

NAG Library

Tuned and Enhanced Routines in the NAG Library for SMP & Multicore

1 Introduction

Tuned routines are user-callable routines that have been parallelized, or otherwise optimized, in the NAG Library for SMP & Multicore to give improved performance over the equivalent routines in the NAG Fortran Library or in the standard netlib version of LAPACK. Enhanced routines are defined to be those user-callable routines which internally call one or more of the tuned routines, and hence may also exhibit improved performance and scalability. There are a total of 169 tuned routines and a total of 312 enhanced routines within the Library.

The NAG Library for SMP & Multicore is designed to be used in conjunction with the appropriate vendor library on each platform, as it relies upon the vendor library for optimized BLAS and FFT routines. The vendor libraries generally include LAPACK as well, and the vendor may also have parallelized or otherwise optimized some of these LAPACK routines. For each implementation, the performance of the LAPACK routines listed in Section 2 has been investigated, and the best combination of NAG Library for SMP & Multicore and vendor library versions is selected. Thus, in a given implementation, not all of the routines listed in Section 2 will actually be the NAG Library for SMP & Multicore version – consult the Users' Note for your implementation for further information.

2 Tuned LAPACK Routines

There are 77 tuned LAPACK routines within the Library.

Routine Name	Purpose
F07ADF	<i>LU</i> factorization of real m by n matrix
F07AEF	Solution of real system of linear equations, multiple right-hand sides, matrix already factorized by F07ADF (DGETRF)
F07AHF	Refined solution with error bounds of real system of linear equations, multiple right-hand sides
F07ARF	<i>LU</i> factorization of complex m by n matrix
F07ASF	Solution of complex system of linear equations, multiple right-hand sides, matrix already factorized by F07ARF (ZGETRF)
F07AVF	Refined solution with error bounds of complex system of linear equations, multiple right-hand sides
F07BDF	<i>LU</i> factorization of real m by n band matrix
F07BEF	Solution of real band system of linear equations, multiple right-hand sides, matrix already factorized by F07BDF (DGBTRF)
F07BHF	Refined solution with error bounds of real band system of linear equations, multiple right-hand sides
F07BRF	<i>LU</i> factorization of complex m by n band matrix
F07BSF	Solution of complex band system of linear equations, multiple right-hand sides, matrix already factorized by F07BRF (ZGBTRF)
F07BVF	Refined solution with error bounds of complex band system of linear equations, multiple right-hand sides
F07CHF	Refined solution with error bounds of real tridiagonal system of linear equations, multiple right-hand sides

F07CVF	Refined solution with error bounds of complex tridiagonal system of linear equations, multiple right-hand sides
F07FDF	Cholesky factorization of real symmetric positive-definite matrix
F07FEF	Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FDF (DPOTRF)
F07FHF	Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides
F07FRF	Cholesky factorization of complex Hermitian positive-definite matrix
F07FSF	Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07FRF (ZPOTRF)
F07FVF	Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides
F07GEF	Solution of real symmetric positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GDF (DPPTRF), packed storage
F07GHF	Refined solution with error bounds of real symmetric positive-definite system of linear equations, multiple right-hand sides, packed storage
F07GSF	Solution of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, matrix already factorized by F07GRF (ZPPTRF), packed storage
F07GVF	Refined solution with error bounds of complex Hermitian positive-definite system of linear equations, multiple right-hand sides, packed storage
F07HEF	Solution of real symmetric positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HDF (DPBTRF)
F07HHF	Refined solution with error bounds of real symmetric positive-definite band system of linear equations, multiple right-hand sides
F07HSF	Solution of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides, matrix already factorized by F07HRF (ZPBTRF)
F07HVF	Refined solution with error bounds of complex Hermitian positive-definite band system of linear equations, multiple right-hand sides
F07JHF	Refined solution with error bounds of real symmetric positive-definite tridiagonal system of linear equations, multiple right-hand sides
F07JVF	Refined solution with error bounds of complex Hermitian positive-definite tridiagonal system of linear equations, multiple right-hand sides
F07MHF	Refined solution with error bounds of real symmetric indefinite system of linear equations, multiple right-hand sides
F07MVF	Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides
F07NVF	Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides
F07PHF	Refined solution with error bounds of real symmetric indefinite system of linear equations, multiple right-hand sides, packed storage
F07PVF	Refined solution with error bounds of complex Hermitian indefinite system of linear equations, multiple right-hand sides, packed storage
F07QVF	Refined solution with error bounds of complex symmetric system of linear equations, multiple right-hand sides, packed storage
F07THF	Error bounds for solution of real triangular system of linear equations, multiple right-hand sides

