GAUSS™

Language Reference

Aptech Systems, Inc.— *Mathematical and Statistical System*

Part Number: 2368
Version 4.0
Revised January 25, 2002

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1 Introduction

This GAUSS™ Language Reference describes each of the commands, procedures, and functions available in the GAUSS programming language. These functions can be divided into four categories:

- Mathematical, statistical, and scientific functions.
- Data handling routines, including data matrix manipulation and description routines, and file I/O.
- Programming statements, including branching, looping, display features, error checking, and shell commands.
- Graphics functions.

The first category contains those functions to be expected in a high-level mathematical language: trigonometric functions and other transcendental functions, distribution functions, random number generators, numerical differentiation and integration routines, Fourier transforms, Bessel functions, and polynomial evaluation routines. And, as a matrix programming language, GAUSS includes a variety of routines that perform standard matrix operations. Among these are routines to calculate determinants, matrix inverses, decompositions, eigenvalues and eigenvectors, and condition numbers.

Data handling routines include functions that return dimensions of matrices, and information about elements of data matrices, including functions to locate values lying in specific ranges or with certain values. Also under data handling routines fall all

those functions that create, save, open, and read from and write to GAUSS data sets. A variety of sorting routines that will operate on both numeric and character data are also available.

Programming statements are all of the commands that make it possible to write complex programs in GAUSS. These include conditional and unconditional branching, looping, file I/O, error handling, and system-related commands to execute OS shells and access directory and environment information.

The graphics functions of GAUSS Publication Quality Graphics (PQG) are a set of routines built on the graphics functions in GraphiC by Scientific Endeavors Corporation. GAUSS PQG consists of a set of main graphing procedures and several additional procedures and global variables for customizing the output.

Documentation Conventions

The following table describes how text formatting is used to identify GAUSS programming elements.

Text Style	Use	Example
regular text	narrative	"...text formatting is used..."
bold text	emphasis	"...not supported under **UNIX**."
italic text	variables	"...If *vnames* is a string or has fewer elements than *x* has columns, it will be..."

`monospace`	code example	`if scalerr(cm);`
		`  cm = inv(x);`
		`endif;`

`monospace bold`	Refers to a GAUSS programming element within a narrative paragraph.	"...as explained under **`create`**..."

Using This Manual

Users who are new to GAUSS should make sure they have familiarized themselves with "Language Fundamentals" in the *User's Guide* before proceeding here. That chapter contains the basics of GAUSS programming.

In all, there are over 400 routines described in this GAUSS Language Reference. We suggest that new GAUSS users skim through Chapter 2, and then browse through Chapter 3, the main part of this manual. Here, users can familiarize themselves with the kinds of tasks that GAUSS can handle easily.

Chapter 2 gives a categorical listing of all functions in this GAUSS Language Reference, and a short discussion of the functions in each category. Complete syntax, description of input and output arguments, and general remarks regarding each function are given in Chapter 3.

If a function is an "extrinsic" (that is, part of the Run-Time Library), its source code can be found on the `.src` subdirectory. The name of the file containing the source code is given in Chapter 3 under the discussion of that function.

Global Control Variables

Several GAUSS functions use global variables to control various aspects of their performance. The files gauss.ext, gauss.dec, and gauss.lcg contain the **`external`** statements, **`declare`** statements, and **`library`** references to these globals. All globals used by the GAUSS Run-Time library begin with an underscore '_'.

Default values for these common globals can be found in the file `gauss.dec`, located on the `.src` subdirectory. The default values can be changed by editing this file.

Changing the Default Values

To permanently change the default setting of a common global, two files need to be edited: `gauss.dec` and `gauss.src`.

To change the value of the common global **`__output`** from 2 to 0, for example, edit the file `gauss.dec` and change the statement

```
declare matrix __output = 2;
```

to read

```
declare matrix __output = 0;
```

Also, edit the procedure **`gausset`**, located in the file `gauss.src`, and modify the statement

```
__output = 2;
```

similarly.

The Procedure gausset

The global variables affect your program, even if you have not set them directly in a particular command file. If you have changed them in a previous run, they will retain their changed values until you exit GAUSS or execute the **new** command.

The procedure **gausset** will reset the Run-Time Library globals to their default values:

```
gausset;
```

If your program changes the values of these globals, you can use **gausset** to reset them whenever necessary. **gausset** resets the globals as a whole; you can write your own routine to reset specific ones.

Commands by Category 2

Mathematical Functions

Scientific Functions

abs	Returns absolute value of argument.
arccos	Computes inverse cosine.
arcsin	Computes inverse sine.
atan	Computes inverse tangent.
atan2	Computes angle given a point *x*,*y*.
besselj	Computes Bessel function, first kind.
bessely	Computes Bessel function, second kind.
cos	Computes cosine.
cosh	Computes hyperbolic cosine.
exp	Computes the exponential function of *x*.
gamma	Computes gamma function value.
ln	Computes the natural log of each element.
lnfact	Computes natural log of factorial function.

log	Computes the $\log_{10}$ of each element.
pi	Returns π.
sin	Computes sine.
sinh	Computes the hyperbolic sine.
spline1D	Computes a smoothing spline for a curve.
spline2D	Computes a smoothing spline for a surface.
sqrt	Computes the square root of each element.
tan	Computes tangent.
tanh	Computes hyperbolic tangent

All trigonometric functions take or return values in radian units.

Differentiation and Integration

gradp	Computes first derivative of a function.
hessp	Computes second derivative of a function.
intgrat2	Integrates a 2-dimensional function over a user-defined region.
intgrat3	Integrates a 3-dimensional function over a user-defined region.
intquad1	Integrates a 1-dimensional function.
intquad2	Integrates a 2-dimensional function over a user-defined rectangular region.
intquad3	Integrates a 3-dimensional function over a user-defined rectangular region.
intsimp	Integrates by Simpson's method.

gradp and **hessp** use a finite difference approximation to compute the first and second derivatives. Use **gradp** to calculate a Jacobian.

intquad1, **intquad2**, and **intquad3** use Gaussian quadrature to calculate the integral of the user-defined function over a rectangular region.

To calculate an integral over a region defined by functions of *x* and *y*, use **intgrat2** and **intgrat3**.

To get a greater degree of accuracy than that provided by **intquad1**, use **intsimp** for 1-dimensional integration.

Linear Algebra

balance	Balances a matrix.

chol	Computes Cholesky decomposition, $X = Y'Y$.
choldn	Performs Cholesky downdate on an upper triangular matrix.
cholsol	Solves a system of equations given the Cholesky factorization of a matrix.
cholup	Performs Cholesky update on an upper triangular matrix.
cond	Computes condition number of a matrix.
crout	Computes Crout decomposition, $X = LU$ (real matrices only).
croutp	Computes Crout decomposition with row pivoting (real matrices only).
det	Computes determinant of square matrix.
detl	Computes determinant of decomposed matrix.
hess	Computes upper Hessenberg form of a matrix (real matrices only).
inv	Inverts a matrix.
invpd	Inverts a positive definite matrix.
invswp	Generalized sweep inverse.
lapeighb	Computes eigenvalues only of a real symmetric or complex Hermitian matrix selected by bounds.
lapeighi	Computes eigenvalues only of a real symmetric or complex Hermitian matrix selected by index.
lapeighvb	Computes eigenvalues and eigenvectors of a real symmetric or complex Hermitian matrix selected by bounds.
lapeighvi	Computes selected eigenvalues and eigenvectors of a real symmetric or complex Hermitian matrix.
lapgeig	Computes generalized eigenvalues for a pair of real or complex general matrices.
lapgeigh	Computes generalized eigenvalues for a pair of real symmetric or Hermitian matrices.
lapgeighv	Computes generalized eigenvalues and eigenvectors for a pair of real symmetric or Hermitian matrices.
lapgeigv	Computes generalized eigenvalues, left eigenvectors, and right eigenvectors for a pair of real or complex general matrices.
lapgsvds	Compute the generalized singular value decomposition of a pair of real or complex general matrices.
lapgsvdcst	Compute the generalized singular value decomposition of a pair of real or complex general matrices.

lapgsvdst	Compute the generalized singular value decomposition of a pair of real or complex general matrices.
lapschur	Compute the generalized Schur form of a pair of real or complex general matrices.
lapsvdcusv	Computes the singular value decomposition a real or complex rectangular matrix, returns compact u and v.
lapsvds	Computes the singular values of a real or complex rectangular matrix
lapsvdusv	Computes the singular value decomposition a real or complex rectangular matrix.
lu	Computes LU decomposition with row pivoting (real and complex matrices).
null	Computes orthonormal basis for right null space.
null1	Computes orthonormal basis for right null space.
orth	Computes orthonormal basis for column space *x*.
pinv	Generalized pseudo-inverse: Moore-Penrose.
qqr	QR decomposition: returns Q_1 and *R*.
qqre	QR decomposition: returns Q_1, *R*, and a permutation vector, *E*.
qqrep	QR decomposition with pivot control: returns Q_1, *R*, and *E*.
qr	QR decomposition: returns *R*.
qre	QR decomposition: returns *R* and *E*.
qrep	QR decomposition with pivot control: returns *R* and *E*.
qrsol	Solves a system of equations *Rx=b* given an upper triangular matrix, typically the *R* matrix from a QR decomposition.
qrtsol	Solves a system of equations $R'x = b$ given an upper triangular matrix, typically the *R* matrix from a QR decomposition.
qtyr	QR decomposition: returns $Q'Y$ and *R*.
qtyre	QR decomposition: returns $Q'Y$, *R*, and *E*.
qtyrep	QR decomposition with pivot control: returns $Q'Y$, *R*, and *E*.
qyr	QR decomposition: returns *QY* and *R*.
qyre	QR decomposition: returns *QY, R*, and *E*.
qyrep	QR decomposition with pivot control: returns *QY, R*, and *E*.
rank	Computes rank of a matrix.

rcondl	Returns reciprocal of the condition number of last decomposed matrix.
rref	Computes reduced row echelon form of a matrix.
schur	Computes Schur decomposition of a matrix (real matrices only).
solpd	Solves a system of positive definite linear equations.
svd	Computes the singular values of a matrix.
svd1	Computes singular value decomposition, $X = USV'$.
svd2	Computes **svd1** with compact *U*.

The decomposition routines are **chol** for Cholesky decomposition, **crout** and **croutp** for Crout decomposition, **qqr**-**qyrep** for QR decomposition, and **svd**, **svd1**, and **svd2** for singular value decomposition.

null, **null1**, and **orth** calculate orthonormal bases.

inv, **invpd**, **solpd**, **cholsol**, **qrsol**, and the "**/**" operator can all be used to solve linear systems of equations.

rank and **rref** will find the rank and reduced row echelon form of a matrix.

det, **detl**, and **cond** will calculate the determinant and condition number of a matrix.

Eigenvalues

eig	Computes eigenvalues of general matrix.
eigh	Computes eigenvalues of complex Hermitian or real symmetric matrix.
eighv	Computes eigenvalues and eigenvectors of complex Hermitian or real symmetric matrix.
eigv	Computes eigenvalues and eigenvectors of general matrix.

There are four eigenvalue-eigenvector routines. Two calculate eigenvalues only, and two calculate eigenvalues and eigenvectors. The types of matrices handled by these routines are:

General:	**eig**, **eigv**
Symmetric or Hermitian:	**eigh**, **eighv**

Polynomial Operations

polychar	Computes characteristic polynomial of a square matrix.

polyeval	Evaluates polynomial with given coefficients.
polyint	Calculates N^{th} order polynomial interpolation given known point pairs.
polymake	Computes polynomial coefficients from roots.
polymat	Returns sequence powers of a matrix.
polymult	Multiplies two polynomials together.
polyroot	Computes roots of polynomial from coefficients.

See also **recserrc**, **recsercp**, and **conv**.

Fourier Transforms

dfft	Computes discrete 1-D FFT.
dffti	Computes inverse discrete 1-D FFT.
fft	Computes 1- or 2-D FFT.
ffti	Computes inverse 1- or 2-D FFT.
fftm	Computes multi-dimensional FFT.
fftmi	Computes inverse multi-dimensional FFT.
fftn	Computes 1- or 2-D FFT using prime factor algorithm.
rfft	Computes real 1- or 2-D FFT.
rffti	Computes inverse real 1- or 2-D FFT.
rfftip	Computes inverse real 1- or 2-D FFT from packed format FFT.
rfftn	Computes real 1- or 2-D FFT using prime factor algorithm.
rfftnp	Computes real 1- or 2-D FFT using prime factor algorithm, returns packed format FFT.
rfftp	Computes real 1- or 2-D FFT, returns packed format FFT.

Random Numbers

rndbeta	Computes random numbers with beta distribution.
rndcon	Changes constant of the LC random number generator.
rndgam	Computes random numbers with gamma distribution.
rndi	Returns random integers, 0 <= y < 2^32.
rndKMbeta	Computes beta pseudo-random numbers.
rndKMgam	Computes gamma pseudo-random numbers.
rndKMi	Returns random integers, 0 <= y < 2^32.

rndKMn	Computes standard normal pseudo-random numbers.
rndKMnb	Computes negative binomial pseudo-random numbers.
rndKMp	Computes Poisson pseudo-random numbers.
rndKMu	Computes uniform pseudo-random numbers.
rndKMvm	Computes von Mises pseudo-random numbers.
rndLCbeta	Computes beta pseudo-random numbers.
rndLCgam	Computes gamma pseudo-random numbers.
rndLCi	Returns random integers, 0 <= y < 2^32.
rndLCn	Computres standard normal pseudo-random numbers.
rndLCnb	Computes negative binomial pseudo-random numbers.
rndLCp	Computes Poisson pseudo-random numbers.
rndLCu	Computes uniform pseudo-random numbers.
rndLCvm	Computes von Mises pseudo-random numbers.
rndmult	Changes multiplier of the LC random number generator.
rndn	Computes random numbers with Normal distribution.
rndnb	Computes random numbers with negative binomial distribution.
rndp	Computes random numbers with Poisson distribution.
rndseed	Changes seed of the LC random number generator.
rndu	Computes random numbers with uniform distribution.

Fuzzy Conditional Functions

dotfeq	Fuzzy .==
dotfge	Fuzzy .≥
dotfgt	Fuzzy .>
dotfle	Fuzzy .≤
dotflt	Fuzzy .<
dotfne	Fuzzy ./=
feq	Fuzzy ==
fge	Fuzzy ≥
fgt	Fuzzy >
fle	Fuzzy ≤
flt	Fuzzy <
fne	Fuzzy /=

The global variable **_fcomptol** controls the tolerance used for comparison. By default, this is 1e-15. The default can be changed by editing the file `fcompare.dec`.

Statistical Functions

acf	Computes sample autocorrelations.
conv	Computes convolution of two vectors.
corrm	Computes correlation matrix of a moment matrix.
corrvc	Computes correlation matrix from a variance-covariance matrix.
corrx	Computes correlation matrix.
crossprd	Computes cross product.
design	Creates a design matrix of 0's and 1's.
dstat	Computes descriptive statistics of a data set or matrix.
loess	Computes coefficients of locally weighted regression.
meanc	Computes mean value of each column of a matrix.
median	Computes medians of the columns of a matrix.
moment	Computes moment matrix $(x'x)$ with special handling of missing values.
momentd	Computes moment matrix from a data set.
ols	Computes least squares regression of data set or matrix.
olsqr	Computes OLS coefficients using QR decomposition.
olsqr2	Computes OLS coefficients, residuals, and predicted values using QR decomposition.
pacf	Computes sample partial autocorrelations.
princomp	Computes principal components of a data matrix.
stdc	Computes standard deviation of the columns of a matrix.
toeplitz	Computes Toeplitz matrix from column vector.
varmall	Computes the log-likelihood of a Vector ARMA model.
varmares	Computes the residuals of a Vector ARMA model.
vcm	Computes a variance-covariance matrix from a moment matrix.
vcx	Computes a variance-covariance matrix from a data matrix.

Advanced statistics and optimization routines are available in the GAUSS Applications programs. (Contact Aptech Systems for more information.)

Optimization and Solution

eqsolve	Solves a system of nonlinear equations.
QNewton	Optimizes a function using the BFGS descent algorithm.
QProg	Solves the quadratic programming problem.
sqpSolve	Solves the nonlinear programming problem using a sequential quadratic programming method.

Statistical Distributions

cdfbeta	Computes integral of beta function.
cdfbvn	Computes lower tail of bivariate Normal cdf.
cdfchic	Computes complement of cdf of χ^2.
cdfchii	Computes χ^2 abscissae values given probability and degrees of freedom.
cdfchinc	Computes integral of noncentral χ^2.
cdffc	Computes complement of cdf of *F*.
cdffnc	Computes integral of noncentral *F*.
cdfgam	Computes integral of incomplete Γ function.
cdfmvn	Computes multivariate Normal cdf.
cdfn	Computes integral of Normal distribution: lower tail, or cdf.
cdfn2	Computes interval of Normal cdf.
cdfnc	Computes complement of cdf of Normal distribution (upper tail).
cdftc	Computes complement of cdf of *t*-distribution.
cdftnc	Computes integral of noncentral *t*-distribution.
cdftvn	Computes lower tail of trivariate Normal cdf.
erf	Computes Gaussian error function.
erfc	Computes complement of Gaussian error function.
lncdfbvn	Computes natural log of bivariate Normal cdf.
lncdfmvn	Computes natural log of multivariate Normal cdf.
lncdfn	Computes natural log of Normal cdf.
lncdfn2	Computes natural log of interval of Normal cdf.
lncdfnc	Computes natural log of complement of Normal cdf.
lnpdfmvn	Computes multivariate Normal log-probabilities.

lnpdfn	Computes Normal log-probabilities.
pdfn	Computes standard Normal probability density function.

Series and Sequence Functions

recserar	Computes autoregressive recursive series.
recsercp	Computes recursive series involving products.
recserrc	Computes recursive series involving division.
seqa	Creates an additive sequence.
seqm	Creates a multiplicative sequence.

Precision Control

base10	Converts number to *x.xxx* and a power of 10.
ceil	Rounds up towards $+\infty$.
floor	Rounds down towards $-\infty$.
prcsn	Sets computational precision for matrix operations.
round	Rounds to the nearest integer.
trunc	Truncates toward 0.

All calculations in GAUSS are done in double precision, with the exception of some of the intrinsic functions on OS/2 and DOS. These may use extended precision (18-19 digits of accuracy). Use **prcsn** to change the internal accuracy used in these cases.

round, **trunc**, **ceil**, and **floor** convert floating point numbers into integers. The internal representation for the converted integer is double precision (64 bits).

Each matrix element in memory requires 8 bytes of memory.

Finance Functions

AmericanBinomCall	American binomial method Call.
AmericanBinomCall_Greeks	American binomial method call Delta, Gamma, Theta, Vega, and Rho.
AmericanBinomCall_ImpVol	Implied volatilities for American binomial method calls.
AmericanBinomPut	American binomial method Put.

AmericanBinomPut_Greeks	American binomial method put Delta, Gamma, Theta, Vega, and Rho.
AmericanBinomPut_ImpVol	Implied volatilities for American binomial method puts.
AmericanBSCall	American Black and Scholes Call.
AmericanBSCall_Greeks	American Black and Scholes call Delta, Gamma, Omega, Theta, and Vega.
AmericanBSCall_ImpVol	Implied volatilities for American Black and Scholes calls.
AmericanBSPut	American Black and Scholes Put.
AmericanBSPut_Greeks	American Black and Scholes put Delta, Gamma, Omega, Theta, and Vega.
AmericanBSPut_ImpVol	Implied volatilities for American Black and Scholes puts.
annualTradingDays	Compute number of trading days in a given year.
elapsedTradingDays	Compute number of trading days between two dates inclusively.
EuropeanBinomCall	European binomial method call.
EuropeanBinomCall_Greeks	European binomial method call Delta, Gamma, Theta, Vega and Rho.
EuropeanBinomCall_ImpVol	Implied volatilities for European binomial method calls.
EuropeanBinomPut	European binomial method Put.
EuropeanBinomPut_Greeks	European binomial method put Delta, Gamma, Theta, Vega, and Rho.
EuropeanBinomPut_ImpVol	Implied volatilities for European binomial method puts.
EuropeanBSCall	European Black and Scholes Call.
EuropeanBSCall_Greeks	European Black and Scholes call Delta, Gamma, Omega, Theta, and Vega.
EuropeanBSCall_ImpVol	Implied volatilities for European Black and Scholes calls.
EuropeanBSPut	European Black and Scholes Put.
EuropeanBSPut_Greeks	European Black and Scholes put Delta, Gamma, Omega, Theta, and Vega.

EuropeanBSPut_ImpVol	Implied volatilities for European Black and Scholes puts.
getNextTradingDay	Returns the next trading day.
getNextWeekDay	Returns the next day that is not on a weekend.
getPreviousTradingDay	Returns the previous trading day.
getPreviousWeekDay	Returns the previous day that is not on a weekend.

Matrix Manipulation

Creating Vectors and Matrices

editm	Simple matrix editor.
eye	Creates identity matrix.
let	Creates matrix from list of constants.
matalloc	Allocates a matrix with unspecified contents.
matinit	Allocates a matrix with unspecified contents.
medit	Full-screen spreadsheet-like matrix editor.
ones	Creates a matrix of ones.
zeros	Creates a matrix of zeros.

Use **zeros** or **ones** to create a constant vector or matrix.

medit is a full-screen editor that can be used to create matrices to be stored in memory, or to edit matrices that already exist.

Matrices can also be loaded from an ASCII file, from a GAUSS matrix file, or from a GAUSS data set. (See “Procedures and Keywords” in the *User Guide* for more information.)

Loading and Storing Matrices

loadd	Loads matrix from data set.
loadm	Loads matrix from ASCII or matrix file.
save	Saves matrix to matrix file.
saved	Saves matrix to data set.

Size, Ranking, and Range

cols	Returns number of columns in a matrix.
colsf	Returns number of columns in an open data set.
counts	Returns number of elements of a vector falling in specified ranges.
countwts	Returns weighted count of elements of a vector falling in specified ranges.
cumprodc	Computes cumulative products of each column of a matrix.
cumsumc	Computes cumulative sums of each column of a matrix.
indexcat	Returns indices of elements falling within a specified range.
maxc	Returns largest element in each column of a matrix.
maxindc	Returns row number of largest element in each column of a matrix.
minc	Returns smallest element in each column of a matrix.
minindc	Returns row number of smallest element in each column of a matrix.
prodc	Computes the product of each column of a matrix.
rankindx	Returns rank index of Nx1 vector. (Rank order of elements in vector.)
rows	Returns number of rows in a matrix.
rowsf	Returns number of rows in an open data set.
sumc	Computes the sum of each column of a matrix.

These functions are used to find the minimum, maximum and frequency counts of elements in matrices.

Use **rows** and **cols** to find the number of rows or columns in a matrix. Use **rowsf** and **colsf** to find the numbers of rows or columns in an open GAUSS data set.

Sparse Matrix Functions

denseSubmat	Returns dense submatrix of sparse matrix.
isSparse	Tests whether a matrix is a sparse matrix.
sparseCols	Returns number of columns in sparse matrix.
sparseEye	Creates sparse identity matrix.
sparseFD	Converts dense matrix to sparse matrix.
sparseFP	Converts packed matrix to sparse matrix.

sparseHConcat	Horizontally concatenates sparse matrices.
sparseNZE	Returns the number of nonzero elements in sparse matrix.
sparseOnes	Generates sparse matrix of ones and zeros.
sparseRows	Returns number of rows in sparse matrix.
sparseSet	Resets sparse library globals.
sparseSolve	Solves $Ax = B$ for x where A is a sparse matrix.
sparseSubmat	Returns sparse submatrix of sparse matrix.
sparseTD	Multiplies sparse matrix by dense matrix.
sparseTrTD	Multiplies sparse matrix transposed by dense matrix.
sparseVConcat	Vertically concatenates sparse matrices.

Miscellaneous Matrix Manipulation

complex	Creates a complex matrix from two real matrices.
delif	Deletes rows from a matrix using a logical expression.
diag	Extracts the diagonal of a matrix.
diagrv	Puts a column vector into the diagonal of a matrix.
exctsmpl	Creates a random subsample of data set, with replacement.
imag	Returns the imaginary part of a complex matrix.
intrsect	Returns the intersection of two vectors.
lowmat	Returns the main diagonal and lower triangle.
lowmat1	Returns a main diagonal of 1's and the lower triangle.
real	Returns the real part of a complex matrix.
reshape	Reshapes a matrix to new dimensions.
rev	Reverses the order of rows of a matrix.
rotater	Rotates the rows of a matrix, wrapping elements as necessary.
selif	Selects rows from a matrix using a logical expression.
setdif	Returns elements of one vector that are not in another.
shiftr	Shifts rows of a matrix, filling in holes with a specified value.
submat	Extracts a submatrix from a matrix.
trimr	Trims rows from top or bottom of a matrix.
union	Returns the union of two vectors.
upmat	Returns the main diagonal and upper triangle.
upmat1	Returns a main diagonal of 1's and the upper triangle.

vec	Stacks columns of a matrix to form a single column.
vech	Reshapes the lower triangular portion of a symmetric matrix into a column vector.
vecr	Stacks rows of a matrix to form a single column.
xpnd	Expands a column vector into a symmetric matrix.

vech and **xpnd** are complementary functions. **vech** provides an efficient way to store a symmetric matrix; **xpnd** expands the stored vector back to its original symmetric matrix.

delif and **selif** are complementary functions. **delif** deletes rows of a matrix based on a logical comparison; **selif** selects rows based on a logical comparison.

lowmat, **lowmat1**, **upmat**, and **upmat1** extract triangular portions of a matrix.

To delete rows that contain missing values from a matrix in memory, see **packr**.

Data Handling

Data Sets

close	Closes an open data set (`.dat` file).
closeall	Closes all open data sets.
create	Creates and opens a data set.
eof	Tests for end of file.
iscplxf	Returns whether a data set is real or complex.
loadd	Loads a small data set.
open	Opens an existing data set.
readr	Reads rows from open data set.
saved	Creates small data sets.
seekr	Moves pointer to specified location in open data set.
typef	Returns the element size (2, 4, or 8 bytes) of data in open data set.
writer	Writes matrix to an open data set.

These functions all operate on GAUSS data sets (`.dat` files). (See “File I/O” in the *User’s Guide* for more information.)

To create a GAUSS data set from a matrix in memory, use **saved**. To create a data set from an existing one, use **create**. To create a data set from a large ASCII file, use the utility **atog.** (See "Utilities" in the *User's Guide*.)

Data sets can be opened, read from, and written to using **open**, **readr**, **seekr** and **writer**. Test for the end of a file using **eof**, and close the data set using **close** or **closeall**.

The data in data sets may be specified as character or numeric. (See "File I/O" in the *User's Guide*.) See also **create** and **vartypef**.

typef returns the element size of the data in an open data set.

Data Set Variable Names

getname	Returns column vector of variable names in a data set.
getnamef	Returns string array of variable names in a data set.
indcv	Returns column numbers of variables within a data set.
indices	Retrieves column numbers and names from a data set.
indices2	Similar to **indices**, but matches columns with names for dependent and independent variables.
makevars	Decomposes matrix to create column vectors.
mergevar	Concatenates column vectors to create larger matrix.
setvars	Creates globals using the names in a data set.
vartype	Returns column vector of variable types (numeric/character) in a data set.
vartypef	Returns column vector of variable types (numeric/character) in a data set.

Use **getnamef** to retrieve the variable names associated with the columns of a GAUSS data set, and **vartypef** to retrieve the variable types. Use **makevars** and **setvars** to create global vectors from those names. Use **indices** and **indices2** to match names with column numbers in a data set.

getname and **vartype** are supported for backwards compatibility.

Data Coding

code	Codes the data in a vector by applying a logical set of rules to assign each data value to a category.
dummy	Creates a dummy matrix, expanding values in vector to rows with ones in columns corresponding to true categories and zeros elsewhere.

dummybr	Similar to **dummy**.
dummydn	Similar to **dummy**.
ismiss	Returns 1 if matrix has any missing values, 0 otherwise.
isinfnanmiss	Returns true if the argument contains an infinity, NaN, or missing value.
miss	Changes specified values to missing value code.
missex	Changes elements to missing value using logical expression.
missrv	Changes missing value codes to specified values.
msym	Sets symbol to be interpreted as missing value.
packr	Deletes rows with missing values.
recode	Similar to **code**, but leaves the original data in place if no condition is met.
scalinfnanmiss	Returns true if the argument is a scalar infinity, NaN, or missing value.
scalmiss	Tests whether a scalar is the missing value code.
subscat	Simpler version of **recode**, but uses ascending bins instead of logical conditions.
substute	Similar to **recode**, but operates on matrices.

code, **recode**, and **subscat** allow the user to code data variables and operate on vectors in memory. **substute** operates on matrices, and **dummy**, **dummybr**, and **dummydn** create matrices.

missex, **missrv**, and **miss** should be used to recode missing values.

Sorting and Merging

intrleav	Produces one large sorted data file from two smaller sorted files having the same keys.
mergeby	Produces one large sorted data file from two smaller sorted files having a single key column in common.
sortc	Quick-sorts rows of matrix based on numeric key.
sortcc	Quick-sorts rows of matrix based on character key.
sortd	Sorts data set on a key column.
sorthc	Heap-sorts rows of matrix based on numeric key.
sorthcc	Heap-sortsrows of matrix based on character key.
sortind	Returns a sorted index of a numeric vector.
sortindc	Returns a sorted index of a character vector.

sortmc	Sorts rows of matrix on the basis of multiple columns.
uniqindx	Returns a sorted unique index of a vector.
unique	Removes duplicate elements of a vector.

sortc, **sorthc**, and **sortind** operate on numeric data only. **sortcc**, **sorthcc**, and **sortindc** operate on character data only.

Sortd, **sortmc**, **unique**, and **uniqindx** operate on both numeric and character data.

Use **sortd** to sort the rows of a data set on the basis of a key column.

Both **intrleav** and **mergeby** operate on data sets.

Compiler Control

#define	Defines a case-insensitive text-replacement or flag variable.
#definecs	Defines a case-sensitive text-replacement or flag variable.
#else	Alternates clause for **#if**-**#else**-**#endif** code block.
#endif	End of **#if**-**#else**-**#endif** code block.
#ifdef	Compiles code block if a variable has been **#define**'d.
#ifdos	Compiles code block if running DOS.
#iflight	Compiles code block if running GAUSS Light.
#ifndef	Compiles code block if a variable has not been **#define**'d.
#ifos2win	Compiles code block if running OS/2 or Windows.
#ifunix	Compiles code block if running UNIX.
#include	Includes code from another file in program.
#linesoff	Compiles program without line number and file name records.
#lineson	Compiles program with line number and file name records.
#srcfile	Inserts source file name record at this point (currently used when doing data loop translation).
#srcline	Inserts source file line number record at this point (currently used when doing data loop translation).
#undef	Undefines a text-replacement or flag variable.

These commands are compiler directives. That is, they do not generate GAUSS program instructions; rather, they are instructions that tell GAUSS how to process a program during compilation. They determine what the final compiled form of a

program will be. They are not executable statements and have no effect at run-time. (See “Language Fundamentals” in the *User’s Guide* for more information.)

Program Control

Execution Control

end	Terminates a program and close all files.
pause	Pauses for the specified time.
run	Runs a program in a text file.
sleep	Sleeps for the specified time.
stop	Stops a program and leave files open.
system	Quits and returns to the OS.

Both **stop** and **end** will terminate the execution of a program; **end** will close all open files, and **stop** will leave those files open. Neither **stop** nor **end** is required in a GAUSS program.

Branching

goto	Unconditional branching.
if..endif	Conditional branching.
pop	Retrieve **goto** arguments.

```
if iter > itlim;
   goto errout(“Iteration limit exceeded”);
elseif iter == 1;
   j = setup(x,y);
else;
   j = iterate(x,y);
endif;
.
.
.
```

```
errout:
   pop errmsg;
   print errmsg;
   end;
```

Looping

break Jump out the bottom of a **do** or **for** loop.

continue Jump to the top of a **do** or **for** loop.

do while..endo
Loop if *TRUE*.

do until..endo Loop if *FALSE*.

for.. endfor Loop with integer counter.

```
   iter = 0;
   do while dif > tol;
      { x,x0 } = eval(x,x0);
      dif = abs(x-x0);
      iter = iter + 1;
      if iter > maxits;
         break;
      endif;
      if not prtiter;
         continue;
      endif;
      format /rdn 1,0;
      print “Iteration: ” iter;;
      format /re 16,8;
      print “, Error:   ”maxc(dif);
   endo;
```

```
for i (1, cols(x), 1);
   for j (1, rows(x), 1);
      x[i,j] = x[i,j] + 1;
   endfor;
endfor;
```

Subroutines

gosub	Branch to subroutine.
pop	Retrieve **gosub** arguments.
return	Return from subroutine.

Arguments can be passed to subroutines in the branch to the subroutine label and then popped, in first-in-last-out order, immediately following the subroutine label definition. See Chapter 3, "Command Reference", for details.

Arguments can then be returned in an analogous fashion through the **return** statement.

Procedures

endp	Terminates a procedure definition.
local	Declares variables local to a procedure.
proc	Begins definition of multi-line procedure.
retp	Returns from a procedure.

Here is an example of a GAUSS procedure:

```
proc (3) = crosprod(x,y);
   local r1, r2, r3;
   r1 = x[2,.].*y[3,.]-x[3,.].*y[2,.];
   r2 = x[3,.].*y[1,.]-x[1,.].*y[3,.];
   r3 = x[1,.].*y[2,.]-x[2,.].*y[1,.];
   retp( r1,r2,r3 );
endp;
```

The "**(3) =** " indicates that the procedure returns three arguments. All local variables, except those listed in the argument list, must appear in the **local** statement. Procedures may reference global variables. There may be more than one **retp** per procedure definition; none is required if the procedure is defined to return 0 arguments. The **endp** is always necessary and must appear at the end of the procedure definition. Procedure definitions cannot be nested. The syntax for using this example function is

```
{ a1,a2,a3 } = crosprod(u,v);
```

See "Procedures and Keywords" and "Libraries" in the *User's Guide* for details.

Libraries

call	Calls function and discard return values.
declare	Initializes variables at compile time.
external	External symbol definitions.
lib	Builds or updates a GAUSS library.
library	Sets up list of active libraries.

call allows functions to be called when return values are not needed. This is especially useful if a function produces printed output (**dstat**, **ols** for example) as well as return values.

Compiling

compile	Compiles and saves a program to a `.gcg` file.
loadp	Loads compiled procedure.
save	Saves the compiled image of a procedure to disk.
saveall	Saves the contents of the current workspace to a file.
use	Loads previously compiled code.

GAUSS procedures and programs may be compiled to disk files. By then using this compiled code, the time necessary to compile programs from scratch is eliminated. Use **compile** to compile a command file. All procedures, matrices and strings referenced by that program will be compiled as well.

Stand-alone applications may be created by running compiled code under the Run-Time Module. (Contact Aptech Systems for more information on this product.)

To save the compiled images of procedures that do not make any global references, use **save**. This will create an `.fcg` file. To load the compiled procedure into memory, use **loadp**. (This is not recommended because of the restriction on global

references and the need to explicitly load the procedure in each program that references it. It is included here to maintain backward compatibility with previous versions.)

OS Functions

cdir	Returns current directory.
ChangeDir	Changes directory in program.
chdir	Changes directory interactively.
dfree	Returns free space on disk.
envget	Gets an environment string.
exec	Executes an executable program file.
fileinfo	Takes a file specification, returns names and information of files that match.
files	Takes a file specification, returns names of files that match.
filesa	Takes a file specification, returns names of files that match.
shell	Shells to OS.

Workspace Management

clear	Sets matrices equal to 0.
clearg	Sets global symbols to 0.
delete	Deletes specified global symbols.
hasimag	Examines matrix for nonzero imaginary part.
iscplx	Returns whether a matrix is real or complex.
maxvec	Returns maximum allowed vector size.
new	Clears current workspace.
show	Displays global symbol table.
type	Returns types of argument (matrix or string).
typecv	Returns types of symbol (argument contains the names of the symbols to be checked).

When working with limited workspace, it is a good idea to **clear** large matrices that are no longer needed by your program.

coreleft is most commonly used to determine how many rows of a data set may be read into memory at one time.

Error Handling and Debugging

#linesoff	Omits line number and file name records from program.
#lineson	Includes line number and file name records in program.
debug	Executes a program under the source level debugger.
disable	Disabls invalid operation interrupt of coprocessor.
enable	Enables invalid operation interrupt of coprocessor.
error	Creates user-defined error code.
errorlog	Sendserror message to screen and log file.
ndpchk	Examines status word of coprocessor.
ndpclex	Clears coprocessor exception flags.
ndpcntrl	Sets and gets coprocessor control word.
scalerr	Tests for a scalar error code.
trace	Traces program execution for debugging.
trap	Controls trapping of program errors.
trapchk	Examines the trap flag.

To trace the execution of a program, use **trace**.

User-defined error codes may be generated using **error**.

String Handling

chrs	Converts ASCII values to a string.
ftocv	Converts an NxK matrix to a character matrix.
ftos	Converts a floating point scalar to string.
ftostrC	Converts a matrix to a string array using a C language format specification.
getf	Loads ASCII or binary file into string.
loads	Loads a string file (`.fst` file).
lower	Converts a string to lowercase.
putf	Writes a string to disk file.
stof	Converts a string to floating point numbers.
strindx	Finds starting location of one string in another string.
strlen	Returns length of a string.

strrindx	Finds starting location of one string in another string, searching from the end to the start of the string.
strsect	Extracts a substring of a string.
strsplit	Splits an Nx1 string vector into an NxK string array of the individual tokens.
strsplitPad	Splits a string vector into a string array of the individual tokens. Pads on the right with null strings.
strtof	Converts a string array to a numeric matrix.
strtofcplx	Converts a string array to a complex numeric matrix.
upper	Changes a string to uppercase.
vals	Converts a string to ASCII values.
varget	Accesses the global variable named by a string.
vargetl	Accesses the local variable named by a string.
varput	Assigns a global variable named by a string.
varputl	Assigns a local variable named by a string.

strlen, **strindx**, **strrindx**, and **strsect** can be used together to parse strings.

Use **ftos** to print to a string.

To create a list of generic variable names (X1, X2, X3, X4... for example), use **ftocv**.

Time and Date Functions

date	Returns current system date.
datestr	Formats date as “mm/dd/yy”.
datestring	Formats date as “mm/dd/yyyy”.
datestrymd	Formats date as “yyyymmdd”.
dayinyr	Returns day number of a date.
dayofweek	Returns day of week.
dtdate	Creates a matrix in DT scalar format.
dtday	Creates a matrix in DT scalar format containing only the year, month and day. Time of day information is zeroed out.
dttime	Creates a matrix in DT scalar format containing only the hour, minute and second. The date information is zeroed out.
dttodtv	Converts DT scalar format to DTV vector format.

dttostr	Converts a matrix containing dates in DT scalar format to a string array.
dttoutc	Converts DT scalar format to UTC scalar format.
dtvnormal	Normalizes a date and time (DTV) vector.
dtvtodt	Converts DT vector format to DT scalar format.
etdays	Difference between two times in days.
ethsec	Difference between two times in 100ths of a second.
etstr	Converts elapsed time to string.
hsec	Returns elapsed time since midnight in 100ths of a second.
strtodt	Converts a string array of dates to a matrix in DT scalar format.
time	Returns current system time.
timedt	Returns system date and time in DT scalar format.
timestr	Formats time as “hh:mm:ss”.
todaydt	Returns system date in DT scalar format. The time returned is always midnight (00:00:00), the beginning of the returned day.
utctodt	Converts UTC scalar format to DT scalar format.
utctodtv	Converts UTC scalar format to DTV vector format.

Use **hsec** to time segments of code. For example,

```
et = hsec;
x = y*y;
et = hsec - et;
```

will time the GAUSS multiplication operator.

Console I/O

con	Requests console input, create matrix.
cons	Requests console input, create string.
key	Gets the next key from the keyboard buffer. If buffer is empty, returns a 0.
keyav	Check if keystroke is available.
keyw	Gets the next key from the keyboard buffer. If buffer is empty, waits for a key.
wait	Waits for a keystroke.

waitc	Flushes buffer, then waits for a keystroke.

key can be used to trap most keystrokes. For example, the following loop will trap the ALT-H key combination:

```
kk = 0;
do until kk == 1035;
   kk = key;
endo;
```

Other key combinations, function keys, and cursor key movement can also be trapped. See **key**.

cons and **con** can be used to request information from the console. **keyw**, **wait**, and **waitc** will wait for a keystroke.

