequence
G05YKF	21	Generates a log-normal quasi-random number sequence
G05YLF	22	Initializes a quasi-random number generator
G05YMF	22	Generates a uniform quasi-random number sequence
G05YNF	22	Initializes a scrambled quasi-random number generator

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
G13AMF	22	Univariate time series, exponential smoothing
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 Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
G13DDF	22	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 G13DDF
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 $(\epsilon_{t-1} + \gamma\epsilon_{t-1})^2$
G13FDF	20	Univariate time series, forecast function for a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma\epsilon_{t-1})^2$
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), using E04NKF/E04NKA
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 and Searching

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
M01NAF	22	Binary search in set of real numbers
M01NBF	22	Binary search in set of integer numbers
M01NCF	22	Binary search in set of character data
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 Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

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 $\operatorname{Ci}(x)$
S13ADF	5	Sine integral $\operatorname{Si}(x)$
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 $\operatorname{erfc}(x)$
S15AEF	4	Error function $\operatorname{erf}(x)$
S15AFF	7	Dawson's integral
S15AGF	22	Scaled complement of error function, $\operatorname{erfcx}(x)$
S15DDF	14	Scaled complex complement of error function, $\exp(-z^2) \operatorname{erfc}(-iz)$
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 $\operatorname{Ai}(x)$
S17AHF	8	Airy function $\operatorname{Bi}(x)$
S17AJF	8	Airy function $\operatorname{Ai}'(x)$
S17AKF	8	Airy function $\operatorname{Bi}'(x)$
S17ALF	20	Zeros of Bessel functions $J_\alpha(x)$, $J'_\alpha(x)$, $Y_\alpha(x)$ or $Y'_\alpha(x)$
S17DCF	13	Bessel functions $Y_{\nu+a}(z)$, real $a \geq 0$, complex z , $\nu = 0, 1, 2, \dots$
S17DEF	13	Bessel functions $J_{\nu+a}(z)$, real $a \geq 0$, complex z , $\nu = 0, 1, 2, \dots$
S17DGF	13	Airy functions $\operatorname{Ai}(z)$ and $\operatorname{Ai}'(z)$, complex z
S17DHF	13	Airy functions $\operatorname{Bi}(z)$ and $\operatorname{Bi}'(z)$, complex z
S17DLF	13	Hankel functions $H_{\nu+a}^{(j)}(z)$, $j = 1, 2$, real $a \geq 0$, complex z , $\nu = 0, 1, 2, \dots$
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 $e^{- x } I_0(x)$
S18CFF	10	Scaled modified Bessel function $e^{- x } I_1(x)$
S18DCF	13	Modified Bessel functions $K_{\nu+a}(z)$, $\text{real } a \geq 0$, complex z , $\nu = 0, 1, 2, \dots$
S18DEF	13	Modified Bessel functions $I_{\nu+a}(z)$, $\text{real } a \geq 0$, complex z , $\nu = 0, 1, 2, \dots$
S18GKF	21	Bessel function of the 1st kind $J_{\alpha \pm n}(z)$
S19AAF	11	Kelvin function $\text{ber } x$
S19ABF	11	Kelvin function $\text{bei } x$
S19ACF	11	Kelvin function $\text{ker } x$
S19ADF	11	Kelvin function $\text{kei } x$
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 $R_J(x, y, z, r)$
S21BEF	22	Elliptic integral of 1st kind, Legendre form, $F(\phi m)$
S21BFF	22	Elliptic integral of 2nd kind, Legendre form, $E(\phi m)$
S21BGF	22	Elliptic integral of 3rd kind, Legendre form, $\Pi(n; \phi m)$
S21BHF	22	Complete elliptic integral of 1st kind, Legendre form, $K(m)$
S21BJF	22	Complete elliptic integral of 2nd kind, Legendre form, $E(m)$
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 $F(z, k', a, b)$ of complex argument
S22AAF	20	Legendre functions of 1st kind $P_n^m(x)$ or $\overline{P_n^m}(x)$
S30AAF	22	Black–Scholes–Merton option pricing formula
S30ABF	22	Black–Scholes–Merton option pricing formula with Greeks
S30BAF	22	Floating-strike lookback option pricing formula
S30BBF	22	Floating-strike lookback option pricing formula with Greeks
S30CAF	22	Binary option: cash-or-nothing pricing formula
S30CBF	22	Binary option: cash-or-nothing pricing formula with Greeks
S30CCF	22	Binary option: asset-or-nothing pricing formula
S30CDF	22	Binary option: asset-or-nothing pricing formula with Greeks
S30FAF	22	Standard barrier option pricing formula

S30JAF	22	Jump-diffusion, Merton's model, option pricing formula
S30JBF	22	Jump-diffusion, Merton's model, option pricing formula with Greeks
S30NAF	22	Heston's model option pricing formula
S30QCF	22	American option: Bjerk Sund and Stensland pricing formula
S30SAF	22	Asian option: geometric continuous average rate pricing formula
S30SBF	22	Asian option: geometric continuous average rate pricing formula with Greeks

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 Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.
X02DJF	12	The floating-point model parameter ROUNDS Note: this routine is scheduled for withdrawal at Mark 24, see Advice on Replacement Calls for Withdrawn/Superseded Routines for further information.

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