F07TVF	Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides
F07UEF	Solution of real triangular system of linear equations, multiple right-hand sides, packed storage
F07UHF	Error bounds for solution of real triangular system of linear equations, multiple right-hand sides, packed storage
F07USF	Solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07UVF	Error bounds for solution of complex triangular system of linear equations, multiple right-hand sides, packed storage
F07VEF	Solution of real band triangular system of linear equations, multiple right-hand sides
F07VHF	Error bounds for solution of real band triangular system of linear equations, multiple right-hand sides
F07VSF	Solution of complex band triangular system of linear equations, multiple right-hand sides
F07VVF	Error bounds for solution of complex band triangular system of linear equations, multiple right-hand sides
F08AEF	QR factorization of real general rectangular matrix
F08AFF	Form all or part of orthogonal Q from QR factorization determined by F08AEF (DGEQRF) or F08BEF (DGEQPF)
F08AGF	Apply orthogonal transformation determined by F08AEF (DGEQRF) or F08BEF (DGEQPF)
F08ASF	QR factorization of complex general rectangular matrix
F08ATF	Form all or part of unitary Q from QR factorization determined by F08ASF (ZGEQRF) or F08BSF (ZGEQPF)
F08AUF	Apply unitary transformation determined by F08ASF (ZGEQRF) or F08BSF (ZGEQPF)
F08FEF	Orthogonal reduction of real symmetric matrix to symmetric tridiagonal form
F08FFF	Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08FEF (DSYTRD)
F08FSF	Unitary reduction of complex Hermitian matrix to real symmetric tridiagonal form
F08FTF	Generate unitary transformation matrix from reduction to tridiagonal form determined by F08FSF (ZHETRD)
F08GFF	Generate orthogonal transformation matrix from reduction to tridiagonal form determined by F08GEF (DSPTRD)
F08GTF	Generate unitary transformation matrix from reduction to tridiagonal form determined by F08GSF (ZHPTRD)
F08HEF	Orthogonal reduction of real symmetric band matrix to symmetric tridiagonal form
F08HSF	Unitary reduction of complex Hermitian band matrix to real symmetric tridiagonal form
F08JEF	All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from real symmetric matrix using the implicit QL or QR algorithm
F08JFF	Selected eigenvalues of real symmetric tridiagonal matrix by bisection
F08JKF	Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in real array
F08JSF	All eigenvalues and eigenvectors of real symmetric tridiagonal matrix, reduced from complex Hermitian matrix, using the implicit QL or QR algorithm
F08JXF	Selected eigenvectors of real symmetric tridiagonal matrix by inverse iteration, storing eigenvectors in complex array

F08KEF	Orthogonal reduction of real general rectangular matrix to bidiagonal form
F08KSF	Unitary reduction of complex general rectangular matrix to bidiagonal form
F08MEF	SVD of real bidiagonal matrix reduced from real general matrix
F08MSF	SVD of real bidiagonal matrix reduced from complex general matrix
F08PKF	Selected right and/or left eigenvectors of real upper Hessenberg matrix by inverse iteration
F08PXF	Selected right and/or left eigenvectors of complex upper Hessenberg matrix by inverse iteration
F08TAF	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage
F08TBF	Computes selected eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage
F08TCF	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem, packed storage (divide-and-conquer)
F08TNF	Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage
F08TPF	Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage
F08TQF	Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem, packed storage (divide-and-conquer)

3 Routines Enhanced by Calling Tuned LAPACK Routines

These routines call one or more of the tuned LAPACK routines as part of their core operations and may thereby exhibit improved performance and scalability. There are 239 of these routines within the Library.

Routine

Name Purpose

C02AKF	All zeros of real cubic equation
C02ALF	All zeros of real quartic equation
C02AMF	All zeros of complex cubic equation
C02ANF	All zeros of complex quartic equation
C05NBF	Solution of system of nonlinear equations using function values only (easy-to-use)
C05NCF	Solution of system of nonlinear equations using function values only (comprehensive)
C05NDF	Solution of system of nonlinear equations using function values only (reverse communication)
C05PBF	Solution of system of nonlinear equations using first derivatives (easy-to-use)
C05PCF	Solution of system of nonlinear equations using first derivatives (comprehensive)
C05PDF	Solution of system of nonlinear equations using first derivatives (reverse communication)
D02HAF	Ordinary differential equations, boundary value problem, shooting and matching, boundary values to be determined
D02HBF	Ordinary differential equations, boundary value problem, shooting and matching, general parameters to be determined
D02NEF	Implicit ordinary differential equations/DAEs, initial value problem, DASSL method integrator
D02SAF	Ordinary differential equations, boundary value problem, shooting and matching technique, subject to extra algebraic equations, general parameters to be determined
D02TKF	Ordinary differential equations, general nonlinear boundary value problem, collocation technique

D03NCF	Finite difference solution of the Black–Scholes equations
D05BDF	Nonlinear convolution Volterra–Abel equation, second kind, weakly singular
D05BEF	Nonlinear convolution Volterra–Abel equation, first kind, weakly singular
E04FCF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using function values only (comprehensive)
E04FYF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using function values only (easy-to-use)
E04GBF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-Newton algorithm using first derivatives (comprehensive)
E04GDF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using first derivatives (comprehensive)
E04GYF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)
E04GZF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using first derivatives (easy-to-use)
E04HEF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm, using second derivatives (comprehensive)
E04HYF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm, using second derivatives (easy-to-use)
E04NCF	Convex QP problem or linearly-constrained linear least-squares problem (dense)
E04UCF	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (comprehensive)
E04UFF	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (reverse communication, comprehensive)
E04USF	Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive)
F01ABF	Inverse of real symmetric positive-definite matrix using iterative refinement
F01ADF	Inverse of real symmetric positive-definite matrix
F01ECF	Real matrix exponential
F02ECF	Selected eigenvalues and eigenvectors of real nonsymmetric matrix (Black Box)
F02FJF	Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)
F02GCF	Selected eigenvalues and eigenvectors of complex nonsymmetric matrix (Black Box)
F02WDF	QR factorization, possibly followed by SVD
F02WGF	Computes leading terms in the singular value decomposition of a real general matrix; also computes corresponding left and right singular vectors
F02WUF	SVD of real upper triangular matrix (Black Box)
F02XUF	SVD of complex upper triangular matrix (Black Box)
F03ABF	Determinant of real symmetric positive-definite matrix (Black Box)
F03AEF	LL^T factorization and determinant of real symmetric positive-definite matrix
F04ABF	Solution of real symmetric positive-definite simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04ASF	Solution of real symmetric positive-definite simultaneous linear equations, one right-hand side using iterative refinement (Black Box)