Output Functions

Text Output

cls	Clears the window.
color	Sets pixel, text, background colors.
comlog	Controls interactive command logging.
csrcol	Gets column position of cursor on window.
csrlin	Gets row position of cursor on window.
ed	Accesses an alternate editor.
edit	Edits a file with the GAUSS editor.
format	Defines format of matrix printing.
locate	Positions the cursor on the window.
lpos	Returns print head position in printer buffer.
lprint	Prints expression to the printer.
lprint [[**on**|**off**]]	Switches auto printer mode on and off.
lpwidth	Specifies printer width.
lshow	Prints global symbol table on the printer.
output	Redirects **print** statements to auxiliary output.
outwidth	Sets line width of auxiliary output.

plot	Plots elements of two matrices in text mode.
plotsym	Controls data symbol used by **plot**.
print	Prints to window.
print [[**on**|**off**]]	Turns auto window print on and off.
printdos	Prints a string for special handling by the OS.
printfm	Prints matrices using a different format for each column.
screen [[**on**|**off**]]	Directs/suppresses **print** statements to window.
screen out	Dumps snapshot of window to auxiliary output.
scroll	Scrolls a section of the window.
tab	Positions the cursor on the current line.

The results of all printing can be sent to an output file using **output**. This file can then be printed or ported as an ASCII file to other software.

printdos can be used to print in reverse video, or using different colors. It requires that `ansi.sys` be installed.

To produce boxes, etc. using characters from the extended ASCII set, use **chrs**.

Window Graphics

color	Sets color.
graph	Sets pixels.
line	Draws lines.
setvmode	Sets video mode.

graph allows the user to plot individual pixels.

Graphics

This section summarizes all procedures and global variables available within the Publication Quality Graphics (PQG) System. A general usage description will be found in "Publications Quality Graphics" in the *User's Guide*.

Graph Types

bar	Generates bar graph.
box	Graphs data using the box graph percentile method.
contour	Graphs contour data.

draw	Supplies additional graphic elements to graphs.
hist	Computes and graphs frequency histogram.
histf	Graphs a histogram given a vector of frequency counts.
histp	Graphs a percent frequency histogram of a vector.
loglog	Graphs X,Y using logarithmic X and Y axes.
logx	Graphs X,Y using logarithmic X axis.
logy	Graphs X,Y using logarithmic Y axis.
surface	Graphs a 3-D surface.
xy	Graphs X,Y using Cartesian coordinate system.
xyz	Graphs X, Y, Z using 3-D Cartesian coordinate system.

Axes Control and Scaling

_pxpmax	Controls precision of numbers on X axis.
_paxes	Turns axes on or off.
_pcross	Controls where axes intersect.
_pgrid	Controls major and minor grid lines.
_pticout	Controls direction of tick marks on axes.
_pxsci	Controls use of scientific notation on X axis.
_pypmax	Controls precision of numbers on Y axis.
_pysci	Controls use of scientific notation on Y axis.
_pzpmax	Controls precision of numbers on Z axis.
_pzsci	Controls use of scientific notation on Z axis.
scale	Scales X,Y axes for 2-D plots.
scale3d	Scales X,Y, and Z axes for 3-D plots.
xtics	Scales X axis and control tick marks.
ytics	Scales Y axis and control tick marks.
ztics	Scales Z axis and control tick marks.

Text, Labels, Titles, and Fonts

_pnumht	Controls size of axes numeric labels.
_ptitlht	Controls main title size.
_paxht	Controls size of axes labels.
_pdate	Dates string contents and control.

_plegctl	Sets location and size of plot legend.
_plegstr	Specifies legend text entries.
_pmsgctl	Controls message position.
_pmsgstr	Specifies message text.
_pnum	Axes numeric label control and orientation.
asclabel	Defines character labels for tick marks.
fonts	Loads fonts for labels, titles, messages and legend.
title	Specifies main title for graph.
xlabel	X axis label.
ylabel	Y axis label.
zlabel	Z axis label.

Main Curve Lines and Symbols

_pboxctl	Controls box plotter.
_pboxlim	Outputs percentile matrix from box plotter.
_pcolor	Controls line color for main curves.
_plctrl	Controls main curve and frequency of data symbols.
_pltype	Controls line style for main curves.
_plwidth	Controls line thickness for main curves.
_pstype	Controls symbol type for main curves.
_psymsiz	Controls symbol size for main curves.
_pzclr	Z level color control for **contour** and **surface**.

Extra Lines and Symbols

_parrow	Creates arrows.
_parrow3	Creates arrows for 3-D graphs.
_perrbar	Plots error bars.
_pline	Plots extra lines and circles.
_pline3d	Plots extra lines for 3-D graphs.
_psym	Plots extra symbols.
_psym3d	Plots extra symbols for 3-D graphs.

Graphic Panel, Page, and Plot Control

_pageshf	Shifts the graph for printer output.
_pagesiz	Controls size of graph for printer output.
_plotshf	Controls plot area position.
_plotsiz	Controls plot area size.
_protate	Rotates the graph 90 degrees.
axmargin	Controls axes margins and plot size.
begwind	Graphic panel initialization procedure.
endwind	End graphic panel manipulation, display graphs.
getwind	Gets current graphic panel number.
loadwind	Loads a graphic panel configuration from a file.
makewind	Creates graphic panel with specified size and position.
margin	Controls graph margins.
nextwind	Sets to next available graphic panel number.
savewind	Saves graphic panel configuration to a file.
setwind	Sets to specified graphic panel number.
window	Creates tiled graphic panels of equal size.

axmargin is preferred to the older **_plotsiz** and **_plotshf** globals for establishing an absolute plot size and position.

Output Options

_pscreen	Controls graphics output to window.
_psilent	Controls final beep.
_ptek	Controls creation and name of `graphics.tkf` file.
_pzoom	Specifies zoom parameters.
graphprt	Generates print, conversion file.
pqgwin	Sets the graphics viewer mode.
setvwrmode	Sets the graphics viewer mode.
tkf2eps	Converts **.tkf** file to Encapsulated PostScript file.
tkf2ps	Converts **.tkf** file to PostScript file.

Miscellaneous

_pbox	Draws a border around graphic panel/window.
_pcrop	Controls cropping of graphics data outside axes area.
_pframe	Draws a frame around 2-D, 3-D plots.
_pmcolor	Controls colors to be used for axes, title, x and y labels, date, box, and background.
graphset	Resets all PQG globals to default values.
rerun	Displays most recently created graph.
view	Sets 3-D observer position in workbox units.
viewxyz	Sets 3-D observer position in plot coordinates.
volume	Sets length, width, and height ratios of 3-D workbox.

Command Reference 3

Command Components

The following list describes each of the components used in the GAUSS Language Command Reference.

Purpose Describes the function of the command.

Library Describes where the Run-Time Library functions can be found in the GAUSS program structure.

Format Illustrates use of the command syntax.

Input Describes the input parameters of the command.

Global Input Describes the global variables that are referenced by the command.

Output Describes the parameters that will be returned as a result of the input.

Global Output Describes the global variables that are updated by the command.

Portability Describes how GAUSS behaves under various operating systems.

Remarks Explanatory material pertinent to the command.

Example Sample code strings using the command.

Source The source file in which Run-Time Library function is defined.

Globals Global variables that are accessed by the command.

See also Other commands that have similar characteristics.

Technical Notes Technical discussion and reference source citations.

References Reference material citations.

abs

Purpose Returns the absolute value or complex modulus of *x*.

Format *y* **= abs(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix containing absolute values of *x*.

Example

```
x = rndn(2,2);
y = abs(x);
```

$$x = \begin{matrix} 0.675243 & 1.053485 \\ -0.190746 & -1.229539 \end{matrix}$$

$$y = \begin{matrix} 0.675243 & 1.053485 \\ 0.190746 & 1.229539 \end{matrix}$$

In this example, a 2x2 matrix of Normal random numbers is generated and the absolute value of the matrix is computed.

acf

Purpose Computes sample autocorrelations.

Format *rk* **= acf(***y*,*k*,*d***);**

Input

y	Nx1 vector, data.
k	scalar, maximum number of autocorrelations to compute.
d	scalar, order of differencing.

Output

rk	Kx1 vector, sample autocorrelations.

Example

```
x = { 20.80,
      18.58,
      23.39,
      20.47,
      21.78,
      19.56,
      19.58,
      18.91,
      20.08,
      21.88 };

rk = acf(x,4,2);
print rk;

      -0.74911771
       0.48360914
      -0.34229330
       0.17461180
```

Source tsutil.src

AmericanBinomCall

Purpose

American binomial method Call.

Format

c **= AmericanBinomCall(***S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

c	Mx1 vector, call premiums

Example

```
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = AmericanBinomCall(S0,K,r,0,tau,sigma,60);
print c;

17.190224
14.905054
12.673322
```

AmericanBinomCall

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

AmericanBinomCall_Greeks

Purpose

American binomial method call Delta, Gamma, Theta, Vega, and Rho.

Format

{ *d*,*g*,*t*,*v*,*rh* **} =**
AmericanBinomCall_Greeks(*S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
div = 0;
{ d,g,t,v,rh } = AmericanBinomCall_Greeks
      (S0,K,r,div,tau,sigma,30);
print d;
print g;
print t;
```

AmericanBinomCall_Greeks

```
print v;
print rh;


0.706312
0.000764
-17.400851
68.703849
76.691829
```

Source

finprocs.src

Globals

_fin_thetaType scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.

_fin_epsilon scalar, finite difference stepsize. Default = 1e-8.

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

AmericanBinomCall_ImpVol

Purpose

Implied volatilities for American binomial method calls.

Format

sigma **=**
AmericanBinomCall_ImpVol(*c*,*S0*,*K*,*r*,*div*,*tau*,*N***);**

Input

c	Mx1 vector, call premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
N	number of time segments

Output

sigma	Mx1 vector, volatility

Example

```
c = { 13.70, 11.90, 9.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
div = 0;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
sigma = AmericanBinomCall_ImpVol
      (c,S0,K,r,div,tau,30);
print sigma;

0.1981
```

AmericanBinomCall_ImpVol

```
0.1715

0.1301
```

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

AmericanBinomPut

Purpose American binomial method Put.

Format *c* **= AmericanBinomPut(***S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

c	Mx1 vector, put premiums

Example:

```
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = AmericanBinomPut(S0,K,r,0,tau,sigma,60);
print c;

16.862683
19.606573
22.433590
```

AmericanBinomPut

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

AmericanBinomPut_Greeks

Purpose

American binomial method put Delta, Gamma, Theta, Vega, and Rho.

Format

{ *d*,*g*,*t*,*v*,*rh* **} =**
AmericanBinomPut_Greeks(*S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
div = 0;
sigma = .25;
tau = .33;
{ d,g,t,v,rh } = AmericanBinomPut_Greeks
      (S0,K,r,div,tau,sigma,60);
print d;
print g;
print t;
```

AmericanBinomPut_Greeks

```
print v;
print rh;


-0.38324908
0.00076381912
8.1336630
68.337294
-27.585043
```

Source

finprocs.src

Globals

_fin_thetaType	scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.
_fin_epsilon	scalar, finite difference stepsize. Default = 1e-8.

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

AmericanBinomPut_ImpVol

Purpose

Implied volatilities for American binomial method puts.

Format

sigma **= AmericanBinomPut_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau*,*N***);**

Input

c	Mx1 vector, put premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
N	number of time segments

Output

sigma	Mx1 vector, volatility

Example

```
p = { 14.60, 17.10, 20.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
div = 0;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
sigma = AmericanBinomPut_ImpVol
      (p,S0,K,r,div,tau,30);
print sigma;

0.1254
```

AmericanBinomPut_ImpVol

```
0.1668

0.2134
```

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

AmericanBSCall

Purpose American Black and Scholes Call.

Format *c* **= AmericanBSCall(***S0*,*K*,*r*,*div*,*tau*,*sigma***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output:

c	Mx1 vector, call premiums

Example

```
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = AmericanBSCall(S0,K,r,0,tau,sigma);
print c;

16.093640
13.846830
11.829059
```

Source finprocs.src

AmericanBSCall_Greeks

Purpose

American Black and Scholes call Delta, Gamma, Omega, Theta, and Vega.

Format

```
{ d,g,t,v,rh } =
AmericanBSCall_Greeks(S0,K,r,div,tau,sigma);
```

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
{ d,g,t,v,rh } = AmericanBSCall_Greeks
     (S0,K,r,0,tau,sigma);
print d;
print g;
print t;
print v;
```

```
print rh;
0.40034039
0.016804021
-55.731079
115.36906
46.374528
```

Source finprocs.src

Globals

_fin_thetaType	scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.
_fin_epsilon	scalar, finite difference stepsize. Default = 1e-8.

AmericanBSCall_ImpVol

Purpose

Implied volatilities for American Black and Scholes calls.

Format

sigma **= AmericanBSCall_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau***);**

Input

c	Mx1 vector, call premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading

Output

sigma	Mx1 vector, volatility

Example

```
c = { 13.70, 11.90, 9.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
sigma = AmericanBSCall_ImpVol
      (c,S0,K,r,0,tau);
print sigma;

0.10350708
0.089202881
0.066876221
```

Source finprocs.src

AmericanBSPut

Purpose

American Black and Scholes Put.

Format

c **= AmericanBSPut(***S0*,*K*,*r*,*div*,*tau*,*sigma***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

c	Mx1 vector, put premiums

Example

```
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = AmericanBSPut(S0,K,r,0,tau,sigma);
print c;

16.748987
19.41627
22.318856
```

Source

finprocs.src

AmericanBSPut_Greeks

Purpose

American Black and Scholes put Delta, Gamma, Omega, Theta, and Vega.

Format

{ *d*,*g*,*t*,*v*,*rh* **} =**
AmericanBSPut_Greeks(*S0*,*K*,*r*,*div*,*tau*,*sigma***);**

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
{ d,g,t,v,rh } =
      AmericanBSPut_Greeks(S0,K,r,0,tau,sigma);
print d;
print g;
print t;
print v;
```

AmericanBSPut_Greeks

```
print rh;
-0.33296721
0.0091658294
-17.556118
77.614238
-40.575963
```

Source

finprocs.src

Globals

_fin_thetaType	scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.
_fin_epsilon	scalar, finite difference stepsize. Default = 1e-8.

AmericanBSPut_ImpVol

Purpose Implied volatilities for American Black and Scholes puts.

Format *sigma* **= AmericanBSPut_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau***);**

Input

c	Mx1 vector, put premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading

Output

sigma	Mx1 vector, volatility

Example

```
p = { 14.60, 17.10, 20.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
sigma = AmericanBSPut_ImpVol(p,S0,K,r,0,tau);
print sigma;

0.12829346
0.16885986
0.21544312
```

Source finprocs.src

annualTradingDays

Purpose Compute number of trading days in a given year.

Format *n* **= annualTradingDays(***a***);**

Input

a	scalar, year.

Output

n	number of trading days in year

Remarks A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2004. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

Source `finutils.src`

arccos

Purpose Computes the inverse cosine.

Format *y* **= arccos(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the angle in radians whose cosine is *x*.

Remarks If *x* is complex or has any elements whose absolute value is greater than 1, complex results are returned.

Example

```
x = { -1, -0.5, 0, 0.5, 1 };
y = arccos(x);
```

```
      −1.000000
      −0.500000
x =    0.000000
       0.500000
       1.000000
```

```
      3.141593
      2.094395
y =   1.570796
      1.047198
      0.000000
```

Source trig.src

arcsin

Purpose Computes the inverse sine.

Format *y* **= arcsin(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix, the angle in radians whose sine is *x*.

Remarks If *x* is complex or has any elements whose absolute value is greater than 1, complex results are returned.

Example

```
x = { -1, -0.5, 0, 0.5, 1 };
y = arcsin(x);
```

```
      −1.000000
      −0.500000
x =    0.000000
       0.500000
       1.000000

      −1.570796
      −0.523599
y =    0.000000
       0.523599
       1.570796
```

Source trig.src

asclabel

Purpose Sets up character labels for the X and Y axes.

Library pgraph

Format **asclabel(***xl,yl***);**

Input

xl string or Nx1 character vector, labels for the tick marks on the X axis. Set to 0 if no character labels for this axis are desired.

yl string or Mx1 character vector, labels for the tick marks on the Y axis. Set to 0 if no character labels for this axis are desired.

Example This illustrates how to label the X axis with the months of the year:

```
let lab = JAN FEB MAR APR MAY JUN JUL AUG SEP
OCT NOV DEC;
asclabel(lab,0);
```

This will also work:

```
lab = "JAN FEB MAR APR MAY JUN JUL AUG SEP OCT
NOV DEC";
asclabel(lab,0);
```

If the string format is used, then escape characters may be embedded in the labels. For example, the following produces character labels that are multiples of λ. The font Simgrma must be previously loaded in a **fonts** command. (See Chapter 13 in *Using GAUSS for Windows95*.)

```
fonts("simplex simgrma");
lab = "\2010.25\202l \2010.5\202l
\2010.75\202l l";
asclabel(lab,0);
```

Here, the **202l** produces the "λ" symbol from Simgrma.

Source pgraph.src

asclabel

See also xtics, ytics, scale, scale3d, fonts

atan

Purpose Returns the arctangent of its argument.

Format *y* **= atan(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the arctangent of *x* in radians.

Remarks *y* will be a matrix the same size as *x*, containing the arctangents of the corresponding elements of *x*.

For real *x*, the arctangent of *x* is the angle whose tangent is *x*. The result is a value in radians in the range $\frac{-\pi}{2}$ to $\frac{+\pi}{2}$. To convert radians to degrees, multiply by $\frac{180}{\pi}$.

For complex *x*, the arctangent is defined everywhere except *i* and -*i*. If *x* is complex, *y* will be complex.

Example

```
x = { 2, 4, 6, 8 };
z = x/2;
y = atan(z);
```

$$y = \begin{matrix} 0.785398 \\ 1.107149 \\ 1.249046 \\ 1.325818 \end{matrix}$$

See also **atan2, sin, cos, pi, tan**

atan2

Purpose

Computes an angle from an *x*,*y* coordinate.

Format

z **= atan2(***y*,*x***);**

Input

y	NxK matrix, the *Y* coordinate.
x	LxM matrix, ExE conformable with *y*, the *X* coordinate.

Output

z	max(N,L) by max(K,M) matrix.

Remarks

Given a point *x*,*y* in a Cartesian coordinate system, **atan2** will give the correct angle with respect to the positive X axis. The answer will be in radians from -pi to +pi.

To convert radians to degrees, multiply by $\frac{180}{\pi}$.

atan2 operates only on the real component of *x*, even if *x* is complex.

Example

```
x = 2;
y = { 2, 4, 6, 8 };
z = atan2(y,x);
```

$$z = \begin{matrix} 0.785398 \\ 1.107149 \\ 1.249046 \\ 1.325818 \end{matrix}$$

See also

atan, sin, cos, pi, tan, arcsin, arccos

axmargin

Purpose

Set absolute margins for the plot axes which control placement and size of plot.

Library

pgraph

Format

axmargin(*l*,*r*,*t*,*b***);**

Input

l	scalar, the left margin in inches.
r	scalar, the right margin in inches.
t	scalar, the top margin in inches.
b	scalar, the bottom margin in inches.

Remarks

axmargin sets an absolute distance from the axes to the edge of the graphic panel. Note that the user is responsible for allowing enough space in the margin if axes labels, numbers, and title are used on the graph, since **axmargin** does not size the plot automatically as in the case of **margin**.

All input inch values for this procedure are based on a full size window of 9 x 6.855 inches. If this procedure is used within a graphic panel, the values will be scaled to window inche**s** automatically.

If both **margin** and **axmargin** are used for a graph, **axmargin** will override any sizes specified by **margin**.

Example

The statement

```
axmargin(1,1,.5,.855);
```

will create a plot area of 7 inches horizontally by 5.5 inches vertically, and positioned 1 inch right and .855 up from the lower left corner of the graphic panel/page.

Source

pgraph.src

balance

Purpose

Balances a square matrix.

Format

{ *b,z* **} = balance(**x**)**

Input

x	KxK matrix.

Output

b	KxK matrix, balanced matrix.
z	KxK matrix, diagonal scale matrix.

Remarks

balance returns a balanced matrix *b* and another matrix *z* with scale factors in powers of two on its diagonal. *b* is balanced in the sense that the absolute sums of the magnitudes of elements in corresponding rows and columns are nearly equal.

balance is most often used to scale matrices to improve the numerical stability of the calculation of their eigenvalues. It is also useful in the solution of matrix equations.

In particular,

$$b = z^{-1}xz$$

balance uses the BALANC function from EISPACK.

Example

```
let x[3,3] = 100  200  300
               40   50   60
                7    8    9;
{ b,z } = balance(x);
```

```
      100.0  100.0  37.5
  =    80.0   50.0  15.0
       56.0   32.0   9.0

       4.0  0.0  0.0
  =    0.0  2.0  0.0
       0.0  0.0  0.5
```

band

Purpose Extracts bands from a symmetric banded matrix.

Format *a* **= band(***y,n***);**

Input

y	KxK symmetric banded matrix.
n	scalar, number of subdiagonals.

Output

a	Kx(N+1) matrix, 1 subdiagonal per column.

Remarks *y* can actually be a rectangular PxQ matrix. K is then defined as min(P,Q). It will be assumed that *a* is symmetric about the principal diagonal for *y*[1:K,1:K].

The subdiagonals of *y* are stored right to left in *a*, with the principal diagonal in the rightmost (N+1'th) column of *a*. The upper left corner of *a* is unused; it is set to 0.

This compact form of a banded matrix is what **bandchol** expects.

Example

```
x = { 1 2 0 0,
      2 8 1 0,
      0 1 5 2,
      0 0 2 3 };
bx = band(x,1);
```

```
        0.0000000  1.0000000
bx =    2.0000000  8.0000000
        1.0000000  5.0000000
        2.0000000  3.0000000
```

bandchol

Purpose

Computes the Cholesky decomposition of a positive definite banded matrix.

Format

l **= bandchol(***a***);**

Input

a	KxN compact form matrix.

Output

l	KxN compact form matrix, lower triangle of the Cholesky decomposition of *a*.

Remarks

Given a positive definite banded matrix *A*, there exists a matrix *L*, the lower triangle of the Cholesky decomposition of *A*, such that $A = L \times L'$. *a* is the compact form of *A*. See **band** for a description of the format of *a*.

l is the compact form of *L*. This is the form of matrix that **bandcholsol** expects.

Example

```
x = { 1 2 0 0,
      2 8 1 0,
      0 1 5 2,
      0 0 2 3 };
bx = band(x,1);
```

$$bx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 8.0000000 \\ 1.0000000 & 5.0000000 \\ 2.0000000 & 3.0000000 \end{matrix}$$

```
cx = bandchol(bx);
```

$$cx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 2.0000000 \\ 0.50000000 & 2.1794495 \\ 0.91766294 & 1.4689774 \end{matrix}$$

bandcholsol

Purpose

Solves the system of equations $Ax = b$ for x, given the lower triangle of the Cholesky decomposition of a positive definite banded matrix A.

Format

x **= bandcholsol(***b,l***);**

Input

b	KxM matrix.
l	KxN compact form matrix.

Output

x	KxM matrix.

Remarks

Given a positive definite banded matrix A, there exists a matrix L, the lower triangle of the Cholesky decomposition of A, such that A = L*L'. *l* is the compact form of L; see **band** for a description of the format of *l*.

b can have more than one column. If so, $Ax = b$ is solved for each column. That is,

```
A*x[.,i] = b[.,i]
```

Example

```
x = { 1 2 0 0,
      2 8 1 0,
      0 1 5 2,
      0 0 2 3 };
bx = band(x,1);
```

$$bx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 8.0000000 \\ 1.0000000 & 5.0000000 \\ 2.0000000 & 3.0000000 \end{matrix}$$

bandcholsol

```
cx = bandchol(bx);
```

$$cx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 2.0000000 \\ 0.50000000 & 2.1794495 \\ 0.91766294 & 1.4689774 \end{matrix}$$

```
xi = bandcholsol(eye(4),cx);
```

$$xi = \begin{matrix} 2.0731707 & -0.05365854 & 0.14634146 & 0.09756098 \\ -0.53658537 & 0.26829268 & -0.07317073 & 0.04878049 \\ 0.14634146 & -0.07317073 & 0.29268293 & -0.19512195 \\ -0.09756098 & 0.04878049 & -0.19512195 & 0.46341463 \end{matrix}$$

bandltsol

Purpose

Solves the system of equations $Ax = b$ for x, where A is a lower triangular banded matrix.

Format

x **= bandltsol(***b,A***);**

Input

b	KxM matrix.
A	KxN compact form matrix.

Output

x	KxM matrix.

Remarks

A is a lower triangular banded matrix in compact form. See **band** for a description of the format of *A*.

b can have more than one column. If so, $Ax = b$ is solved for each column. That is,

```
A*x[.,i] = b[.,i]
```

Example

$$bx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 8.0000000 \\ 1.0000000 & 5.0000000 \\ 2.0000000 & 3.0000000 \end{matrix}$$

```
cx = bandchol(bx);
```

$$cx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 2.0000000 \\ 0.50000000 & 2.1794495 \\ 0.91766294 & 1.4689774 \end{matrix}$$

bandltsol

```
xci = bandltsol(eye(4),cx);
```

$$xci = \begin{matrix} 1.0000000 & 0.0000000 & 0.0000000 & 0.0000000 \\ -1.0000000 & 0.50000000 & 0.0000000 & 0.0000000 \\ 0.22941573 & -0.11470787 & 0.45883147 & 0.0000000 \\ -0.14331487 & 0.07165744 & -0.28662975 & 0.68074565 \end{matrix}$$

bandrv

Purpose Creates a symmetric banded matrix, given its compact form.

Format *y* **= bandrv(***a***);**

Input

a	KxN	compact form matrix.

Output

y	KxK	symmetrix banded matrix.

Remarks *a* is the compact form of a symmetric banded matrix, as generated by **band**. *a* stores subdiagonals right to left, with the principal diagonal in the rightmost (N^{th}) column. The upper left corner of *a* is unused. **bandchol** expects a matrix of this form.

y is the fully expanded form of *a*, a KxK matrix with N-1 subdiagonals.

Example

$$bx = \begin{matrix} 0.0000000 & 1.0000000 \\ 2.0000000 & 8.0000000 \\ 1.0000000 & 5.0000000 \\ 2.0000000 & 3.0000000 \end{matrix}$$

```
x = bandrv(bx);
```

$$x = \begin{matrix} 1.0000000 & 2.0000000 & 0.0000000 & 0.0000000 \\ 2.0000000 & 8.0000000 & 1.0000000 & 0.0000000 \\ 0.0000000 & 1.0000000 & 5.0000000 & 2.0000000 \\ 0.0000000 & 0.0000000 & 2.0000000 & 3.0000000 \end{matrix}$$

bandsolpd

Purpose

Solves the system of equations $Ax = b$ for x, where A is a positive definite banded matrix.

Format

x **= bandsolpd(***b,A***);**

Input

b	KxM matrix.
A	KxN compact form matrix.

Output

x	KxM matrix.

Remarks

A is a positive definite banded matrix in compact form. See **band** for a description of the format of *A*.

b can have more than one column. If so, $Ax = b$ is solved for each column. That is,

```
A*x[.,i] = b[.,i]
```

bar

Purpose Bar graph.

Library pgraph

Format **bar(***val*,*ht***);**

Input

val Nx1 numeric vector, bar labels. If scalar 0, a sequence from 1 to **rows(***ht***)** will be created.

ht NxK numeric vector, bar heights.

K overlapping or side-by-side sets of N bars will be graphed.

For overlapping bars, the first column should contain the set of bars with the greatest height and the last column should contain the set of bars with the least height. Otherwise, the bars that are drawn first may be obscured by the bars drawn last. This is not a problem if the bars are plotted side-by-side.

Global Input

_pbarwid global scalar, width and positioning of bars in bar graphs and histograms. The valid range is 0-1. If this is 0, the bars will be a single pixel wide. If this is 1, the bars will touch each other.

If this value is positive, the bars will overlap. If negative, the bars will be plotted side-by-side. The default is 0.5.

_pbartyp Kx2 matrix.

The first column controls the bar shading:

- **0** no shading.
- **1** dots.
- **2** vertical cross-hatch.
- **3** diagonal lines with positive slope.
- **4** diagonal lines with negative slope.
- **5** diagonal cross-hatch.
- **6** solid.

The second column controls the bar color. See “Colors Appendix” on page B-1.

bar

Remarks

Use **scale** or **ytics** to fix the scaling for the bar heights.

Example

In this example, three overlapping sets of bars will be created. The three heights for the i^{th} bar are stored in *x[i,.]*.

```
library pgraph;
graphset;

t = seqa(0,1,10);
x = (t^2/2).*(1~0.7~0.3);

_plegctl = { 1 4 };
_plegstr = "Accnt #1\000Accnt #2\000Accnt #3";
title("Theoretical Savings Balance");
xlabel("Years");
ylabel("Dollars x 1000");
_pbartyp = { 1 10 }; /* Set color of the */
                     /* bars to 10 (magenta) */
_pnum = 2;
bar(t,x);   /* Use t vector to label X axis */
```

Source

pbar.src

See also

asclabel, xy, logx, logy, loglog, scale, hist

base10

Purpose Break number into a number of the form #.####... and a power of 10.

Format **{** *M,P* **} = base10(***x***);**

Input

x	scalar, number to break down.

Output

M	scalar, in the range -10 < *M* < 10.
P	scalar, integer power such that: $M * 10^P = x$

Example

```
{ b, e } = base10(4500);
b = 4.5000000
e = 3.0000000
```

Source base10.src

begwind

Purpose Initialize global graphic panel variables.

Library **pgraph**

Format **begwind;**

Remarks This procedure must be called before any other graphic panel functions are called.

Source pwindow.src

See also **endwind, window, makewind, setwind, nextwind, getwind**

besselj

Purpose Computes a Bessel function of the first kind, $J_n(x)$.

Format *y* **= besselj(***n,x***);**

Input

n	NxK matrix, the order of the Bessel function. Nonintegers will be truncated to an integer.
x	LxM matrix, ExE conformable with *n*.

Output

y	max(N,L) by max(K,M) matrix.

Example

```
n = { 0, 1 };
x = { 0.1 1.2, 2.3 3.4 };
y = besselj(n,x);
```

```
y =  0.99750156   0.67113274
     0.53987253   0.17922585
```

See also **bessely, mbesseli**

bessely

Purpose To compute a Bessel function of the second kind (Weber's function), $Y_n(x)$.

Format *y* **= bessely(***n,x***);**

Input

n	NxK matrix, the order of the Bessel function. Nonintegers will be truncated to an integer.
x	LxM matrix, ExE conformable with *n*.

Output

y	max(N,L) by max(K,M) matrix.

Example

```
n = { 0, 1 };
x = { 0.1 1.2, 2.3 3.4 };
y = bessely(n,x);
```

$$y = \begin{matrix} -1.5342387 & 0.22808351 \\ 0.05227732 & 0.40101529 \end{matrix}$$

See also **besselj, mbesseli**

box

Purpose

Graph data using the box graph percentile method.

Library

pgraph

Format

box(*grp*,*y***);**

Input

grp 1xM vector. This contains the group numbers corresponding to each column of *y* data. If scalar 0, a sequence from 1 to **cols(***y***)** will be generated automatically for the X axis.

y NxM matrix. Each column represents the set of *y* values for an individual percentiles box symbol.

Global Input

_pboxctl 5x1 vector, controls box style, width, and color.

[1] box width between 0 and 1. If zero, the box plot is drawn as two vertical lines representing the quartile ranges with a filled circle representing the 50^{th} percentile.

[2] box color. If this is set to 0, the colors may be individually controlled using the global variable **_pcolor**.

[3] Min/max style for the box symbol. One of the following:

1 Minimum and maximum taken from the actual limits of the data. Elements 4 and 5 are ignored.

2 Statistical standard with the minimum and maximum calculated according to interquartile range as follows:

$$\begin{aligned} intqrange &= 75^{th} - 25^{th} \\ min &= 25^{th} - 1.5intqrange \\ max &= 75^{th} + 1.5intqrange \end{aligned}$$

Elements 4 and 5 are ignored.

3 Minimum and maximum percentiles taken from elements 4 and 5.

[4] Minimum percentile value (0-100) if **_pboxctl***[3]* = 3.

	[5]	Maximum percentile value (0-100) if **_pboxctl***[3]* = 3.
_plctrl	1xM vector or scalar as follows:	
	0	Plot boxes only, no symbols.
	1	Plot boxes and plot symbols that lie outside the min and max box values.
	2	Plot boxes and all symbols.
	-1	Plot symbols only, no boxes.
	These capabilities are in addition to the usual line control capabilities of **_plctrl**.	
_pcolor	1xM vector or scalar for symbol colors. If scalar, all symbols will be one color. See “Colors Appendix” on page B-1.	

Remarks

If missing values are encountered in the *y* data, they will be ignored during calculations and will not be plotted.

Source

pbox.src

boxcox

Purpose

Computes the Box-Cox function.

Format

y = **boxcox (***x*,*lambda* **);**

Input

x	MxN matrix.
lambda	KxL matrix, ExE conformable to x.

Output

y	max(M,L) x max(N,K).

Remarks

Allowable range for *x* is:

$x > 0$

The **boxcox** function computes

$$boxcox(x) = \frac{x^{\lambda} - 1}{\lambda}$$

Example

```
x = {.2 .3, 1.5 2.5};
lambda = {.4, 2};
y = boxcox(x,lambda)
```

$$y = \begin{matrix} -1.1867361 & -0.95549787 \\ 0.62500000 & 2.62500000 \end{matrix}$$

break

Purpose Breaks out of a **do** or **for** loop.

Format **break;**

Example

```
x = rndn(4,4);
r = 0;
do while r < rows(x);
   r = r + 1;
   c = 0;
   do while c < cols(x);
      c = c + 1;
      if c == r;
         x[r,c] = 1;
      elseif c > r;
         break;  /* terminate inner do loop */
      else;
         x[r,c] = 0;
      endif;
   endo;  /* break jumps to the statement */
          /* after this endo */
endo;
```

$$x = \begin{matrix} 1.000 & 0.326 & -2.682 & -0.594 \\ 0.000 & 1.000 & -0.879 & 0.056 \\ 0.000 & 0.000 & 1.000 & -0.688 \\ 0.000 & 0.000 & 0.000 & 1.000 \end{matrix}$$

Remarks This command works just like in C.

See also `continue, do, for`

call

Purpose Calls a function or procedure when the returned value is not needed and can be ignored, or when the procedure is defined to return nothing.

Format
```
call function_name(argument_list);
call function_name;
```

Remarks This is useful when you need to execute a function or procedure and do not need the value that it returns. It can also be used for calling procedures that have been defined to return nothing.

function_name can be any intrinsic GAUSS function, a procedure (**proc**), or any valid expression.

Example
```
call chol(x);

y = detl;
```

The above example is the fastest way to compute the determinant of a positive definite matrix. The result of **chol** is discarded and **detl** is used to retrieve the determinant that was computed during the call to **chol**.

See also proc

cdfbeta

Purpose Computes the incomplete beta function (i.e., the cumulative distribution function of the beta distribution).

Format *y* **= cdfbeta(***x,a,b***);**

Input

x	NxK matrix.
a	LxM matrix, ExE conformable with *x*.
b	PxQ matrix, ExE conformable with *x* and *a*.

Output

y	max(N,L,P) by max(K,M,Q) matrix.

Remarks *y* is the integral from 0 to *x* of the beta distribution with parameters *a* and *b*. Allowable ranges for the arguments are:

$0 \leq x \leq 1$

$a > 0$

$b > 0$

A -1 is returned for those elements with invalid inputs.

Example

```
x = { .1, .2, .3, .4 };
a = 0.5;
b = 0.3;
y = cdfbeta(x,a,b);
```

$$y = \begin{matrix} 0.142285 \\ 0.206629 \\ 0.260575 \\ 0.310875 \end{matrix}$$

See also **cdfchic, cdffc, cdfn, cdfnc, cdftc, gamma**

cdfbeta

Technical Notes

cdfbeta has the following approximate accuracy:

max(a,b) ≤ 500	the absolute error is approx. ±5e-13
500 < max(a,b) ≤ 10,000	the absolute error is approx. ±5e-11
10,000 < max(a,b) ≤ 200,000	the absolute error is approx. ±1e-9
200,000 < max(a,b)	Normal approximations are used and the absolute error is approx. ±2e-9

References

Bol'shev, L.N. "Asymptotically Pearson's Transformations." Teor. Veroyat. Primen. (*Theory of Probability and its Applications*). Vol. 8 No. 2, 1963, 129-55.

Bosten, N. E., and E.L. Battiste. "Remark on Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 17 No. 3, March 1974, 156-57.

Ludwig, O.G. "Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 6 No. 6, June 1963, 314.

Mardia, K.V., and P.J. Zemroch. "Tables of the F- and related distributions with algorithms." Academic Press, NY, 1978. ISBN 0-12-471140-5

Peizer, D.B., and J.W. Pratt. "A Normal Approximation for Binomial, F, Beta, and Other Common, Related Tail Probabilities, I." *Journal of American Statistical Association*. Vol. 63, Dec. 1968, 1416-56.

Pike, M.C., and I.D. Hill. "Remark on Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 10 No. 6, June 1967, 375-76.

cdfbvn

Purpose

Computes the cumulative distribution function of the standardized bivariate Normal density (lower tail).

Format

c **= cdfbvn(***h,k,r***);**

Input

h	NxK matrix, the upper limits of integration for variable 1.
k	LxM matrix, ExE conformable with *h*, the upper limits of integration for variable 2.
r	PxQ matrix, ExE conformable with *h* and *k*, the correlation coefficients between the two variables.

Output

c	max(N,L,P) by max(K,M,Q) matrix, the result of the double integral from -∞ to *h* and -∞ to *k* of the standardized bivariate Normal density *f*(*x*,*y*,*r*).

Remarks

The function integrated is:

$$f(x, y, r) = \frac{e^{-0.5w}}{2\pi\sqrt{1-r^2}}$$

with

$$w = \frac{x^2 - 2rxy + y^2}{1-r^2}$$

Thus, *x* and *y* have 0 means, unit variances, and correlation = *r*.

Allowable ranges for the arguments are:

$-\infty < h < +\infty$

$-\infty < k < +\infty$

$-1 \leq r \leq 1$

A -1 is returned for those elements with invalid inputs.

To find the integral under a general bivariate density, with *x* and *y* having nonzero means and any positive standard deviations, use the transformation equations:

```
h = (ht - ux) ./ sx;
k = (kt - uy) ./ sy;
```

cdfbvn

where **ux** and **uy** are the (vectors of) means of *x* and *y*, **sx** and **sy** are the (vectors of) standard deviations of *x* and *y*, and **ht** and **kt** are the (vectors of) upper integration limits for the untransformed variables, respectively.

See also

cdfn, cdftvn

Technical Notes

The absolute error for **cdfbvn** is approximately ±5.0e-9 for the entire range of arguments.

References

Daley, D.J. "Computation of Bi- and Tri-variate Normal Integral." *Appl. Statist.* Vol. 23 No. 3, 1974, 435-38.

Owen, D.B. "A Table of Normal Integrals." *Commun. Statist.-Simula. Computa*., B9(4). 1980, 389-419.

cdfbvn2

Purpose

Returns cdfbvn of a bounded rectangle.

Format

y **= cdfbvn2(***h*,*dh*,*k*,*dk*,*r***);**

Input

h	Nx1 vector, starting points of integration for variable 1.
dh	Nx1 vector, increments for variable 1.
k	Nx1 vector, starting points of integration for variable 2.
dk	Nx1 vector, increments for variable 2.
r	Nx1 vector, correlation coefficients between the two variables.

Output

y	Nx1 vector, the integral over the rectangle bounded by *h*, *h*+*dh*, *k*, and *k*+*dk* of the standardized bivariate Normal distribution.

Remarks

Scalar input arguments are okay; they will be expanded to Nx1 vectors.

cdfbvn2 computes:

cdfbvn(*h*+*dh*,*k*+*dk*,*r*) + **cdfbvn**(*h*,*k*,*r*) - **cdfbvn**(*h*,*k*+*dk*,*r*) - **cdfbvn**(*h*+*dh*,*k*,*r*).

cdfbvn2 computes an error estimate for each set of inputs. The size of the error depends on the input arguments. If **trap 2** is set, a warning message is displayed when the error reaches 0.01***abs**(*y*).

For an estimate of the actual error, see **cdfbvn2e**.

Example

Example 1

```
cdfbvn2(1,-1,1,-1,0.5);
```

produces:

```
1.4105101488974692e-001
```

Example 2

```
cdfbvn2(1,-1e-15,1,-1e-15,0.5);
```

produces:

```
4.9303806576313238e-32
```

cdfbvn2

Example 3

```
cdfbvn2(1,-1e-45,1,-1e-45,0.5);
```

produces:

```
0.0000000000000000e+000
```

Example 4

```
trap 2,2;
cdfbvn2(1,-1e-45,1,1e-45,0.5);
```

produces:

```
WARNING: Dubious accuracy from cdfbvn2:
0.000e+000 +/- 2.8e-060
0.0000000000000000e+000
```

Source lncdfn.src

See also **cdfbvn2e, lncdfbvn2**

cdfbvn2e

Purpose

Returns cdfbvn of a bounded rectangle.

Format

{ *y*, *e* **} = cdfbvn2e(***h*,*dh*,*k*,*dk*,*r***);**

Input

h	Nx1 vector, starting points of integration for variable 1.
dh	Nx1 vector, increments for variable 1.
k	Nx1 vector, starting points of integration for variable 2.
dk	Nx1 vector, increments for variable 2.
r	Nx1 vector, correlation coefficients between the two variables.

Output

y	Nx1 vector, the integral over the rectangle bounded by *h*, *h*+*dh*, *k*, and *k*+*dk* of the standardized bivariate Normal distribution.
e	Nx1 vector, an error estimate.

Remarks

Scalar input arguments are okay; they will be expanded to Nx1 vectors.

cdfbvn2e computes **cdfbvn**(*h*+*dh*,*k*+*dk*,*r*) + **cdfbvn**(*h*,*k*,*r*) - **cdfbvn**(*h*,*k*+*dk*,*r*) - **cdfbvn**(*h*+*dh*,*k*,*r*).

The real answer is *y*±e. The size of the error depends on the input arguments.

Example

Example 1

```
cdfbvn2e(1,-1,1,-1,0.5);
```

produces:

```
1.4105101488974692e-001
1.9927918166193113e-014
```

Example 2

```
cdfbvn2e(1,-1e-15,1,-1e-15,0.5);
```

produces:

cdfbvn2e

```
7.3955709864469857e-032
2.8306169312687801e-030
```

Example 3

```
cdfbvn2e(1,-1e-45,1,-1e-45,0.5);
```

produces:

```
0.0000000000000000e+000
2.8306169312687770e-060
```

See also

cdfbvn2, lncdfbvn2

cdfchic

Purpose

Computes the complement of the cdf of the chi-square distribution.

Format

y **= cdfchic(***x,n***)**

Input

x	NxK matrix.
n	LxM matrix, ExE conformable with *x*.

Output

y	max(N,L) by max(K,M) matrix.

Remarks

y is the integral from *x* to ∞ of the chi-square distribution with *n* degrees of freedom.

The elements of *n* must all be positive integers. The allowable ranges for the arguments are:

$$x \geq 0$$

$$n > 0$$

A -1 is returned for those elements with invalid inputs.

This equals 1-*F*(*x*,*n*), where *F* is the chi-square cdf with *n* degrees of freedom. Thus, to get the chi-square cdf, subtract **cdfchic(***x,n***)** from 1. The complement of the cdf is computed because this is what is most commonly needed in statistical applications, and because it can be computed with fewer problems of roundoff error.

Example

```
x = { .1, .2, .3, .4 };
n = 3;
y = cdfchic(x,n);
```

$$y = \begin{matrix} 0.991837 \\ 0.977589 \\ 0.960028 \\ 0.940242 \end{matrix}$$

See also

cdfbeta, cdffc, cdfn, cdfnc, cdftc, gamma

cdfchic

Technical Notes

For n ≤ 1000, the incomplete gamma function is used and the absolute error is approx. ±6e-13. For n > 1000, a Normal approximation is used and the absolute error is ±2e-8.

For higher accuracy when n > 1000, use:

```
1-cdfgam(0.5*x,0.5*n);
```

References

Bhattacharjee, G.P. "Algorithm AS 32, The Incomplete Gamma Integral." *Applied Statistics*. Vol. 19, 1970, 285-87.

Mardia, K.V., and P.J. Zemroch. "Tables of the F- and related distributions with algorithms." Academic Press, NY, 1978. ISBN 0-12-471140-5

Peizer, D.B., and J.W. Pratt. "A Normal Approximation for Binomial, F, Beta, and Other Common, Related Tail Probabilities, I." *Journal of American Statistical Association*. Vol. 63, Dec. 1968, 1416-56.

cdfchii

Purpose Compute chi-square abscissae values given probability and degrees of freedom.

Format *c* **= cdfchii(***p,n***);**

Input

p	MxN matrix, probabilities.
n	LxK matrix, ExE conformable with *p*, degrees of freedom.

Output

c	max(M,L) by max(N,K) matrix, abscissae values for chi-square distribution.

Example The following generates a 3x3 matrix of pseudo-random numbers with a chi-squared distribution with expected value of 4:

```
rndseed 464578;
x = cdfchii(rndu(3,3),4+zeros(3,3));
```

$$x = \begin{matrix} 2.1096456 & 1.9354989 & 1.7549182 \\ 4.4971008 & 9.2643386 & 4.3639694 \\ 4.5737473 & 1.3706243 & 2.5653688 \end{matrix}$$

Source cdfchii.src

See also **gammaii**

cdfchinc

Purpose

The integral under noncentral chi-square distribution, from 0 to *x*. It can return a vector of values, but the degrees of freedom and noncentrality parameter must be the same for all values of *x*.

Format

y **= cdfchinc(***x,v,d***);**

Input

x	Nx1 vector, values of upper limits of integrals, must be greater than 0.
v	scalar, degrees of freedom, $v > 0$.
d	scalar, noncentrality parameter, $d > 0$. This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. (See Scheffe, *The Analysis of Variance*, App. IV. 1959.)

Output

y	Nx1 vector, integrals from 0 to *x* of noncentral chi-square.

Example

```
x = { .5, 1, 5, 25 };
p = cdfchinc(x,4,2);
```

```
0.0042086234
 0.016608592
  0.30954232
  0.99441140
```

Source

cdfnonc.src

See also

cdffnc, cdftnc

Technical Notes

Relation to cdfchic:

```
cdfchic(x,v) = 1 - cdfchinc(x,v,0);
```

The formula used is taken from Abramowitz and Stegun, *Handbook of Mathematical Functions*. Formula 26.4.25. 1970, 942.

cdffc

Purpose

Computes the complement of the cdf of the *F* distribution.

Format

y **= cdffc(***x,n1,n2***);**

Input

x	NxK matrix.
n1	LxM matrix, ExE conformable with *x*.
n2	PxQ matrix, ExE conformable with *x* and *n1*.

Output

y	max(N,L,P) by max(K,M,Q) matrix.

Remarks

y is the integral from x to ∞ of the *F* distribution with *n1* and *n2* degrees of freedom.

Allowable ranges for the arguments are:

$$x \geq 0$$
$$n1 > 0$$
$$n2 > 0$$

A -1 is returned for those elements with invalid inputs.

This equals 1-*G*(*x,n1,n2*), where *G* is the *F* cdf with *n1* and *n2* degrees of freedom. Thus, to get the *F* cdf, subtract **cdffc**(*x,n1,n2*) from 1. The complement of the cdf is computed because this is what is most commonly needed in statistical applications, and because it can be computed with fewer problems of roundoff error.

Example

```
x = { .1, .2, .3, .4 };
n1 = 0.5;
n2 = 0.3;
y = cdffc(x,n1,n2);
```

$$y = \begin{matrix} 0.751772 \\ 0.708152 \\ 0.680365 \\ 0.659816 \end{matrix}$$

cdffc

See also

cdfbeta, cdfchic, cdfn, cdfnc, cdftc, gamma

Technical Notes

For max(n1,n2) ≤ 1000, the absolute error is approximately ±5e-13. For max(n1,n2) > 1000, Normal approximations are used and the absolute error is approximately ±2e-6.

For higher accuracy when max(n1,n2) > 1000, use:

```
cdfbeta(n2/(n2+n1*x), n2/2, n1/2);
```

References

Bol'shev, L.N. "Asymptotically Pearson's Transformations." Teor. Veroyat. Primen. (*Theory of Probability and its Applications*). Vol. 8 No. 2, 1963, 129-55.

Bosten, N. E., and E.L. Battiste. "Remark on Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 17 No. 3, March 1974, 156-57.

Kennedy, W.J., Jr., and J.E. Gentle. *Statistical Computing*. Marcel Dekker, Inc., NY, 1980.

Ludwig, O.G. "Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 6 No. 6, June 1963, 314.

Mardia, K.V., and P.J. Zemroch. "Tables of the F- and related distributions with algorithms." Academic Press, NY, 1978. ISBN 0-12-471140-5

Peizer, D.B., and J.W. Pratt. "A Normal Approximation for Binomial, F, Beta, and Other Common, Related Tail Probabilities, I." *Journal of American Statistical Association*. Vol. 63, Dec. 1968, 1416-56.

Pike, M.C., and I.D. Hill. "Remark on Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 10 No. 6, June 1967, 375-76.

cdffnc

Purpose

The integral under noncentral *F* distribution, from 0 to *x*.

Format

y **= cdffnc(***x,v1,v2,d***);**

Input

x	Nx1 vector, values of upper limits of integrals, $x > 0$.
v1	scalar, degrees of freedom of numerator, $v1 > 0$.
v2	scalar, degrees of freedom of denominator, $v2 > 0$.
d	scalar, noncentrality parameter, $d > 0$. This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. (See Scheffe, *The Analysis of Variance*, App. IV. 1959.)

Output

y	Nx1 vector of integrals from 0 to *x* of noncentral *F*.

Source

cdfnonc.src

See also

cdftnc, cdfchinc

Technical Notes

Relation to **cdffc**:

```
cdffc(x,v1,v2) = 1 - cdffnc(x,v1,v2,0);
```

The formula used is taken from Abramowitz and Stegun, *Handbook of Mathematical Functions*. Formula 26.6.20. 1970, 947.

cdfgam

Purpose

Incomplete gamma function.

Format

g **= cdfgam(***x*,*intlim***);**

Input

x	NxK matrix of data.
intlim	LxM matrix, ExE compatible with *x*, containing the integration limit.

Output

g	max(N,L) by max(K,M) matrix.

Remarks

The incomplete gamma function returns the integral

$$\int_0^{intlim} \frac{e^{-t}t^{(x-1)}}{gamma(x)}dt$$

The allowable ranges for the arguments are:

$$x > 0$$
$$intlim \geq 0$$

A -1 is returned for those elements with invalid inputs.

Example

```
x = { 0.5 1 3 10 };
intlim = seqa(0,.2,6);
g = cdfgam(x,intlim);
```

$$x = \begin{matrix} 0.500000 & 1.00000 & 3.00000 & 10.00000 \end{matrix}$$

$$intlim = \begin{matrix} 0.000000 \\ 0.200000 \\ 0.400000 \\ 0.600000 \\ 0.800000 \\ 1.000000 \end{matrix}$$

$$g = \begin{matrix} 0.000000 & 0.000000 & 0.000000 & 0.000000 \\ 0.472911 & 0.181269 & 0.00114848 & 2.35307E-014 \\ 0.628907 & 0.329680 & 0.00792633 & 2.00981E-011 \\ 0.726678 & 1.451188 & 0.0231153 & 9.66972E-010 \\ 0.794097 & 0.550671 & 0.0474226 & 1.43310E-008 \\ 0.842701 & 0.632120 & 0.0803014 & 1.11425E-007 \end{matrix}$$

This computes the integrals over the range from 0 to 1, in increments of .2, at the parameter values 0.5, 1, 3, 10.

Technical Notes

cdfgam has the following approximate accuracy:

$x < 500$	the absolute error is approx. ±6e-13
$500 \le x \le 10{,}000$	the absolute error is approx. ±3e-11
$10{,}000 < x$	a Normal approximation is used and the absolute error is approx. ±3e-10

References

Bhattacharjee, G.P. "Algorithm AS 32, The Incomplete Gamma Integral." *Applied Statistics*. Vol. 19, 1970, 285-87.

Peizer, D.B., and J.W. Pratt. "A Normal Approximation for Binomial, F, Beta, and Other Common, Related Tail Probabilities, I." *Journal of American Statistical Association*. Vol. 63, Dec. 1968, 1416-56.

Pike, M.C., and I.D. Hill. "Remark on Algorithm 179 Incomplete Beta Ratio." *Comm. ACM*. Vol. 10 No. 6, June 1967, 375-76.

cdfmvn

Purpose Computes multivariate Normal cumulative distribution function.

Format *y* **= cdfmvn(***x,r***);**

Input

x	KxL matrix, abscissae.
r	KxK matrix, correlation matrix.

Output

y	Lx1 vector, $Pr(X < x \mid r)$.

Source lncdfn.src

See also **cdfbvn, cdfn, cdftvn, lncdfmvn**

cdfn, cdfnc

Purpose

cdfn computes the cumulative distribution function (cdf) of the Normal distribution. **cdfnc** computes 1 minus the cdf of the Normal distribution.

Format

n **= cdfn(***x***);**
nc **= cdfnc(***x***);**

Input

x	NxK matrix.

Output

n	NxK matrix.
nc	NxK matrix.

Remarks

n is the integral from -∞ to *x* of the Normal density function, and *nc* is the integral from x to +∞.

Note that: **cdfn**(*x*) + **cdfnc**(*x*) = 1. However, many applications expect **cdfn**(*x*) to approach 1, but never actually reach it. Because of this, we have capped the return value of **cdfn** at 1 - machine epsilon, or approximately 1 - 1.11e-16. As the relative error of **cdfn** is about ±5e-15 for **cdfn**(*x*) around 1, this does not invalidate the result. What it does mean is that for **abs**(*x*) > (*approx.*) 8.2924, the identity does not hold true. If you have a need for the uncapped value of **cdfn**, the following code will return it:

```
n = cdfn(x);
if n >= 1-eps;
   n = 1;
endif;
```

where the value of machine epsilon is obtained as follows:

```
x = 1;
do while 1-x /= 1;
   eps = x;
   x = x/2;
endo;
```

Note that this is an alternate definition of machine epsilon. Machine epsilon is usually defined as the smallest number such that 1 + machine

cdfn, cdfnc

epsilon > 1, which is about 2.23e-16. This defines machine epsilon as the smallest number such that 1 - machine epsilon < 1, or about 1.11e-16.

The **erf** and **erfc** functions are also provided, and may sometimes be more useful than **cdfn** and **cdfnc**.

Example

```
x = { -2 -1 0 1 2 };

n = cdfn(x);

nc = cdfnc(x);
```

x =	-2.00000	-1.00000	0.00000	1.00000	2.00000
n =	0.02275	0.15866	0.50000	0.84134	0.97725
nc =	0.97725	0.84134	0.50000	0.15866	0.02275

See also

erf, erfc, cdfbeta, cdfchic, cdftc, cdffc, gamma

Technical Notes

For the integral from -∞ to *x*:

$x \leq -37$,	**cdfn** underflows and 0.0 is returned
$-36 < x < -10$,	**cdfn** has a relative error of approx. ±5e-12
$-10 < x < 0$,	**cdfn** has a relative error of approx. ±1e-13
$0 < x$,	**cdfn** has a relative error of approx. ±5e-15

For **cdfnc**, i.e., the integral from *x* to +∞, use the above accuracies but change *x* to -*x*.

References

Adams, A.G. "Remark on Algorithm 304 Normal Curve Integral." *Comm. ACM*. Vol. 12 No. 10, Oct. 1969, 565-66.

Hill, I.D., and S.A. Joyce. "Algorithm 304 Normal Curve Integral." *Comm. ACM*. Vol. 10 No. 6, June 1967, 374-75.

Holmgren, B. "Remark on Algorithm 304 Normal Curve Integral." *Comm. ACM*. Vol. 13 No. 10, Oct. 1970.

Mardia, K.V., and P.J. Zemroch. "Tables of the F- and related distributions with algorithms." Academic Press, NY, 1978. ISBN 0-12-471140-5

cdfn2

Purpose Computes the integral over a Normal density function interval.

Format *y* **= cdfn2(***x,dx***);**

Input

x	MxN matrix, abscissae.
dx	KxL matrix, ExE conformable to *x*, intervals.

Output

y	max(M,K) by max(N,L) matrix, the integral from *x* to *x*+*dx* of the Normal distribution, i.e., $Pr(x \le X \le x + dx)$.

Remarks The relative error is:

$\|x\| \le 1$ and $dx \le 1$	±1*e*-14
$1 < \|x\| < 37$ and $\|dx\| < 1/\|x\|$	±1*e*-13
$min(x,x+dx) > -37$ and $y >$ 1e-300	±1*e*-11 or better

A relative error of ±1*e*-14 implies that the answer is accurate to better than ±1 in the 14th digit.

Example

```
print cdfn2(1,0.5);
9.1848052662599017e-02
print cdfn2(20,0.5);
2.7535164718736454e-89
print cdfn2(20,1e-2);
5.0038115018684521e-90
print cdfn2(-5,2);
1.3496113800582164e-03
print cdfn2(-5,0.15);
3.3065580013000255e-07
```

Source lncdfn.src

See also **lncdfn2**

cdfni

Purpose Computes the inverse of the cdf of the Normal distribution.

Format *x* **= cdfni(***p***);**

Input

p	NxK real matrix, Normal probability levels, $0 \leq p \leq 1$.

Output

x	NxK real matrix, Normal deviates, such that **cdfn**(*x*) = *p*

Remarks **cdfn**(**cdfni(***p***)**) = *p* to within the errors given below:

$p \leq$ 4.6..e-308	-37.5 is returned
4.6..e-308 < p < 5e-24	accurate to ±5 in 12th digit
5e-24 < p < 0.5	accurate to ±1 in 13th digit
0.5 < p < 1 - 2.22045e-16	accurate to ±5 in 15th digit
$p \geq$ 1 - 2.22045e-16	8.12589... is returned

cdftc

Purpose

Computes the complement of the cdf of the Student's *t* distribution.

Format

y **= cdftc(***x*,*n***);**

Input

x	NxK matrix.
n	LxM matrix, ExE conformable with *x*.

Output

y	max(N,L) by max(K,M) matrix.

Remarks

y is the integral from *x* to ∞ of the *t* distribution with *n* degrees of freedom.

Allowable ranges for the arguments are:

$$-\infty < x < +\infty$$
$$n > 0$$

A -1 is returned for those elements with invalid inputs.

This equals 1-*F*(*x*,*n*), where *F* is the *t* cdf with *n* degrees of freedom. Thus, to get the *t* cdf, subtract **cdftc(***x*,*n***)** from 1. The complement of the cdf is computed because this is what is most commonly needed in statistical applications, and because it can be computed with fewer problems of roundoff error.

Example

```
x = { .1, .2, .3, .4 };
n = 25;
y = cdftc(x,n);
print y;
```

$$y = \begin{matrix} 0.473165 \\ 0.447100 \\ 0.422428 \\ 0.399555 \end{matrix}$$

See also

cdfbeta, cdfchic, cdffc, cdfn, cdfnc, gamma

cdftc

Technical Notes

For results greater than 0.5e-30, the absolute error is approximately ±1e-14 and the relative error is approximately ±1e-12. If you multiply the relative error by the result, then take the minimum of that and the absolute error, you have the maximum actual error for any result. Thus, the actual error is approximately ±1e-14 for results greater than 0.01. For results less than 0.01, the actual error will be less. For example, for a result of 0.5e-30, the actual error is only ±0.5e-42.

References

Abramowitz, M., and I. A. Stegun, eds. *Handbook of Mathematical Functions*. 7th ed. Dover, NY, 1970. ISBN 0-486-61272-4

Hill, G.W. "Algorithm 395 Student's t-Distribution." *Comm. ACM*. Vol. 13 No. 10, Oct. 1970.

Hill, G.W. "Student's t-Distribution Quantiles to 20D." *Division of Mathematical Statistics Technical Paper No. 35*. Commonwealth Scientific and Industrial Research Organization, Australia, 1972.

cdftci

Purpose

Computes the inverse of the complement of the Student's t cdf.

Format

x **= cdftci(***p*,*n***);**

Input

p	NxK real matrix, complementary Student's t probability levels, $0 \leq p \leq 1$.
n	LxM real matrix, degrees of freedom, $n \geq 1$, *n* need not be integral. ExE conformable with *p*.

Output

x	max(N,L) by max(K,M) real matrix, Student's t deviates, such that **cdftc**(*x*,*n*) = *p*.

Remarks

cdftc(**cdftci(***p*,*n***)**) = *p* to within the errors given below:

0.5e-30 < *p* < 0.01	accurate to ±1 in 12th digit
0.01 < *p*	accurate to ±1e-14

Extreme values of arguments can give rise to underflows, but no overflows are generated.

cdftnc

Purpose

The integral under noncentral Student's *t* distribution, from -∞ to *x*. It can return a vector of values, but the degrees of freedom and noncentrality parameter must be the same for all values of *x*.

Format

y **= cdftnc(***x,v,d***);**

Input

x	Nx1 vector, values of upper limits of integrals.
v	scalar, degrees of freedom, $v > 0$.
d	scalar, noncentrality parameter. This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. (See Scheffe, *The Analysis of Variance*, App. IV. 1959.)

Output

y	Nx1 vector, integrals from -∞ to *x* of noncentral *t*.

Source

cdfnonc.src

See also

cdffnc, cdfchinc

Technical Notes

Relation to **cdftc**:

```
cdftc(x,v) = 1 - cdftnc(x,v,0);
```

The formula used is based on the formula in *SUGI Supplemental Library User's Guide*. SAS Institute. 1983, 232 (which is attributed to Johnson and Kotz, 1970).

The formula used here is a modification of that formula. It has been tested against direct numerical integration, and against simulation experiments in which noncentral **t** random variates were generated and the cdf found directly.

cdftvn

Purpose

Computes the cumulative distribution function of the standardized trivariate Normal density (lower tail).

Format

c **= cdftvn(***x1,x2,x3,rho12,rho23,rho31***);**

Input

x1	Nx1 vector of upper limits of integration for variable 1.
x2	Nx1 vector of upper limits of integration for variable 2.
x3	Nx1 vector of upper limits of integration for variable 3.
rho12	scalar or Nx1 vector of correlation coefficients between the two variables *x1* and *x2*.
rho23	scalar or Nx1 vector of correlation coefficients between the two variables *x2* and *x3*.
rho31	scalar or Nx1 vector of correlation coefficients between the two variables *x1* and *x3*.

Output

c Nx1 vector containing the result of the triple integral from -∞ to *x1*, -∞ to *x2*, and -∞ to *x3* of the standardized trivariate Normal density:

```
f(x1,x2,x3,rho12,rho23,rho31)
```

Remarks

Allowable ranges for the arguments are:

$-\infty < x1 < +\infty$

$-\infty < x2 < +\infty$

$-\infty < x3 < +\infty$

$-1 < rho12 < 1$

$-1 < rho23 < 1$

$-1 < rho31 < 1$

In addition, *rho12*, *rho23*, and *rho31* must come from a legitimate positive definite matrix. A -1 is returned for those rows with invalid inputs.

A separate integral is computed for each row of the inputs.

The first 3 arguments (*x1*,*x2*,*x3*) must be the same length, *N*. The second 3 arguments (*rho12*,*rho23*,*rho31*) must also be the same length, and this

cdftvn

length must be *N* or 1. If it is 1, then these values will be expanded to apply to all values of *x1,x2,x3*. All inputs must be column vectors.

To find the integral under a general trivariate density, with *x1*, *x2*, and *x3* having nonzero means and any positive standard deviations, transform by subtracting the mean and dividing by the standard deviation. For example:

```
x1 = ( x1 - meanc(x1) ) / stdc(x1);
```

See also

cdfn, cdfbvn

Technical Notes

The absolute error for **cdftvn** is approximately ±2.5e-8 for the entire range of arguments.

References

Daley, D.J. "Computation of Bi- and Tri-variate Normal Integral." *Appl. Statist.* Vol. 23 No. 3, 1974, 435-38.

Steck, G.P. "A Table for Computing Trivariate Normal Probabilities." *Ann. Math. Statist*. Vol. 29, 780-800.

cdir

Purpose Returns the current directory.

Format *y* **= cdir(***s***);**

Input

s	string, if the first character is 'A'-'Z' and the second character is a colon ':' then that drive will be used. If not, the current default drive will be used.

Output

y	string containing the drive and full path name of the current directory on the specified drive.

Remarks If the current directory is the root directory, the returned string will end with a backslash, otherwise it will not.

A null string or scalar zero can be passed in as an argument to obtain the current drive and path name.

Example

```
x = cdir(0);
y = cdir("d:");
print x;
print y;

C:\GAUSS
D:\
```

See also **files**

ceil

Purpose Round up toward +∞.

Format *y* **= ceil(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix.

Remarks This rounds every element in the matrix *x* to an integer. The elements are rounded up toward +∞.

Example

```
x = 100*rndn(2,2);
y = ceil(x);
```

$$x = \begin{matrix} 77.68 & -14.10 \\ 4.73 & -158.88 \end{matrix}$$

$$y = \begin{matrix} 78.00 & -14.00 \\ 5.00 & -158.00 \end{matrix}$$

See also **floor, trunc**

ChangeDir

Purpose Changes the working directory.

Format *d* **= ChangeDir(***s***);**

Input *s* string, directory to change to.

Output *d* string, new working directory, or null string if change failed.

See also **chdir**

chdir

Purpose Changes working directory.

Format **chdir** *dirstr*;

Input

dirstr	literal or ^string, directory to change to.

Remarks This is for interactive use. Use **ChangeDir** in a program.

If the directory change fails, **chdir** prints an error message.

chol

Purpose Computes the Cholesky decomposition of a symmetric, positive definite matrix.

Format *y* **= chol(***x***);**

Input

x	NxN matrix.

Output

y	NxN matrix containing the Cholesky decomposition of *x*.

Remarks *y* is the "square root" matrix of *x*. That is, it is an upper triangular matrix such that $x = y'y$.

chol does not check to see that the matrix is symmetric. **chol** will look only at the upper half of the matrix including the principal diagonal.

If the matrix *x* is symmetric but not positive definite, either an error message or an error code will be generated, depending on the lowest order bit of the trap flag:

trap 0 Print error message and terminate program.

trap 1 Return scalar error code 10.

See **scalerr** and **trap** for more details about error codes.

Example

```
x = moment(rndn(100,4),0);
y = chol(x);
ypy = y'y;
```

$$x = \begin{matrix} 90.746566 & -6.467195 & -1.927489 & -15.696056 \\ -6.467195 & 87.806557 & 6.319043 & -2.435953 \\ -1.927489 & 6.319043 & 101.973276 & 4.355520 \\ -15.696056 & -2.435953 & 4.355520 & 99.042850 \end{matrix}$$

$$y = \begin{matrix} 9.526099 & -0.678892 & -0.202338 & -1.647690 \\ 0.000000 & 9.345890 & 0.661433 & -0.380334 \\ 0.000000 & 0.000000 & 10.074465 & 0.424211 \\ 0.000000 & 0.000000 & 0.000000 & 9.798130 \end{matrix}$$

chol

$$ypy = \begin{matrix} 90.746566 & -6.467195 & -1.927489 & -15.696056 \\ -6.467195 & 87.806557 & 6.319043 & -2.435953 \\ -1.927489 & 6.319043 & 101.973276 & 4.355520 \\ -15.696056 & -2.435953 & 4.355520 & 99.042850 \end{matrix}$$

See also

crout, solpd

choldn

Purpose

Performs a Cholesky downdate of one or more rows on an upper triangular matrix.

Format

r **= choldn(***C,x***);**

Input

C	KxK upper triangular matrix.
x	NxK matrix, the rows to downdate *C* with.

Output

r	KxK upper triangular matrix, the downdated matrix.

Remarks

C should be a Cholesky factorization.

choldn(C,x) is equivalent to **chol(C′C - x′x)**, but **choldn** is numerically much more stable.

Warning: it is possible to render a Cholesky factorization non-positive definite with **choldn**. You should keep an eye on the ratio of the largest diagonal element of *r* to the smallest — if it gets very large, *r* may no longer be positive definite. This ratio is a rough estimate of the condition number of the matrix.

Example

```
let C[3,3] =  20.16210005 16.50544413 9.86676135
              0           11.16601462 2.97761666
              0           0           11.65496052;
let x[2,3] =  1.76644971  7.49445820  9.79114666
              6.87691156  4.41961438  4.32476921;
r = choldn(C,x);
```

```
          18.87055964 15.32294435  8.04947012
r =        0.00000000  9.30682813 –2.12009339
           0.00000000  0.00000000  7.62878355
```

See also

cholup

cholsol

Purpose

Solves a system of linear equations given the Cholesky factorization of the system.

Format

x **= cholsol(***b,C***);**

Input

b	NxK matrix.
C	NxN matrix.

Output

x	NxK matrix.

Remarks

C is the Cholesky factorization of a linear system of equations *A*. *x* is the solution for *Ax* = *b*. *b* can have more than one column. If so, the system is solved for each column, i.e., *A*x*[.,*i*] = *b*[.,*i*].

cholsol(eye(N),C) is equivalent to **invpd(A)**. Thus, if you have the Cholesky factorization of *A*, **cholsol** is the most efficient way to obtain the inverse of *A*.

Example

```
let b[3,1] = 0.03177513 0.41823100 1.70129375;
let C[3,3] = 1.73351215 1.53201723 1.78102499
             0          1.09926365 0.63230050
             0          0          0.67015361;
x = cholsol(b,C);
```

$$x = \begin{matrix} -1.94396905 \\ -1.52686768 \\ 3.21579513 \end{matrix}$$

$$A0 = \begin{matrix} 3.00506436 & 2.65577048 & 3.08742844 \\ 2.65577048 & 3.55545737 & 3.42362593 \\ 3.08742844 & 3.42362593 & 4.02095978 \end{matrix}$$

cholup

Purpose Performs a Cholesky update of one or more rows on an upper triangular matrix.

Format *r* **= cholup(***C,x***);**

Input

C	KxK upper triangular matrix.
x	NxK matrix, the rows to update *C* with.

Output

r	KxK upper triangular matrix, the updated matrix.

Remarks *C* should be a Cholesky factorization.

cholup(C,x) is equivalent to **chol(C′C + x′x)**, but **cholup** is numerically much more stable.

Example

```
let C[3,3] = 18.87055964 15.32294435 8.04947012
             0           9.30682813  -2.12009339
             0           0           7.62878355;
let x[2,3] = 1.76644971  7.49445820  9.79114666
             6.87691156  4.41961438  4.32476921;
r = cholup(C,x);
```

```
          20.16210005 16.50544413  9.86676135
r =        0.00000000 11.16601462  2.97761666
           0.00000000  0.00000000 11.65496052
```

See also **choldn**

chrs

Purpose Converts a matrix of ASCII values into a string containing the appropriate characters.

Format *y* **= chrs(***x***);**

Input

x	NxK matrix.

Output

y	string of length N*K containing the characters whose ASCII values are equal to the values in the elements of *x*.

Remarks This function is useful for embedding control codes in strings and for creating variable length strings when formatting printouts, reports, etc.

Example

```
n = 5;
print chrs(ones(n,1)*42);

*****
```

Since the ASCII value of the asterisk character is 42, the program above will print a string of **n** asterisks.

```
y = chrs(67~65~84);
print y;

CAT
```

See also **vals, ftos, stof**

clear

Purpose Clears space in memory by setting matrices equal to scalar zero.

Format **clear** *x, y*;

Remarks **clear x;** is equivalent to **x = 0;**.

Matrix names are retained in the symbol table after they are cleared.

Matrices can be **clear**'ed even though they have not previously been defined. **clear** can be used to initialize matrices to scalar 0.

Example

```
clear x;
```

See also **clearg, new, show, delete**

clearg

Purpose This command clears global symbols by setting them equal to scalar zero.

Format **clearg** *a,b,c*;

Output *a,b,c* scalar global matrices containing 0.

Remarks **clearg x;** is equivalent to **x = 0;**, where **x** is understood to be a global symbol. **clearg** can be used to initialize symbols not previously referenced. This command can be used inside procedures to clear global matrices. It will ignore any locals by the same name.

Example

```
x = 45;
clearg x;
```

x = 0.0000000

See also **clear, delete, new, show, local**

close

Purpose

Close a GAUSS file.

Format

y **= close(***handle***);**

Input

handle scalar, the file handle given to the file when it was opened with the **open**, **create**, or **fopen** command.

Output

y scalar, 0 if successful, -1 if unsuccessful.

Remarks

handle is the scalar file handle created when the file was opened. It will contain an integer which can be used to refer to the file.

close will close the file specified by handle, and will return a 0 if successful and a -1 if not successful. The handle itself is not affected by **close** unless the return value of **close** is assigned to it.

If *f1* is a file handle and it contains the value 7, then after:

```
call close(f1);
```

the file will be closed but *f1* will still have the value 7. The best procedure is to do the following:

```
f1 = close(f1);
```

This will set *f1* to 0 upon a successful close.

It is important to set unused file handles to zero because both **open** and **create** check the value that is in a file handle before they proceed with the process of opening a file. During **open** or **create**, if the value that is in the file handle matches that of an already open file, the process will be aborted and a "File already open" message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happened, you would no longer be able to access the first file.

An advantage of the **close** function is that it returns a result which can be tested to see if there were problems in closing a file. The most common reason for having a problem in closing a file is that the disk on which the file is located is no longer in the disk drive — or the handle was invalid. In both of these cases, **close** will return a -1.

Files are not automatically closed when a program terminates. This allows users to run a program that opens files, and then access the files

close

from interactive mode after the program has been run. Files are automatically closed when GAUSS exits to the operating system or when a program is terminated with the **end** statement. **stop** will terminate a program but not close files.

As a rule it is good practice to make **end** the last statement in a program, unless further access to the open files is desired from interactive mode. You should close files as soon as you are done writing to them to protect against data loss in the case of abnormal termination of the program due to a power or equipment failure.

The danger in not closing files is that anything written to the files may be lost. The disk directory will not reflect changes in the size of a file until the file is closed and system buffers may not be flushed.

Example

```
open f1 = dat1 for append;
y = writer(f1,x);
f1 = close(f1);
```

See also

closeall

closeall

Purpose

Close all currently open GAUSS files.

Format

```
closeall;
closeall list_of_handles;
```

Remarks

list_of_handles is a comma-delimited list of file handles.

closeall with no specified list of handles will close all files. The file handles will not be affected. The main advantage of using **closeall** is ease of use; the file handles do not have to be specified, and one statement will close all files.

When a list of handles follows **closeall**, all files are closed and the file handles listed are set to scalar 0. This is safer than **closeall** without a list of handles because the handles are cleared.

It is important to set unused file handles to zero because both **open** and **create** check the value that is in a file handle before they proceed with the process of opening a file. During **open** or **create**, if the value that is in the file handle matches that of an already open file, the process will be aborted and a "File already open" message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happened, you would no longer be able to access the first file.

Files are not automatically closed when a program terminates. This allows users to run a program that opens files, and then access the files from interactive mode after the program has been run. Files are automatically closed when GAUSS exits to the operating system or when a program is terminated with the **end** statement. **stop** will terminate a program but not close files.

As a rule it is good practice to make **end** the last statement in a program, unless further access to the open files is desired from interactive mode. You should close files as soon as you are done writing to them to protect against data loss in the case of abnormal termination of the program due to a power or equipment failure.

The danger in not closing files is that anything written to the files may be lost. The disk directory will not reflect changes in the size of a file until the file is closed and system buffers may not be flushed.

closeall

Example

```
open f1 = dat1 for read;
open f2 = dat1 for update;
x = readr(f1,rowsf(f1));
x = sqrt(x);
call writer(f2,x);
closeall f1,f2;
```

See also **close, open**

cls

Purpose

Clear the window.

Format

```
cls;
```

Portability

UNIX 3.2 only

cls clears the active graphic panel. For Text graphic panels, this means the graphic panel buffer is cleared to the background color. For TTY graphic panels, the current output line is panned to the top of the graphic panel, effectively clearing the display. The output log is still intact. To clear the output log of a TTY graphic panel, use **WinClearTTYLog**. For PQG graphic panels, the graphic panel is cleared to the background color, and the related graphics file is truncated to zero length.

UNIX 3.5+

cls will clear the screen on some terminals.

Windows

cls clears the Command window if you're in Cmnd I/O mode, the Output window if you're in Split I/O mode.

OS/2

cls clears the Main window.

Remarks

This command will cause the window to clear and will locate the cursor at the upper left hand corner of the window.

See also

locate

code

Purpose

Allows a new variable to be created (coded) with different values depending upon which one of a set of logical expressions is true.

Format

y **= code(***e,v***);**

Input

e NxK matrix of 1's and 0's. Each column of this matrix is created by a logical expression using "dot" conditional and boolean operators. Each of these expressions should return a column vector result. The columns are horizontally concatenated to produce *e*. If more than one of these vectors contains a 1 in any given row, the **code** function will terminate with an error message.

v (K+1)x1 vector containing the values to be assigned to the new variable.

Output

y Nx1 vector containing the new values.

Remarks

If none of the K expressions is true, the new variable is assigned the default value, which is given by the last element of *v*.

Example

```
let x1 = 0 /* column vector of original values */
          5
         10
         15
         20;

let v = 1 /* column vector of new values */
        2
        3; /* the last element of v is the
           :: "default"
           */
```

```
e1 = (0 .lt x1) .and (x1 .le 5); /* expression 1
                                    */
e2 = (5 .lt x1) .and (x1 .le 25); /* expression 2
                                     */
e = e1~e2; /* concatenate e1 & e2 to make a 1,0
           :: mask with one less column than the
           :: number of new values in v.
           */

y = code(e,v);
```

$x1[5, 1] =$

0
5
10
15
20

(column vector of original values)

$v[3, 1] =$ 1 2 3 (Note: *v* is a column vector)

$e[5, 2] =$

0 0
1 0
0 1
0 1
0 1

$y[5, 1] =$

3
1
2
2
2

For every row in *e*, if a 1 is in the first column, the first element of *v* is used. If a 1 is in the second column, the second element of *v* is used, and

code

so on. If there are only zeros in the row, the last element of *v* is used. This is the default value.

If there is more than one 1 in any row of *e*, the function will terminate with an error message.

Source datatran.src

See also **recode, substute**

code (dataloop)

Purpose

Creates new variables with different values based on a set of logical expressions.

Format

```
code [[#]] [[$]] var [[default defval]] with
   val_1 for expression_1,
   val_2 for expression_2,
       .
       .
       .
   val_n for expression_n;
```

Input

var	literal, the new variable name.
defval	scalar, the default value if none of the expressions are *TRUE*.
val	scalar, value to be used if corresponding expression is *TRUE*.
expression	logical scalar-returning expression that returns nonzero *TRUE* or zero *FALSE*.

Remarks

If '**$**' is specified, the new variable will be considered a character variable. If '**#**' or nothing is specified, the new variable will be considered numeric.

The logical expressions must be mutually exclusive; i.e., only one may return *TRUE* for a given row (observation).

Any variables referenced must already exist, either as elements of the source data set, as externs, or as the result of a previous **make**, **vector**, or **code** statement.

If no default value is specified, 999 is used.

code (dataloop)

Example

```
code agecat default 5 with
   1 for age < 21,
   2 for age >= 21 and age < 35,
   3 for age >= 35 and age < 50,
   4 for age >= 50 and age < 65;
code $ sex with
   “MALE” for gender == 1,
   “FEMALE” for gender == 0;
```

See also **recode**

color

Purpose

Set pixel, text, background color, or VGA palette color registers.

Format

y = **color(***cv***)**

Input

cv scalar, 2x1 or 3x1 vector of color values or Nx4 matrix of palette color values. See Portability, below, for platform specifics.

If the input vector is smaller than 3x1 or the corresponding element in the input vector is -1, the corresponding color will be left unchanged.