F04BAF	Computes the solution and error-bound to a real system of linear equations
F04BBF	Computes the solution and error-bound to a real banded system of linear equations
F04BDF	Computes the solution and error-bound to a real symmetric positive-definite system of linear equations
F04BEF	Computes the solution and error-bound to a real symmetric positive-definite system of linear equations, packed storage
F04BFF	Computes the solution and error-bound to a real symmetric positive-definite banded system of linear equations
F04CAF	Computes the solution and error-bound to a complex system of linear equations
F04CBF	Computes the solution and error-bound to a complex banded system of linear equations
F04CDF	Computes the solution and error-bound to a complex Hermitian positive-definite system of linear equations
F04CEF	Computes the solution and error-bound to a complex Hermitian positive-definite system of linear equations, packed storage
F04CFF	Computes the solution and error-bound to a complex Hermitian positive-definite banded system of linear equations
F04JGF	Least-squares (if $\text{rank} = n$) or minimal least-squares (if $\text{rank} < n$) solution of m real equations in n unknowns, $m \geq n$
F07AAF	Computes the solution to a real system of linear equations
F07ABF	Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a real system of linear equations
F07ACF	Mixed precision real system solver
F07ANF	Computes the solution to a complex system of linear equations
F07APF	Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a complex system of linear equations
F07AQF	Mixed precision complex system solver
F07BAF	Computes the solution to a real banded system of linear equations
F07BBF	Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a real banded system of linear equations
F07BNF	Computes the solution to a complex banded system of linear equations
F07BPF	Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a complex banded system of linear equations
F07CBF	Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a real tridiagonal system of linear equations
F07CPF	Uses the <i>LU</i> factorization to compute the solution, error-bound and condition estimate for a complex tridiagonal system of linear equations
F07FAF	Computes the solution to a real symmetric positive-definite system of linear equations
F07FBF	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a real symmetric positive-definite system of linear equations
F07FNF	Computes the solution to a complex Hermitian positive-definite system of linear equations
F07FPF	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a complex Hermitian positive-definite system of linear equations
F07GAF	Computes the solution to a real symmetric positive-definite system of linear equations, packed storage

F07GBF	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
F07GNF	Computes the solution to a complex Hermitian positive-definite system of linear equations, packed storage
F07GPF	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
F07HAF	Computes the solution to a real symmetric positive-definite banded system of linear equations
F07HBF	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a real symmetric positive-definite banded system of linear equations
F07HNF	Computes the solution to a complex Hermitian positive-definite banded system of linear equations
F07HPF	Uses the Cholesky factorization to compute the solution, error-bound and condition estimate for a complex Hermitian positive-definite banded system of linear equations
F07JBF	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
F07JPF	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
F07MBF	Uses the diagonal pivoting factorization to compute the solution to a real symmetric system of linear equations
F07MPF	Uses the diagonal pivoting factorization to compute the solution to a complex Hermitian system of linear equations
F07NPF	Uses the diagonal pivoting factorization to compute the solution to a complex symmetric system of linear equations
F07PBF	Uses the diagonal pivoting factorization to compute the solution to a real symmetric system of linear equations, packed storage
F07PPF	Uses the diagonal pivoting factorization to compute the solution to a complex Hermitian system of linear equations, packed storage
F07QPF	Uses the diagonal pivoting factorization to compute the solution to a complex symmetric system of linear equations, packed storage
F08AAF	Solves an overdetermined or underdetermined real linear system
F08ANF	Solves an overdetermined or underdetermined complex linear system
F08BAF	Computes the minimum-norm solution to a real linear least-squares problem
F08BFF	<i>QR</i> factorization of real general rectangular matrix with column pivoting, using BLAS-3
F08BNF	Computes the minimum-norm solution to a complex linear least-squares problem
F08BTF	<i>QR</i> factorization of complex general rectangular matrix with column pivoting, using BLAS-3
F08FAF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric matrix
F08FBF	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix
F08FCF	Computes all eigenvalues and, optionally, all eigenvectors of real symmetric matrix (divide-and-conquer)
F08FDF	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix (Relatively Robust Representations)
F08FGF	Apply orthogonal transformation determined by F08FEF (DSYTRD)
F08FNF	Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix
F08FPF	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix

F08FQF	Computes all eigenvalues and, optionally, all eigenvectors of complex Hermitian matrix (divide-and-conquer)
F08FRF	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix (Relatively Robust Representations)
F08FUF	Apply unitary transformation matrix determined by F08FSF (ZHETRD)
F08GAF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric matrix, packed storage
F08GBF	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric matrix, packed storage
F08GCF	Computes all eigenvalues and, optionally, all eigenvectors of real symmetric matrix, packed storage (divide-and-conquer)
F08GNF	Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix, packed storage
F08GPF	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian matrix, packed storage
F08GQF	Computes all eigenvalues and, optionally, all eigenvectors of complex Hermitian matrix, packed storage (divide-and-conquer)
F08HAF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric band matrix
F08HBF	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric band matrix
F08HCF	Computes all eigenvalues and, optionally, all eigenvectors of real symmetric band matrix (divide-and-conquer)
F08HNF	Computes all eigenvalues and, optionally, eigenvectors of a complex Hermitian band matrix
F08HPF	Computes selected eigenvalues and, optionally, eigenvectors of a complex Hermitian band matrix
F08HQF	Computes all eigenvalues and, optionally, all eigenvectors of complex Hermitian band matrix (divide-and-conquer)
F08JAF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix
F08JBF	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix
F08JCF	Computes all eigenvalues and, optionally, all eigenvectors of real symmetric tridiagonal matrix (divide-and-conquer)
F08JDF	Computes selected eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix (Relatively Robust Representations)
F08JGF	Computes all eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from real symmetric positive-definite matrix
F08JHF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a matrix reduced to this form (divide-and-conquer)
F08JLF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a symmetric matrix reduced to this form (Relatively Robust Representations)
F08JUF	Computes all eigenvalues and eigenvectors of real symmetric positive-definite tridiagonal matrix, reduced from complex Hermitian positive-definite matrix
F08JVF	Computes all eigenvalues and, optionally, eigenvectors of a real symmetric tridiagonal matrix or a complex Hermitian matrix reduced to this form (divide-and-conquer)
F08JYF	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	Computes the minimum-norm solution to a real linear least-squares problem using singular value decomposition
F08KBF	Computes the singular value decomposition of a real matrix, optionally computing the left and/or right singular vectors
F08KCF	Computes the minimum-norm solution to a real linear least-squares problem using singular value decomposition (divide-and-conquer)
F08KDF	Computes the singular value decomposition of a real matrix, optionally computing the left and/or right singular vectors (divide-and-conquer)
F08KFF	Generate orthogonal transformation matrices from reduction to bidiagonal form determined by F08KEF (DGEBRD)
F08KGF	Apply orthogonal transformations from reduction to bidiagonal form determined by F08KEF (DGEBRD)
F08KNF	Computes the minimum-norm solution to a complex linear least-squares problem using singular value decomposition
F08KPF	Computes the singular value decomposition of a complex matrix, optionally computing the left and/or right singular vectors
F08KQF	Computes the minimum-norm solution to a complex linear least-squares problem using singular value decomposition (divide-and-conquer)
F08KRF	Computes the singular value decomposition of a complex matrix, optionally computing the left and/or right singular vectors (divide-and-conquer)
F08KTF	Generate unitary transformation matrices from reduction to bidiagonal form determined by F08KSF (ZGEBRD)
F08KUF	Apply unitary transformations from reduction to bidiagonal form determined by F08KSF (ZGEBRD)
F08MDF	Computes the singular value decomposition of a real bidiagonal matrix, optionally computing the singular vectors (divide-and-conquer)
F08NAF	Computes all eigenvalues and, optionally, left and/or right eigenvectors of a real nonsymmetric matrix
F08NBF	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
F08NFF	Generate orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (DGEHRD)
F08NGF	Apply orthogonal transformation matrix from reduction to Hessenberg form determined by F08NEF (DGEHRD)
F08NNF	Computes all eigenvalues and, optionally, left and/or right eigenvectors of a complex nonsymmetric matrix
F08NPF	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
F08NTF	Generate unitary transformation matrix from reduction to Hessenberg form determined by F08NSF (ZGEHRD)
F08NUF	Apply unitary transformation matrix from reduction to Hessenberg form determined by F08NSF (ZGEHRD)
F08PAF	Computes for real square nonsymmetric matrix, the eigenvalues, the real Schur form, and, optionally, the matrix of Schur vectors

F08PBF	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	Computes the eigenvalues and Schur factorization of real upper Hessenberg matrix reduced from real general matrix
F08PNF	Computes for complex square nonsymmetric matrix, the eigenvalues, the Schur form, and, optionally, the matrix of Schur vectors
F08PPF	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	Computes the eigenvalues and Schur factorization of complex upper Hessenberg matrix reduced from complex general matrix
F08SAF	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem
F08SBF	Computes selected eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem
F08SCF	Computes all the eigenvalues, and optionally, the eigenvectors of a real generalized symmetric-definite eigenproblem (divide-and-conquer)
F08SNF	Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem
F08SPF	Computes selected eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem
F08SQF	Computes all the eigenvalues, and optionally, the eigenvectors of a complex generalized Hermitian-definite eigenproblem (divide-and-conquer)
F08UAF	Computes all the eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem
F08UBF	Computes selected eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem
F08UCF	Computes all the eigenvalues, and optionally, the eigenvectors of a real banded generalized symmetric-definite eigenproblem (divide-and-conquer)
F08UNF	Computes all the eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem
F08UPF	Computes selected eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem
F08UQF	Computes all the eigenvalues, and optionally, the eigenvectors of a complex banded generalized Hermitian-definite eigenproblem (divide-and-conquer)
F08WAF	Computes, for a real nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors
F08WBF	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
F08WNF	Computes, for a complex nonsymmetric matrix pair, the generalized eigenvalues, and optionally, the left and/or right generalized eigenvectors
F08WPF	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