If the input is an Nx4 matrix, it will initialize the VGA palette (DOS) or active graphic panel's colormap (UNIX) with user-defined RGB colors interpreted as follows:

[N,1] palette register index 0-255

[N,2] red value 0-63

[N,3] green value 0-63

[N,4] blue value 0-63

Output

y vector, or Nx4 matrix the same size as the input which contains the original color values or palette values.

Portability

DOS

[1] pixel color

[2] text color

[3] ignored

UNIX 3.2 only

color affects the active graphic panel. X supports foreground and background colors. The **color** command makes no distinction between text and pixel colors; both affect the foreground color of the active graphic panel. If both a pixel color and text color are specified, the pixel color will be ignored, and the text color will be used to set the foreground color. Thus:

[1] foreground

or

[1] ignored

color

[2] foreground

or

[1] ignored

[2] foreground

[3] background

OS/2, Windows, UNIX 3.5+

This function is not supported under OS/2 or Windows.

Remarks

This changes the window colors for your program's output. The editor and interactive mode will not be affected.

See "Colors Appendix" on page B-1 for a color value table.

Under DOS, the VGA color palette registers may be set only if the display adapter has been already been initialized to VGA graphics mode 19 (320x200, 256 colors) with the **setvmode** command. The registers will retain the new values until the adapter is reset to text mode, which resets the palette to the default VGA colors.

This function is useful for obtaining 64 shades of a single color and/or mixing colors to user-specification.

See also

graph, line, setvmode

cols, colsf

Purpose

cols returns the number of columns in a matrix.

colsf returns the number of columns in a GAUSS data (.dat) file or GAUSS matrix (.fmt) file.

Format

y **= cols(***x***);**
yf **= colsf(***fh***);**

Input

x	any valid expression that returns a matrix.
fh	file handle of an open file.

Output

y	number of columns in *x*.
yf	number of columns in the file that has the handle *fh*.

Remarks

If *x* is an empty matrix, **rows(***x***)** and **cols(***x***)** return 0.

For **colsf**, the file must be open.

Example

```
x = rndn(100,3);
y = cols(x);

y = 3.000000

create fp = myfile with x,10,4;
b = colsf(fp);

b = 10.000000
```

See also

rows, rowsf, show, lshow

comlog

Purpose

Controls logging of interactive mode commands to a disk file.

Format

comlog [[**file=***filename*]] [[**on**|**off**|**reset**]];

Input

filename literal or ^string.

The **file**=*filename* subcommand selects the file to log interactive mode statements to. This can be any legal file name.

If the name of the file is to be taken from a string variable, the name of the string must be preceded by the ^ (caret) operator.

There is no default file name.

on, **off**, **reset** literal, mode command:

on	turns on command logging to the current log file. If the file already exists, subsequent commands will be appended.
off	closes the log file and turns off command logging.
reset	similar to the **on** subcommand, except that it resets the log file by deleting any previous commands.

Remarks

Interactive mode statements are always logged into the file specified in the **log_file** configuration variable, regardless of the state of **comlog**.

The command **comlog file**=*filename* selects the file but does not turn on logging.

The command **comlog off** will turn off logging. The filename will remain the same. A subsequent **comlog on** will cause logging to resume. A subsequent **comlog reset** will cause the existing contents of the log file to be destroyed and a new file created.

The command **comlog** by itself will cause the name and status of the current log file to be printed in the window.

In interactive mode under DOS, **F10** will load the current log file into the editor if logging is **on**. If logging is **off**, the default log file listed in the **log_file** configuration variable will be loaded into the editor.

compile

Purpose

Compiles a source file to a compiled code file. See also "Compiler" in the *User's Guide*.

Format

compile *source fname*;

Input

source literal or ^string, the name of the file to be compiled.

fname literal or ^string, optional, the name of the file to be created. If not given, the file will have the same filename and path as source. It will have a .gcg extension.

Remarks

The *source* file will be searched for in the **src_path** if the full path is not specified and it is not present in the current directory.

The source file is a regular DOS text file containing a GAUSS program. There can be references to global symbols, Run-Time Library references, etc.

If there are **library** statements in *source*, they will be used during the compilation to locate various procedures and symbols used in the program. Since all of these library references are resolved at compile time, the **library** statements are not transferred to the compiled file. The compiled file can be run without activating any libraries.

If you do not want extraneous matter saved in the compiled image, put a **new** at the top of the *source file* or execute a **new** from interactive level before compiling.

The program saved in the compiled file can be run with the **run** command. If no extension is given, the **run** command will look for a file with the correct extension for the version of GAUSS. The **src_path** will be used to locate the file if the full path name is not given and it is not located on the current directory.

When the compiled file is **run**, all previous symbols and procedures are deleted before the program is loaded. It is therefore unnecessary to execute a **new** before **run**'ning a compiled file.

If you want line number records in the compiled file you can put a **#lineson** statement in the *source* file or turn line tracking on from the Options menu.

Do not try to include compiled files with **#include**.

compile

Example

```
compile qxy.e;
```

In this example, the **src_path** would be searched for qxy.e, which would be compiled to a file called qxy.gcg on the same subdirectory qxy.e was found.

```
compile qxy.e xy;
```

In this example, the **src_path** would be searched for qxy.e which would be compiled to a file called xy.gcg on the current subdirectory.

See also

run, use, saveall

complex

Purpose Converts a pair of real matrices to a complex matrix.

Format *z* **= complex(***xr,xi***);**

Input

xr	NxK real matrix, the real elements of *z*.
xi	NxK real matrix or scalar, the imaginary elements of *z*.

Output

z	NxK complex matrix.

Example

```
x = { 4 6 ,
      9 8 };

y = { 3 5 ,
      1 7 };

t = complex(x,y);
```

$$t = \begin{matrix} 4.0000000 + 3.0000000i & 6.0000000 + 5.0000000i \\ 9.0000000 + 1.0000000i & 8.0000000 + 7.0000000i \end{matrix}$$

See also **imag, real**

con

Purpose

Requests input from the keyboard, and returns it in a matrix.

Format

x **= con(***r*,*c***);**

Input

r	scalar, row dimension of matrix.
c	scalar, column dimension of matrix.

Output

x	RxC matrix.

Remarks

Enter **?** to get a help screen at the **con** function prompt. The following commands are available:

u	Up one row	U	First row
d	Down one row	D	Last row
l	Left one column	L	First column
r	Right one column	R	Last column

t	First element
b	Last element
g #, #	Goto element
g #	Goto element of vector

h	Move horizontally, default
v	Move vertically
\	Move diagonally

s	Show size of matrix
n	Display element as numeric, default
c	Display element as character

e	exp(1)
p	pi
.	missing value

?	help

x exit

Use a leading single quote for character input.

See also **`cons, let, load`**

cond

Purpose This procedure will compute the condition number of a matrix using the singular value decomposition.

Format *c* **= cond(***x***);**

Input

x NxK matrix.

Output

c scalar, an estimate of the condition number of *x*. This equals the ratio of the largest singular value to the smallest. If the smallest singular value is zero or not all of the singular values can be computed, the return value is 10^{300}.

Example

```
x = { 4 2 6,
      8 5 7,
      3 8 9 };
y = cond(x);
```

y = 9.8436943

Source svd.src

conj

Purpose Returns the complex conjugate of a matrix.

Format *y* **= conj(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix, the complex conjugate of *x*.

Remarks Compare **conj** with the transpose (′) operator.

Example

```
x =  { 1+9i 2,
       4+4i 5i,
       7i 8-2i };
y = conj(x);
```

$$x = \begin{matrix} 1.0000000 + 9.0000000i & 2.0000000 \\ 4.0000000 + 4.0000000i & 0.0000000 + 5.0000000i \\ 0.0000000 + 7.0000000i & 8.0000000 - 2.0000000i \end{matrix}$$

$$y = \begin{matrix} 1.0000000 - 9.0000000i & 2.0000000 \\ 4.0000000 - 4.0000000i & 0.0000000 - 5.0000000i \\ 0.0000000 - 7.0000000i & 8.0000000 + 2.0000000i \end{matrix}$$

cons

Purpose Retrieves a character string from the keyboard.

Format *x* **= cons;**

Output The characters entered from the keyboard. The output will be of type string.

Remarks If you are working in terminal mode GAUSS will not "see'' any input until you press ENTER. *x* is assigned the value of a character string typed in at the keyboard. The program will pause to accept keyboard input. The maximum length of the string that can be entered is 254 characters. The program will resume execution when the ENTER key is pressed. The standard DOS editing keys will be in effect.

Example

```
x = cons;
```

At the cursor enter:

```
probability
```

x = "probability"

See also **con**

continue

Purpose Jumps to the top of a **do** or **for** loop.

Format **continue;**

Remarks This command works just like in C.

Example

```
x = rndn(4,4);
r = 0;
do while r < rows(x);
   r = r + 1;
   c = 0;
   do while c < cols(x); /* continue jumps here */
      c = c + 1;
      if c == r;
         continue;
      endif;
      x[r,c] = 0;
   endo;
endo;
```

$$x = \begin{matrix} -1.032195 & 0000000 & 0.000000 & 0.000000 \\ 0.000000 & -1.033763 & 0.000000 & 0.000000 \\ 0.000000 & 0.000000 & 0.061205 & 0.000000 \\ 0.000000 & 0.000000 & 0.000000 & -0.225936 \end{matrix}$$

contour

Purpose To graph a matrix of contour data.

Library pgraph

Format **contour(***x,y,z***);**

Input

x	1xK vector, the X axis data. K must be odd.
y	Nx1 vector, the Y axis data. N must be odd.
z	NxK matrix, the matrix of height data to be plotted.

Global Input

_plev	Kx1 vector, user-defined contour levels for **contour**. Default 0.
_pzclr	Nx1 or Nx2 vector. This controls the Z level colors. See **surface** for a complete description of how to set this global.

Remarks A vector of evenly spaced contour levels will be generated automatically from the *z* matrix data. Each contour level will be labeled. For unlabeled contours, use **ztics**.

To specify a vector of your own unequal contour levels, set the vector **_plev** before calling **contour**.

To specify your own evenly spaced contour levels, see **ztics**.

Source pcontour.src

See also **surface**

conv

Purpose Computes the convolution of two vectors.

Format *c* **= conv(***b*,*x*,*f*,*l***);**

Input

b	Nx1 vector.
x	Lx1 vector.
f	scalar, the first convolution to compute.
l	scalar, the last convolution to compute.

Output

c	Qx1 result, where $Q = (l - f + 1)$. If *f* is 0, the first to the *l*'th convolutions are computed. If *l* is 0, the *f*'th to the last convolutions are computed. If *f* and *l* are both zero, all the convolutions are computed.

Remarks If *x* and *b* are vectors of polynomial coefficients, this is the same as multiplying the two polynomials.

Example

```
x = { 1,2,3,4 };
y = { 5,6,7,8 };
z1 = conv(x,y,0,0);
z2 = conv(x,y,2,5);
```

```
       5
      16
      34
z1 =  60
      61
      52
      32
```

conv

$$z2 = \begin{matrix} 16 \\ 34 \\ 60 \\ 61 \end{matrix}$$

See also

`polymult`

coreleft

Purpose

Returns the amount, in bytes, of free workspace memory.

Format

y **= coreleft;**

Output

y scalar, number of bytes free.

Portability

DOS only

All others will return the **coreleft** value specified in the GAUSS configuration (`.cfg`) file.

Remarks

The amount of free memory is dynamic and can change rapidly as expressions and procedures are being executed. **coreleft** returns the amount of workspace memory free at the time it is called. Workspace memory is used for storing matrices, strings, procedures, and for manipulating matrices and strings.

This function can be used to write programs that automatically adjust their use of memory so they do not crash with the "Insufficient memory" error if they are used on machines with less free memory than the one used for development, or if the size of the data used becomes larger. A common use is to adjust the number of rows that are read per iteration of a read loop in programs that access data from a disk.

Example

```
open fp = myfile;
k = colsf(fp);  /* columns in file */
fac = 4;
/* check amount of memory available */
nr = coreleft/(fac*k*8);
```

In this example, **nr**, the number of rows to read, is computed by taking the number of bytes free (**coreleft**) divided by **fac*k*8**. **fac** is a guesstimate of the number of copies of the data read each iteration that the algorithm we are using will require, plus a little. **k*8** is the number of columns times the number of bytes per element.

See also

dfree, new

corrm, corrvc, corrx

Purpose

Computes a correlation matrix.

Format

cx **= corrm(***m***);**
cx **= corrvc(***vc***);**
cx **= corrx(***x***);**

Input

m	KxK moment (*x′x*) matrix. A constant term MUST have been the first variable when the moment matrix was computed.
vc	KxK variance-covariance matrix (of data or parameters).
x	NxK matrix of data.

Output

cx	PxP correlation matrix. For **corrm**, *P* = *K*-1. For **corrvc** and **corrx**, *P* = *K*.

Source

corr.src

See also

momentd

cos

Purpose Returns the cosine of its argument.

Format *y* **= cos(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix.

Remarks For real matrices, *x* should contain angles measured in radians.

To convert degrees to radians, multiply the degrees by $\frac{\pi}{180}$.

Example

```
x = { 0, .5, 1, 1.5 };
y = cos(x);
```

$$y = \begin{matrix} 1.00000000 \\ 0.87758256 \\ 0.54030231 \\ 0.07073720 \end{matrix}$$

See also **atan, atan2, pi**

cosh

Purpose Computes the hyperbolic cosine.

Format *y* **= cosh(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the hyperbolic cosines of the elements of *x*.

Example

```
x = { -0.5, -0.25, 0, 0.25, 0.5, 1 };
x = x * pi;
y = cosh(x);
```

$$x = \begin{matrix} -1.570796 \\ -0.785398 \\ 0.000000 \\ 0.785398 \\ 1.570796 \\ 3.141593 \end{matrix}$$

$$y = \begin{matrix} 2.509178 \\ 1.324609 \\ 1.000000 \\ 1.324609 \\ 2.509178 \\ 11.591953 \end{matrix}$$

Source trig.src

counts

Purpose Count the numbers of elements of a vector that fall into specified ranges.

Format *c* **= counts(***x***,***v***);**

Input

x Nx1 vector containing the numbers to be counted.

v Px1 vector containing breakpoints specifying the ranges within which counts are to be made. The vector *v* MUST be sorted in ascending order.

Output

c Px1 vector, the counts of the elements of *x* that fall into the regions:

$$\begin{aligned} & x \le v[1], \\ v[1] < & x \le v[2], \\ & \vdots \\ v[p\text{-}1] < & x \le v[p]. \end{aligned}$$

Remarks If the maximum value of *x* is greater than the last element (the maximum value) of *v*, the sum of the elements of the result, *c*, will be less than *N*, the total number of elements in *x*.

If

$$x = \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix} \quad \textit{and} \quad v = \begin{matrix} 4 \\ 5 \\ 8 \end{matrix}$$

counts

then

$$c = \begin{matrix} 4 \\ 1 \\ 3 \end{matrix}$$

The first category can be a missing value if you need to count missings directly. Also +∞ or -∞ are allowed as breakpoints. The missing value must be the first breakpoint if it is included as a breakpoint and infinities must be in the proper location depending on their sign. -∞ must be in the [2,1] element of the breakpoint vector if there is a missing value as a category as well, otherwise it has to be in the [1,1] element. If +∞ is included, it must be the last element of the breakpoint vector.

Example

```
x = { 1, 3, 2,
      4, 1, 3 };
v = { 0, 1, 2, 3, 4 };

c = counts(x,v);
```

```
c =  0.0000000
     2.0000000
     1.0000000
     2.0000000
     1.0000000
```

countwts

Purpose

Returns a weighted count of the numbers of elements of a vector that fall into specified ranges.

Format

c **= countwts(***x***,***v***,***w***);**

Input

x	Nx1 vector, the numbers to be counted.
v	Px1 vector, the breakpoints specifying the ranges within which counts are to be made. This MUST be sorted in ascending order (lowest to highest).
w	Nx1 vector, containing weights.

Output

c Px1 vector, the counts of the elements of *x* that fall into the regions:

$$\begin{aligned} & x \le v[1], \\ v[1] < \; & x \le v[2], \\ & \vdots \\ v[p\text{-}1] < \; & x \le v[p]. \end{aligned}$$

That is, when $x[i]$ falls into region j, the weight $w[i]$ is added to the j^{th} counter.

Remarks

If any elements of *x* are greater than the last element of *v*, they will not be counted.

Missing values are not counted unless there is a missing in *v*. A missing value in *v* MUST be the first element in *v*.

countwts

Example

```
x = {   1, 3,    2,  4,   1, 3 };
w = { .25, 1, .333, .1, .25, 1 };
v = { 0, 1, 2, 3, 4 };
c = countwts(x,v,w);
```

```
      0.000000
      0.500000
c =   0.333000
       2.00000
      0.100000
```

create

Purpose

Creates and opens a GAUSS data set for subsequent writing.

Format

create [[*vflag*]] [[**complex**]] *fh* **=** *filename* **with** *vnames*,*col*,*dtyp*,*vtyp*;

create [[*vflag*]] [[**complex**]] *fh* **=** *filename* **using** *comfile*;

Input

vflag version flag.

-v89 supported for read

-v92 for read/write

-v96 for read/write

For details on the various versions, see "File I/O" in the *User's Guide*. The default format can be specified in gauss.cfg by setting the **dat_fmt_version** configuration variable. If **dat_fmt_version** is not set, the default is **v96**.

filename literal or ^string.

filename is the name to be given the file on the disk. The name can include a path if the directory to be used is not the current directory. This file will automatically be given the extension .dat. If an extension is specified, the .dat will be overridden. If the name of the file is to be taken from a string variable, the name of the string must be preceded by the ^ (caret) operator.

create... with...

vnames literal or ^string or ^character matrix.

vnames controls the names to be given to the columns of the data file. If the names are to be taken from a string or character matrix, the ^ (caret) operator must be placed before the name of the string or character matrix. The number of columns parameter, *col*, also has an effect on the way the names will be created. See below and see the examples for details on the ways names are assigned to a data file.

col scalar expression.

col is a scalar expression containing the number of columns in the data file. If *col* is 0, the number of columns will be controlled by the contents of *vnames*. If *col* is positive, the file will contain *col* columns and the names to be given each column will be created as necessary depending on the *vnames* parameter. See the examples.

dtyp scalar expression.

dtyp is the precision used to store the data. This is a scalar expression containing 2, 4, or 8, which is the number of bytes per element.

2	signed integer
4	single precision
8	double precision

Data Type	Digits	Range
integer	4	$-32768 \leq X \leq 32767$
single	6-7	$8.43 \times 10^{-37} \leq \lvert X \rvert \leq 3.37 \times 10^{+38}$
double	15-16	$4.19 \times 10^{-307} \leq \lvert X \rvert \leq 1.67 \times 10^{+308}$

If the integer type is specified, numbers will be rounded to the nearest integer as they are written to the data set. If the data to be written to the file contains character data, the precision must be 8 or the character information will be lost.

vtyp matrix, types of variables.

The types of the variables in the data set. If **rows**(*vtyp*)***cols**(*vtyp*) < *col* only the first element is used. Otherwise nonzero elements indicate a numeric variable and zero elements indicate character variables. *vtyp* is ignored for **v89** files.

create... using...

comfile literal or ^string.

comfile is the name of a command file that contains the information needed to create the file. The default extension for the command file is .gcf, which can be overridden.

There are three possible commands in this file:

numvar *n str*;

outvar *varlist*;

outtyp *dtyp*;

numvar and **outvar** are alternate ways of specifying the number and names of the variables in the data set to be created.

When **numvar** is used, *n* is a constant which specifies the number of variables (columns) in the data file and *str* is a string literal specifying the prefix to be given to all the variables. Thus:

```
numvar 10 xx;
```

says that there are 10 variables and that they are to be named **xx01** through **xx10**. The numeric part of the names will be padded on the left with zeros as necessary so the names will sort correctly:

```
xx1,     ... xx9     1-9 names
xx01,    ... xx10    10-99 names
xx001,   ... xx100   100-999 names
xx0001,  ... xx1000  1000-8100 names
```

If *str* is omitted, the variable prefix will be "X".

When **outvar** is used, *varlist* is a list of variable names, separated by spaces or commas. For instance:

```
outvar x1, x2, zed;
```

specifies that there are to be 3 variables per row of the data set, and that they are to be named **x1**, **x2**, **zed**, in that order.

outtyp specifies the precision. It can be a constant: 2, 4, or 8, or it can be a literal: I, F, or D. For an explanation of the available data types, see *dtyp* in **create... with...**, previously.

The **outtyp** statement does not have to be included. If it is not, then all data will be stored in 4 bytes as single precision floating point numbers.

create

Output

fh scalar.

fh is the file handle which will be used by most commands to refer to the file within GAUSS. This file handle is actually a scalar containing an integer value that uniquely identifies each file. This value is assigned by GAUSS when the **create** (or **open**) command is executed.

Remarks

If the **complex** flag is included, the new data set will be initialized to store complex number data. Complex data is stored a row at a time, with the real and imaginary halves interleaved, element by element.

Example

```
let vnames = age sex educat wage occ;
create f1 = simdat with ^vnames,0,8;
obs = 0;
nr = 1000;
do while obs < 10000;
   data = rndn(nr,colsf(f1));
   if writer(f1,data) /= nr;
      print "Disk Full";
      end;
   endif;
   obs = obs+nr;
endo;
closeall f1;
```

uses **create... with...** to create a double precision data file called **simdat.dat** on the default drive with 5 columns. The **writer** command is used to write 10000 rows of Normal random numbers into the file. The variables (columns) will be named: **AGE**, **SEX**, **EDUCAT**, **WAGE**, **OCC**.

Following are examples of the variable names that will result when using a character vector of names in the argument to the **create** function.

```
vnames = { AGE PAY SEX JOB };
typ = { 1, 1, 0, 0 };
create fp = mydata with ^vnames,0,2,typ;
```

The names in this example will be: **AGE PAY SEX JOB**

AGE and PAY are numeric variables, SEX and JOB are character variables.

```
create fp = mydata with ^vnames,3,2;
```

The names will be: **AGE PAY SEX**

```
create fp = mydata with ^vnames,8,2;
```

The names will now be: **AGE PAY SEX JOB1 JOB2 JOB3 JOB4 JOB5**

If a literal is used for the *vnames* parameter, the number of columns should be explicitly given in the *col* parameter and the names will be created as follows:

```
create fp = mydata with var,4,2;
```

giving the names: **var1 var2 var3 var4**

The next example assumes a command file called comd.gcf containing the following lines created using a text editor:

```
outvar age, pay, sex;
outtyp i;
```

Then the following could be used to write 100 rows of random integers into a file called smpl.dat in the subdirectory called /gauss/data:

```
filename = "/gauss/data/smpl";
create fh = ^filename using comd;
x = rndn(100,3)*10;
if writer(fh,x) /= rows(x);
   print Disk Full;
   end;
endif;
closeall fh;
```

create

For platforms using the backslash as a path separator, remember that two backslashes (\\) are required to enter one backslash inside double quotes. This is because a backslash is the escape character used to embed special characters in strings.

See also **open, readr, writer, eof, close, output, iscplxf**

crossprd

Purpose Computes the cross-products (vector products) of sets of 3x1 vectors.

Format *z* **= crossprd(***x***,***y***);**

Input

x	3xK matrix, each column is treated as a 3x1 vector.
y	3xK matrix, each column is treated as a 3x1 vector.

Output

z	3xK matrix, each column is the cross-product (sometimes called vector product) of the corresponding columns of *x* and *y*.

Remarks The cross-product vector *z* is orthogonal to both *x* and *y*. **sumc(***x***.****z***)** and **sumc(***y***.****z***)** will be Kx1 vectors all of whose elements are 0 (except for rounding error).

Example

```
x = { 10  4,
      11 13,
      14 13 };
y = {  3 11,
       5 12,
       7  9 };
z = crossprd(x,y);
```

```
      7.0000000 –39.000000
z =  –28.000000  107.00000
      17.000000 –95.000000
```

Source crossprd.src

crout

Purpose

Computes the Crout decomposition of a square matrix without row pivoting, such that: $X = LU$.

Format

y **= crout(***x***);**

Input

x NxN square nonsingular matrix.

Output

y NxN matrix containing the lower (*L*) and upper (*U*) matrices of the Crout decomposition of *x*. The main diagonal of *y* is the main diagonal of the lower matrix *L*. The upper matrix has an implicit main diagonal of ones. Use **lowmat** and **upmat1** to extract the *L* and *U* matrices from *y*.

Remarks

Since it does not do row pivoting, it is intended primarily for teaching purposes. (See **croutp** for a decomposition with pivoting.)

Example

```
X = { 1  2 -1,
      2  3 -2,
      1 -2  1 };

y = crout(x);
L = lowmat(y);
U = upmat1(y);
```

$$y = \begin{matrix} 1 & 2 & -1 \\ 2 & -1 & 0 \\ 1 & -4 & 2 \end{matrix}$$

$$L = \begin{matrix} 1 & 0 & 0 \\ 2 & -1 & 0 \\ 1 & -4 & 2 \end{matrix}$$

$$U = \begin{matrix} 1 & 2 & -1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

See also **croutp, chol, lowmat, lowmat1, lu, upmat, upmat1**

croutp

Purpose

Computes the Crout decomposition of a square matrix with partial (row) pivoting.

Format

y **= croutp(***x***);**

Input

x NxN square nonsingular matrix.

Output

y (N+1)xN matrix containing the lower (*L*) and upper (*U*) matrices of the Crout decomposition of a permuted *x*. The N+1 row of the matrix *y* gives the row order of the *y* matrix. The matrix must be reordered prior to extracting the L and U matrices. Use **lowmat** and **upmat1** to extract the *L* and *U* matrices from the reordered *y* matrix.

Example

This example illustrates a procedure for extracting *L* and *U* of the permuted *x* matrix. It continues by sorting the result of *LU* to compare with the original matrix *x*.

```
X = { 1  2 -1,
      2  3 -2,
      1 -2  1 };
y = croutp(x);
r = rows(y);    /* the number of rows of y */
indx = y[r,.]'; /* get the index vector */
z = y[indx,.];  /* z is indexed RxR matrix y */
L = lowmat(z); /* obtain L and U of permuted */
               /* matrix X */
U = upmat1(z);
q = sortc(indx~(L*U),1); /* sort L*U against */
                         /* index */
x2 = q[.,2:cols(q)]; /* remove index column */
```

$$X = \begin{matrix} 1 & 2 & -1 \\ 2 & 3 & -2 \\ 1 & -2 & 1 \end{matrix}$$

$$y = \begin{matrix} 1 & 0.5 & 0.2857 \\ 2 & 1.5 & -1 \\ 1 & -3.5 & -0.5714 \\ 2 & 3 & 1 \end{matrix}$$

$$r = 4$$

$$indx = \begin{matrix} 2 \\ 3 \\ 1 \end{matrix}$$

$$z = \begin{matrix} 2 & 1.5 & -1 \\ 1 & -3.5 & -0.5714 \\ 1 & 0.5 & 0.2857 \end{matrix}$$

$$L = \begin{matrix} 2 & 0 & 0 \\ 1 & -3.5 & 0 \\ 1 & 0.5 & 0.2857 \end{matrix}$$

$$U = \begin{matrix} 1 & 1.5 & -1 \\ 0 & 1 & -0.5714 \\ 0 & 0 & 1 \end{matrix}$$

$$q = \begin{matrix} 1 & 1 & 2 & -1 \\ 2 & 2 & 3 & -2 \\ 3 & 1 & -2 & 1 \end{matrix}$$

croutp

$$x2 = \begin{matrix} 1 & 2 & -1 \\ 2 & 3 & -2 \\ 1 & -2 & 1 \end{matrix}$$

See also **crout, chol, lowmat, lowmat1, lu, upmat, upmat1**

csrcol, csrlin

Purpose

Returns the position of the cursor.

Format

```
y = csrcol;
y = csrlin;
```

Portability

UNIX 3.2 only

csrcol returns the cursor column for the active graphic panel. For Text graphic panels, this value is the cursor column with respect to the text buffer. For TTY graphic panels, this value is the cursor column with respect to the current output line, i.e., it will be the same whether the text is wrapped or not. For PQG graphic panels, this value is meaningless.

csrlin returns the cursor line for the active graphic panel. For Text graphic panels, this value is the cursor row with respect to the text buffer. For TTY graphic panels, this value is the current output line number (i.e., the number of lines logged + 1). For PQG graphic panels, this value is meaningless.

UNIX 3.5+

csrcol and **csrlin** always return 1.

OS/2, Windows

csrcol returns the cursor column with respect to the current output line, i.e., it will return the same value whether the text is wrapped or not. **csrlin** returns the cursor line with respect to the top line in the graphic panel.

DOS

Under DOS, columns are usually numbered 1-80, rows are usually numbered 1-25. **setvmode** will return the current window dimensions.

Remarks

y will contain the current column or row position of the cursor in the graphic panel. The upper left corner is (1,1).

csrcol returns the column position of the cursor. **csrlin** returns the row position.

The **locate** statement allows the cursor to be positioned at a specific row and column.

Example

```
r = csrlin;
```

csrcol, csrlin

```
c = csrcol;
cls;
locate r,c;
```

In this example the window is cleared without affecting the cursor position.

See also

cls, locate, lpos

csrtype

Purpose To set the cursor shape.

Format *old* **= csrtype(***mode***);**

Portability **UNIX**

This function is not supported in terminal mode.

OS/2, Windows

This function is not supported under OS/2 or Windows.

Input

mode scalar, cursor type to set.

DOS

0	cursor off
1	normal cursor
2	large cursor

UNIX 3.2

0	cursor off
1	normal cursor
2	large cursor
3	triangular cursor

Output *old* scalar, original cursor type.

Remarks Under DOS, this function will set the same cursor shape that GAUSS is already using for its three modes.

Example

```
x = csrtype(2);
```

See also **csrcol, csrlin**

cumprodc

Purpose Computes the cumulative products of the columns of a matrix.

Format *y* **= cumprodc(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the cumulative products of the columns of *x*.

Remarks This is based on the recursive series **recsercp**. **recsercp** could be called directly as follows:

```
recserp(x,zeros(1,cols(x)))
```

to accomplish the same thing.

Example

```
x = { 1 -3,
      2  2,
      3 -1 };
y = cumprodc(x);
```

$$y = \begin{matrix} 1.00 & -3.00 \\ 2.00 & -6.00 \\ 6.00 & 6.00 \end{matrix}$$

Source cumprodc.src

See also **cumsumc, recsercp, recserar**

cumsumc

Purpose Computes the cumulative sums of the columns of a matrix.

Format *y* **= cumsumc(***x***);**

Input

x NxK matrix.

Output

y NxK matrix containing the cumulative sums of the columns of *x*.

Remarks This is based on the recursive series function **recserar**. **recserar** could be called directly as follows:

```
recserar(x,x[1,.], ones(1,cols(x)))
```

to accomplish the same thing.

Example

```
x = { 1 -3,
      2  2,
      3 -1 };
y = cumsumc(x);
```

$$y = \begin{matrix} 1 & -3 \\ 3 & -1 \\ 6 & -2 \end{matrix}$$

Source cumsumc.src

See also **cumprodc, recsercp, recserar**

curve

Purpose

Computes a one-dimensional smoothing curve.

Format

{ *u*,*v* **} = curve(***x*,*y*,*d*,*s*,*sigma*,*G***);**

Input

x	Kx1 vector, x-abscissae (x-axis values).
y	Kx1 vector, y-ordinates (y-axis values).
d	Kx1 vector or scalar, observation weights.
s	scalar, smoothing parameter. If *s* = 0, **curve** performs an interpolation. If *d* contains standard deviation estimates, a reasonable value for *s* is K.
sigma	scalar, tension factor.
G	scalar, grid size factor.

Output

u	K*Gx1 vector, x-abscissae, regularly spaced.
v	K*Gx1 vector, y-ordinates, regularly spaced.

Remarks

sigma contains the tension factor. This value indicates the curviness desired. If *sigma* is nearly zero (e.g., .001), the resulting curve is approximately the tensor product of cubic curves. If *sigma* is large, (e.g., 50.0) the resulting curve is approximately bi-linear. If *sigma* equals zero, tensor products of cubic curves result. A standard value for *sigma* is approximately 1.

G is the grid size factor. It determines the fineness of the output grid. For *G* = 1, the input and output vectors will be the same size. For *G* = 2, the output grid is twice as fine as the input grid, i.e., *u* and *v* will have twice as many rows as *x* and *y*.

Source

spline.src

cvtos

Purpose Converts a character vector to a string.

Format *s* **= cvtos(***v***);**

Input

v	Nx1 character vector, to be converted to a string.

Output

s	string, contains the contents of *v*.

Remarks **cvtos** in effect appends the elements of *v* together into a single string.

cvtos was written to operate in conjunction with **stocv**. If you pass it a character vector that does not conform to the output of **stocv**, you may get unexpected results. For example, **cvtos** DOES NOT look for 0 terminating bytes in the elements of *v*; it assumes every element except the last is 8 characters long. If this is not true, there will be 0's in the middle of *s*.

If the last element of *v* does not have a terminating 0 byte, **cvtos** supplies one for *s*.

Example

```
let v = { “Now is t” “he time ” “for all ” “good
      men” };

s = cvtos(v);
```

s = “Now is the time for all good men”

See also **stocv, vget, vlist, vput, vread**

datalist

Purpose

List selected variables from a data set.

Format

datalist *dataset* [[*var1* [[*var2*...]]]] **;**

Input

dataset	literal, name of the dataset.
var#	literal, the names of the variables to list.

Global Input

_range global scalar, the range of rows to list. The default is all rows.

_miss global scalar, controls handling of missing values.

- **0** display rows with missing values.
- **1** do not display rows with missing values.

The default is 0.

_prec global scalar, the number of digits to the right of the decimal point to display. The default is 3.

Remarks

The variables are listed in an interactive mode. As many rows and columns as will fit in the window are displayed. You can use the cursor keys to pan and scroll around in the listing.

Example

```
datalist freq age sex pay;
```

This command will display the variables **age**, **sex**, and **pay** from the data set `freq.dat`.

Source

datalist.src

dataloop (dataloop)

Purpose Specifies the beginning of a data loop.

Format **dataloop** *infile outfile*;

Input *infile* string variable or literal, the name of the source data set.

Output *outfile* string variable or literal, the name of the output data set.

Remarks The statements between the **dataloop... endata** commands are assumed to be metacode to be translated at compile time. The data from *infile* is manipulated by the specified statements, and stored to the data set *outfile*. Case is not significant within the **dataloop... endata** section, except for within quoted strings. Comments can be used as in any GAUSS code.

Example

```
src = "source";

   dataloop ^src dest;

   make newvar = x1 + x2 + log(x3);

   x6 = sqrt(x4);

   keep x6, x5, newvar;

endata;
```

Here, **src** is a string variable requiring the caret operator (**^**) , while **dest** is a string literal.

date

Purpose Returns the current date in a 4-element column vector, in the order: year, month, day, and hundredths of a second since midnight.

Format *y* **= date;**

Remarks The hundredths of a second since midnight can be accessed using **hsec**.

Example

```
print date;
```

```
   1998.0000
   6.0000000
   15.000000
   4011252.7
```

See also **time, timestr, ethsec, hsec, etstr**

datestr

Purpose Returns a date in a string.

Format *str* **= datestr(***d***);**

Input

d 4x1 vector, like the **date** function returns. If this is 0, the **date** function will be called for the current system date.

Output

str 8 character string containing current date in the form: **mo/dy/yr**

Example

```
d = { 1998, 6, 15, 0 };
y = datestr(d);
print y;


   6/15/98
```

Source time.src

See also **date, datestring, datestrymd, time, timestr, ethsec**

datestring

Purpose Returns a date in a year-2000-compliant string.

Format *str* **= datestring(***d***);**

Input

d 4x1 vector, like the **date** function returns. If this is 0, the **date** function will be called for the current system date.

Output

str 10 character string containing current date in the form: **mm/dd/yyyy**

Example

```
y = datestring(0);
print y;

   6/15/1998
```

Source time.src

See also **date, datestr, datestrymd, time, timestr, ethsec**

datestrymd

Purpose Returns a date in a string.

Format *str* **= datestrymd(***d***);**

Input

d	4x1 vector, like the **date** function returns. If this is 0, the **date** function will be called for the current system date.

Output

str	8 character string containing current date in the form: **yyyymmdd**

Example

```
d = { 1998, 6, 15, 0 };
y = datestrymd(d);
print y;


   19980615
```

Source time.src

See also **date, datestr, datestring, time, timestr, ethsec**

dayinyr

Purpose Returns day number in the year of a given date.

Format *daynum* **= dayinyr(***dt***);**

Input

dt 3x1 or 4x1 vector, date to check. The date should be in the form returned by **date**.

Output *daynum* scalar, the day number of that date in that year, 1-366.

Example

```
x = { 1998, 6, 15, 0 };
y = dayinyr(x);
print y;


   166.00000
```

Source time.src

Globals **_isleap**

dayofweek

Purpose Returns day of week.

Format *d* **= dayofweek(***a***);**

Input

a Nx1 vector, dates in DT format.

Output

d Nx1 vector, integers indicating day of week of each date:

[1] Sunday
[2] Monday
[3] Tuesday
[4] Wednesday
[5] Thursday
[6] Friday
[7] Saturday

Remarks The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

20010421183207

represents 18:32:07 or 6:32:07 PM on April 21, 2001.

Source time.src

debug

Purpose Runs a program under the source level debugger.

Format **debug** *filename*;

Input *filename* Literal or name of file to debug.

Remarks See "Debugging" in the *User's Guide*.

declare

Purpose

To initialize matrices and strings at compile time.

Format

declare [[*type*]] *symbol* [[*aop* *clist*]]**;**

Input

type optional literal, specifying the type of the symbol.

matrix

string

if *type* is not specified, **matrix** is assumed.

symbol the name of the symbol being declared.

aop the type of assignment to be made.

=	if not initialized, initialize. if already initialized, reinitialize.
!=	if not initialized, initialize. if already initialized, reinitialize.
:=	if not initialized, initialize. if already initialized, redefinition error.
?=	if not initialized, initialize. if already initialized, leave as is.

If *aop* is specified, *clist* must be also.

clist a list of constants to assign to *symbol*.

If *aop clist* is not specified, *symbol* is initialized as a scalar 0 or a null string.

Remarks

The **declare** syntax is similar to the **let** statement.

declare generates no executable code. This is strictly for compile time initialization. The data on the right-hand side of the equal sign must be constants. No expressions or variables are allowed.

declare statements are intended for initialization of global matrices and strings that are used by procedures in a library system.

It is best to place **declare** statements in a separate file from procedure definitions. This will prevent redefinition errors when rerunning the same program without clearing your workspace.

Complex numbers can be entered by joining the real and imaginary parts with a sign (+ or -); there should be no spaces between the numbers and

the sign. Numbers with no real part can be entered by appending an 'i' to the number.

There should be only one declaration for any symbol in a program. Multiple declarations of the same symbol should be considered a programming error. When GAUSS is looking through the library to reconcile a reference to a matrix or a string, it will quit looking as soon as a symbol with the correct name is found. If another symbol with the same name existed in another file, it would never be found. Only the first one in the search path would be available to programs.

Here are some of the possible uses of the three forms of declaration:

!=, = Interactive programming or any situation where a global by the same name will probably be listed in the symbol table when the file containing the **declare** statement is compiled. The symbol will be reset.

This allows mixing **declare** statements with the procedure definitions that reference the global matrices and strings, or placing them in your main file.

:= Redefinition is treated as an error. This will not allow you to assign one symbol with another value already in your program. Rename one of them.

Place **declare** statements in a separate file from the rest of your program and procedure definitions.

?= Interactive programming where some global defaults were set when you started and you do not want them reset for each successive run even if the file containing the **declare**'s gets recompiled. Be careful when using.

CTRL+W controls the **declare** statement warning level. If **declare** warnings are on, you will be warned whenever a **declare** statement encounters a symbol that is already initialized. This happens when you declare a symbol that is already initialized when **declare** warnings are turned on:

declare != Reinitialize and warn.

declare := Crash with fatal error.

declare ?= Leave as is and warn.

If **declare** warnings are off, no warnings are given for the **!=** and **?=** cases.