F08XAF	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	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
F08XNF	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	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
F08ZAF	Solves the real linear equality-constrained least-squares (LSE) problem
F08ZBF	Solves a real general Gauss–Markov linear model (GLM) problem
F08ZEF	Computes a generalized QR factorization of a real matrix pair
F08ZFF	Computes a generalized RQ factorization of a real matrix pair
F08ZNF	Solves the complex linear equality-constrained least-squares (LSE) problem
F08ZPF	Solves a complex general Gauss–Markov linear model (GLM) problem
F08ZSF	Computes a generalized QR factorization of a complex matrix pair
F08ZTF	Computes a generalized RQ factorization of a complex matrix pair
F12FCF	Returns the converged approximations (as determined by F12FBBF) 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
F12FGF	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
G01HBF	Computes probabilities for the multivariate Normal distribution
G02BYF	Computes partial correlation/variance-covariance matrix from correlation/variance-covariance matrix computed by G02BXF
G02CGF	Multiple linear regression, from correlation coefficients, with constant term
G02CHF	Multiple linear regression, from correlation-like coefficients, without constant term
G02DAF	Fits a general (multiple) linear regression model
G02DDF	Estimates of linear parameters and general linear regression model from updated model
G02EAF	Computes residual sums of squares for all possible linear regressions for a set of independent variables
G02EEF	Fits a linear regression model by forward selection
G02GAF	Fits a generalized linear model with Normal errors
G02GBF	Fits a generalized linear model with binomial errors
G02GCF	Fits a generalized linear model with Poisson errors
G02GDF	Fits a generalized linear model with gamma errors
G02HAF	Robust regression, standard M -estimates
G02HDF	Robust regression, compute regression with user-supplied functions and weights
G02HFF	Robust regression, variance-covariance matrix following G02HDF
G02JAF	Linear mixed effects regression using Restricted Maximum Likelihood (REML)

G02JBF	Linear mixed effects regression using Maximum Likelihood (ML)
G02KAF	Ridge regression, optimizing a ridge regression parameter
G02KBF	Ridge regression using a number of supplied ridge regression parameters
G02LAF	Partial least-squares (PLS) regression using singular value decomposition
G02LCF	PLS parameter estimates following partial least-squares regression by G02LAF or G02LBF
G03AAF	Performs principal component analysis
G03ACF	Performs canonical variate analysis
G03ADF	Performs canonical correlation analysis
G03BAF	Computes orthogonal rotations for loading matrix, generalized orthomax criterion
G03BCF	Computes Procrustes rotations
G03BDF	ProMax rotations
G03DAF	Computes test statistic for equality of within-group covariance matrices and matrices for discriminant analysis
G03FAF	Performs principal coordinate analysis, classical metric scaling
G04BBF	Analysis of variance, randomized block or completely randomized design, treatment means and standard errors
G04BCF	Analysis of variance, general row and column design, treatment means and standard errors
G05PJF	Generates a realization of a multivariate time series from a VARMA model
G08RAF	Regression using ranks, uncensored data
G08RBF	Regression using ranks, right-censored data
G11CAF	Returns parameter estimates for the conditional analysis of stratified data
G11SAF	Contingency table, latent variable model for binary data
G12BAF	Fits Cox's proportional hazard model
G13AEF	Univariate time series, estimation, seasonal ARIMA model (comprehensive)
G13AFF	Univariate time series, estimation, seasonal ARIMA model (easy-to-use)
G13AJF	Univariate time series, state set and forecasts, from fully specified seasonal ARIMA model
G13ASF	Univariate time series, diagnostic checking of residuals, following G13AEF or G13AFF
G13BAF	Multivariate time series, filtering (pre-whitening) by an ARIMA model
G13BBF	Multivariate time series, filtering by a transfer function model
G13BDF	Multivariate time series, preliminary estimation of transfer function model
G13BEF	Multivariate time series, estimation of multi-input model
G13BJF	Multivariate time series, state set and forecasts from fully specified multi-input model
G13DBF	Multivariate time series, multiple squared partial autocorrelations
G13DDF	Multivariate time series, estimation of VARMA model
G13DJF	Multivariate time series, forecasts and their standard errors
G13DNF	Multivariate time series, sample partial lag correlation matrices, χ^2 statistics and significance levels
G13DPF	Multivariate time series, partial autoregression matrices
G13DSF	Multivariate time series, diagnostic checking of residuals, following G13DDF
G13DXF	Calculates the zeros of a vector autoregressive (or moving average) operator

G13FAF	Univariate time series, parameter estimation for either a symmetric GARCH process or a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma)^2$
G13FCF	Univariate time series, parameter estimation for a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma\epsilon_{t-1})^2$
G13FEF	Univariate time series, parameter estimation for an asymmetric Glosten, Jagannathan and Runkle (GJR) GARCH process
G13FGF	Univariate time series, parameter estimation for an exponential GARCH (EGARCH) process

4 Tuned NAG-specific Routines

These NAG-specific routines have been parallelized, or otherwise optimized, in the NAG Library for SMP & Multicore compared to the equivalent routine in the NAG Fortran Library. There are 92 of these routines within the Library.

Routine Name	Purpose
C06FKF	Circular convolution or correlation of two real vectors, extra workspace for greater speed
C06FPF	Multiple one-dimensional real discrete Fourier transforms
C06FQF	Multiple one-dimensional Hermitian discrete Fourier transforms
C06FRF	Multiple one-dimensional complex discrete Fourier transforms
C06FUF	Two-dimensional complex discrete Fourier transform
C06FXF	Three-dimensional complex discrete Fourier transform
C06HAF	Discrete sine transform
C06HBF	Discrete cosine transform
C06HCF	Discrete quarter-wave sine transform
C06HDF	Discrete quarter-wave cosine transform
C06PAF	Single one-dimensional real and Hermitian complex discrete Fourier transform, using complex storage format for Hermitian sequences
C06PFF	One-dimensional complex discrete Fourier transform of multi-dimensional data (using Complex data type)
C06PJF	Multi-dimensional complex discrete Fourier transform of multi-dimensional data (using Complex data type)
C06PKF	Circular convolution or correlation of two complex vectors
C06PPF	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex storage format for Hermitian sequences
C06PQF	Multiple one-dimensional real and Hermitian complex discrete Fourier transforms, using complex storage format for Hermitian sequences
C06PRF	Multiple one-dimensional complex discrete Fourier transforms using complex data type
C06PSF	Multiple one-dimensional complex discrete Fourier transforms using complex data type and sequences stored as columns
C06PUF	Two-dimensional complex discrete Fourier transform, complex data type
C06PXF	Three-dimensional complex discrete Fourier transform, Complex data type
C06RAF	Discrete sine transform (easy-to-use)
C06RBF	Discrete cosine transform (easy-to-use)

C06RCF	Discrete quarter-wave sine transform (easy-to-use)
C06RDF	Discrete quarter-wave cosine transform (easy-to-use)
D01DAF	Two-dimensional quadrature, finite region
D01FCF	Multi-dimensional adaptive quadrature over hyper-rectangle
D01GAF	One-dimensional quadrature, integration of function defined by data values, Gill–Miller method
D03RAF	General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectangular region
D03RBF	General system of second-order PDEs, method of lines, finite differences, remeshing, two space variables, rectilinear region
E01SGF	Interpolating functions, modified Shepard’s method, two variables
E01SHF	Interpolated values, evaluate interpolant computed by E01SGF, function and first derivatives, two variables
E01TGF	Interpolating functions, modified Shepard’s method, three variables
E01THF	Interpolated values, evaluate interpolant computed by E01TGF, function and first derivatives, three variables
E02CAF	Least-squares surface fit by polynomials, data on lines parallel to one independent coordinate axis
E02CBF	Evaluation of fitted polynomial in two variables
E02DFE	Evaluation of fitted bicubic spline at a mesh of points
F01CTF	Sum or difference of two real matrices, optional scaling and transposition
F01CWF	Sum or difference of two complex matrices, optional scaling and transposition
F04AFF	Solution of real symmetric positive-definite simultaneous linear equations using iterative refinement (coefficient matrix already factorized by F03AEF)
F04AGF	Solution of real symmetric positive-definite simultaneous linear equations (coefficient matrix already factorized by F03AEF)
F04AHF	Solution of real simultaneous linear equations using iterative refinement (coefficient matrix already factorized by F03AFF)
F04AJF	Solution of real simultaneous linear equations (coefficient matrix already factorized by F03AFF)
F05AAF	Gram–Schmidt orthogonalisation of n vectors of order m
F11BEF	Real sparse nonsymmetric linear systems, preconditioned RGMRES, CGS, Bi-CGSTAB or TFQMR method
F11BSF	Complex sparse non-Hermitian linear systems, preconditioned RGMRES, CGS, Bi-CGSTAB or TFQMR method
F11GEF	Real sparse symmetric linear systems, preconditioned conjugate gradient or Lanczos
F11GSF	Complex sparse Hermitian linear systems, preconditioned conjugate gradient or Lanczos
F11MEF	LU factorization of real sparse matrix
F11MFF	Solution of real sparse simultaneous linear equations (coefficient matrix already factorized)
F11MHF	Refined solution with error bounds of real system of linear equations, multiple right-hand sides
F11MKF	Real sparse nonsymmetric matrix-matrix multiply, compressed column storage
F11XAF	Real sparse nonsymmetric matrix vector multiply
F11XEF	Real sparse symmetric matrix vector multiply

F11XNF	Complex sparse non-Hermitian matrix vector multiply
F11XSF	Complex sparse Hermitian matrix vector multiply
F12ABF	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
F12AGF	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
G02AAF	Computes the nearest correlation matrix to a real square matrix, using the method of Qi and Sun
G02BAF	Pearson product-moment correlation coefficients, all variables, no missing values
G02BDF	Correlation-like coefficients (about zero), all variables, no missing values
G02BNF	Kendall/Spearman non-parametric rank correlation coefficients, no missing values, overwriting input data
G02BPF	Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, overwriting input data
G02BQF	Kendall/Spearman non-parametric rank correlation coefficients, no missing values, preserving input data
G02BRF	Kendall/Spearman non-parametric rank correlation coefficients, casewise treatment of missing values, preserving input data
G03CAF	Computes maximum likelihood estimates of the parameters of a factor analysis model, factor loadings, communalities and residual correlations
G03EAF	Computes distance matrix
G03ECF	Hierarchical cluster analysis
G05RCF	Generates a matrix of pseudorandom numbers from a Student's <i>t</i> -copula
G05RDF	Generates a matrix of pseudorandom numbers from a Gaussian copula
G05YJF	Generates a Normal quasi-random number sequence
G05YKF	Generates a log-normal quasi-random number sequence
G05YMF	Generates a uniform quasi-random number sequence
G13EAF	Combined measurement and time update, one iteration of Kalman filter, time-varying, square root covariance filter
G13EBF	Combined measurement and time update, one iteration of Kalman filter, time-invariant, square root covariance filter
M01CAF	Sort a vector, real numbers
M01CBF	Sort a vector, integer numbers
M01CCF	Sort a vector, character data
S30AAF	Black–Scholes–Merton option pricing formula
S30ABF	Black–Scholes–Merton option pricing formula with Greeks
S30BAF	Floating-strike lookback option pricing formula
S30BBF	Floating-strike lookback option pricing formula with Greeks
S30CAF	Binary option: cash-or-nothing pricing formula
S30CBF	Binary option: cash-or-nothing pricing formula with Greeks
S30CCF	Binary option: asset-or-nothing pricing formula

S30CDF	Binary option: asset-or-nothing pricing formula with Greeks
S30FAF	Standard barrier option pricing formula
S30JAF	Jump-diffusion, Merton's model, option pricing formula
S30JBF	Jump-diffusion, Merton's model, option pricing formula with Greeks
S30NAF	Heston's model option pricing formula
S30QCF	American option: Bjerk Sund and Stensland pricing formula
S30SAF	Asian option: geometric continuous average rate pricing formula
S30SBF	Asian option: geometric continuous average rate pricing formula with Greeks

5 Routines Enhanced by Calling Tuned NAG-specific Routines

These routines call one or more of the tuned NAG-specific routines as part of their core operations and may thereby exhibit improved performance and scalability. There are 128 of these routines within the Library.