Example

```
declare matrix x,y,z;
```

```
   x = 0
   y = 0
   z = 0
```

```
declare string x = “This string.”;
   x = “This string.”
```

```
declare matrix x;
```

$$x = 0$$

```
declare matrix x != { 1 2 3, 4 5 6, 7 8 9 };
```

$$x = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{matrix}$$

```
declare matrix x[3,3] = 1 2 3 4 5 6 7 8 9;
```

$$x = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{matrix}$$

```
declare matrix x[3,3] = 1;
```

$$x = \begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$$

```
declare matrix x[3,3];
```

$$x = \begin{matrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{matrix}$$

declare

```
declare matrix x = 1 2 3 4 5 6 7 8 9;
```

$$x = \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

```
declare matrix x = dog cat;
```

$$x = \begin{matrix} \text{DOG} \\ \text{CAT} \end{matrix}$$

```
declare matrix x = “dog” “cat”;
```

$$x = \begin{matrix} \text{dog} \\ \text{cat} \end{matrix}$$

See also **let, external**

delete

Purpose

Deletes global symbols from the symbol table.

Format

delete [[**-***flags*]] [[*symbol1*]] [[*symbol2*]] [[*symbol3*]]**;**

Input

flags	specify the type(s) of symbols to be deleted	
	p	procedures
	k	keywords
	f	**fn** functions
	m	matrices
	s	strings
	g	only symbols with global references
	l	only symbols with all local references
	n	no pause for confirmation
symbol	literal, name of symbol to be deleted. If symbol ends in an asterisk, all symbols matching the leading characters will be deleted.	

Remarks

This completely and irrevocably deletes symbols from GAUSS's memory and workspace.

Flags must be preceded by a slash (e.g., **-pfk**). If the **n** (no pause) flag is used, you will not be asked for confirmation for each symbol.

This command is supported only from interactive level. Since the interpreter executes a compiled pseudo-code, this command would invalidate a previously compiled code image and therefore would destroy any program it was a part of. If any symbols are deleted, all procedures, keywords, and functions with global references will be deleted as well.

Example

```
print x;

   96.000000
   6.0000000
   14.000000
   3502965.9
```

delete

```
delete -m x;
```

At the Delete? [Yes No Previous Quit] prompt, enter y.

```
show x;
```

x no longer exists.

delete (dataloop)

Purpose Removes specific rows in a data loop based on a logical expression.

Format **delete** *logical expression*;

Remarks Deletes only those rows for which *logical expression* is *TRUE*. Any variables referenced must already exist, either as elements of the source data set, as externs, or as the result of a previous **make**, **vector**, or **code** statement.

GAUSS expects *logical expression* to return a row vector of 1's and 0's. The relational and other operators (e.g., **<**) are already interpreted in terms of their dot equivalents (**.<**), but it is up to the user to make sure that function calls within *logical expression* result in a vector.

Example

```
delete age < 40 or sex == 'FEMALE';
```

See also **select**

delif

Purpose

Deletes rows from a matrix. The rows deleted are those for which there is a 1 in the corresponding row of *e*.

Format

y **= delif(***x*,*e***);**

Input

x	NxK data matrix.
e	Nx1 logical vector (vector of 0's and 1's).

Output

y	MxK data matrix consisting of the rows of *y* for which there is a 0 in the corresponding row of *e*. If no rows remain, **delif** will return a scalar missing.

Remarks

The input *e* will usually be generated by a logical expression using dot operators. For instance:

```
y = delif(x, x[.,2] .> 100);
```

will delete all rows of *x* whose second element is greater than 100. The remaining rows of *x* will be assigned to *y*.

Example

```
x =      { 0 10 20,
           30 40 50,
           60 70 80};
 /* logical vector */


e = (x[.,1] .gt 0) .and (x[.,3] .lt 100);
y = delif(x,e);
```

Here is the resulting matrix *y*:

```
0 10 20
```

All rows for which the elements in column 1 are greater than 0 and the elements in column 3 are less than 100 are deleted.

Source

datatran.src

See also `selif`

denseSubmat

Purpose Returns dense submatrix of sparse matrix.

Format *e* **= denseSubmat(***x*,*r*,*c*);

Input

x	MxN	sparse matrix.
r	Kx1	vector, row indices.
c	Lx1	vector, column indices.

Output

e	KxL	dense matrix.

Remarks If *r* or *c* are scalar zeros, all rows or columns will be returned.

Source sparse.src

See also **sparseFd, sparseFp**

design

Purpose Creates a design matrix of 0's and 1's from a column vector of numbers specifying the columns in which the 1's should be placed.

Format *y* **= design(***x***);**

Input

x Nx1 vector.

Output

y NxK matrix, where K = **maxc(***x***)**; each row of *y* will contain a single 1, and the rest 0's. The one in the i^{th} row will be in the **round(***x***[i,1])** column.

Remarks Note that *x* does not have to contain integers: it will be rounded to nearest if necessary.

Example

```
x = { 1, 1.2, 2, 3, 4.4 };
y = design(x);
```

$$y = \begin{matrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

Source design.src

See also **cumprodc, cumsumc, recserrc**

det

Purpose Returns the determinant of a square matrix.

Format *y* **= det(***x***);**

Input

x	NxN square matrix.

Output

y	determinant of *x*.

Remarks *x* may be any valid expression that returns a square matrix (number of rows equals number of columns).

det computes a LU decomposition.

detl can be much faster in many applications.

Example

```
x =       { 3 2  1,
              0 1 -2,
              1 3  4};
y = det(x);
```

$$x = \begin{matrix} 3 & 2 & 1 \\ 0 & 1 & -2 \\ 1 & 3 & 4 \end{matrix}$$

$y = 25$

See also **detl**

detl

Purpose

Returns the determinant of the last matrix that was passed to one of the intrinsic matrix decomposition routines.

Format

y **= detl;**

Remarks

Whenever one of the following functions is executed, the determinant of the matrix is also computed and stored in a system variable. This function will return the value of that determinant and, because the value has been computed in a previous instruction, this will require no computation.

The following functions will set the system variable used by **detl**:

chol(*x***)**	
crout(*x***)**	
croutp(*x***)**	
det(*x***)**	
inv(*x***)**	
invpd(*x***)**	
solpd(*y***,***x***)**	determinant of *x*
y/x	determinant of *x* when neither argument is a scalar or determinant of *x′x* if *x* is not square

Example

If both the inverse and the determinant of the matrix are needed, the following two commands will return both with the minimum amount of computation:

```
xi = inv(x);
xd = detl;
```

The function **det(***x***)** returns the determinant of a matrix using the Crout decomposition. If you only want the determinant of a positive definite matrix, the following code will be the fastest for matrices larger than 10x10:

```
call chol(x);
xd = detl;
```

detl

The Cholesky decomposition is computed and the result from that is discarded. The determinant saved during that instruction is retrieved using **detl**. This can execute up to 2.5 times faster than **det(***x***)** for large positive definite matrices.

See also

det

dfft

Purpose Computes a discrete Fourier transform.

Format *y* **= dfft(***x***);**

Input *x* Nx1 vector.

Output *y* Nx1 vector.

Remarks The transform is divided by *N*.

This uses a second-order Goertzel algorithm. It is considerably slower than **fft**, but it may have some advantages in some circumstances. For one thing, *N* does not have to be an even power of 2.

Source dfft.src

See also **dffti, fft, ffti**

dffti

Purpose Computes inverse discrete Fourier transform.

Format *y* **= dffti(***x***);**

Input

x	Nx1 vector.

Output

y	Nx1 vector.

Remarks The transform is divided by *N*.

This uses a second-order Goertzel algorithm. It is considerably slower than **ffti**, but it may have some advantages in some circumstances. For one thing, *N* does not have to be an even power of 2.

Source dffti.src

See also **fft, dffti, ffti**

dfree (DOS only)

Purpose Returns the amount of room left on a diskette or hard disk.

Format *y* **= dfree(***drive***);**

Input *drive* scalar, valid disk drive number.

Output *y* number of bytes free.

Portability All others return -1

Remarks Valid disk drive numbers are 0 = default, 1 = A, 2 = B, etc. If an error is encountered, **dfree** will return -1.

See also **coreleft**

diag

Purpose Creates a column vector from the diagonal of a matrix.

Format *y* **= diag(***x***);**

Input

x	NxK matrix.

Output

y	min(N,K)x1 vector.

Remarks The matrix need not be square.

diagrv reverses the procedure and puts a vector into the diagonal of a matrix.

Example

```
x = rndu(3,3);
y = diag(x);
```

$$x = \begin{matrix} 0.660818 & 0.367424 & 0.302208 \\ 0.204800 & 0.077357 & 0.145755 \\ 0.712284 & 0.353760 & 0.642567 \end{matrix}$$

$$y = \begin{matrix} 0.660818 \\ 0.077357 \\ 0.642567 \end{matrix}$$

See also **diagrv**

diagrv

Purpose Inserts a vector into the diagonal of a matrix.

Format *y* **= diagrv(***x*,*v***);**

Input

x	NxK matrix.
v	min(N,K) vector.

Output

y	NxK matrix equal to x with its principal diagonal elements equal to those of *v*.

Remarks **diag** reverses the procedure and pulls the diagonal out of a matrix.

Example

```
x = rndu(3,3);
v = ones(3,1);
y = diagrv(x,v);
```

$$x = \begin{matrix} 0.660818 & 0.367424 & 0.302208 \\ 0.204800 & 0.077357 & 0.145755 \\ 0.712284 & 0.353760 & 0.642567 \end{matrix}$$

$$v = \begin{matrix} 1.000000 \\ 1.000000 \\ 1.000000 \end{matrix}$$

$$y = \begin{matrix} 1.000000 & 0.367424 & 0.302208 \\ 0.204800 & 1.000000 & 0.145755 \\ 0.712284 & 0.353760 & 1.000000 \end{matrix}$$

See also **diag**

dlibrary

Purpose

Dynamically links and unlinks shared libraries.

Format

dlibrary *lib1* **[***lib2***...]**;

dlibrary -a *lib1* **[***lib2***...]**;

dlibrary -d

dlibrary

Input

lib1 lib2... literal, the base name of the library or the pathed name of the library.

dlibrary takes two types of arguments, "base" names and file names. Arguments without any "\" path separators are assumed to be library base names, and are expanded by adding the suffix `.dll`. They are searched for in the default dynamic library directory. Arguments that include "\" path separators are assumed to be file names, and are not expanded. Relatively pathed file names are assumed to be specified relative to the current working directory, not relative to the dynamic library directory.

-a append flag, the DLL's listed are added to the current set of DLL's rather than replacing them. For search purposes, the new DLL's follow the already active ones. Without the **-a** flag, any previously linked libraries are dumped.

-d dump flag, ALL DLL's are unlinked and the functions they contain are no longer available to your programs. If you use **dllcall** to call one of your functions after executing a **dlibrary -d**, your program will terminate with an error.

Remarks

If no flags are used, the DLL's listed are linked into GAUSS and any previously linked libraries are dumped. When you call **dllcall**, the DLL's will be searched in the order listed for the specified function. The first instance of the function found will be called.

dlibrary with no arguments prints out a list of the currently linked DLL's. The order in which they are listed is the order in which they are searched for functions.

dlibrary recognizes a default directory in which to look for dynamic libraries. You can specify this by setting the variable **dlib_path** in `gauss.cfg`. Set it to point to a single directory, not a sequence of

directories. A new case (case 24) has also been added to **sysstate** for getting and setting this default.

GAUSS maintains its own DLL, `gauss.dll`. `gauss.dll` is listed when you execute **dlibrary** with no arguments, and searched when you call **dllcall**. By default, `gauss.dll` is searched last, after all other DLL's but you can force it to be searched earlier by listing it explicitly in a **dlibrary** statement. `gauss.dll` is always active. It is not unlinked when you execute **dlibrary -d**. `gauss.dll` is located in the `gauss.exe` directory.

See also

dllcall, sysstate-case 24

dllcall

Purpose

Calls functions located in dynamic libraries.

Format

dllcall [-r] [-v] *func***[(***arg1***[,***arg2***...])];**

dllcall works in conjunction with **dlibrary**. **dlibrary** is used to link dynamic-link libraries (DLL's) into GAUSS; **dllcall** is used to access the functions contained in those DLL's. **dllcall** searches the DLL's (see **dlibrary** for an explanation of the search order) for a function named *func*, and calls the first instance it finds. The default DLL, `gauss.dll`, is searched last.

Input

func	the name of a function contained in a DLL (linked into GAUSS with **dlibrary**). If *func* is not specified or cannot be located in a DLL, **dllcall** will fail.
arg#	arguments to be passed to *func*; optional. These must be elementary variable; they cannot be expressions.
-r	optional flag. If **-r** is specified, **dllcall** examines the value returned by *func*, and fails if it is nonzero.
-v	optional flag. Normally, **dllcall** passes parameters to *func* in a list. If **-v** is specified, **dllcall** passes them in a vector. See below for more details.

Remarks

func should be written to:

1. Take 0 or more pointers to doubles as arguments.
2. Take arugments either in a list of a vector.
3. Return an integer.

In C syntax, func should take one of the following forms:

1. **int** *func* **(void);**
2. **int** *func* **(double ***_arg1_**[,double ***_arg2_**...]);**
3. **int** *func* **(double ***_argv_**[]);**

dllcall can pass a list of up to 100 arguments to *func*; if it requires more arguments than that, you MUST write it to take a vector of arguments, and you MUST specify the **-v** flag when calling it. **dllcall** can pass up to 1000 arguments in vector format. In addition, in vector format **dllcall** appends a null pointer to the vector, so you can write

func to take a variable number of arguments and just test for the null pointer.

Arguments are passed to *func* by reference. This means you can send back more than just the return value, which is usually jsut a success/failure code. (It also means that you need to be careful not to overwrite the contents of matrices or strings you want to preserve.) To return data from *func*, simply set up one or more of its arguments as return matrices (basically, by making them the size of what you intend to return), and inside *func* assign the results to them before returning.

See also

dlibrary, sysstate-case 24

do while, do until

Purpose

Executes a series of statements in a loop as long as a given expression is true (or false).

Format

do while *expression*;
or
do until *expression*;

.
.
.

statements in loop

.
.
.

endo;

Remarks

expression is any expression that returns a scalar. It is TRUE if it is nonzero and FALSE if it is zero.

In a **do while** loop, execution of the loop will continue as long as the expression is TRUE.

In a **do until** loop, execution of the loop will continue as long as the expression is FALSE.

The condition is checked at the top of the loop. If execution can continue, the statements of the loop are executed until the **endo** is encountered. Then GAUSS returns to the top of the loop and checks the condition again.

The **do** loop does not automatically increment a counter. See the first example, following.

do loops may be nested.

It is often possible to avoid using loops in GAUSS by using the appropriate matrix operator or function. It is almost always preferable to avoid loops when possible, since the corresponding matrix operations can be much faster.

Example

```
format /rdn 1,0;
space = "     ";
comma = ",";
i = 1;
do while i <= 4;
   j = 1;
   do while j <= 3;
      print space i comma j;;
      j = j+1;
   endo;
   i = i+1;
   print;
endo;
```

```
1, 1   1, 2   1, 3
2, 1   2, 2   2, 3
3, 1   3, 2   3, 3
4, 1   4, 2   4, 3
```

In the example above, two nested loops are executed and the loop counter values are printed out. Note that the inner loop counter must be reset inside the outer loop before entering the inner loop. An empty **print** statement is used to print a carriage return/line feed sequence after the inner loop finishes.

do while, do until

The following are examples of simple loops that execute a predetermined number of times. These loops will both have the result shown.

First loop

```
format /rd 1,0;
i = 1;
do while i <= 10;
print i;;
i = i+1;
endo;
```

produces

1 2 3 4 5 6 7 8 9 10

Second loop

```
format /rd 1,0;
i = 1;
do until i > 10;
print i;;
i = i+1;
endo;
```

produces

1 2 3 4 5 6 7 8 9 10

See also **continue, break**

dos

Purpose

Provides access to the operating system from within GAUSS.

Format

dos [[*s*]];

Input

s literal or ^string, the OS command to be executed.

Portability

UNIX

Control and output go to the controlling terminal, if there is one.

This function may be used in terminal mode.

OS/2, Windows

The **dos** function opens a new terminal.

Running programs in the background is allowed in all three of the aforementioned platforms.

Remarks

This allows all operating system commands to be used from within GAUSS. It allows other programs to be run even though GAUSS is still resident in memory.

If no operating system command (for instance, **dir** or **copy**) or program name is specified, a shell of the operating system will be entered which can be used just like the base level OS. The **exit** command must be given from the shell to get back into GAUSS. If a command or program name is included, the return to GAUSS is automatic after the **DOS** command has been executed.

All matrices are retained in memory when the OS is accessed in this way. This command allows the use of word processing, communications, and other programs from within GAUSS.

Do not execute programs that terminate and remain resident because they will be left resident inside GAUSS's workspace. Some examples are programs that create RAM disks or print spoolers.

If the command is to be taken from a string variable, the ^ (caret) must precede the string.

The shorthand ">" can be used in place of the word "DOS".

dos

Example

```
comstr = “basic myprog”;

dos ^comstr;
```

This will cause the BASIC program **myprog** to be run. When that program is finished, control will automatically return to GAUSS.

```
>dir *.prg;
```

This will use the DOS **dir** command to print a directory listing of all files with a `.prg` extension. When the listing is finished, control will be returned to GAUSS.

```
dos;
```

This will cause a second level OS shell to be entered. The OS prompt will appear and OS commands or other programs can be executed. To return to GAUSS, type **exit**.

See also

exec

doswin

Purpose Opens the DOS compatibility window with default settings.

Format **doswin;**

Portability **Windows only**

Remarks Calling **doswin** is equivalent to:

```
call DOSWinOpen("",error(0));
```

Source gauss.src

DOSWinCloseall

Purpose Closes the DOS compatibility window.

Format **DOSWinCloseall;**

Portability **Windows only**

Remarks Calling **DOSWinCloseall** closes the DOS window immediately, without asking for confirmation. If a program is running, its I/O reverts to the Command window.

Example

```
let attr = 50 50 7 0 7;
if not DOSWinOpen("Legacy Window", attr);
   errorlog "Failed to open DOS window, aborting";
   stop;
endif;
 .
 .
DOSWinCloseall;
```

DOSWinOpen

Purpose

Opens the DOS compatibility window and gives it the specified title and attributes.

Format

ret = DOSWinOpen(*title*,*attr*);

Portability

Windows 3.2 only

Input

title string, window title.

attr 5x1 vector or scalar missing, window attributes.

[1]	window x position	
[2]	window y position	
[3]	text foreground color	
[4]	text background color	
[5]	close action bit flags	
	bit 0 (1's bit)]	issue dialog
	bit 1 (2's bit)]	close window
	bit 2 (4's bit)]	stop program

Output

ret scalar, success flag, 1 if successful, 0 if not.

Remarks

If *title* is a null string (“”), the window will be titled “**GAUSS-DOS**”.

Defaults are defined for the elements of *attr*. To use the default, set an element to a missing value. Set *attr* to a scalar missing to use all defaults

[1]	*varies*	use x position of previous DOS window
[2]	*varies*	use y position of previous DOS window
[3]	7	white foreground
[4]	0	black background
[5]	6	4+2: stop program and close window without confirming

If the DOS window is already open, the new title and attr will be applied to it. Elements of attr that are missing are not reset to the default values, but are left as is.

To set the close action flags value (*attr*[5]), just sum the desired bit values. For example:

stop program (4) + close window (2) + confirm close (1) = 7

The close action flags are only relevant when a user attempts to interactively close the DOS window while a program is running. If GAUSS is idle, the window will be closed immediately. Likewise, if a program calls **DOSWinCloseall**, the window is closed, but the program does not get terminated.

Example

```
let attr = 50 50 7 0 7;
if not DOSWinOpen("Legacy Window", attr);
   errorlog "Failed to open DOS window, aborting";
   stop;
endif;
```

This example opens the DOS window at screen location (50,50), with white text on a black background. The close action flags are 4 + 2 + 1 (stop program + close window + issue confirm dialog) = 7. Thus, if the user attempts to close the window while a program is running, he/she will be asked for confirmation. Upon confirmation, the window will be closed and the program terminated.

dotfeq, dotfge, dotfgt, dotfle, dotflt, dotfne

Purpose

Fuzzy comparison functions. These functions use **_fcmptol** to fuzz the comparison operations to allow for roundoff error.

Format

```
y = dotfeq(a,b);
y = dotfge(a,b);
y = dotfgt(a,b);
y = dotfle(a,b);
y = dotflt(a,b);
y = dotfne(a,b);
```

Input

a	NxK matrix, first matrix.
b	LxM matrix, second matrix, ExE compatible with *a*.

Global Input

_fcmptol	global scalar, comparison tolerance. The default value is 1.0e-15.

Output

y	max(N,L) by max(K,M) matrix of 1's and 0's.

Remarks

The return value is 1 if true and 0 if false.

The statement:

```
y = dotfeq(a,b);
```

is equivalent to:

```
y = a .eq b;
```

The calling program can reset **_fcmptol** before calling these procedures.

```
_fcmptol = 1e-12;
```

dotfeq, dotfge, dotfgt, dotfle, dotflt, dotfne

Example

```
x = rndu(2,2);
y = rndu(2,2);
t = dotfge(x,y);
```

$$x = \begin{matrix} 0.85115559 & 0.98914218 \\ 0.12703276 & 0.43365175 \end{matrix}$$

$$y = \begin{matrix} 0.41907226 & 0.49648058 \\ 0.58039125 & 0.98200340 \end{matrix}$$

$$t = \begin{matrix} 1.0000000 & 1.0000000 \\ 0.0000000 & 0.0000000 \end{matrix}$$

Source fcompare.src

Globals **_fcmptol**

See also **feq-fne**

draw

Purpose Graphs lines, symbols, and text using the PQG global variables. This procedure does not require actual X, Y, or Z data since its main purpose is to manually build graphs using **_pline**, **_pmsgctl**, **_psym**, **_paxes**, **_parrow** and other globals.

Library **pgraph**

Format **draw;**

Remarks **draw** is especially useful when used in conjunction with transparent graphic panels.

Example

```
library pgraph;
graphset;
begwind;
/* make full size window for plot */
makewind(9,6.855,0,0,0);
/* make small overlapping window for text*/
makewind(3,1,3,3,0);
          setwind(1);
   x = seqa(.1,.1,100);
   y = sin(x);
   /* plot data in first window*/
   xy(x,y);
```

draw

```
                nextwind;
                   _pbox = 15;
                   _paxes = 0;
                   _pnum = 0;
                   _ptitlht = 1;
                   margin(0,0,2,0);
                   title("This is a text window.");
                   draw;
                           /* add a smaller text window */
                endwind;   /* create graph*/
```

Source pdraw.src

See also **window, makewind**

drop (dataloop)

Purpose Specifies columns to be dropped from the output data set in a data loop.

Format

```
drop variable_list;
```

Remarks Commas are optional in **variable_list**.

Deletes the specified variables from the output data set. Any variables referenced must already exist, either as elements of the source data set, or as the result of a previous **make**, **vector**, or **code** statement.

If neither **keep** nor **drop** is used, the output data set will contain all variables from the source data set, as well as any defined variables. The effects of multiple **keep** and **drop** statements are cumulative.

Example

```
drop age, pay, sex;
```

See also **keep**

dstat

Purpose

Compute descriptive statistics.

Format

{ *vnam,mean,var,std,min,max,valid,mis* **} = dstat(***dataset,vars***);**

Input

dataset string, name of data set.

If dataset contains the name of a GAUSS data set, *vars* will be interpreted as:

vars the variables.

If dataset is null or 0, *vars* will be assumed to be a matrix containing the data.

Kx1 character vector names of variables.

Kx1 numeric vector indices of columns.

These can be any size subset of the variables in the data set and can be in any order. If a scalar 0 is passed, all columns of the data set will be used.

If dataset is null or 0, *vars* will be interpreted as:

NxK matrix the data on which to compute the descriptive statistics.

Defaults are provided for the following global input variables, so they can be ignored unless you need control over the other options provided by this procedure.

__altnam global matrix, default 0.

This can be a Kx1 character vector of alternate variable names for the output.

__miss global scalar, default 0.

- **0** there are no missing values (fastest).
- **1** listwise deletion, drop a row if any missings occur in it.
- **2** pairwise deletion.

__row global scalar, the number of rows to read per iteration of the read loop.

if 0, (default) the number of rows will be calculated internally.

__output global scalar, controls output, default 1.

- **1** print output table.
- **0** do not print output.

Output

vnam Kx1 character vector, the names of the variables used in the statistics.

mean Kx1 vector, means.

var Kx1 vector, variance.

std Kx1 vector, standard deviation.

min Kx1 vector, minima.

max Kx1 vector, maxima.

valid Kx1 vector, the number of valid cases.

mis Kx1 vector, the number of missing cases.

Remarks

If pairwise deletion is used, the minima and maxima will be the true values for the valid data. The means and standard deviations will be computed using the correct number of valid observations for each variable.

Source

dstat.src

Globals

__output, _dstatd, _dstatx

dtdate

Purpose Creates a matrix in DT scalar format.

Format *dt* **= dtdate(***year***,** *month***,** *day***,** *hour***,** *minute***,** *second***);**

Input

year	NxK matrix of years.
month	NxK matrix of months, 1-12.
day	NxK matrix of days, 1-31.
hour	NxK matrix of hours, 0-23.
minute	NxK matrix of minutes, 0-59.
second	NxK matrix of seconds, 0-59.

Output

dt	NxK matrix of DT scalar format dates.

Remarks The arguments must be ExE conformable.

Source time.src

See also **dtday, dttime, utctodt, dttostr**

dtday

Purpose

Creates a matrix in DT scalar format containing only the year, month and day. Time of day information is zeroed out.

Format

dt **= dtday(***year*, *month*, *day***);**

Input

year	NxK matrix of years.
month	NxK matrix of months, 1-12.
day	NxK matrix of days, 1-31.

Output

dt	NxK matrix of DT scalar format dates.

Remarks

This amounts to 00:00:00 or midnight on the given day. The arguments must be ExE conformable.

Source

time.src

See also

dttime, dtdate, utctodt, dttostr

dttime

Purpose

Creates a matrix in DT scalar format containing only the hour, minute and second. The date information is zeroed out.

Format

dt **= dttime(***hour***,** *minute***,** *second***);**

Input

hour	NxK matrix of hours, 0-23.
minute	NxK matrix of minutes, 0-59.
second	NxK matrix of seconds, 0-59.

Output

dt	NxK matrix of DT scalar format times.

Remarks

The arguments must be ExE conformable.

Source

time.src

See also

dtday, dtdate, utctodt, dttostr

dttodtv

Purpose Converts DT scalar format to DTV vector format.

Format *dtv* **= dttodtv(***dt***);**

Input

dt	Nx1 vector, DT scalar format.

Output

dtv	Nx8 matrix, DTV vector format.

Remarks In DT scalar format, 11:06:47 on March 15, 2001 is 20010315110647.

Each row of *dtv*, in DTV vector format, contains:

[N,1]	Year
[N,2]	Month in Year, 1-12
[N,3]	Day of month, 1-31
[N,4]	Hours since midnight, 0-23
[N,5]	Minutes, 0-59
[N,6]	Seconds, 0-59
[N,7]	Day of week, 0-6, 0 = Sunday
[N,8]	Days since Jan 1 of current year, 0-365

Example

```
dt = 20010326110722;
print "dt = " dt;
dtv = dttodtv(dt);
print "dtv = " dtv;
```

produces:

```
dt = 20010326110722
dtv = 2001 3 26 11 7 22 1 84
```

Source time.src

See also **dtvnormal, timeutc, utctodtv, dtvtodt, dttoutc, dtvtodt, strtodt, dttostr**

dttostr

Purpose

Converts a matrix containing dates in DT scalar format to a string array.

Format

sa **= dttostr(***x*, *fmt***);**

Input

x	NxK matrix containing dates in DT scalar format.
fmt	string containing date/time format characters.

Output

sa	NxK string array.

Remarks

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

20010421183207

represents 18:32:07 or 6:32:07 PM on April 21, 2001. **dttostr** converts a date in DT scalar format to a character string using the format string in *fmt*.

The following formats are supported:

YYYY	4 digit year
YR	Last two digits of year
MO	Number of month, 01-12
DD	Day of month, 01-31
HH	Hour of day, 00-23
MI	Minute of hour, 00-59
SS	Second of minute, 00-59

Example

```
s0 = dttostr(utctodt(timeutc),
      "YYYY-MO-DD HH:MI:SS");
Print ("Date and Time are: " $+ s0);
```

produces:

```
Date and time are: 2001-03-25 14:59:40
```

```
print dttostr(utctodt(timeutc),
      "Today is DD-MO-YR")
```

produces:

```
Today is 25-03-01
```

```
s = dttostr(x, "YYYY-MO-DD");
```

```
if x = 20000317060424
       20010427031213
       20010517020437
       20011117161422
       20010717120448
       20010817043451
       20010919052320
       20011017032203
       20011107071418

then s = 2000-03-17
         2001-04-27
         2001-05-17
         2001-11-17
         2001-07-17
         2001-08-17
         2001-09-19
```

dttostr

```
                        2001-10-17
                        2001-11-07
```

See also **strtodt, dttoutc, utctodt**

dttoutc

Purpose Converts DT scalar format to UTC scalar format.

Format *utc* **= dttoutc(***dt***);**

Input

dt	Nx1 vector, DT scalar format.

Output

utc	Nx1 vector, UTC scalar format.

Remarks In DT scalar format, 11:06:47 on March 15, 2001 is 20010315110647. A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time.

Example

```
dt = 20010326085118;
tc = dttoutc(dt);
print "utc = " utc;
```

produces:

```
tc = 985633642;
```

Source time.src

See also **dtvnormal, timeutc, utctodtv, dttodtv, dtvtodt, dtvtoutc, dtvtodt, strtodt, dttostr**

dtvnormal

Purpose

Normalizes a date and time (DTV) vector.

Format

d **= dtvnormal(***t***);**

Input

t	1x8 date and time vector that has one or more elements outside the normal range.

Output

d	Normalized 1x8 date and time vector.

Remarks

The date and time vector is a 1x8 vector whose elements consist of:

Year:	Year, four digit integer.
Month:	1-12, Month in year.
Day:	1-31, Day of month.
Hour:	0-23, Hours since midnight.
Min:	0-59, Minutes.
Sec:	0-59, Seconds.
DoW:	0-6, Day of week, 0 = Sunday.
DiY:	0-365, Days since Jan 1 of year.

The last two elements are ignored on input.

Example

```
format /rd 10,2;
x = { 1996 14 21 6 21 37 0 0 };
d = dtvnormal(x);
```

```
  d:97.00 2.00 21.00 6.00 21.00 37.00 2.00 51.00
```

See also

date, ethsec, etstr, time, timestr, timeutc, utctodtv

dtvtodt

Purpose Converts DT vector format to DT scalar format.

Format *dt* **= dtvtodt(***dtv***);**

Input

dtv	Nx8 matrix, DTV vector format.

Output

dt	Nx1 vector, DT scalar format.

Remarks In DT scalar format, 11:06:47 on March 15, 2001 is 20010315110647.

Each row of *dtv*, in DTV vector format, contains:

[N,1]	Year
[N,2]	Month in Year, 1-12
[N,3]	Day of month, 1-31
[N,4]	Hours since midnight, 0-23
[N,5]	Minutes, 0-59
[N,6]	Seconds, 0-59
[N,7]	Day of week, 0-6, 0 = Sunday
[N,8]	Days since Jan 1 of current year, 0-365

Example

```
let dtv = { 2001 3 26 11 7 22 1 84 };
print "dtv = " dtv;
dt = dtvtodt(dtv);
print "dt = " dt;
```

produces:

```
dtv = 2001 3 26 11 7 22 1 84;
dt = 20010326110722
```

Source time.src

See also **dtvnormal, timeutc, utctodtv, dttodtv, dtvtodt, dttoutc, dtvtodt, strtodt, dttostr**

dtvtoutc

Purpose

Converts DTV vector format to UTC scalar format.

Format

utc **= dtvtoutc(***dtv***);**

Input

dtv Nx8 matrix, DTV vector format.

Output

utc Nx1 vector, UTC scalar format.

Remarks

A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time.

Each row of *dtv*, in DTV vector format, contains:

[N,1] Year
[N,2] Month in Year, 1-12
[N,3] Day of month, 1-31
[N,4] Hours since midnight, 0-23
[N,5] Minutes, 0-59
[N,6] Seconds, 0-59
[N,7] Day of week, 0-6, 0 = Sunday
[N,8] Days since Jan 1 of current year, 0-365

Example

```
dtv = utctodtv(timeutc);
print "dtv = " dtv;
utc = dtvtoutc(dtv);
print "utc = " utc;
```

produces:

```
dtv = 2001 3 26 11 7 22 1
utc = 84985633642
```

See also

dtvnormal, timeutc, utctodt, dttodtv, dttoutc, dtvtodt, dtvtoutc, strtodt, dttostr

dummy

Purpose

Creates a set of dummy (0/1) variables by breaking up a variable into specified categories. The highest (rightmost) category is unbounded on the right.

Format

y **= dummy(***x*,*v***);**

Input

x	Nx1 vector of data that is to be broken up into dummy variables.
v	(K-1)x1 vector specifying the K-1 breakpoints (these must be in ascending order) that determine the K categories to be used. These categories should not overlap.

Output

y	NxK matrix containing the K dummy variables.

Remarks

Missings are deleted before the dummy variables are created.

All categories are open on the left (i.e., do not contain their left boundaries) and all but the highest are closed on the right (i.e., do contain their right boundaries). The highest (rightmost) category is unbounded on the right. Thus, only K-1 breakpoints are required to specify K dummy variables.

The function **dummybr** is similar to **dummy**, but in that function the highest category is bounded on the right. The function **dummydn** is also similar to **dummy**, but in that function a specified column of dummies is dropped.

Example

```
x = { 0, 2, 4, 6 };
v = { 1, 5, 7 };
y = dummy(x,v);
```

The result *y* looks like this:

```
1 0 0 0
0 1 0 0
0 1 0 0
0 0 1 0
```

dummy

The vector *v* will produce 4 dummies satisfying the following conditions:

$$x \leq 1$$

$$1 < x \leq 5$$

$$5 < x \leq 7$$

$$7 < x$$

Source datatran.src

See also **dummybr, dummydn**

dummybr

Purpose

Creates a set of dummy (0/1) variables. The highest (rightmost) category is bounded on the right.

Format

y **= dummybr(***x*,*v***);**

Input

x	NX1 vector of data that is to be broken up into dummy variables.
v	KX1 vector specifying the K breakpoints (these must be in ascending order) that determine the K categories to be used. These categories should not overlap.

Output

y	NXK matrix containing the K dummy variables. Each row will have a maximum of one 1.

Remarks

Missings are deleted before the dummy variables are created.

All categories are open on the left (i.e., do not contain their left boundaries) and are closed on the right (i.e., do contain their right boundaries). Thus, K breakpoints are required to specify K dummy variables.

The function **dummy** is similar to **dummybr**, but in that function the highest category is unbounded on the right.

Example

```
x =  { 0,
       2,
       4,
       6};

v =  { 1,
       5,
       7};

y = dummybr(x,v);
```

The resulting matrix y looks like this:

1 0 0
0 1 0
0 1 0
0 0 1

The vector v = 1 5 7 will produce 3 dummies satisfying the following conditions:

$$x \leq 1$$

$$1 < x \leq 5$$

$$5 < x \leq 7$$

Source datatran.src

See also dummydn, dummy

dummydn

Purpose

Creates a set of dummy (0/1) variables by breaking up a variable into specified categories. The highest (rightmost) category is unbounded on the right, and a specified column of dummies is dropped.

Format

y **= dummydn(***x*,*v*,*p***);**

Input

x	Nx1 vector of data to be broken up into dummy variables.
v	Kx1 vector specifying the K-1 breakpoints (these must be in ascending order) that determine the K categories to be used. These categories should not overlap.
p	positive integer in the range [1,K], specifying which column should be dropped in the matrix of dummy variables.

Output

y	Nx(K-1) matrix containing the K-1 dummy variables.

Remarks

This is just like the function **dummy**, except that the p^{th} column of the matrix of dummies is dropped. This ensures that the columns of the matrix of dummies do not sum to 1, and so these variables will not be collinear with a vector of ones.

Missings are deleted before the dummy variables are created.

All categories are open on the left (i.e., do not contain their left boundaries) and all but the highest are closed on the right (i.e., do contain their right boundaries). The highest (rightmost) category is unbounded on the right. Thus, only K-1 breakpoints are required to specify K dummy variables.

Example

```
x = { 0, 2, 4, 6 };
v = { 1, 5, 7 };
p = 2;
y = dummydn(x,v,p);
```

The resulting matrix y looks like this:

```
1 0 0
0 0 0
0 0 0
0 1 0
```

The vector v = 1 5 7 will produce 4 dummies satisfying the following conditions:

$$x \leq 1$$

$$1 < x \leq 5$$

$$5 < x \leq 7$$

$$7 < x$$

Source datatran.src

See also dummy, dummybr

ed

Purpose Accesses an alternate editor.

Format **ed** *filename*;

Input *filename* The name of the file to be edited.

Remarks The default name of the editor is set in `gauss.cfg`. To change the name of the editor used type:

```
ed = editor_name flags;
```

or

```
ed = "editor_name flags";
```

The flags are any command line flags you may want between the name of the editor and the filename when your editor is invoked. The quoted version will prevent the flags, if any, from being forced to uppercase.

This command can be placed in the startup file so it will be set for you automatically when you start GAUSS.

edit

Purpose Edits a disk file.

Format **edit** *filename*;

Remarks The edit command does not follow the src_path to locate files. You must specify the location in the filename. The default location is the current directory.

Example

```
edit test1.e;
```

See also **run**

eig

Purpose Computes the eigenvalues of a general matrix.

Format *va* **= eig(***x***);**

Input

x	NxN matrix.

Output

va	Nx1 vector, the eigenvalues of *x*.

Remarks If the eigenvalues cannot all be determined, *va*[1] is set to an error code. Passing *va*[1] to the **scalerr** function will return the index of the eigenvalue that failed. The eigenvalues for indices **scalerr**(*va*[1])+1 to N should be correct.

Error handling is controlled with the low bit of the trap flag.

trap 0	set *va*[1] and terminate with message
trap 1	set *va*[1] and continue execution

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first.

Example

```
x = { 4 8 1 ,
      9 4 2 ,
      5 5 7 };
va = eig(x);
```

```
       -4.4979246
va =    14.475702
        5.0222223
```

See also **eigh, eighv, eigv**

eigcg

Purpose

Computes the eigenvalues of a complex, general matrix. (Included for backwards compatibility — use **eig** instead.)

Format

{ *var*,*vai* **} = eigcg(**_xr_,_xi_**);**

Input

xr	NxN matrix, real part.
xi	NxN matrix, imaginary part.

Output

var	Nx1 vector, real part of eigenvalues.
vai	Nx1 vector, imaginary part of eigenvalues.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices **_eigerr**+1 to N should be correct.

Remarks

Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first.

Source

eigcg.src

Globals

_eigerr

See also

eigcg2, eigch, eigrg, eigrs

eigcg2

Purpose

Computes eigenvalues and eigenvectors of a complex, general matrix. (Included for backwards compatibility — use **eigv** instead.)

Format

{ *var*,*vai*,*ver*,*vei* **} = eigcg2(***xr*,*xi***);**

Input

xr	NxN matrix, real part.
xi	NxN matrix, imaginary part.

Output

var	Nx1 vector, real part of eigenvalues.
vai	Nx1 vector, imaginary part of eigenvalues.
ver	NxN matrix, real part of eigenvectors.
vei	NxN matrix, imaginary part of eigenvectors.

Global Input

_eigerr global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices **_eigerr**+1 to N should be correct. The eigenvectors are not computed.

Remarks

Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first. The columns of *ver* and *vei* contain the real and imaginary eigenvectors of *x* in the same order as the eigenvalues. The eigenvectors are not normalized.

Source

eigcg.src

Globals

_eigerr

See also

eigcg, eigch, eigrg, eigrs

eigch

Purpose

Computes the eigenvalues of a complex, hermitian matrix. (Included for backwards compatibility — use **eigh** instead.)

Format

va **= eigch(***xr***,***xi***);**

Input

xr	NxN matrix, real part.
xi	NxN matrix, imaginary part.

Output

va	Nx1 vector, real part of eigenvalues.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices 1 to **_eigerr**-1 should be correct.

Remarks

Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are in ascending order. The eigenvalues for a complex hermitian matrix are always real so this procedure returns only one vector.

Source

eigch.src

Globals

_eigerr

See also

eigch2, eigcg, eigrg, eigrs

eigch2

Purpose

Computes eigenvalues and eigenvectors of a complex, hermitian matrix. (Included for backwards compatibility — use **eighv** instead.)

Format

{ *var*,*vai*,*ver*,*vei* **} = eigch2(**_xr_,_xi_**);**

Input

xr	NxN matrix, real part.
xi	NxN matrix, imaginary part.

Output

var	Nx1 vector, real part of eigenvalues.
vai	Nx1 vector, imaginary part of eigenvalues.
ver	NxN matrix, real part of eigenvectors.
vei	NxN matrix, imaginary part of eigenvectors.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices 1 to **_eigerr**-1 should be correct. The eigenvectors are not computed.

Remarks

Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are in ascending order. The eigenvalues of a complex hermitian matrix are always real. This procedure returns a vector of zeros for the imaginary part of the eigenvalues so the syntax is consistent with other **eig***xx* procedure calls. The columns of *ver* and *vei* contain the real and imaginary eigenvectors of *x* in the same order as the eigenvalues. The eigenvectors are orthonormal.

Source

eigch.src

Globals

_eigerr

See also

eigch, eigcg, eigrg, eigrs

eigh

Purpose

Computes the eigenvalues of a complex hermitian or real symmetric matrix.

Format

va **= eigh(***x***);**

Input

x NxN matrix.

Output

va Nx1 vector, the eigenvalues of *x*.

Remarks

If the eigenvalues cannot all be determined, *va*[1] is set to an error code. Passing *va*[1] to the **scalerr** function will return the index of the eigenvalue that failed. The eigenvalues for indices 1 to **scalerr**(*va*[1])-1 should be correct.

Error handling is controlled with the low bit of the trap flag.

trap 0 set *va*[1] and terminate with message
trap 1 set *va*[1] and continue execution

The eigenvalues are in ascending order.

The eigenvalues of a complex hermitian or real symmetric matrix are always real.

See also

eig, eighv, eigv

eighv

Purpose

Computes eigenvalues and eigenvectors of a complex hermitian or real symmetric matrix.

Format

{ *va*,*ve* **} = eighv(**x**);**

Input

x	NxN matrix.

Output

va	Nx1 vector, the eigenvalues of *x*.
ve	NxN matrix, the eigenvectors of *x*.

Remarks

If the eigenvalues cannot all be determined, *va*[1] is set to an error code. Passing *va*[1] to the **scalerr** function will return the index of the eigenvalue that failed. The eigenvalues for indices 1 to **scalerr**(*va*[1])-1 should be correct. The eigenvectors are not computed.

Error handling is controlled with the low bit of the trap flag.

trap 0 set *va*[1] and terminate with message

trap 1 set *va*[1] and continue execution

The eigenvalues are in ascending order. The columns of *ve* contain the eigenvectors of *x* in the same order as the eigenvalues. The eigenvectors are orthonormal.

The eigenvalues of a complex hermitian or real symmetric matrix are always real.

See also

eig, eigh, eigv

eigrg

Purpose

Computes the eigenvalues of a real, general matrix. (Included for backwards compatibility — use **eig** instead.)

Format

{ *var*,*vai* **} = eigrg(**x**);**

Input

x	NxN matrix.

Output

var	Nx1 vector, real part of eigenvalues.
vai	Nx1 vector, imaginary part of eigenvalues.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices **_eigerr**+1 to N should be correct.

Remarks

Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first.

Example

```
x = { 1 2i 3,
      4i 5+3i 6,
      7 8 9i };
{y,n} = eigrg(x);
```

```
      –6.3836054
y =     2.0816489
       10.301956

       7.2292503
n =   –1.4598755
       6.2306252
```

Source eigrg.src

Globals **_eigerr**

See also **eigrg2, eigcg, eigch, eigrs**

eigrg2

Purpose Computes eigenvalues and eigenvectors of a real, general matrix. (Included for backwards compatibility — use **eigv** instead.)

Format **{** *var*,*vai*,*ver*,*vei* **} = eigrg2(**x**);**

Input

x	NxN matrix.

Output

var	Nx1 vector, real part of eigenvalues.
vai	Nx1 vector, imaginary part of eigenvalues.
ver	NxN matrix, real part of eigenvectors.
vei	NxN matrix, imaginary part of eigenvectors.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices **_eigerr**+1 to N should be correct. The eigenvectors are not computed.

Remarks Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first. The columns of *ver* and *vei* contain the real and imaginary eigenvectors of *x* in the same order as the eigenvalues. The eigenvectors are not normalized.

Source eigrg.src

Globals **_eigerr**

See also **eigrg, eigcg, eigch, eigrs**

eigrs

Purpose Computes the eigenvalues of a real, symmetric matrix. (Included for backwards compatibility — use **eigh** instead.)

Format *va* **= eigrs(***x***);**

Input

x	NxN matrix.

Output

va	Nx1 vector, eigenvalues of *x*.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues for indices 1 to **_eigerr**-1 should be correct.

Remarks Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are in ascending order. The eigenvalues for a real symmetric matrix are always real so this procedure returns only one vector.

Source eigrs.src

Globals **_eigerr**

See also **eigrs2, eigcg, eigch, eigrg**

eigrs2

Purpose

Computes eigenvalues and eigenvectors of a real, symmetric matrix. (Included for backwards compatibility — use **eighv** instead.)

Format

{ *va*,*ve* **} = eigrs2(**x**);**

Input

x	NxN matrix.

Output

va	Nx1 vector, eigenvalues of *x*.
ve	NxN matrix, eigenvectors of *x*.
_eigerr	global scalar, if all the eigenvalues can be determined **_eigerr** = 0, otherwise **_eigerr** is set to the index of the eigenvalue that failed. The eigenvalues and eigenvectors for indices 1 to **_eigerr**-1 should be correct.

Remarks

Error handling is controlled with the low bit of the trap flag.

trap 0 set **_eigerr** and terminate with message
trap 1 set **_eigerr** and continue execution

The eigenvalues are in ascending order. The columns of *ve* contain the eigenvectors of *x* in the same order as the eigenvalues. The eigenvectors are orthonormal.

The eigenvalues and eigenvectors for a real symmetric matrix are always real so this procedure returns only the real parts.

Source

eigrs.src

Globals

_eigerr

See also

eigrs, eigcg, eigch, eigrg

eigv

Purpose

Computes eigenvalues and eigenvectors of a general matrix.

Format

{ *va*,*ve* **} = eigv(**x**);**

Input

x	NxN matrix.

Output

va	Nx1 vector, the eigenvalues of *x*.
ve	NxN matrix, the eigenvectors of *x*.

Remarks

If the eigenvalues cannot all be determined, *va*[1] is set to an error code. Passing *va*[1] to the **scalerr** function will return the index of the eigenvalue that failed. The eigenvalues for indices **scalerr**(*va*[1])+1 to N should be correct. The eigenvectors are not computed.

Error handling is controlled with the low bit of the trap flag.

trap 0 set *va*[1] and terminate with message
trap 1 set *va*[1] and continue execution

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first. The columns of *ve* contain the eigenvectors of *x* in the same order as the eigenvalues. The eigenvectors are not normalized.

Example

```
x = { 4 8 1,
      9 4 2,
      5 5 7 };
{y,n} = eigv(x);
```

$$y = \begin{matrix} -4.4979246 \\ 14.475702 \\ 5.0222223 \end{matrix}$$

$$n = \begin{matrix} -0.66930459 & -0.64076622 & -0.40145623 \\ 0.71335708 & -0.72488533 & -0.26047487 \\ -0.01915672 & -0.91339349 & 1.6734214 \end{matrix}$$

eigv

See also **eig, eigh, eighv**

elapsedTradingDays

Purpose Compute number of trading days between two dates inclusively.

Format *n* **= elapsedTradingDays(***a***,***b***);**

Input

a	scalar, date in DT scalar format.
b	scalar, date in DT scalar format.

Output

n	number of trading days between dates inclusively, that is, elapsed time includes the dates *a* and *b*.

Remarks A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2004. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

Source `finutils.src`

end

Purpose Terminates a program.

Format

```
end;
```

Remarks **end** causes GAUSS to revert to interactive mode, and closes all open files. **end** also closes the auxiliary output file and turns the screen on. It is not necessary to put an **end** statement at the end of a program.

An **end** command can be placed above a label which begins a subroutine to make sure that a program does not enter a subroutine without a **gosub**.

stop also terminates a program but closes no files and leaves the screen setting as it is.

Example

```
output on;
screen off;
print x;
end;
```

In this example, a matrix **x** is printed to the auxiliary output. The output to the screen is turned off to speed up the printing. The **end** statement is used to terminate the program so the output file will be closed and the screen will be turned back on.

See also **new, stop, system**

endp

Purpose Closes a procedure or keyword definition.

Format **endp;**

Remarks **endp** marks the end of a procedure definition that began with a **proc** or **keyword** statement. (For details on writing and using procedures, see "Procedures and Keywords" in the *User's Guide*.)

Example

```
proc regress(y,x);
   retp(inv(x'x)*x'y);
endp;

x = { 1 3 2, 7 4 9, 1 1 6, 3 3 2 };
y = { 3, 5, 2, 7 };

b = regress(y,x);
```

$$x = \begin{matrix} 1.00000000 & 3.00000000 & 2.00000000 \\ 7.00000000 & 4.00000000 & 9.00000000 \\ 1.00000000 & 1.00000000 & 6.00000000 \\ 3.00000000 & 3.00000000 & 2.00000000 \end{matrix}$$

$$y = \begin{matrix} 3.00000000 \\ 5.00000000 \\ 2.00000000 \\ 7.00000000 \end{matrix}$$

$$b = \begin{matrix} 0.15456890 \\ 1.50276345 \\ -0.12840825 \end{matrix}$$

endp

See also proc, keyword, retp

endwind

Purpose Ends graphic panel manipulation; display graphs with **rerun**.

Library **pgraph**

Format **endwind;**

Remarks This function uses **rerun** to display the most recently created `.tkf` file.

Source `pwindow.src`

See also **begwind, window, makewind, setwind, nextwind, getwind**

envget

Purpose Searches the environment table for a defined name.

Format *y* **= envget(***s***);**

Input

s	string, the name to be searched for.

Output

y	string, the string that corresponds to that name in the environment or a null string if it is not found.

Example

```
proc dopen(file);
   local fname,fp;
   fname = envget(“DPATH”);
   if fname $== “”;
      fname = file;
   else;
      if strsect(fname,strlen(fname),1) $== “\\”;
         fname = fname $+ file;
      else;
         fname = fname $+ “\\” $+ file;
      endif;
   endif;
   open fp = ^fname;
   retp(fp);
endp;
```

This is an example of a procedure which will open a data file using a path stored in an environment string called DPATH. The procedure returns the file handle and is called as follows:

```
fp = dopen(“myfile”);
```

See also **cdir**

eof

Purpose Tests if the end of a file has been reached.

Format *y* **= eof(***fh***);**

Input

fh	scalar, file handle.

Output

y	scalar, 1 if end of file has been reached, else 0.

Remarks This function is used with the **readr** and **fgets***xxx* commands to test for the end of a file.

The **seekr** function can be used to set the pointer to a specific row position in a data set; the **fseek** function can be used to set the pointer to a specific byte offset in a file opened with **fopen**.

Example

```
open f1 = dat1;

xx = 0;

do until eof(f1);

   xx = xx+moment(readr(f1,100),0);

endo;
```

In this example, the data file `dat1.dat` is opened and given the handle **f1**. Then the data are read from this data set and are used to create the moment (**x'x**) matrix of the data. On each iteration of the loop, 100 additional rows of data are read in and the moment matrix for this set of rows is computed, and added to the matrix **xx**. When all the data have been read, **xx** will contain the entire moment matrix for the data set.

GAUSS will keep reading until **eof(f1)** returns the value 1, which it will when the end of the data set has been reached. On the last iteration of the loop, all remaining observations are read in if there are 100 or fewer left.

See also **open, readr, seekr**

eqSolve

Purpose

Solves a system of nonlinear equations

Format

{ *x*, *retcode* **} = eqSolve(&***F*,*start*);

Input

start Kx1 vector, starting values.

&*F* scalar, a pointer to a procedure which computes the value at *x* of the equations to be solved.

Global Input

The folowing are set by **eqsolveset**.

_eqs_JacobianProc pointer to a procedure which computes the analytical Jacobian. By default, **eqSolve** will compute the Jacobian numerically.

_eqs_MaxIters scalar, the maximum number of iterations. Default = 100.

_eqs_StepTol scalar, the step tolerance. Default = **__macheps**^(2/3).

_eqs_TypicalF Kx1 vector of the typical F(*x*) values at a point not near a root, used for scaling. This becomes important when the magnitudes of the components of F(*x*) are expected to be very different. By default, function values are not scaled.

_eqs_TypicalX Kx1 vector of the typical magnitude of *x*, used for scaling. This becomes important when the magnitudes of the components of *x* are expected to be very different. By default, variable values are not scaled.

_eqs_IterInfo scalar, if nonzero, iteration information is printed. Default = 0.

The following are set by **gausset**.

__Tol scalar, the tolerance of the scalar function $f = 0.5*||F(x)||^2$ required to terminate the algorithm. Default = 1e-5.

__altnam	Kx1 character vector of alternate names to be used by the printed output. By default, the names X1, X2, X3... or X01, X02, X03 (depending on how **__vpad** is set) will be used.
__output	scalar. If non-zero, final results are printed.
__title	string, a custom title to be printed at the top of the iterations report. By default, only a generic title will be printed.

Output

x Kx1 vector, solution.

retcode scalar, the return code:

- **1** Norm of the scaled function value is less than **__Tol**. *x* given is an approximate root of F(*x*) (unless **__Tol** is too large).
- **2** The scaled distance between the last two steps is less than the step-tolerance (**_eqs_StepTol**). *x* may be an approximate root of F(*x*), but it is also possible that the algorithm is making very slow progress and is not near a root, or the step-tolerance is too large.
- **3** The last global step failed to decrease norm2(F(*x*)) sufficiently; either *x* is close to a root of F(*x*) and no more accuracy is possible, or an incorrectly coded analytic Jacobian is being used, or the secant approximation to the Jacobian is inaccurate, or the step-tolerance is too large.
- **4** Iteration limit exceeded.
- **5** Five consecutive steps of maximum step length have been taken; either norm2(F(*x*)) asymptotes from above to a finite value in some direction or the maximum step length is too small.
- **6** *x* seems to be an approximate local minimizer of norm2(F(*x*)) that is not a root of F(*x*). To find a root of F(*x*), restart **eqSolve** from a different region.

Remarks

The equation procedure should return a column vector containing the result for each equation. For example:

```
Equation 1: x1^2 + x2^2 - 2 = 0

Equation 2: exp(x1-1) + x2^3 - 2 = 0
```

eqSolve

```
   proc f(var);
      local x1,x2,eqns;

      x1 = var[1];
      x2 = var[2];
      eqns[1] = x1^2 + x2^2 - 2; /* Equation 1 */
      eqns[2] = exp(x1-1) + x2^3 - 2; /* Equation
                                        /* 2 */
      retp( eqns );
   endp;
```


Example

```
eqSolveset;

proc f(x);
      local f1,f2,f3;
      f1 = 3*x[1]^3 + 2*x[2]^2 + 5*x[3] - 10;
      f2 = -x[1]^3 - 3*x[2]^2 + x[3] + 5;
      f3 = 3*x[1]^3 + 2*x[2]^2 - 4*x[3];
      retp(f1|f2|f3);
endp;

proc fjc(x);
   local fjc1,fjc2, fjc3;
   fjc1 = 9*x[1]^2 ~ 4*x[2] ~ 5;
   fjc2 = -3*x[1]^2 ~ -6*x[2] ~ 1;
   fjc3 = 9*x[1]^2 ~ 4*x[2] ~ -4;
   retp(fjc1|fjc2|fjc3);
endp;
```

```
start = { -1, 12, -1 };

_eqs_JacobianProc = &fjc;

{ x,tcode } = eqSolve(&f,start);
```

Produces

```
================================================
EqSolve Version 3.2.22          2/24/97   9:54 am
================================================
||F(X)|| at final solution:           0.93699762
------------------------------------------------
Termination Code = 1:
Norm of the scaled function value is less than
     __Tol;
------------------------------------------------

------------------------------------------------
VARIABLE  START      ROOTS        F(ROOTS)
------------------------------------------------
X1        -1.00000   0.54144351    4.4175402e-06
X2        12.00000   1.4085912    -6.6263102e-06
X3        -1.00000   1.1111111     4.4175402e-06
------------------------------------------------
```

Source eqsolve.src

eqSolveset

Purpose Sets global input used by **eqSolve** to default values.

Format **eqSolveset;**

Global Output

__eqs_TypicalX = 0

__eqs_TypicalF = 0

__eqs_IterInfo = 0

__eqs_JacobianProc = 0

__eqs_MaxIters = 100

__eqs_StepTol **__macheps^(2/3)**

erf, erfc

Purpose Computes the Gaussian error function (**erf**) and its complement (**erfc**).

Format
```
y = erf(x);
y = erfc(x);
```

Input *x* NxK matrix.

Output *y* NxK matrix.

Remarks The allowable range for *x* is:

$$x \geq 0$$

The **erf** and **erfc** functions are closely related to the Normal distribution:

$$cdfn(x) = \begin{cases} \frac{1}{2}\left(1 + erf\left(\frac{x}{\sqrt{2}}\right)\right) & x \geq 0 \\ \frac{1}{2} erfc\left(\frac{-x}{\sqrt{2}}\right) & x < 0 \end{cases}$$

Example
```
x = { .5 .4 .3,
      .6 .8 .3 };
y = erf(x);
```

$$y = \begin{matrix} 0.52049988 & 0.42839236 & 0.32862676 \\ 0.60385609 & 0.74210096 & 0.32862676 \end{matrix}$$

```
x = { .5 .4 .3,
      .6 .8 .3 };
y = erfc(x);
```

$$y = \begin{matrix} 0.47950012 & 0.57160764 & 0.67137324 \\ 0.39614391 & 0.25789904 & 0.67137324 \end{matrix}$$

See also

cdfn, cdfnc

Technical Notes

erf and **erfc** are computed by summing the appropriate series and continued fractions. They are accurate to about 10 digits.

error

Purpose

Allows the user to generate a user-defined error code which can be tested quickly with the **scalerr** function.

Format

y **= error(***x***);**

Input

x	scalar, in the range 0-65535.

Output

y	scalar error code which can be interpreted as an integer with the **scalerr** function.

Remarks

The user may assign any number in the range 0-65535 to denote particular error conditions. This number may be tested for as an error code by **scalerr**.

The **scalerr** function will return the value of the error code and so is the reverse of **error**. These user-generated error codes work in the same way as the intrinsic GAUSS error codes which are generated automatically when **trap 1** is on and certain GAUSS functions detect a numerical error such as a singular matrix.

error(0) is equal to the missing value code.

Example

```
proc syminv(x);
   local oldtrap,y;
   if not x == x';
      retp(error(99));
   endif;
   oldtrap = trapchk(0xffff);
   trap 1;
   y = invpd(x);
   if scalerr(y);
      y = inv(x);
   endif;
```

error

```
trap oldtrap,0xffff;
   retp(y);
endp;
```

The procedure **syminv** returns error code 99 if the matrix is not symmetric. If **invpd** fails, it returns error code 20. If **inv** fails, it returns error code 50. The original trap state is restored before the procedure returns.

See also

scalerr, trap, trapchk

errorlog

Purpose Prints an error message to the window and error log file.

Format **errorlog** *str*;

Input *str* string, the error message to print.

Remarks This function prints to the screen and the error log file.

etdays

Purpose

Computes the difference between two times, as generated by the **date** command, in days.

Format

days **= etdays(***tstart***,***tend***);**

Input

tstart 3x1 or 4x1 vector, starting date, in the order: yr, mo, day. (Only the first 3 elements are used.)

tend 3x1 or 4x1 vector, ending date, in the order: yr, mo, day. (Only the first 3 elements are used.) MUST be later than *tstart*.

Output

days scalar, elapsed time measured in days.

Remarks

This will work correctly across leap years and centuries. The assumptions are a Gregorian calendar with leap years on the years evenly divisible by 4 and not evenly divisible by 400.

Example

```
let date1 = 1986 1 2;
let date2 = 1987 10 25;
d = etdays(date1,date2);
```

d = 661

Source

time.src

See also

dayinyr

ethsec

Purpose Computes the difference between two times, as generated by the **date** command, in hundredths of a second.

Format *hs* **= ethsec(***tstart***,***tend***);**

Input

tstart 4x1 vector, starting date, in the order: yr, mo, day, hundredths of a second.

tend 4x1 vector, ending date, in the order: yr, mo, day, hundredths of a second. MUST be later than *tstart*.

Output

hs scalar, elapsed time measured in hundredths of a second.

Remarks This will work correctly across leap years and centuries. The assumptions are a Gregorian calendar with leap years on the years evenly divisible by 4 and not evenly divisible by 400.

Example

```
let date1 = 1986 1 2 0;
let date2 = 1987 10 25 0;
t = ethsec(date1,date2);
```

t = 5711040000

Source time.src

See also **dayinyr**

etstr

Purpose Formats an elapsed time, measured in hundredths of a second, to a string.

Format *str* **= etstr(***tothsecs***);**

Input

tothsecs scalar, an elapsed time measured in hundredths of a second, as given, for instance, by the **ethsec** function.

Output

str string containing the elapsed time in the form:

days # hours # minutes #.## seconds

Example

```
d1 = { 86, 1, 2, 0 };
d2 = { 86, 2, 5, 815642 };
t = ethsec(d1,d2);
str = etstr(t);
```

$t = 2.9457564e+08$

str = 34 *days* 2 *hours* 15 *minutes* 56.42 *seconds*

Source time.src

EuropeanBinomCall

Purpose

European binomial method call.

Format

c **= EuropeanBinomCall(***S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

c	Mx1 vector, call premiums

Example

```
S0 = 718.46;
K = { 720, 725, 730 };
b = .0498;
r = .0498;
sigma = .2493;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = EuropeanBinomCall(S0,K,r,div,tau,sigma,N);
print c;

17.1071
15.0067
```

EuropeanBinomCall

```
12.9064
```

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

EuropeanBinomCall_Greeks

Purpose

European binomial method call Delta, Gamma, Theta, Vega and Rho.

Format

{ *d*,*g*,*t*,*v*,*rh* **} =**
EuropeanBinomCall_Greeks(*S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
N = 30;
{ d,g,t,v,rh } = EuropeanBinomCall_Greeks
      (S0,K,r,div,tau,sigma,N);
print d;
print g;
print t;
```

EuropeanBinomCall_Greeks

```
print v;
print rh;


0.6738
0.0008
-44.7874
69.0880
96.9225
```

Source

finprocs.src

Globals

_fin_thetaType scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.

_fin_epsilon scalar, finite difference stepsize. Default = 1e-8.

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

EuropeanBinomCall_ImpVol

Purpose

Implied volatilities for European binomial method calls.

Format

sigma **= EuropeanBinomCall_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau*,*N***);**

Input

c	Mx1 vector, call premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
N	number of time segments

Output

sigma	Mx1 vector, volatility

Example

```
c = { 13.70, 11.90, 9.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) / annualTrading-
      Days(2001);
N = 30;
sigma = EuropeanBinomCall_ImpVol
      (c,S0,K,r,div,tau,N);
print sigma;

0.1982
```

EuropeanBinomCall_ImpVol

```
0.1716

0.1301
```

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

EuropeanBinomPut

Purpose European binomial method Put.

Format *c* **= EuropeanBinomPut(***S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

c	Mx1 vector, put premiums

Example:

```
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
N = 30;
c = EuropeanBinomPut
      (S0,K,r,div,tau,sigma,N);
print c;

16.6927
```

EuropeanBinomPut

```
19.5266
22.3604
```

Source finprocs.src

EuropeanBinomPut_Greeks

Purpose

European binomial method put Delta, Gamma, Theta, Vega, and Rho.

Format

{ *d*,*g*,*t*,*v*,*rh* **} =**
EuropeanBinomPut_Greeks(*S0*,*K*,*r*,*div*,*tau*,*sigma*,*N***);**

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility
N	number of time segments

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
N = 30;
{ d,g,t,v,rh } = EuropeanBinomPut_Greeks
      (S0,K,r,div,tau,sigma,N);
print d;
print g;
print t;
```

EuropeanBinomPut_Greeks

```
print v;
print rh;


-0.3804
0.0038
-17.9838
69.0880
-33.7666
```

Globals

_fin_thetaType	scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.
_fin_epsilon	scalar, finite difference stepsize. Default = 1e-8.

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

EuropeanBinomPut_ImpVol

Purpose Implied volatilities for European binomial method puts.

Format *sigma* **= EuropeanBinomPut_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau*,*N***);**

Input

c	Mx1 vector, put premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
N	number of time segments

Output *sigma* Mx1 vector, volatility

Example:

```
p = { 14.60, 17.10, 20.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
N = 30;
sigma = EuropeanBinomPut_ImpVol
      (p,S0,K,r,div,tau,N);
print sigma;

0.1307
```

EuropeanBinomPut_ImpVol

```
0.1714

0.2165
```

Source

finprocs.src

Technical Notes

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

EuropeanBSCall

Purpose

European Black and Scholes Call.

Format

c **= EuropeanBSCall(***S0*,*K*,*r*,*div*,*tau*,*sigma***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

c	Mx1 vector, call premiums

Example

```
S0 = 718.46;
K = { 720, 725, 730 };
b = .0498;
r = .0498;
div = 0;
sigma = .2493;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = EuropeanBSCall(S0,K,r,div,tau,sigma);
print c;

17.0975
14.7583
```

EuropeanBSCall

```
                12.6496
```

Source finprocs.src

EuropeanBSCall_Greeks

Purpose

European Black and Scholes call Delta, Gamma, Omega, Theta, and Vega.

Format

{ *d*,*g*,*t*,*v*,*rh* **} =**
EuropeanBSCall_Greeks(*S0*,*K*,*r*,*div*,*tau*,*sigma***);**

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
{ d,g,t,v,rh } = EuropeanBSCall_Greeks
      (S0,K,r,div,tau,sigma);
print d;
print g;
print t;
print v;
```

EuropeanBSCall_Greeks

```
print rh;
0.6446
0.0085
-38.5054
65.2563
56.8720
```

Source

finprocs.src

Globals

_fin_thetaType scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.

EuropeanBSCall_ImpVol

Purpose Implied volatilities for European Black and Scholes calls.

Format *sigma* **= EuropeanBSCall_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau***);**

Input

c	Mx1 vector, call premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading

Output

sigma	Mx1 vector, volatility

Example

```
c = { 13.70, 11.90, 9.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
div = 0;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
sigma = EuropeanBSCall_ImpVol
      (c,S0,K,r,div,tau);
print sigma;

0.1991
0.1725
```

EuropeanBSCall_ImpVol

```
                0.1310
```

Source finprocs.src

EuropeanBSPut

Purpose

European Black and Scholes Put.

Format

c **= EuropeanBSPut(***S0*,*K*,*r*,*div*,*tau*,*sigma***);**

Input

S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

c	Mx1 vector, put premiums

Example

```
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
div = 0;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
c = EuropeanBSPut(S0,K,r,div,tau,sigma);
print c;

16.6403
19.2872
22.1647
```

EuropeanBSPut

Source finprocs.src

EuropeanBSPut_Greeks

Purpose

European Black and Scholes put Delta, Gamma, Omega, Theta, and Vega.

Format

```
{ d,g,t,v,rh } =
EuropeanBSPut_Greeks(S0,K,r,div,tau,sigma);
```

Input

S0	scalar, current price
K	Mx1 vector, strike price
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading
sigma	scalar, volatility

Output

d	Mx1 vector, delta
g	Mx1 vector, gamma
t	Mx1 vector, theta
v	Mx1 vector, vega
rh	Mx1 vector, rho

Example

```
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
{ d,g,t,v,rh } = EuropeanBSPut_Greeks
      (S0,K,r,div,tau,sigma);
print d;
print g;
print t;
print v;
```

EuropeanBSPut_Greeks

```
print rh;
-0.3554
0.0085
-15.1307
65.2563
-39.5486
```

Source

finprocs.src

Globals

_fin_thetaType scalar, if 1, one day look ahead, else, infinitesmal. Default = 0.

EuropeanBSPut_ImpVol

Purpose Implied volatilities for European Black and Scholes puts.

Format *sigma* **= EuropeanBSPut_ImpVol(***c*,*S0*,*K*,*r*,*div*,*tau***);**

Input

c	Mx1 vector, put premiums
S0	scalar, current price
K	Mx1 vector, strike prices
r	scalar, risk free rate
div	continuous dividend yield
tau	scalar, elapsed time to exercise in annualized days of trading

Output

sigma	Mx1 vector, volatility

Example

```
p = { 14.60, 17.10, 20.10 };
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
t0 = dtday (2001, 1, 30);
t1 = dtday (2001, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2001);
sigma = EuropeanBSPut_ImpVol(p,S0,K,r,div,tau);
print sigma;

0.2123
0.2493
0.2937
```

Source finprocs.src

exctsmpl

Purpose

Computes a random subsample of a data set.

Format

n **= exctsmpl(***infile***,***outfile***,***percent***);**

Input

infile	string, the name of the original data set.
outfile	string, the name of the data set to be created.
percent	scalar, the percentage random sample to take. This must be in the range 0-100.

Output

n scalar, number of rows in output data set.

Error returns are controlled by the low bit of the trap flag.

trap 0 terminate with error message

trap 1 return scalar negative integer

- **-1** can't open input file
- **-2** can't open output file
- **-3** disk full

Remarks

Random sampling is done with replacement. Thus, an observation may be in the resulting sample more than once. If *percent* is 100, the resulting sample will not be identical to the original sample, though it will be the same size.

Example

```
n = exctsmpl("freq.dat","rout",30);
```

n = 30

`freq.dat` is an example data set provided with GAUSS. Switching to the GAUSS examples directory will make it possible to do the above example as shown. Otherwise substitute data set names will need to be used.

Source

exctsmpl.src

exec

Purpose

Executes an executable program and returns the exit code to GAUSS.

Format

y **= exec(***program***,***comline***);**

Input

program string, the name of the program to be executed.

comline string, the arguments to be placed on the command line of the program being executed.

Output

y the exit code returned by *program*.

If **exec** cannot execute *program*, the error returns will be negative.

- **-1** file not found
- **-2** the file is not an executable file
- **-3** not enough memory
- **-4** command line too long

Remarks

Under Windows, the file can be given an extension or a "." meaning no extension. Otherwise the file will be searched for with the following extensions in their given order: `.com`, `.exe`, `.bat`, `.cmd`.

Example

```
y = exec("atog","comd1.cmd");
if y;
   errorlog "atog failed";
   end;
endif;
```

In this example, the ATOG ASCII conversion utility is executed under the **exec** function. The name of the command file to be used, `comd1.cmd`, is passed to ATOG on its command line. The exit code **y** returned by **exec** is tested to see if ATOG was successful; if not, the program will be terminated after printing an error message. See "Utilities" in the *User Guide*.

exp

Purpose Calculates the exponential function.

Format *y* **= exp(***x***);**

Input

x NxK matrix.

Output

y NxK matrix containing *e*, the base of natural logs, raised to the powers given by the elements of *x*.

Example

```
x = eye(3);
y = exp(x);
```

```
      1.000000 0.000000 0.000000
x =   0.000000 1.000000 0.000000
      0.000000 0.000000 1.000000

      2.718282 1.000000 1.000000
y =   1.000000 2.718282 1.000000
      1.000000 1.000000 2.718282
```

This example creates a 3x3 identity matrix and computes the exponential function for each one of its elements. Note that **exp(1)** returns *e*, the base of natural logs.

See also **ln**

export

Purpose Exports a GAUSS matrix to a spreadsheet, database or ASCII file.

Format *ret* **= export(***x*,*fname*,*namel***);**

Input

x	MxK matrix, data to export.
fname	string, name of file to export with optional path.
namel	Kx1 vector, column names, or scalar 0 for default column names.

Output

ret	scalar, success flag, 1 if successful, 0 if not.
fname	file in the selected format.

Portability **Windows only**

Remarks Setting *namel* to 0 results in default column names of Var:1 to Var:K.

Example

```
fname = “c:\\temp\\testdata.xls”;
matx = rndn(7,4);
let names = gnp invest pop export;
call export(matx, fname, names);
```

This will export the matrix **matx** to the file **c:\temp\testdata.xls** in Excel format.

If the first line had been

```
fname = "c:\\temp\\testdata.dbf";
```

the file would have been exported in dBase format.

Globals **_dxaschdr, _dxftype, _dxmiss, _dxprcn, _dxprint, _dxtxdlim, _dxtype, _dxwidth, _dxwkshd**

See also **exportf, import, importf**

exportf

Purpose Exports a GAUSS data set to a spreadsheet, database, or ASCII file.

Format *ret* **= exportf(***dname*,*fname*,*namel***);**

Input

dname	string, name of GAUSS data set with optional path
fname	string, name of file to export with optional path.
namel	Kx1 vector, column names, or 0 for all columns.

Output

ret	scalar, success flag, 1 if successful, 0 if not.
fname	file in the specified format.

Portability **Windows only**

Remarks The columns of the data set listed in *namel* will be exported. If *namel* is 0, the entire data set will be exported.

Example

```
dname = "c:\\gauss\\data\\mydata.dat";
fname = "c:\\temp\\testdata2.wk1";
call exportf(dname, fname, 0);
```

This will export the data set **dname** to the file **c:\temp\testdata2.wk1** in Lotus format.

Globals **_dxaschdr, _dxftype, _dxmiss, _dxprcn, _dxprint, _dxtxdlim, _dxtype, _dxwidth, _dxwkshdr**

See also **export, import, importf**

extern (dataloop)

Purpose

Allows access to matrices or strings in memory from inside a data loop.

Format

extern *variable_list*;

Remarks

Commas in *variable_list* are optional.

extern tells the translator not to generate local code for the listed variables, and not to assume they are elements of the input data set.

extern statements should be placed before any reference to the symbols listed. The specified names should not exist in the input data set, or be used in a **make** statement.

Example

This example shows how to assign the contents of an external vector to a new variable in the data set, by iteratively assigning a range of elements to the variable. The reserved variable **x_x** contains the data read from the input data set on each iteration. The external vector must have at least as many rows as the data set.

```
base = 1;  /* used to index a range of elements
           /* from exvec */
dataloop oldata newdata;
   extern base, exvec;
   make ndvar = exvec[seqa(base,1,rows(x_x))];
   /* execute command literally */
   # base = base + rows(x_x);
endata;
```

external

Purpose

Lets the compiler know about symbols that are referenced above or in a separate file from their definitions.

Format

```
external proc dog,cat;
external keyword dog;
external fn dog;
external matrix x,y,z;
external string mstr,cstr;
```

Remarks

See "Procedures and Keywords" in the *User's Guide*.

You may have several procedures in different files that reference the same global variable. By placing an **external** statement at the top of each file, you can let the compiler know if the symbol is a matrix, string, or procedure. If the symbol is listed and strongly typed in an active library, no **external** statement is needed.

If a matrix or string appears in an **external** statement it needs to appear once in a **declare** statement. If no declaration is found, an **Undefined symbol** error will result.

Example

The general eigenvalue procedure, **eigrg**, sets a global variable **_eigerr** if it cannot compute all of the eigenvalues.

```
external matrix _eigerr;


x = rndn(4,4);
xi = inv(x);
xev = eigrg(x);
if _eigerr;
   print "Eigenvalues not computed";
   end;
endif;
```

Without the **external** statement, the compiler would assume that **_eigerr** was a procedure and incorrectly compile this program. The file

containing the **eigrg** procedure also contains an external statement that defines **_eigerr** as a matrix, but this would not be encountered until the **if** statement containing the reference to **_eigerr** in the main program file had already been incorrectly compiled.

See also

declare

eye

Purpose Creates an identity matrix.

Format *y* **= eye(***n***);**

Input

n	scalar, size of identity matrix to be created.

Output

y	NxN identity matrix.

Remarks If *n* is not an integer, it will be truncated to an integer.

The matrix created will contain 1's down the diagonal and 0's everywhere else.

Example

```
x = eye(3);
```

```
x =  1.000000 0.000000 0.000000
     0.000000 1.000000 0.000000
     0.000000 0.000000 1.000000
```

See also **zeros, ones**

fcheckerr

Purpose Gets the error status of a file.

Format *err* **= fcheckerr(***f***);**

Input

f	scalar, file handle of a file opened with **fopen**.

Output

err	scalar, error status.

Remarks If there has been a read or write error on a file, **fcheckerr** returns 1, otherwise 0.

If you pass **fcheckerr** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

fclearerr

Purpose

Gets the error status of a file, then clears it.

Format

err **= fclearerr(***f***);**

Input

f scalar, file handle of a file opened with **fopen**.

Output

err scalar, error status.

Remarks

Each file has an error flag that is set when there is an I/O error on the file. Typically, once this flag is set, you can no longer do I/O on the file, even if the error is a recoverable one. **fclearerr** clears the file's error flag, and you can attempt to continue using it.

If there has been a read or write error on a file, **fclearerr** returns 1, otherwise 0.

If you pass **fclearerr** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

The flag accessed by **fclearerr** is not the same as that accessed by **fstrerror**.

feq, fge, fgt, fle, flt, fne

Purpose

Fuzzy comparison functions. These functions use **_fcmptol** to fuzz the comparison operations to allow for roundoff error.

Format

y **= feq(***a*,*b***);**
y **= fge(***a*,*b***);**
y **= fgt(***a*,*b***);**
y **= fle(***a*,*b***);**
y **= flt(***a*,*b***);**
y **= fne(***a*,*b***);**

Input

a	NxK matrix, first matrix.
b	LxM matrix, second matrix, ExE compatible with *a*.

Global Input

_fcmptol	global scalar, comparison tolerance. The default value is 1.0e-15.

Output

y	scalar, 1 (true) or 0 (false).

Remarks

The return value is true if every comparison is true.

The statement:

```
y = feq(a,b);
```

is equivalent to:

```
y = a eq b;
```

The calling program can reset **_fcmptol** before calling these procedures.