Routine Name	Purpose
D01PAF	Multi-dimensional quadrature over an n -simplex
D02AGF	Ordinary differential equations, boundary value problem, shooting and matching technique, allowing interior matching point, general parameters to be determined
D02EJF	Ordinary differential equations, stiff initial value problem, backward differential formulae method, until function of solution is zero, intermediate output (simple driver)
D02NBF	Explicit ordinary differential equations, stiff initial value problem, full Jacobian (comprehensive)
D02NCF	Explicit ordinary differential equations, stiff initial value problem, banded Jacobian (comprehensive)
D02NDF	Explicit ordinary differential equations, stiff initial value problem, sparse Jacobian (comprehensive)
D02NGF	Implicit/algebraic ordinary differential equations, stiff initial value problem, full Jacobian (comprehensive)
D02NHF	Implicit/algebraic ordinary differential equations, stiff initial value problem, banded Jacobian (comprehensive)
D02NJF	Implicit/algebraic ordinary differential equations, stiff initial value problem, sparse Jacobian (comprehensive)
D02NMF	Explicit ordinary differential equations, stiff initial value problem (reverse communication, comprehensive)
D02NNF	Implicit/algebraic ordinary differential equations, stiff initial value problem (reverse communication, comprehensive)
D03FAF	Elliptic PDE, Helmholtz equation, three-dimensional Cartesian coordinates
D03PCF	General system of parabolic PDEs, method of lines, finite differences, one space variable
D03PDF	General system of parabolic PDEs, method of lines, Chebyshev C^0 collocation, one space variable
D03PEF	General system of first-order PDEs, method of lines, Keller box discretisation, one space variable

D03PFF	General system of convection-diffusion PDEs with source terms in conservative form, method of lines, upwind scheme using numerical flux function based on Riemann solver, one space variable
D03PHF	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, one space variable
D03PJF	General system of parabolic PDEs, coupled DAEs, method of lines, Chebyshev C^0 collocation, one space variable
D03PKF	General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, one space variable
D03PLF	General system of convection-diffusion PDEs with source terms in conservative form, coupled DAEs, method of lines, upwind scheme using numerical flux function based on Riemann solver, one space variable
D03PPF	General system of parabolic PDEs, coupled DAEs, method of lines, finite differences, remeshing, one space variable
D03PRF	General system of first-order PDEs, coupled DAEs, method of lines, Keller box discretisation, remeshing, one space variable
D03PSF	General system of convection-diffusion PDEs with source terms in conservative form, coupled DAEs, method of lines, upwind scheme using numerical flux function based on Riemann solver, remeshing, one space variable
D05AAF	Linear non-singular Fredholm integral equation, second kind, split kernel
D05ABF	Linear non-singular Fredholm integral equation, second kind, smooth kernel
D06CBF	Generates a sparsity pattern of a Finite Element matrix associated with a given mesh
D06CCF	Renumbers a given mesh using Gibbs method
E02RAF	Padé approximants
E04FCF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using function values only (comprehensive)
E04FYF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using function values only (easy-to-use)
E04GBF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-Newton algorithm using first derivatives (comprehensive)
E04GDF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using first derivatives (comprehensive)
E04GYF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and quasi-Newton algorithm, using first derivatives (easy-to-use)
E04GZF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm using first derivatives (easy-to-use)
E04HEF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm, using second derivatives (comprehensive)
E04HYF	Unconstrained minimum of a sum of squares, combined Gauss–Newton and modified Newton algorithm, using second derivatives (easy-to-use)
E04NCF	Convex QP problem or linearly-constrained linear least-squares problem (dense)
E04UCF	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (comprehensive)
E04UFF	Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (reverse communication, comprehensive)

E04USF	Minimum of a sum of squares, nonlinear constraints, sequential QP method, using function values and optionally first derivatives (comprehensive)
E04YCF	Covariance matrix for nonlinear least-squares problem (unconstrained)
E05JBF	Global optimization by multi-level coordinate search, simple bounds, using function values only
F01ABF	Inverse of real symmetric positive-definite matrix using iterative refinement
F02FJF	Selected eigenvalues and eigenvectors of sparse symmetric eigenproblem (Black Box)
F02WDF	QR factorization, possibly followed by SVD
F02WUF	SVD of real upper triangular matrix (Black Box)
F02XUF	SVD of complex upper triangular matrix (Black Box)
F03AAF	Determinant of real matrix (Black Box)
F03ADF	Determinant of complex matrix (Black Box)
F03AFF	LU factorization and determinant of real matrix
F04ABF	Solution of real symmetric positive-definite simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04AEF	Solution of real simultaneous linear equations with multiple right-hand sides using iterative refinement (Black Box)
F04ASF	Solution of real symmetric positive-definite simultaneous linear equations, one right-hand side using iterative refinement (Black Box)
F04ATF	Solution of real simultaneous linear equations, one right-hand side using iterative refinement (Black Box)
F04JGF	Least-squares (if rank = n) or minimal least-squares (if rank < n) solution of m real equations in n unknowns, $m \geq n$
F11DCF	Solution of real sparse nonsymmetric linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DAF
F11DEF	Solution of real sparse nonsymmetric linear system, RGMRES, CGS, Bi-CGSTAB, or TFQMR method, Jacobi or SSOR preconditioner (Black Box)
F11DKF	Real sparse nonsymmetric linear systems, line Jacobi preconditioner
F11DQF	Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, preconditioner computed by F11DNF (Black Box)
F11DSF	Solution of complex sparse non-Hermitian linear system, RGMRES, CGS, Bi-CGSTAB or TFQMR method, Jacobi or SSOR preconditioner Black Box
F11DXF	Complex sparse nonsymmetric linear systems, line Jacobi preconditioner
F11JCF	Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JAF (Black Box)
F11JEF	Solution of real sparse symmetric linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)
F11JQF	Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, preconditioner computed by F11JNF (Black Box)
F11JSF	Solution of complex sparse Hermitian linear system, conjugate gradient/Lanczos method, Jacobi or SSOR preconditioner (Black Box)
F11MDF	Real sparse nonsymmetric linear systems, setup for F11MEF
G01AGF	Lineprinter scatterplot of two variables
G01AHF	Lineprinter scatterplot of one variable against Normal scores