```
_fcmptol = 1e-12;
```

Example

```
x = rndu(2,2);
y = rndu(2,2);
t = fge(x,y);
```

feq, fge, fgt, fle, flt, fne

$$x = \begin{matrix} 0.0382895 & 0.07253527 \\ 0.01471395 & 0.96863611 \end{matrix}$$

$$y = \begin{matrix} 0.25622293 & 0.70636474 \\ 0.00361912 & 0.35913385 \end{matrix}$$

$t = 0.0000000$

Source fcompare.src

Globals **_fcmptol**

See also **dotfeq-dotfne**

fflush

Purpose Flushes a file's output buffer.

Format *ret* **= fflush(***f***);**

Input

f	scalar, file handle of a file opened with **fopen**.

Output

ret	scalar, 0 if successful, -1 if not.

Remarks If **fflush** fails, you can call **fstrerror** to find out why.

If you pass **fflush** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

fft

Purpose

Computes a 1- or 2-D Fast Fourier transform.

Format

y **= fft(***x***);**

Input

x NxK matrix.

Output

y LxM matrix, where L and M are the smallest powers of 2 greater than or equal to N and K, respectively.

Remarks

This computes the FFT of *x*, scaled by 1/N.

This uses a Temperton Fast Fourier algorithm.

If N or K is not a power of 2, *x* will be padded out with zeros before computing the transform.

Example

```
x =  { 22 24 ,
       23 25 };
y = fft(x);
```

$$y = \begin{matrix} 23.500000 & -1.000000 \\ -0.5000000 & 0.00000000 \end{matrix}$$

See also

ffti, rfft, rffti

ffti

Purpose Computes an inverse 1- or 2-D Fast Fourier transform.

Format *y* **= ffti(***x***);**

Input

x	NxK matrix.

Output

y	LxM matrix, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.

Remarks Computes the inverse FFT of *x*, scaled by 1/N.

This uses a Temperton prime factor Fast Fourier algorithm.

Example

```
x =  { 22 24 ,
       23 25 };
y = fft(x);
```

$$y = \begin{matrix} 23.500000 & -1.000000 \\ -0.500000 & 0.0000000 \end{matrix}$$

```
fi = ffti(y);
```

$$fi = \begin{matrix} 22.000000 & 24.000000 \\ 23.000000 & 25.000000 \end{matrix}$$

See also **fft, rfft, rffti**

fftm

Purpose

Computes a multi-dimensional FFT.

Format

y **= fftm(***x*,*dim***);**

Input

x	Mx1 vector, data.
dim	Kx1 vector, size of each dimension.

Output

y	Lx1 vector, FFT of *x*.

Remarks

The multi-dimensional data are laid out in a recursive or heirarchical fashion in the vector *x*. That is to say, the elements of any given dimension are stored in sequence left to right within the vector, with each element containing a sequence of elements of the next smaller dimension. In abstract terms, a 4-dimensional 2x2x2x2 hypercubic *x* would consist of two cubes in sequence, each cube containing two matrices in sequence, each matrix containing two rows in sequence, and each row containing two columns in sequence. Visually, *x* would look something like this:

$$X_{hyper} = X_{cube1} \mid X_{cube2}$$
$$X_{cube1} = X_{mat1} \mid X_{mat2}$$
$$X_{mat1} = X_{row1} \mid X_{row2}$$
$$X_{row1} = X_{col1} \mid X_{col2}$$

Or, in an extended GAUSS notation, *x* would be:

```
Xhyper = x[1,.,.,. ] | x[2,.,.,.  ];
Xcube1 = x[1,1,.,. ] | x[1,2,.,.  ];
Xmat1  = x[1,1,1,. ] | x[1,1,2,.  ];
Xrow1  = x[1,1,1,1 ] | x[1,1,1,2  ];
```

To be explicit, *x* would be laid out like this:

```
x[1,1,1,1] x[1,1,1,2] x[1,1,2,1] x[1,1,2,2]
x[1,2,1,1] x[1,2,1,2] x[1,2,2,1] x[1,2,2,2]
x[2,1,1,1] x[2,1,1,2] x[2,1,2,1] x[2,1,2,2]
x[2,2,1,1] x[2,2,1,2] x[2,2,2,1] x[2,2,2,2]
```

If you look at the last diagram for the layout of *x* you'll notice that each line actually constitutes the elements of an ordinary matrix in normal row-major order. This is easy to achieve with **vecr**. Further, each pair of lines or "matrices" constitutes one of the desired cubes, again with all the elements in the correct order. And finally, the two cubes combine to form the hypercube. So, the process of construction is simply a sequence of concatenations of column vectors, with a **vecr** step if necessary to get started.

Here's an example, this time working with a 2x3x2x3 hypercube.

```
let dim = 2 3 2 3;

let x1[2,3] = 1 2 3 4 5 6;
let x2[2,3] = 6 5 4 3 2 1;
let x3[2,3] = 1 2 3 5 7 11;
xc1 = vecr(x1)|vecr(x2)|vecr(x3); /* cube 1 */

let x1 = 1 1 2 3 5 8;
let x2 = 1 2 6 24 120 720;
let x3 = 13 17 19 23 29 31;
xc2 = x1|x2|x3;                   /* cube 2 */

xh = xc1|xc2;                   /* hypercube */
xhfft = fftm(xh,dim);

let dimi = 2 4 2 4;
xhffti = fftmi(xhfft,dimi);
```

We left out the **vecr** step for the 2nd cube. It's not really necessary when you're constructing the matrices with **let** statements.

dim contains the dimensions of *x*, beginning with the highest dimension. The last element of **dim** is the number of columns, the next to the last element of **dim** is the number of rows, and so on. Thus

fftm

```
dim = { 2, 3, 3 };
```

indicates that the data in *x* is a 2x3x3 three-dimensional array, i.e., two 3x3 matrices of data. Suppose that **x1** is the first 3x3 matrix and **x2** the second 3x3 matrix, then **x = vecr(x1) | vecr(x2)**.

The size of **dim** tells you how many dimensions *x* has.

The arrays have to be padded in each dimension to the nearest power of two. Thus the output array can be larger than the input array. In the 2x3x2x3 hypercube example, *x* would be padded from 2x3x2x3 out to 2x4x2x4. The input vector would contain 36 elements, while the output vector would contain 64 elements. You may have noticed that we used a **dimi** with padded values at the end of the example to check our answer.

Source

fftm.src

See also

fftmi, fft, ffti, fftn

fftmi

Purpose

Computes a multi-dimensional inverse FFT.

Format

y **= fftmi(***x*,*dim***);**

Input

x	Mx1 vector, data.
dim	Kx1 vector, size of each dimension.

Output

y	Lx1 vector, inverse FFT of *x*.

Remarks

The multi-dimensional data are laid out in a recursive or heirarchical fashion in the vector *x*. That is to say, the elements of any given dimension are stored in sequence left to right within the vector, with each element containing a sequence of elements of the next smaller dimension. In abstract terms, a 4-dimensional 2x2x2x2 hypercubic *x* would consist of two cubes in sequence, each cube containing two matrices in sequence, each matrix containing two rows in sequence, and each row containing two columns in sequence. Visually, *x* would look something like this:

$$X_{hyper} = X_{cube1} \mid X_{cube2}$$
$$X_{cube1} = X_{mat1} \mid X_{mat2}$$
$$X_{mat1} = X_{row1} \mid X_{row2}$$
$$X_{row1} = X_{col1} \mid X_{col2}$$

Or, in an extended GAUSS notation, *x* would be:

```
Xhyper = x[1,.,.,. ] | x[2,.,.,.  ];
Xcube1 = x[1,1,.,. ] | x[1,2,.,.  ];
Xmat1  = x[1,1,1,. ] | x[1,1,2,.  ];
Xrow1  = x[1,1,1,1 ] | x[1,1,1,2  ];
```

To be explicit, *x* would be laid out like this:

```
x[1,1,1,1] x[1,1,1,2] x[1,1,2,1] x[1,1,2,2]
x[1,2,1,1] x[1,2,1,2] x[1,2,2,1] x[1,2,2,2]
x[2,1,1,1] x[2,1,1,2] x[2,1,2,1] x[2,1,2,2]
x[2,2,1,1] x[2,2,1,2] x[2,2,2,1] x[2,2,2,2]
```

If you look at the last diagram for the layout of *x* you'll notice that each line actually constitutes the elements of an ordinary matrix in normal row-major order. This is easy to achieve with **vecr**. Further, each pair of lines or "matrices" constitutes one of the desired cubes, again with all the elements in the correct order. And finally, the two cubes combine to form the hypercube. So, the process of construction is simply a sequence of concatenations of column vectors, with a **vecr** step if necessary to get started.

Here's an example, this time working with a 2x3x2x3 hypercube.

```
let dim = 2 3 2 3;


let x1[2,3] = 1 2 3 4 5 6;
let x2[2,3] = 6 5 4 3 2 1;
let x3[2,3] = 1 2 3 5 7 11;
xc1 = vecr(x1)|vecr(x2)|vecr(x3); /* cube 1 */


let x1 = 1 1 2 3 5 8;
let x2 = 1 2 6 24 120 720;
let x3 = 13 17 19 23 29 31;
xc2 = x1|x2|x3;                   /* cube 2 */


xh = xc1|xc2;                   /* hypercube */
xhffti = fftmi(xh,dim);
```

We left out the **vecr** step for the 2nd cube. It's not really necessary when you're constructing the matrices with **let** statements.

dim contains the dimensions of *x*, beginning with the highest dimension. The last element of **dim** is the number of columns, the next to the last element of **dim** is the number of rows, and so on. Thus

```
dim = { 2, 3, 3 };
```

indicates that the data in *x* is a 2x3x3 three-dimensional array, i.e., two 3x3 matrices of data. Suppose that **x1** is the first 3x3 matrix and **x2** the second 3x3 matrix, then **x = vecr(x1) | vecr(x2)**.

The size of **dim** tells you how many dimensions *x* has.

The arrays have to be padded in each dimension to the nearest power of two. Thus the output array can be larger than the input array. In the 2x3x2x3 hypercube example, *x* would be padded from 2x3x2x3 out to 2x4x2x4. The input vector would contain 36 elements, while the output vector would contain 64 elements.

Source `fftm.src`

See also **fftmi, fft, ffti, fftn**

fftn

Purpose

Computes a complex 1- or 2-D FFT.

Format

y **= fftn(***x***);**

Input

x NxK matrix.

Output

y LxM matrix, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.

Remarks

fftn uses the Temperton prime factor FFT algorithm. This algorithm can compute the FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. GAUSS implements the Temperton algorithm for any power of 2, 3, and 5, and one factor of 7. Thus, **fftn** can handle any matrix whose dimensions can be expressed as

$2^p \times 3^q \times 5^r \times 7^s$, p,q,r nonnegative integers, $s = 0$ or 1

If a dimension of *x* does not meet this requirement, it will be padded with zeros to the next allowable size before the FFT is computed.

fftn pads matrices to the next allowable dimensions; however, it generally runs faster for matrices whose dimensions are highly composite numbers, i.e., products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20% faster than a 32768x1 vector, because 33600 is a highly composite number, $2^6 \times 3 \times 5^2 \times 7$, whereas 32768 is a simple power of 2, 2^{15}. For this reason, you may want to hand-pad matrices to optimum dimensions before passing them to **fftn**. The Run-Time Library includes a routine, **optn**, for determining optimum dimensions.

The Run-Time Library also includes the **nextn** routine, for determining allowable dimensions for a matrix. (You can use this to see the dimensions to which **fftn** would pad a matrix.)

fftn scales the computed FFT by 1/(L*M).

See also

fft, ffti, fftm, fftmi, rfft, rffti, rfftip, rfftn, rfftnp, rfftp

fgets

Purpose

Reads a line of text from a file.

Format

str **= fgets(***f*,*maxsize*);

Input

f	scalar, file handle of a file opened with **fopen**.
maxsize	scalar, maximum size of string to read in, including the terminating null byte.

Output

str string.

Remarks

fgets reads text from a file into a string. It reads up to a newline, the end of the file, or *maxsize*-1 characters. The result is placed in *str*, which is then terminated with a null byte. The newline, if present, is retained.

If the file is already at end-of-file when you call **fgets**, your program will terminate with an error. Use **eof** in conjunction with **fgets** to avoid this.

If the file was opened for update (see **fopen**) and you are switching from writing to reading, don't forget to call **fseek** or **fflush** first, to flush the file's buffer.

If you pass **fgets** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

fgetsa

Purpose

Reads lines of text from a file into a string array.

Format

sa **= fgetsa(***f*,*numl*);

Input

f	scalar, file handle of a file opened with **fopen**.
numl	scalar, number of lines to read.

Output

sa	Nx1 string array, N ≤ *numl*.

Remarks

fgetsa reads up to *numl* lines of text. If **fgetsa** reaches the end of the file before reading *numl* lines, *sa* will be shortened. Lines are read in the same manner as **fgets**, except that no limit is placed on the size of a line. Thus, **fgetsa** always returns complete lines of text. Newlines are retained. If *numl* is 1, **fgetsa** returns a string. (This is one way to read a line from a file without placing a limit on the length of the line.)

If the file is already at end-of-file when you call **fgetsa**, your program will terminate with an error. Use **eof** in conjunction with **fgetsa** to avoid this. If the file was opened for update (see **fopen**) and you are switching from writing to reading, don't forget to call **fseek** or **fflush** first, to flush the file's buffer.

If you pass **fgetsa** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

fgetsat

Purpose Reads lines of text from a file into a string array.

Format *sa* **= fgetsat(***f***,** *numl***);**

Input

f	scalar, file handle of a file opened with **fopen**.
numl	scalar, number of lines to read.

Output

sa	Nx1 string array, N ≤ *numl*.

Remarks **fgetsat** operates identically to **fgetsa**, except that newlines are not retained as text is read into *sa*.

In general, you don't want to use **fgetsat** on files opened in binary mode (see **fopen**). **fgetsat** drops the newlines, but it does NOT drop the carriage returns that precede them on some platforms. Printing out such a string array can produce unexpected results.

fgetst

Purpose

Reads a line of text from a file.

Format

str **= fgetst(***f*, *maxsize*);

Input

f	scalar, file handle of a file opened with **fopen**.
maxsize	scalar, maximum size of string to read in, including the null terminating byte.

Output

str string.

Remarks

fgetst operates identically to **fgets**, except that the newline is not retained in the string.

In general, you don't want to use **fgetst** on files opened in binary mode (see **fopen**). **fgetst** drops the newline, but it does NOT drop the preceding carriage return used on some platforms. Printing out such a string can produce unexpected results.

fileinfo

Purpose

Returns names and information for files that match a specification.

Format

{ *fnames*,*finfo* **} = fileinfo(***fspec***);**

Input

fspec string, file specification. Can include path. Wildcards are allowed in the filename.

Output

fnames Nx1 string array of all filenames that match, null string if none are found.

finfo Nx13 matrix, information about matching files.

UNIX

[N, 1]	filesystem ID
[N, 2]	inode number
[N, 3]	mode bit mask
[N, 4]	number of links
[N, 5]	user ID
[N, 6]	group ID
[N, 7]	device ID (char/block special files only)
[N, 8]	size in bytes
[N, 9]	last access time
[N,10]	last data modification time
[N,11]	last file status change time
[N,12]	preferred I/O block size
[N,13]	number of 512-byte blocks allocated

OS/2, Windows

[N, 1]	drive number (A = 0, B = 1, etc.)
[N, 2]	n/a, 0
[N, 3]	mode bit mask
[N, 4]	number of links, always 1
[N, 5]	n/a, 0
[N, 6]	n/a, 0
[N, 7]	n/a, 0
[N, 8]	size in bytes

[N, 9]	last access time
[N,10]	last data modification time
[N,11]	creation time
[N,12]	n/a, 0
[N,13]	n/a, 0

DOS

[N, 1]	drive number (A = 0, B = 1, etc.)
[N, 2]	n/a, 0
[N, 3]	mode bit mask
[N, 4]	number of links, always 1
[N, 5]	n/a, 0
[N, 6]	n/a, 0
[N, 7]	n/a, 0
[N, 8]	size in bytes
[N, 9]	n/a, 0
[N,10]	last data modification time
[N,11]	n/a, 0
[N,12]	n/a, 0
[N,13]	n/a, 0

finfo will be a scalar zero if no matches are found.

Remarks

fnames will contain file *names* only; any path information that was passed is dropped.

The time stamp fields (*finfo*[N,9]-[N,11]) are expressed as the number of seconds since midnight, Jan. 1, 1970, Coordinated Universal Time (UTC).

See also

files, filesa

filesa

Purpose Returns a string array of file names.

Format *y* **= filesa(***n***);**

Input

n string, file specification to search for. Can include path. Wildcards are allowed in the filename.

Output

y Nx1 string array of all filenames that match, or null string if none are found.

Remarks *y* will contain file *names* only; any path information that was passed is dropped.

Example

```
y = filesa("ch*");
```

In this example all files listed in the current directory that begin with "ch" will be returned.

```
proc exist(filename);
   retp(not filesa(filename) $== "" );
endp;
```

This procedure will return 1 if the file exists or 0 if not.

See also **fileinfo, files, shell**

floor

Purpose Rounds down toward -∞.

Format *y* **= floor(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix containing the elements of *x* rounded down.

Remarks This rounds every element in the matrix *x* down to the nearest integer.

Example

```
x = 100*rndn(2,2);
```

$$x = \begin{matrix} 77.68 & -14.10 \\ 4.73 & -158.88 \end{matrix}$$

```
f = floor(x);
```

$$f = \begin{matrix} 77.00 & -15.00 \\ 4.00 & -159.00 \end{matrix}$$

See also **ceil, round, trunc**

fmod

Purpose

Computes the floating-point remainder of *x/y*.

Format

r **= fmod(***x*,*y***);**

Input

x	NxK matrix.
y	LxM matrix, ExE conformable with *x*.

Output

r	max(N,L) by max(K,M) matrix.

Remarks

Returns the floating-point remainder *r* of *x/y* such that $x = iy + r$, where *i* is an integer, *r* has the same sign as *x*, and $|r| < |y|$.

Compare this with **%**, the modulo division operator. (See "Operators" in the *User's Guide*.)

Example

```
x = seqa(1.7,2.3,5)';
y = 2;
r = fmod(x,y);
```

x = 1.7 4 6.3 8.6 10.9

r = 1.7 0 0.3 0.6 0.9

fn

Purpose Allows user to create one-line functions.

Format **fn** *fn_name*(*args*) **=** *code_for_function*;

Remarks Functions can be called in the same way as other procedures.

Example

```
fn area(r) = pi*r*r;
a = area(4);
```

a = 50.265482

fonts

Purpose Loads fonts to be used in the graph.

Library **pgraph**

Format **fonts(***str***);**

Input

str string or character vector containing the names of fonts to be used in the plot.

Simplex	standard sans serif font.
Simgrma	Simplex Greek, math.
Microb	bold and boxy.
Complex	standard font with serif.

The first font specified will be used for the axes numbers.

If *str* is a null string, or **fonts** is not called, Simplex is loaded by default.

Remarks For information on how to select fonts within a text string, see "Publication Quality Graphics in the *User's Guide*.

Source pgraph.src

See also **title, xlabel, ylabel, zlabel**

fopen

Purpose

Opens a file.

Format

f **= fopen(***filename***,***omode***);**

Input

filename	string, name of file to open.
omode	string, file I/O mode. (See Remarks, below.)

Output

f	scalar, file handle.

Portability

UNIX

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

Remarks

filename can contain a path specification.

omode is a sequence of characters that specify the mode in which to open the file. The first character must be one of:

r	Open an existing file for reading. If the file does not exist, **fopen** fails.
w	Open or create a file for writing. If the file already exists, its current contents will be destroyed.
a	Open or create a file for appending. All output is appended to the end of the file.

To this can be appended a **+** and/or a **b**. The **+** indicates the file is to opened for reading and writing, or update, as follows:

r+	Open an existing file for update. You can read from or write to any location in the file. If the file does not exist, **fopen** fails.
w+	Open or create a file for update. You can read from or write to any location in the file. If the file already exists, its current contents will be destroyed.
a+	Open or create a file for update. You can read from any location in the file, but all output will be appended to the end of the file.

Finally, the **b** indicates whether the file is to be opened in text or binary mode. If the file is opened in binary mode, the contents of the file are read verbatim; likewise, anything output to the file is written verbatim. In text mode (the default), carriage return-linefeed sequences are converted on

input to linefeeds, or newlines. Likewise on output, newlines are converted to carriage return-linefeeds. Also in text mode, if a CTRL-Z (char 26) is encountered during a read, it is interpreted as an end-of-file character, and reading ceases. In binary mode, CTRL-Z is read in uninterpreted.

The order of **+** and **b** is not significant; **rb+** and **r+b** mean the same thing.

You can both read from and write to a file opened for update. However, before switching from one to the other, you must make an **fseek** or **fflush** call, to flush the file's buffer.

If **fopen** fails, it returns a 0.

Use **close** and **closeall** to close files opened with **fopen**.

for

Purpose

Begins a **for** loop.

Format

```
for i (start, stop, step);
   .
   .
   .
endfor;
```

Input

i	literal, the name of the counter variable.
start	scalar expression, the initial value of the counter.
stop	scalar expression, the final value of the counter.
step	scalar expression, the increment value.

Remarks

The counter is strictly local to the loop. The expressions *start*, *stop*, and *step* are evaluated only once when the loop initializes. They are converted to integers and stored local to the loop.

The **for** loop is optimized for speed and is much faster than a **do** loop.

The commands **break** and **continue** are supported. The **continue** command steps the counter and jumps to the top of the loop. The **break** command terminates the current loop.

The loop terminates when the value of *i* exceeds *stop*. If **break** is used to terminate the loop and you want the final value of the counter, you need to assign it to a variable before the **break** statement (see the third example, following).

Example

Example 1

```
x = zeros(10, 5);
for i (1, rows(x), 1);
   for j (1, cols(x), 1);
      x[i,j] = i*j;
   endfor;
endfor;
```

Example 2

```
x = rndn(3,3);
y = rndn(3,3);
for i (1, rows(x), 1);
   for j (1, cols(x), 1);
      if x[i,j] ≥ y[i,j];
         continue;
      endif;
      temp = x[i,j];
      x[i,j] = y[i,j];
      y[i,j] = temp;
   endfor;
endfor;
```

Example 3

```
li = 0;
x = rndn(100,1);
y = rndn(100,1);
for i (1, rows(x), 1);
   if x[i] /= y[i];
      li = i;
      break;
   endif;
endfor;
if li;
   print “Compare failed on row ” li;
endif;
```

format

Purpose

Controls the format of matrices and numbers printed out with **print** or **lprint** statements.

Format

format [[*/typ*]] [[*/fmted*]] [[*/mf*]] [[*/jnt*]] [[*f*,*p*]];

Input

/typ literal, symbol type flag(s). Indicate which symbol types you are setting the output format for.

/mat, /sa, /str	Formatting parameters are maintained separately for matrices (**/mat**), string arrays (**/sa**), and strings (**/str**). You can specify more than one */typ* flag; the format will be set for all types indicated. If no */typ* flag is listed, format assumes **/mat**.

/fmted literal, enable formatting flag.

/on, /off	Enable/disable formatting. When formatting is disabled, the contents of a variable are dumped to the window in a "raw" format. **/off** is currently supported only for strings. Raw format for strings means that the entire string is printed, starting at the current cursor position. When formatting is enabled for strings, they are handled the same as string arrays. This shouldn't be too surprising, since a string is actually a 1x1 string array.

/mf literal, matrix row format flag.

/m0	no delimiters before or after rows when printing out matrices.
/m1 or /mb1	print 1 carriage return/line feed pair before each row of a matrix with more than 1 row.
/m2 or /mb2	print 2 carriage return/line feed pairs before each row of a matrix with more than 1 row.
/m3 or /mb3	print "Row 1", "Row 2"... before each row of a matrix with more than one row.

/ma1	print 1 carriage return/line feed pair after each row of a matrix with more than 1 row.
/ma2	print 2 carriage return/line feed pairs after each row of a matrix with more than 1 row.
/a1	print 1 carriage return/line feed pair after each row of a matrix.
/a2	print 2 carriage return/line feed pairs after each row of a matrix.
/b1	print 1 carriage return/line feed pair before each row of a matrix.
/b2	print 2 carriage return/line feed pairs before each row of a matrix.
/b3	print “Row 1”, “Row 2”... before each row of a matrix.

/jnt literal, matrix element format flagcontrols justification, notation and trailing character.

Right-Justified

/rd	Signed decimal number in the form [[-]] ####.####, where #### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed.
/re	Signed number in the form [[-]] ####.####, where # is one decimal digit, ## is one or more decimal digits depending on the precision, and ### is three decimal digits. If precision is 0, the form will be [[-]] #E±### with no decimal point printed.

/ro	This will give a format like **/rd** or **/re** depending on which is most compact for the number being printed. A format like **/re** will be used only if the exponent value is less than -4 or greater than the precision. If a **/re** format is used, a decimal point will always appear. The precision signifies the number of significant digits displayed.
/rz	This will give a format like **/rd** or **/re** depending on which is most compact for the number being printed. A format like **/re** will be used only if the exponent value is less than -4 or greater than the precision. If a **/re** format is used, trailing zeros will be supressed and a decimal point will appear only if one or more digits follow it. The precision signifies the number of significant digits displayed.
Left-Justified	
/ld	Signed decimal number in the form [[-]] ####.####, where #### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed. If the number is positive, a space character will replace the leading minus sign.
/le	Signed number in the form [[-]] #.##E±###, where # is one decimal digit, ## is one or more decimal digits depending on the precision, and ### is three decimal digits. If precision is 0, the form will be [[-]] #E±### with no decimal point printed. If the number is positive, a space character will replace the leading minus sign.

/lo	This will give a format like **/ld** or **/le** depending on which is most compact for the number being printed. A format like **/le** will be used only if the exponent value is less than -4 or greater than the precision. If a **/le** format is used, a decimal point will always appear. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.
/lz	This will give a format like **/ld** or **/le** depending on which is most compact for the number being printed. A format like **/le** will be used only if the exponent value is less than -4 or greater than the precision. If a **/le** format is used, trailing zeros will be supressed and a decimal point will appear only if one or more digits follow it. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.

Trailing Character

The following characters can be added to the */jnt* parameters above to control the trailing character if any:

```
format /rdn 1,3;
```

s	The number will be followed immediately by a space character. This is the default.
c	The number will be followed immediately by a comma.
t	The number will be followed immediately by a tab character.
n	No trailing character.

f scalar expression, controls the field width.

p scalar expression, controls the precision.

Remarks

If character elements are to be printed, the precision should be at least 8 or the elements will be truncated. This does not affect the string data type.

format

For numeric values in matrices, *p* sets the number of significant digits to be printed. For string arrays, strings, and character elements in matrices, *p* sets the number of characters to be printed. If a string is shorter than the specified precision, the entire string is printed. For string arrays and strings, $p = -1$ means print the entire string, regardless of its length. $p = -1$ is illegal for matrices; setting $p \geq 8$ means the same thing for character elements.

The /*xxx* slash parameters are optional. Field and precision are optional also but if one is included, then both must be included.

Slash parameters, if present, must precede the field and precision parameters.

A **format** statement stays in effect until it is overridden by a new **format** statement. The slash parameters may be used in a **print** statement to override the current default.

f and *p* may be any legal expressions that return scalars. Nonintegers will be truncated to integers.

The total width of field will be overridden if the number is too big to fit into the space allotted. For instance, **format /rds 1,0** can be used to print integers with a single space between them, regardless of the magnitudes of the integers.

Complex numbers are printed with the sign of the imaginary half separating them and an "i" appended to the imaginary half. Also, the field parameter refers to the width of field for each half of the number, so a complex number printed with a field of 8 will actually take (at least) 20 spaces to print. The character printed after the imaginary part can be changed (for example, to a "j") with the **sysstate** function, case 9.

The default when GAUSS is first started is:

```
format /mb1 /ros 16,8;
```

Example

This code:

```
x = rndn(3,3);

format /m1 /rd 16,8;
print x;
```

produces:

```
  –1.63533465   1.61350700    –1.06295179
   0.26171282   0.27972294    –1.38937242
   0.58891114   0.46812202     1.08805960
```

This code:

```
format /m1 /rzs 1,10;
print x;
```

produces:

```
 –1.6353346     1.613507    –1.0629518
 0.26171282   0.27972294    –1.3893724
 0.58891114   0.46812202     1.0880596
```

This code:

```
format /m3 /rdn 16,4;
print x;
```

produces:

```
Row 1
       -1.6353  1.6135  -1.0630
Row 2
        0.2617  0.2797  -1.3894
Row 3
        0.5889  0.4681   1.0881
```

This code:

```
format /m1 /ldn 16,4;
print x;
```

produces:

```
  −1.6353   1.6135    −1.0630
   0.2617   0.2797    −1.3894
   0.5889   0.4681     1.0881
```

This code:

```
format /m1 /res 12,4;
print x;
```

produces:

```
  -1.6353E+000    1.6135E+000   -1.0630E+000
   2.6171E-001    2.7972E-001   -1.3894E+000
   5.8891E-001    4.6812E-001    1.0881E+000
```

See also **formatcv, formatnv, print, lprint, output**

formatcv

Purpose Sets the character data format used by **printfmt**.

Format *oldfmt* **= formatcv(***newfmt***);**

Input *newfmt* 1x3 vector, the new format specification.

Output *oldfmt* 1x3 vector, the old format specification.

Remarks See **printfm** for details on the format vector.

Example This example saves the old format, sets the format desired for printing *x*, prints *x*, then restores the old format. This code:

```
x = { A 1, B 2, C 3 };
oldfmt = formatcv("*.*s" ~ 3 ~ 3);
call printfmt(x,0~1);
call formatcv(oldfmt);
```

produces:

```
A          1
B          2
C          3
```

Source gauss.src

Globals **__fmtcv**

See also **formatnv, printfm, printfmt**

formatnv

Purpose Sets the numeric data format used by **printfmt**.

Format *oldfmt* **= formatnv(***newfmt***);**

Input *newfmt* 1x3 vector, the new format specification.

Output *oldfmt* 1x3 vector, the old format specification.

Remarks See **printfm** for details on the format vector.

Example This example saves the old format, sets the format desired for printing *x*, prints *x*, then restores the old format. This code:

```
x = { A 1, B 2, C 3 };
oldfmt = formatnv("*.*lf" ~ 8 ~ 4);
call printfmt(x,0~1);
call formatnv(oldfmt);
```

produces:

```
A  1
B  2
C  3
```

Source gauss.src

Globals __fmtnv

See also **formatcv, printfm, printfmt**

fputs

Purpose

Writes strings to a file.

Format

numl **= fputs(***f*,*sa***);**

Input

f	scalar, file handle of a file opened with **fopen**.
sa	string or string array.

Output

numl	scalar, the number of lines written to the file.

Portability

UNIX

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

Remarks

fputs writes the contents of each string in *sa*, minus the null terminating byte, to the file specified. If the file was opened in text mode (see **fopen**), any newlines present in the strings are converted to carriage return-linefeed sequences on output. If *numl* is not equal to the number of elements in *sa*, there may have been an I/O error while writing the file. You can use **fcheckerr** or **fclearerr** to check this. If there was an error, you can call **fstrerror** to find out what it was. If the file was opened for update (see **fopen**) and you are switching from reading to writing, don't forget to call **fseek** or **fflush** first, to flush the file's buffer. If you pass **fputs** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

fputst

Purpose

Writes strings to a file.

Format

numl **= fputst (***f*,*sa*);

Input

f	scalar, file handle of a file opened with **fopen**.
sa	string or string array.

Output

numl	scalar, the number of lines written to the file.

Portability

UNIX

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

Remarks

fputst works identically to **fputs**, except that a newline is appended to each string that is written to the file. If the file was opened in text mode (see **fopen**), these newlines are also converted to carriage return-linefeed sequences on output.

fseek

Purpose

Positions the file pointer in a file.

Format

ret **= fseek(***f*,*offs*,*base***);**

Input

f	scalar, file handle of a file opened with **fopen**.	
offs	scalar, offset (in bytes).	
base	scalar, base position.	
	0	beginning of file.
	1	current position of file pointer.
	2	end of file.

Output

ret scalar, 0 if successful, 1 if not.

Portability

UNIX

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

Remarks

fseek moves the file pointer *offs* bytes from the specified *base* position. *offs* can be positive or negative. The call may fail if the file buffer needs to be flushed (see **fflush**).

If **fseek** fails, you can call **fstrerror** to find out why.

For files opened for update (see **fopen**), the next operation can be a read or a write.

fseek is not reliable when used on files opened in text mode (see **fopen**). This has to do with the conversion of carriage return-linefeed sequences to newlines. In particular, an **fseek** that follows one of the **fgets***xx* or **fputs***xx* commands may not produce the expected result. For example:

```
p = ftell(f);
s = fgetsa(f,7);
call fseek(f,p,0);
```

is not reliable. The best results are obtained by **fseek**'ing to the beginning of the file and then **fseek**'ing to the desired location, as in

fseek

```
p = ftell(f);
s = fgetsa(f,7);
call fseek(f,0,0);
call fseek(f,p,0);
```

If you pass **fseek** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

fstrerror

Purpose

Returns an error message explaining the cause of the most recent file I/O error.

Format

s **= fstrerror;**

Output

s string, error message.

Remarks

Any time an I/O error occurs on a file opened with **fopen**, an internal error flag is updated. (This flag, unlike those accessed by **fcheckerr** and **fclearerr**, is not specific to a given file; rather, it is system-wide.) **fstrerror** returns an error message based on the value of this flag, clearing it in the process. If no error has occurred, a null string is returned.

Since **fstrerror** clears the error flag, if you call it twice in a row, it will always return a null string the second time.

ftell

Purpose

Gets the position of the file pointer in a file.

Format

pos **= ftell(***f***);**

Input

f	scalar, file handle of a file opened with **fopen**.

Output

pos	scalar, current position of the file pointer in a file.

Remarks

ftell returns the position of the file pointer in terms of bytes from the beginning of the file. The call may fail if the file buffer needs to be flushed (see **fflush**).

If an error occurs, **ftell** returns -1. You can call **fstrerror** to find out what the error was.

If you pass **ftell** the handle of a file opened with **open** (i.e., a data set or matrix file), your program will terminate with a fatal error.

ftocv

Purpose

Converts a matrix containing floating point numbers into a matrix containing the decimal character representation of each element.

Format

y **= ftocv(***x*,*field*,*prec***);**

Input

x	NxK matrix containing numeric data to be converted.
field	scalar, minimum field width.
prec	scalar, the numbers created will have *prec* places after the decimal point.

Output

y	NxK matrix containing the decimal character equivalent of the corresponding elements in *x* in the format defined by *field* and *prec*.

Remarks

If a number is narrower than *field*, it will be padded on the left with zeros.

If *prec* = 0, the decimal point will be suppressed.

Example

```
y = seqa(6,1,5);
x = 0 $+ “cat” $+ ftocv(y,2,0);
```

```
      cat06
      cat07
x =   cat08
      cat09
      cat10
```

Notice that the (0 **$+**) above was necessary to force the type of the result to matrix because the string constant **cat** would be of type string. The left operand in an expression containing a **$+** operator controls the type of the result.

See also

ftos

ftos

Purpose

Converts a scalar into a string containing the decimal character representation of that number.

Format

y **= ftos(***x*,*fmat*,*field*,*prec***);**

Input

x	scalar, the number to be converted.
fmat	string, the format string to control the conversion.
field	scalar or 2x1 vector, the minimum field width. If *field* is 2x1, it specifies separate field widths for the real and imaginary parts of *x*.
prec	scalar or 2x1 vector, the number of places following the decimal point. If *prec* is 2x1, it specifies separate precisions for the real and imaginary parts of *x*.

Output

y	string containing the decimal character equivalent of *x* in the format specified.

Remarks

The format string corresponds to the **format** */jnt* (justification, notation, trailing character) slash parameter as follows:

```
/rdn "%*.*lf"
/ren "%*.*lE"
/ron "%#*.*lG"
/rzn "%*.*lG"

/ldn "%- *.*lf"
/len "%- *.*lE"
/lon "%-# *.*lG"
/lzn "%- *.*lG"
```

If *x* is complex, you can specify separate formats for the real and imaginary parts by putting two format specifications in the format string. You can also specify separate fields and precisions. You can position the sign of the imaginary part by placing a "+" between the two format specifications. If you use two formats, no "i" is appended to the imaginary

part. This is so you can use an alternate format if you prefer, for example, prefacing the imaginary part with a "j".

The format string can be a maximum of 80 characters.

If you want special characters to be printed after *x*, include them as the last characters of the format string. For example:

`"%*.*lf,"`	right-justified decimal followed by a comma.
`"%-*.*s"`	left-justified string followed by a space.
`"%*.*lf"`	right-justified decimal followed by nothing.

You can embed the format specification in the middle of other text.

```
"Time: %*.*lf seconds."
```

If you want the beginning of the field padded with zeros, then put a "0" before the first "*" in the format string:

`"%0*.*lf"`	right-justified decimal.

If *prec* = 0, the decimal point will be suppressed.

Example

You can create custom formats for complex numbers with **ftos**. For example,

```
let c = 24.56124+6.3224e-2i;


field = 1;
prec = 3|5;
fmat = "%lf + j%le is a complex number.";
cc = ftos(c,fmat,field,prec);
```

results in

```
cc = "24.561 + j6.32240e-02 is a complex
number."
```

Some other things you can do with **ftos**:

```
let x = 929.857435324123;
let y = 5.46;
let z = 5;
```

ftos

```
field = 1;
prec = 0;
fmat = "%*.*lf";
zz = ftos(z,fmat,field,prec);

field = 1;
prec = 10;
fmat = "%*.*lE";
xx = ftos(x,fmat,field,prec);

field = 7;
prec = 2;
fmat = "%*.*lf seconds";
s1 = ftos(x,fmat,field,prec);
s2 = ftos(y,fmat,field,prec);

field = 1;
prec = 2;
fmat = "The maximum resistance is %*.*lf
       ohms.";
om = ftos(x,fmat,field,prec);
```

The results:

```
zz = "5"
xx = "9.2985743532E+02"
s1 = " 929.86 seconds"
s2 = "   5.46 seconds"
om = "The maximum resistance is 929.86 ohms."
```

See also `ftocv, stof, format`

ftostrC

Purpose

Converts a matrix to a string array using a C language format specification.

Format

sa **= ftostrC(***x*, *fmt***);**

Input

x	NxK matrix, real or complex.
fmt	Kx1, 1xK or 1x1 string array containing format information.

Output

sa	NxK string array.

Remarks

If *fmt* has K elements, each column of *sa* can be formatted separately. If *x* is complex, there must be two format specifications in each element of *fmt*.

Example

```
declare string fmtr = {
"%6.3lf",
"%11.8lf"
};

declare string fmtc = {
"(%6.3lf, %6.3lf)",
"(%11.8lf, %11.8lf)"
};

xr = rndn(4, 2);
xc = sqrt(xr')';

sar = ftostrC(xr, fmtr);
sac = ftostrC(xc, fmtc);
```

```
print sar;
print sac;
```

produces:

```
-0.166      1.05565441
-1.590     -0.79283296
 0.130     -1.84886957
 0.789      0.86089687

( 0.000, -0.407)      ( 1.02745044,  0.00000000)
( 0.000, -1.261)      ( 0.00000000, -0.89041168)
( 0.361,  0.000)      ( 0.00000000, -1.35973143)
( 0.888,  0.000)      ( 0.92784529,  0.00000000)
```

See also **strtof, strtofcplx**

gamma

Purpose Returns the value of the gamma function.

Format *y* **= gamma(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix.

Remarks For each element of *x*, this function returns the integral

$$\int_0^{\infty} t^{(x-1)} e^{-t} dt$$

All elements of *x* must be positive and less than or equal to 169. Values of *x* greater than 169 will cause an overflow.

The natural log of **gamma** is often what is required and it can be computed without the overflow problems of **gamma**. **lnfact** can be used to compute log gamma.

Example

```
y = gamma(2.5);
```

y = 1.32934

See also **cdfchic, cdfbeta, cdffc, cdfn, cdfnc, cdftc, erf, erfc**

gammaii

Purpose Computes the inverse incomplete gamma function.

Format *x* **= gammaii(***a***,***p***);**

Input

a	MxN matrix, exponents.
p	KxL matrix, ExE conformable with *a*, incomplete gamma values.

Output

x	max(M,K) by max(N,L) matrix, abscissae.

Source cdfchii.src

Globals **_ginvinc, __macheps**

gausset

Purpose Resets the global control variables declared in gauss.dec.

Format **gausset;**

Source gauss.src

Globals **__altnam, __con, __ff, __fmtcv, __fmtnv, __header, __miss, __output, __row, __rowfac, __sort, __title, __tol, __vpad, __vtype, __weight**

getf

Purpose

Loads an ASCII or binary file into a string.

Format

y **= getf(***filename***,***mode***);**

Input

filename	string, any valid file name.
mode	scalar 1 or 0 which determines if the file is to be loaded in ASCII mode (0) or binary mode (1).

Output

y	string containing the file.

Remarks

If the file is loaded in ASCII mode, it will be tested to see if it contains any end of file characters. These are ^Z (ASCII 26). The file will be truncated before the first ^Z and there will be no ^Z's in the string. This is the correct way to load most text files because the ^Z's can cause problems when trying to print the string to a printer.

If the file is loaded in binary mode, it will be loaded just like it is with no changes.

Example

Create a file `examp.e` containing the following program.

```
library pgraph;

graphset;

x = seqa(0,0.1,100);

y = sin(x);

xy(x,y);
```

Then execute the following.