G01ARF	Constructs a stem and leaf plot
G01EMF	Computes probability for the Studentized range statistic
G01HBF	Computes probabilities for the multivariate Normal distribution
G01JDF	Computes lower tail probability for a linear combination of (central) χ^2 variables
G02CGF	Multiple linear regression, from correlation coefficients, with constant term
G02CHF	Multiple linear regression, from correlation-like coefficients, without constant term
G02DAF	Fits a general (multiple) linear regression model
G02DDF	Estimates of linear parameters and general linear regression model from updated model
G02DEF	Add a new independent variable to a general linear regression model
G02DGF	Fits a general linear regression model to new dependent variable
G02DKF	Estimates and standard errors of parameters of a general linear regression model for given constraints
G02EEF	Fits a linear regression model by forward selection
G02GAF	Fits a generalized linear model with Normal errors
G02GBF	Fits a generalized linear model with binomial errors
G02GCF	Fits a generalized linear model with Poisson errors
G02GDF	Fits a generalized linear model with gamma errors
G02GKF	Estimates and standard errors of parameters of a general linear model for given constraints
G02HAF	Robust regression, standard M -estimates
G02HDF	Robust regression, compute regression with user-supplied functions and weights
G02HFF	Robust regression, variance-covariance matrix following G02HDF
G02HKF	Calculates a robust estimation of a correlation matrix, Huber's weight function
G02JAF	Linear mixed effects regression using Restricted Maximum Likelihood (REML)
G02JBF	Linear mixed effects regression using Maximum Likelihood (ML)
G02KAF	Ridge regression, optimizing a ridge regression parameter
G02KBF	Ridge regression using a number of supplied ridge regression parameters
G03ACF	Performs canonical variate analysis
G03ADF	Performs canonical correlation analysis
G04EAF	Computes orthogonal polynomials or dummy variables for factor/classification variable
G05PJF	Generates a realization of a multivariate time series from a VARMA model
G05PYF	Generates a random correlation matrix
G07BEF	Computes maximum likelihood estimates for parameters of the Weibull distribution
G07DAF	Robust estimation, median, median absolute deviation, robust standard deviation
G07DBF	Robust estimation, M -estimates for location and scale parameters, standard weight functions
G07DCF	Robust estimation, M -estimates for location and scale parameters, user-defined weight functions
G07DDF	Computes a trimmed and winsorized mean of a single sample with estimates of their variance
G07EAF	Robust confidence intervals, one-sample
G07EBF	Robust confidence intervals, two-sample

G08AGF	Performs the Wilcoxon one-sample (matched pairs) signed rank test
G08AKF	Computes the exact probabilities for the Mann–Whitney U statistic, ties in pooled sample
G08CBF	Performs the one-sample Kolmogorov–Smirnov test for standard distributions
G08CCF	Performs the one-sample Kolmogorov–Smirnov test for a user-supplied distribution
G08CDF	Performs the two-sample Kolmogorov–Smirnov test
G08RAF	Regression using ranks, uncensored data
G08RBF	Regression using ranks, right-censored data
G11BBF	Computes multiway table from set of classification factors using given percentile/quantile
G11BCF	Computes marginal tables for multiway table computed by G11BAF or G11BBF
G11SAF	Contingency table, latent variable model for binary data
G13ADF	Univariate time series, preliminary estimation, seasonal ARIMA model
G13AEF	Univariate time series, estimation, seasonal ARIMA model (comprehensive)
G13AFF	Univariate time series, estimation, seasonal ARIMA model (easy-to-use)
G13AJF	Univariate time series, state set and forecasts, from fully specified seasonal ARIMA model
G13BEF	Multivariate time series, estimation of multi-input model
G13BJF	Multivariate time series, state set and forecasts from fully specified multi-input model
G13DBF	Multivariate time series, multiple squared partial autocorrelations
G13DDF	Multivariate time series, estimation of VARMA model
G13DNF	Multivariate time series, sample partial lag correlation matrices, χ^2 statistics and significance levels
G13FAF	Univariate time series, parameter estimation for either a symmetric GARCH process or a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma)^2$
G13FCF	Univariate time series, parameter estimation for a GARCH process with asymmetry of the form $(\epsilon_{t-1} + \gamma\epsilon_{t-1})^2$
G13FEF	Univariate time series, parameter estimation for an asymmetric Glosten, Jagannathan and Runkle (GJR) GARCH process
G13FGF	Univariate time series, parameter estimation for an exponential GARCH (EGARCH) process