```
y = getf("examp.e",0);


print y;
```

getf

This produces:

```
library pgraph;
graphset;
x = seqa(0,0.1,100);
y = sin(x);
xy(x,y);
```

See also **load, save, let, con**

getname

Purpose Returns a column vector containing the names of the variables in a GAUSS data set.

Format *y* **= getname(***dset***);**

Input

dset string specifying the name of the data set from which the function will obtain the variable names.

Output

y Nx1 vector containing the names of all of the variables in the specified data set.

Remarks The output, *y*, will have as many rows as there are variables in the data set.

Example

```
y = getname("olsdat");
format 8,8;
print $y;
```

produces:

```
TIME
DIST
TEMP
FRICT
```

The above example assumes the data set **olsdat** contained the variables *TIME*, *DIST*, *TEMP*, *FRICT*.

Note that the extension is not included in the filename passed to the **getname** function.

See also **getnamef, indcv**

getnamef

Purpose Returns a string array containing the names of the variables in a GAUSS data set.

Format *y* **= getnamef(***f***);**

Input

f scalar, file handle of an open data set.

Output

y Nx1 string array containing the names of all of the variables in the specified data set.

Remarks The output, *y*, will have as many rows as there are variables in the data set.

Example

```
open f = olsdat for read;
y = getnamef(f);
t = vartypef(f);
print y;
```

produces:

```
time
dist
temp
frict
```

The above example assumes the data set **olsdat** contained the variables *time*, *dist*, *temp*, *frict*.

Note the use of **vartypef** to determine the types of these variables.

See also **getname, indcv, vartypef**

getNextTradingDay

Purpose Returns the next trading day.

Format *n* **= getNextTradingDay(***a***)**

Input

a	scalar, date in DT scalar format.

Output

n	next trading day in DT scalar format

Remarks A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2004. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

Source `finutils.src`

getNextWeekDay

Purpose Returns the next day that is not on a weekend.

Format *n* **= getNextWeekDay(***a***)**

Input

a	scalar, date in DT scalar format.

Output

n	next week day in DT scalar format

Source finutils.src

getnr

Purpose

Computes number of rows to read per iteration for a program that reads data from a disk file in a loop.

Format

nr **= getnr(***nsets*,*ncols*);

Input

nsets scalar, estimate of the maximum number of duplicate copies of the data matrix read by **readr** to be kept in memory during each iteration of the loop.

ncols scalar, columns in the data file.

Output

nr scalar, number of rows **readr** should read per iteration of the read loop.

Remarks

If **__row** is greater than 0, *nr* will be set to **__row**.

If an insufficient memory error is encountered, change **__rowfac** to a number less than 1.0 (e.g., 0.75). The number of rows read will be reduced in size by this factor.

Source

gauss.src

Globals

__row, __rowfac

getpath

Purpose Returns an expanded filename including the drive and path.

Format *fname* **= getpath(***pfname***);**

Input

pfname string, partial filename with only partial or missing path information.

Output

fname string, filename with full drive and path.

Remarks This function handles relative path references.

Example

```
y = getpath("temp.e");

print y;
```

produces:

```
/gauss/temp.e
```

Source getpath.src

getPreviousTradingDay

Purpose Returns the previous trading day.

Format *n* **= getPreviousTradingDay(***a***)**

Input

a	scalar, date in DT scalar format.

Output

n	Previous trading day in DT scalar format

Remarks A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2004. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

Source `finutils.src`

getPreviousWeekDay

Purpose Returns the previous day that is not on a weekend.

Format *n* **= getPreviousWeekDay(***a***)**

Input

a	scalar, date in DT scalar format.

Output

n	previous week day in DT scalar format

Source finutils.src

getwind

Purpose Retrieves the current graphic panel number.

Library **pgraph**

Format *n* **= getwind;**

Output *n* scalar, graphic panel number of current graphic panel.

Remarks The current graphic panel is the graphic panel in which the next graph will be drawn.

Source pwindow.src

See also **endwind, begwind, window, setwind, nextwind**

gosub

Purpose

Causes a branch to a subroutine.

Format

```
gosub label;

    .
    .
    .

label:

    .
    .
    .

return;
```

Remarks

For multi-line recursive user-defined functions, see "Procedures and Keywords" in the *User's Guide*.

When a **gosub** statement is encountered, the program will branch to the label and begin executing from there. When a **return** statement is encountered, the program will resume executing at the statement following the **gosub** statement. Labels are 1-32 characters long and are followed by a colon. The characters can be A-Z or 0-9 and they must begin with an alphabetic character. Uppercase or lowercase is allowed.

It is possible to pass parameters to subroutines and receive parameters from them when they return. See the second example, following.

The only legal way to enter a subroutine is with a **gosub** statement.

If your subroutines are at the end of your program, you should have an **end** statement before the first one to prevent the program from running into a subroutine without using a **gosub**. This will result in a "return without gosub" error message.

The variables used in subroutines are not local to the subroutine and can be accessed from other places in your program. (See "Procedures and Keywords" in the *User's Guide*.)

Example

In the program below, the name **mysub** is a label. When the **gosub** statement is executed, the program will jump to the label **mysub** and continue executing from there. When the **return** statement is executed, the program will resume executing at the statement following the **gosub**.

```
x = rndn(3,3); z = 0;
gosub mysub;
print z;
end;

/* ------ Subroutines Follow ------ */

mysub:

   z = inv(x);
   return;
```

Parameters can be passed to subroutines in the following way (line numbers are added for clarity):

```
1. gosub mysub(x,y);
2. pop j; /* b will be in j */
3. pop k; /* a will be in k */
4. t = j*k;
5. print t;
6. end;
7.
8. /* ---- Subroutines Follow ----- */
9.
10. mysub:
```

```
11.   pop b; /* y will be in b */
12.   pop a; /* x will be in a */
13.
14.   a = inv(b)*b+a;
15.   b = a'b;
16.   return(a,b);
```

In the previous example, when the **gosub** statement is executed, the following sequence of events results:

1. **x** and **y** are pushed on the stack and the program branches to the label **mysub** in line 10.
11. the second argument that was pushed, **y**, is **pop**'ped into **b**.
12. the first argument that was pushed, **x**, is **pop**'ped into **a**.
14. **inv(b)*b+a** is assigned to **a**.
15. **a/b** is assigned to **b**.
16. **a** and **b** are pushed on the stack and the program branches to the statement following the **gosub**, which is line 2.
2. the second argument that was pushed, **b**, is **pop**'ped into **j**.
3. the first argument that was pushed, **a**, is **pop**'ped into **k**.
4. **j*k** is assigned to **t**.
5. **t** is printed.
6. the program is terminated with the **end** statement.

Matrices are pushed on a last-in/first-out stack in the **gosub()** and **return()** statements. They must be popped off in the reverse order. No intervening statements are allowed between the label and the **pop** or the **gosub** and the **pop**. Only one matrix may be popped per **pop** statement.

See also

goto, proc, pop, return

goto

Purpose

Causes a branch to a label.

Format

goto *label*;

.

.

.

label:

Remarks

Label names can be any legal GAUSS names up to 32 alphanumeric characters, beginning with an alphabetic character or an underscore, not a reserved word.

Labels are always followed immediately by a colon.

Labels do not have to be declared before they are used. GAUSS knows they are labels by the fact that they are followed immediately by a colon.

When GAUSS encounters a **goto** statement, it jumps to the specified label and continues execution of the program from there.

Parameters can be passed in a **goto** statement the same way as they can with a **gosub**.

Example

```
x = seqa(.1,.1,5);
n = { 1 2 3 };
goto fip;
print x;
end;

fip:
print n;
```

produces:

```
      1.0000000  2.0000000   3.0000000
```

goto

See also gosub, if

gradp

Purpose

Computes the gradient vector or matrix (Jacobian) of a vector-valued function that has been defined in a procedure. Single-sided (forward difference) gradients are computed.

Format

g **= gradp(&***f***,***x0***);**

Input

&*f* a pointer to a vector-valued function (*f*:KX1 - > NX1) defined as a procedure. It is acceptable for *f*(*x*) to have been defined in terms of global arguments in addition to *x*, and thus *f* can return an NX1 vector:

```
proc f(x);
      retp( exp(x.*b) );
endp;
```

x0 KX1 vector of points at which to compute gradient.

Output

g NXK matrix containing the gradients of *f* with respect to the variable *x* at *x0*.

Remarks

gradp will return a row for every row that is returned by *f*. For instance, if *f* returns a scalar result, then **gradp** will return a 1XK row vector. This allows the same function to be used regardless of N, where N is the number of rows in the result returned by *f*. Thus, for instance, **gradp** can be used to compute the Jacobian matrix of a set of equations.

Example

```
proc myfunc(x);
   retp( x.*2 .* exp( x.*x./3 ) );
endp;

x0 = 2.5|3.0|3.5;
y = gradp(&myfunc,x0);
```

$$y = \begin{matrix} 82.98901842 & 0.00000000 & 0.00000000 \\ 0.00000000 & 281.19752975 & 0.00000000 \\ 0.00000000 & 0.00000000 & 1087.95414117 \end{matrix}$$

gradp

It is a 3x3 matrix because we are passing it 3 arguments and **myfunc** returns 3 results when we do that; the off-diagonals are zeros because the cross-derivatives of 3 arguments are 0.

Source gradp.src

See also **hessp**

graphprt

Purpose

Controls automatic printer hardcopy and conversion file output.

Library

pgraph

Format

graphprt(*str***);**

Input

str string, control string.

Portability

UNIX

Not supported, use WinPrintPQG instead.

Remarks

graphprt is used to create hardcopy output automatically without user intervention. The input string *str* can have any of the following items, separated by spaces. If *str* is a null string, the interactive mode is entered. This is the default.

-P	print graph.	
-PO=*c*	set print orientation.	
	L	landscape.
	P	portrait.
-C=*n*	convert to another file format.	
	1	Encapsulated PostScript file.
	3	HPGL Plotter file.
	5	BMP (Windows only)
	8	WMF (Windows only)
-CF=*name*	set converted output file name.	
-I	Minimize (iconize) the graphics window.	
-Q	Close window after processing.	
-W=*n*	display graph, wait *n* seconds, then continue.	

If you are not using graphic panels, you can call **graphprt** anytime before the call to the graphics routine. If you are using graphic panels, call **graphprt** just before the **endwind** statement.

The print option default values are set from the viewer application. Any parameters passed through **graphprt** will override the default values. (See "Publication Quality Graphics" in the *User's Guide*.)

Under DOS, this uses a utility called **vwr.exe** by default.

graphprt

Example

Automatic print using a single graphics call.

```
library pgraph;
graphset;
load x,y;
graphprt("-p"); /* tell "xy" to print */
xy(x,y);        /* create graph and print */
```

Automatic print using multiple graphics graphic panels. Note **graphprt** is called once just before the **endwind** call.

```
library pgraph;
graphset;
load x,y;
begwind;
window(1,2,0); /* create two windows */

setwind(1);
xy(x,y); /* first graphics call */

nextwind;
xy(x,y); /* second graphics call */

graphprt("-p");
endwind; /* print page containing all graphs */
```

The next example shows how to build a string to be used with **graphprt**.

```
library pgraph;
graphset;
load x,y;
```

```
cvtnam = “mycvt.eps”; /* name of output file

/* concatenate options into one string */
cmdstr = “-c=1” $+ “ -cf=” $+ cvtnam;
cmdstr = cmdstr $+ “n-q”;

graphprt(cmdstr); /* tell “xy” to convert and
                     close*/
xy(x,y);          /* create graph and print */
```

The above string *cmdstr* will produce:

“-c = 1_n - cf = mycvt.eps$_n$ - q”

Source

pgraph.src

graphset

Purpose Resets graphics globals to default values.

Library pgraph

Format graphset;

Remarks This procedure is used to reset the defaults between graphs.

graphset may be called between each graphic panel to be displayed.

To change the default values of the global control variables, make the appropriate changes in the file pgraph.dec and to the procedure **graphset**.

Source pgraph.src

hasimag

Purpose Tests whether the imaginary part of a complex matrix is negligible.

Format *y* **= hasimag(***x***);**

Input

x NxK matrix.

Output

y scalar, 1 if the imaginary part of *x* has any nonzero elements, 0 if it consists entirely of 0's.

The function **iscplx** tests whether *x* is a complex matrix or not, but it does not test the contents of the imaginary part of *x*. **hasimag** tests the contents of the imaginary part of *x* to see if it is zero.

hasimag actually tests the imaginary part of *x* against a tolerance to determine if it is negligible. The tolerance used is the imaginary tolerance set with the **sysstate** command, case 21.

Some functions are not defined for complex matrices. **iscplx** can be used to determine whether a matrix has no imaginary part and so can pass through those functions. **hasimag** can be used to determine whether a complex matrix has a negligible imaginary part and could thus be converted to a real matrix to pass through those functions.

iscplx is useful as a preliminary check because for large matrices it is much faster than **hasimag**.

Example

```
x = { 1 2 3i,
      4-i 5 6i,
      7 8i 9 };
y = hasimag(x);
```

y = 1.0000000

See also **iscplx**

header

Purpose

Prints a header for a report.

Format

header(*prcnm*,*dataset*,*ver*);

Input

prcnm	string, name of procedure that calls **header**.
dataset	string, name of data set.
ver	2x1 numeric vector, the first element is the major version number of the program, the second element is the revision number. Normally this argument will be the version/revision global **(__??_ver)** associated with the module within which header is called. This argument will be ignored if set to 0.

Global Input

__header	string, containing the letters:	
	t	title is to be printed
	l	lines are to bracket the title
	d	a date and time is to be printed
	v	version number of program is printed
	f	file name being analyzed is printed
__title	string, title for header.	

Source

gauss.src

Globals

__header, __title

hess

Purpose

Computes the Hessenberg form of a square matrix.

Format

{ *h*,*z* **} = hess(**x**);**

Input

x	KxK matrix.

Output

h	KxK matrix, Hessenberg form.
z	KxK matrix, transformation matrix.

Remarks

hess computes the Hessenberg form of a square matrix. The Hessenberg form is an intermediate step in computing eigenvalues. It also is useful for solving certain matrix equations that occur in control theory (see Van Loan, Charles F. "Using the Hessenberg Decomposition in Control Theory," *Algorithms and Theory in FIltering and Control*. Sorenson, D.C., and R.J. Wets, eds., Mathematical Programming Study No. 18, No. Holland, Amsterdam, 1982, 102-11).

z is an orthogonal matrix that transforms *x* into *h* and vice versa. Thus:

$$h = z' x\, z$$

and since z is orthogonal,

$$x = z\, h\, z'$$

x is reduced to upper Hessenberg form using orthogonal similiarity transformations. This preserves the Frobenious norm of the matrix and the condition numbers of the eigenvalues.

hess uses the ORTRAN and ORTHES functions from EISPACK.

Example

```
let x[3,3] = 1 2 3
             4 5 6
             7 8 9;
{ h,z } = hess(x);
```

$$h = \begin{matrix} 1.00000000 & -3.59700730 & -0.24806947 \\ -8.06225775 & 14.04615385 & 2.83076923 \\ 0.00000000 & 0.83076923 & -0.04615385 \end{matrix}$$

hess

$$z = \begin{matrix} 1.00000000 & 0.00000000 & 0.00000000 \\ 0.00000000 & -0.49613894 & -0.86824314 \\ 0.00000000 & -0.86824314 & 0.49613894 \end{matrix}$$

See also

schur

hessp

Purpose

Computes the matrix of second partial derivatives (Hessian matrix) of a function defined as a procedure.

Format

h **= hessp(&***f***,***x0***);**

Input

&*f*	pointer to a single-valued function *f*(*x*), defined as a procedure, taking a single Kx1 vector argument (*f*:Kx1 -> 1x1); *f*(*x*) may be defined in terms of global arguments in addition to *x*.
x0	Kx1 vector specifying the point at which the Hessian of *f*(*x*) is to be computed.

Output

h	KxK matrix of second derivatives of *f* with respect to *x* at *x0*; this matrix will be symmetric.

Remarks

This procedure requires K*(K+1)/2 function evaluations. Thus if K is large, it may take a long time to compute the Hessian matrix.

No more than 3-4 digit accuracy should be expected from this function, though it is possible for greater accuracy to be achieved with some functions.

It is important that the function be properly scaled, in order to obtain greatest possible accuracy. Specifically, scale it so that the first derivatives are approximately the same size. If these derivatives differ by more than a factor of 100 or so, the results can be meaningless.

Example

```
x = { 1, 2, 3 };

proc g(b);
   retp( exp(x'b) );
endp;

b0 = { 3, 2, 1 };
h = hessp(&g,b0);
```

hessp

The resulting matrix of second partial derivatives of **g(b)** evaluated at **b**=**b0** is:

```
22027.12898372  44054.87238165   66083.36762901
44054.87238165  88111.11102645  132168.66742899
66083.36762901 132168.66742899  198256.04087836
```

Source hessp.src

See also **gradp**

hist

Purpose

Computes and graphs a frequency histogram for a vector. The actual frequencies are plotted for each category.

Library

pgraph

Format

{ *b*,*m*,*freq* **} = hist(**x,v**);**

Input

x	Mx1 vector of data.
v	Nx1 vector, the breakpoints to be used to compute the frequencies, or scalar, the number of categories.

Output

b	Px1 vector, the breakpoints used for each category.
m	Px1 vector, the midpoints of each category.
freq	Px1 vector of computed frequency counts.

Remarks

If a vector of breakpoints is specified, a final breakpoint equal to the maximum value of *x* will be added if the maximum breakpoint value is smaller.

If a number of categories is specified, the data will be divided into *v* evenly spaced categories.

Each time an element falls into one of the categories specified in *b*, the corresponding element of *freq* will be incremented by one. The categories are interpreted as follows:

$$
\begin{array}{lcccccc}
freq[1] & = & & & x & \leq & b[1] \\
freq[2] & = & b[1] & < & x & \leq & b[2] \\
freq[3] & = & b[2] & < & x & \leq & b[3] \\
 & & & & & & \\
 & & & & & & \\
freq[P] & = & b[P\text{-}1] & < & x & \leq & b[P]
\end{array}
$$

hist

Example

```
library pgraph;
x = rndn(5000,1);
{ b,m,f } = hist(x,20);
```

Source phist.src

See also **histp, histf, bar**

histf

Purpose Graphs a histogram given a vector of frequency counts.

Library pgraph

Format **histf(***f*,*c*);

Input

f	Nx1 vector, frequencies to be graphed.
c	Nx1 vector, numeric labels for categories. If this is a scalar 0, a sequence from 1 to **rows(***f***)** will be created.

Remarks The axes are not automatically labeled. Use **xlabel** for the category axis and **ylabel** for the frequency axis.

Source phist.src

See also **hist, bar, xlabel, ylabel**

histp

Purpose

Computes and graphs a percent frequency histogram of a vector. The percentages in each category are plotted.

Library

pgraph

Format

{ *b*,*m*,*freq* **} = histp(**x,v**);**

Input

x	Mx1 vector of data.
v	Nx1 vector, the breakpoints to be used to compute the frequencies, or scalar, the number of categories.

Output

b	Px1 vector, the breakpoints used for each category.
m	Px1 vector, the midpoints of each category.
freq	Px1 vector of computed frequency counts. This is the vector of counts, not percentages.

Remarks

If a vector of breakpoints is specified, a final breakpoint equal to the maximum value of *x* will be added if the maximum breakpoint value is smaller.

If a number of categories is specified, the data will be divided into *v* evenly spaced categories.

Each time an element falls into one of the categories specified in *b*, the corresponding element of *freq* will be incremented by one. The categories are interpreted as follows:

$$
\begin{array}{lllllll}
freq[1] & = & & & x & \leq & b[1] \\
freq[2] & = & b[1] & < & x & \leq & b[2] \\
freq[3] & = & b[2] & < & x & \leq & b[3] \\
 & & & & & & \\
 & & & & & & \\
freq[P] & = & b[P\text{-}1] & < & x & \leq & b[P]
\end{array}
$$

Source

phist.src

See also

hist, histf, bar

hsec

Purpose Returns the number of hundredths of a second since midnight.

Format *y* **= hsec;**

Remarks The number of hundredths of a second since midnight can also be accessed as the [4,1] element of the vector returned by the **date** function.

Example

```
x = rndu(100,100);
ts = hsec;
y = x*x;
et = hsec-ts;
```

In this example, **hsec** is used to time a 100x100 multiplication in GAUSS. A 100x100 matrix, **x**, is created, and the current time, in hundredths of a second since midnight, is stored in the variable **ts**. Then the multiplication is carried out. Finally, **ts** is subtracted from **hsec** to give the time difference which is assigned to **et**.

See also **date, time, timestr, ethsec, etstr**

if

Purpose

Controls program flow with conditional branching.

Format

if *scalar_expression*;
list of statements;

elseif *scalar_expression*;
list of statements;

elseif *scalar_expression*;
list of statements;

else;
list of statements;

endif;

Remarks

scalar_expression is any expression that returns a scalar. It is *TRUE* if it is not zero, and *FALSE* if it is zero.

A list of statements is any set of GAUSS statements.

GAUSS will test the expression after the **if** statement. If it is *TRUE* (nonzero), then the first list of statements is executed. If it is *FALSE* (zero), then GAUSS will move to the expression after the first **elseif** statement if there is one and test it. It will keep testing expressions and will execute the first list of statements that corresponds to a *TRUE* expression. If no expression is *TRUE*, then the list of statements following the **else** statement is executed. After the appropriate list of statements is executed, the program will go to the statement following the **endif** and continue on.

if statements can be nested.

One **endif** is required per **if** statement. If an **else** statement is used, there may be only one per **if** statement. There may be as many **elseif**'s as are required. There need not be any **elseif**'s or any **else** statement within an **if** statement.

Note the semicolon after the **else** statement.

Example

```
if x < 0;
   y = -1;
elseif x > 0;
   y = 1;
else;
   y = 0;
endif;
```

See also **do**

imag

Purpose Returns the imaginary part of a matrix.

Format *zi* **= imag(***x***);**

Input

x NxK matrix.

Output

zi NxK matrix, the imaginary part of *x*.

Remarks If *x* is real, *zi* will be an NxK matrix of zeros.

Example

```
x = { 4i 9 3,
      2 5-6i 7i };
y = imag(x);
```

$$y = \begin{matrix} 4.0000000 & 0.0000000 & 0.0000000 \\ 0.0000000 & -6.0000000 & 7.0000000 \end{matrix}$$

See also **complex, real**

import

Purpose

Imports a spreadsheet, database, or ASCII file into a matrix.

Format

{ *x*,*namel* **} = import(***fname*,*range*,*sheet***);**

Input

fname	string, file name with path.
range	string, range of cells (spreadsheet only), field descriptor (ASCII files), or 0.
sheet	scalar, sheet number of multi-sheet spreadsheet or 0.

Output

x	NxK matrix, imported data.
namel	Kx1 vector, column headers.

Portability

Windows only

Remarks

If *sheet* is 0, **import** will import the first (possibly only) sheet of a spreadsheet.

For spreadsheets, *range* indicates the columns to be imported, and can be expressed in the form `B7:K243` or `B7..K243`. A *range* of 0 imports all data.

For packed ASCII files, *range* is a descriptor that defines field name, type, width, and optionally precision. It is a single string of the form

name [[*type*]] *fldspec* [[*name* [[*type*]] *fldspec*`...`]]

where

name is the column name for the field.

type is **$** for a character field, blank for a numeric field.

fldspec is either a column range (e.g., 5-8), a start column and field width (e.g., 5,4 or 5,4.2), or a field width only (e.g., 4 or 4.2). If only a field width is given, the start column is input from the previous field. If the field width is specified with a decimal (e.g., 4.2), then a decimal point will be inserted that many places in from the right edge of the field.

A shorthand for a set of columns is available (e.g., `x01-x09`); the subsequent *type* and *fldspec* are applied to all columns in the set.

import

Example

```
fname = "c:\\temp\\testdata.xls";

{mmx, names} = import(fname, "A3:D12", 3);
```

This will import the range of cells **A3** to **D12** of the third sheet of `testdata.xls` into the GAUSS matrix **mmx** with the column headings defined by **names**. Substituting a `0` or `1` for the **3** would have imported the first (possibly only) sheet.

```
fname = "c:\\temp\\tstdta.asc";

range = "var1 $ 6,2 var2 8-15 var3 18,4.1 gnp 7

cons 6.2 xs1-xs20 2";

{x,names} = import(fname,range,0);
```

Here, a GAUSS matrix **x** is created from a packed ASCII data set, using the descriptor shown.

Globals

_dxaschdr, _dxftype, _dxmiss, _dxprcn, _dxprint, _dxtxdlim, _dxtype, _dxwidth, _dxwkshdr

See also

export, exportf, importf

importf

Purpose

Imports a spreadsheet, database, or ASCII file to a GAUSS data set.

Format

ret **= importf(***fname*,*dset*,*range*,*sheet*);

Input

fname	string, file name with optional path.
dset	string, name of data set with optional path.
range	string, range of cells (spreadsheet only), field descriptor (ASCII files), or 0.
sheet	scalar, sheet number of multi-sheet spreadsheet or 0.

Output

ret	scalar, success flag, 1 if successful, 0 if not.
dset	GAUSS data set.

Portability

Windows only

Remarks

See **import** for details on the *range* and *sheet* parameters.

Example

```
fname = "c:\\temp\\testdata2.dbf";
dname = "c:\\gauss\\data\\mydata.dat";
call importf(dname, fname, 0, 0);
```

This will create a GAUSS data set `c:\gauss\data\mydata.dat` from the data in the dBase III file `c:\temp\testdata2.dbf`.

Globals

_dxaschdr, _dxftype, _dxmiss, _dxprcn, _dxprint, _dxtxdlim, _dxtype, _dxwidth, _dxwkshdr

See also

export, exportf, import

#include

Purpose

Inserts code from another file into a GAUSS program.

Format

#include *filename*;
#include "*filename***";**

Remarks

filename can be any legitimate file name.

This command makes it possible to write a section of general-purpose code, and insert it into other programs.

The code from the **#include**'d file is inserted literally as if it were merged into that place in the program with a text editor.

If a path is specified for the file, then no additional searching will be attempted if the file is not found.

If a path is not specified, the current directory will be searched first, then each directory listed in **src_path**. **src_path** is defined in `gauss.cfg`.

`#include /gauss/myprog.prc;`	No additional search will be made if the file is not found.
`#include myprog.prc;`	The directories listed in **src_path** will be searched for `myprog.prc` if the file is not found in the current directory.

Compile time errors will return the line number and the name of the file in which they occur. For execution time errors, if a program is compiled with **#lineson**, the line number and name of the file where the error occurred will be printed. For files that have been **#include**'d this reflects the actual line number within the **#include**'d file. See **#lineson** for a more complete discussion of the use of and the validity of line numbers when debugging.

Example

```
#include "/gauss/inc/cond.inc";
```

The command will cause the code in the file `cond.inc` to be merged into the current program at the point at which this statement appears.

See also

run, #lineson

indcv

Purpose

Checks one character vector against another and returns the indices of the elements of the first vector in the second vector.

Format

z **= indcv(***what*,*where***);**

Input

what Nx1 character vector which contains the elements to be found in vector *where*.

where Mx1 character vector to be searched for matches to the elements of *what*.

Output

z Nx1 vector of integers containing the indices of the corresponding element of *what* in *where*.

Remarks

If no matches are found for any of the elements in *what*, then the corresponding elements in the returned vector are set to the GAUSS missing value code.

Both arguments will be forced to uppercase before the comparison.

If there are duplicate elements in *where*, the index of the first match will be returned.

Example

```
let what = AGE PAY SEX;
let where = AGE SEX JOB “date” PAY;
z = indcv(what,where);
```

```
what =  AGE
        PAY
        SEX

where =  AGE
         SEX
         JOB
         date
         PAY
```

$$Z = \begin{matrix} 1 \\ 5 \\ 2 \end{matrix}$$

indexcat

Purpose

Returns the indices of the elements of a vector which fall into a specified category.

Format

y **= indexcat(***x*,*v***);**

Input

x Nx1 vector.

v scalar or 2x1 vector.

If scalar, the function returns the indices of all elements of *x* equal to *v*.

If 2x1, then the function returns the indices of all elements of *x* that fall into the range:

$$v[1] < x \leq v[2].$$

If *v* is scalar, it can contain a single missing to specify the missing value as the category.

Output

y Lx1 vector, containing the indices of the elements of *x* which fall into the category defined by *v*. It will contain error code 13 if there are no elements in this category.

Remarks

Use a loop to pull out indices of multiple categories.

Example

```
let x = 1.0 4.0 3.3 4.2 6.0 5.7 8.1 5.5;
let v = 4 6;
y = indexcat(x,v);
```

$$x = \begin{matrix} 1.0 \\ 4.0 \\ 3.3 \\ 4.2 \\ 6.0 \\ 5.7 \\ 8.1 \\ 5.5 \end{matrix}$$

$$v = \begin{matrix} 4 \\ 6 \end{matrix}$$

$$y = \begin{matrix} 4 \\ 5 \\ 6 \\ 8 \end{matrix}$$

indices

Purpose

Processes a set of variable names or indices and returns a vector of variable names and a vector of indices.

Format

{ *name*,*indx* **} = indices(**_dataset_,_vars_**);**

Input

dataset	string, the name of the data set.
vars	Nx1 vector, a character vector of names or a numeric vector of column indices. If scalar 0, all variables in the data set will be selected.

Output

name	Nx1 character vector, the names associated with *vars*.
indx	Nx1 numeric vector, the column indices associated with *vars*.

Remarks

If an error occurs, **indices** will either return a scalar error code or terminate the program with an error message, depending on the **trap** state. If the low order bit of the trap flag is 0, **indices** will terminate with an error message. If the low order bit of the trap flag is 1, **indices** will return an error code. The value of the trap flag can be tested with **trapchk**; the return from **indices** can be tested with **scalerr**. You only need to check one argument; they will both be the same. The following error codes are possible:

1 Can't open dataset.

2 Index of variable out of range, or undefined data set variables.

Source

indices.src

indices2

Purpose

Processes two sets of variable names or indices from a single file. The first is a single variable and the second is a set of variables. The first must not occur in the second set and all must be in the file.

Format

```
{ name1,indx1,name2,indx2 } =
indices2(dataset,var1,var2);
```

Input

dataset	string, the name of the data set.
var1	string or scalar, variable name or index. This can be either the name of the variable, or the column index of the variable. If null or 0, the last variable in the data set will be used.
var2	NX1 vector, a character vector of names or a numeric vector of column indices. If scalar 0, all variables in the data set except the one associated with *var1* will be selected.

Output

name1	scalar character matrix containing the name of the variable associated with *var1*.
indx1	scalar, the column index of *var1*.
name2	NX1 character vector, the names associated with *var2*.
indx2	NX1 numeric vector, the column indices of *var2*.

Remarks

If an error occurs, **indices2** will either return a scalar error code or terminate the program with an error message, depending on the **trap** state. If the low order bit of the trap flag is 0, **indices2** will terminate with an error message. If the low order bit of the trap flag is 1, **indices2** will return an error code. The value of the trap flag can be tested with **trapchk**; the return from **indices2** can be tested with **scalerr**. You only need to check one argument; they will all be the same. The following error codes are possible:

1 Can't open dataset.

2 Index of variable out of range, or undefined data set variables.

3 First variable must be a single name or index.

4 First variable contained in second set.

indices2

Source indices2.src

indnv

Purpose

Checks one numeric vector against another and returns the indices of the elements of the first vector in the second vector.

Format

z **= indnv(***what***,***where***);**

Input

what Nx1 numeric vector which contains the values to be found in vector *where*.

where Mx1 numeric vector to be searched for matches to the values in *what*.

Output

z Nx1 vector of integers, the indices of the corresponding elements of *what* in *where*.

Remarks

If no matches are found for any of the elements in *what*, then those elements in the returned vector are set to the GAUSS missing value code.

If there are duplicate elements in *where*, the index of the first match will be returned.

Example

```
let what = 8 7 3;
let where = 2 7 8 4 3;
z = indnv(what,where);
```

```
        8
what =  7
        3

         2
         7
where =  8
         4
         3
```

indnv

$$z = \begin{matrix} 3 \\ 2 \\ 5 \end{matrix}$$

intgrat2

Purpose

Integrates the following double integral, using user-defined functions *f*, g_1 and g_2, and scalars *a* and *b*:

$$\int_a^b \int_{g_{2(x)}}^{g_{1(x)}} f(x,y)\,dy\,dx$$

Format

y **= intgrat2(&***f***,***xl***,***gl***);**

Input

&*f*	scalar, pointer to the procedure containing the function to be integrated.
xl	2x1 or 2xN matrix, the limits of *x*. These must be scalar limits.
gl	2x1 or 2xN matrix of function pointers, the limits of *y*. For *xl* and *gl*, the first row is the upper limit and the second row is the lower limit. N integrations are computed.

Global Input

_intord	scalar, the order of the integration. The larger **_intord**, the more precise the final result will be. **_intord** may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40. Default = 12.
_intrec	scalar. This variable is used to keep track of the level of recursion of **intgrat2** and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set **_intrec** explicitly to 0 before any call to **intgrat2**.

Output

y	Nx1 vector of the estimated integral(s) of *f*(*x*,*y*) evaluated between the limits given by *xl* and *gl*.

Remarks

The user-defined functions specified by *f* and *gl* must either

Return a scalar constant, OR

Return a vector of function values. **intgrat2** will pass to user-defined functions a vector or matrix for *x* and *y* and expect a vector or matrix to be returned. Use **.*** and **./** instead of ***** and **/**.

intgrat2

Example

```
proc f(x,y);
   retp(cos(x) + 1).*(sin(y) + 1));
endp;

proc g1(x);
   retp(sqrt(1-x^2));
endp;

proc g2(x);
   retp(0);
endp;

xl = 1|-1;
g0 = &g1|&g2;
_intord = 40;
_intrec = 0;
y = intgrat2(&f,xl,g0);
```

This will integrate the function $f(x,y) = (cos(x)+1)(sin(y)+1)$ over the upper half of the unit circle. Note the use of the **.*** operator instead of just ***** in the definition of $f(x,y)$. This allows *f* to return a vector or matrix of function values.

Source intgrat.src

Globals **_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8, _intrec**

See also **intgrat3, intquad1, intquad2, intquad3, intsimp**

intgrat3

Purpose

Integrates the following triple integral, using user-defined functions and scalars for bounds:

$$\int_a^b \int_{g_{2(x)}}^{g_{1(x)}} \int_{h_{2(x,y)}}^{h_{1(x,y)}} f(x, y, z)\, dz\, dy\, dx$$

Format

y **= intgrat3(&***f***,***xl***,***gl***,***hl***);**

Input

&*f*	scalar, pointer to the procedure containing the function to be integrated. *F* is a function of (*x*,*y*,*z*).
xl	2x1 or 2xN matrix, the limits of *x*. These must be scalar limits.
gl	2x1 or 2xN matrix of function pointers. These procedures are functions of *x*.
hl	2x1 or 2xN matrix of function pointers. These procedures are functions of *x* and *y*.

For *xl*, *gl*, and *hl*, the first row is the upper limit and the second row is the lower limit. N integrations are computed.

Global Input

_intord	scalar, the order of the integration. The larger **_intord**, the more precise the final result will be. **_intord** may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40. Default = 12.
_intrec	scalar. This variable is used to keep track of the level of recursion of **intgrat3** and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set **_intrec** explicitly to 0 before any call to **intgrat3**.

Output

y	Nx1 vector of the estimated integral(s) of *f*(*x*,*y*,*z*) evaluated between the limits given by *xl*, *gl*, and *hl*.

intgrat3

Remarks

User-defined functions *f*, and those used in *gl* and *hl*, must either:

Return a scalar constant, OR

Return a vector of function values. **intgrat3** will pass to user-defined functions a vector or matrix for *x* and *y* and expect a vector or matrix to be returned. Use **.*** and **./** operators instead of just ***** or **/**.

Example

```
proc f(x,y,z);
   retp(2);
endp;

proc g1(x);
   retp(sqrt(25-x^2));
endp;

proc g2(x);
   retp(-g1(x));
endp;

proc h1(x,y);
   retp(sqrt(25 - x^2 - y^2));
endp;

proc h2(x,y);
   retp(-h1(x,y));
endp;
```

```
xl = 5|-5;
g0 = &g1|&g2;
h0 = &h1|&h2;
_intrec = 0;
_intord = 40;
y = intgrat3(&f,xl,g1,hl);
```

This will integrate the function $f(x,y,z) = 2$ over the sphere of radius 5. The result will be approximately twice the volume of a sphere of radius 5.

Source intgrat.src

Globals **_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8, _intrec**

See also **intgrat2, intquad1, intquad2, intquad3, intsimp**

intquad1

Purpose

Integrates a specified function using Gauss-Legendre quadrature. A suite of upper and lower bounds may be calculated in one procedure call.

Format

y **= intquad1(&***f***,***xl***);**

Input

&*f*	scalar, pointer to the procedure containing the function to be integrated. This must be a function of *x*.
xl	2xN matrix, the limits of *x*. The first row is the upper limit and the second row is the lower limit. N integrations are computed.
_intord	scalar, the order of the integration. The larger **_intord**, the more precise the final result will be. **_intord** may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40. Default = 12.

Global Input

_intord	scalar, the order of the integration. The larger **_intord**, the more precise the final result will be. **_intord** may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40. Default = 12.

Output

y	Nx1 vector of the estimated integral(s) of *f*(*x*) evaluated between the limits given by *xl*.

Remarks

The user-defined function *f* must return a vector of function values. **intquad1** will pass to the user-defined function a vector or matrix for *x* and expect a vector or matrix to be returned. Use the **.*** and **./** instead of ***** and **/**.

Example

```
proc f(x);
   retp(x.*sin(x));
endp;

xl = 1|0;
y = intquad1(&f,xl);
```

This will integrate the function $f(x) = xsin(x)$ between 0 and 1. Note the use of the **.*** instead of ***.

Source integral.src

Globals **_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8**

See also **intsimp, intquad2, intquad3, intgrat2, intgrat3**

intquad2

Purpose

Integrates a specified function using Gauss-Legendre quadrature. A suite of upper and lower bounds may be calculated in one procedure call.

Format

y **= intquad2(&***f***,***xl***,***yl***);**

Input

&*f*	scalar, pointer to the procedure containing the function to be integrated.
xl	2x1 or 2xN matrix, the limits of *x*.
yl	2x1 or 2xN matrix, the limits of *y*.
	For *xl* and *yl*, the first row is the upper limit and the second row is the lower limit. N integrations are computed.

Global Input

_intord	global scalar, the order of the integration. The larger **_intord**, the more precise the final result will be. **_intord** may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40.
	Default = 12.
_intrec	global scalar. This variable is used to keep track of the level of recursion of **intquad2** and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set **_intrec** explicitly to 0 before any calls to **intquad2**.

Output

y	Nx1 vector of the estimated integral(s) of *f*(*x*,*y*) evaluated between the limits given by *xl* and *yl*.

Remarks

The user-defined function *f* must return a vector of function values. **intquad2** will pass to user-defined functions a vector or matrix for *x* and *y* and expect a vector or matrix to be returned. Use **.*** and **./** instead of ***** and **/**.

intquad2 will expand scalars to the appropriate size. This means that functions can be defined to return a scalar constant. If users write their functions incorrectly (using ***** instead of **.***, for example), **intquad2** may not compute the expected integral, but the integral of a constant function.

To integrate over a region which is bounded by functions, rather than just scalars, use **intgrat2** or **intgrat3**.

Example

```
proc f(x,y);
   retp(x.*sin(x+y));
endp;

xl = 1|0;
yl = 1|0;

_intrec = 0;
y = intquad2(&f,xl,yl);
```

This will integrate the function **x.*sin(x+y)** between **x** = 0 and 1, and between **y** = 0 and 1.

Source

integral.src

Globals

_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8, _intrec

See also

intquad1, intquad3, intsimp, intgrat2, intgrat3

intquad3

Purpose

Integrates a specified function using Gauss-Legendre quadrature. A suite of upper and lower bounds may be calculated in one procedure call.

Format

y **= intquad3(&***f***,***xl***,***yl***,***zl***);**

Input

&*f*	scalar, pointer to the procedure containing the function to be integrated. *f* is a function of (*x*,*y*,*z*).
xl	2x1 or 2xN matrix, the limits of *x*.
yl	2x1 or 2xN matrix, the limits of *y*.
zl	2x1 or 2xN matrix, the limits of *z*.
	For *xl*, *yl*, and *zl*, the first row is the upper limit and the second row is the lower limit. N integrations are computed.

Global Input

_intord	global scalar, the order of the integration. The larger **_intord**, the more precise the final result will be. **_intord** may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40. Default = 12.
_intrec	global scalar. This variable is used to keep track of the level of recursion of **intquad3** and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set **_intrec** explicitly to 0 before any calls to **intquad3**.

Output

y	Nx1 vector of the estimated integral(s) of *f*(*x*,*y*,*z*) evaluated between the limits given by *xl*, *yl*, and *zl*.

Remarks

The user-defined function *f* must return a vector of function values. **intquad3** will pass to the user-defined function a vector or matrix for *x*, *y*, and *z* and expect a vector or matrix to be returned. Use **.*** and **./** instead of ***** and **/**.

intquad3 will expand scalars to the appropriate size. This means that functions can be defined to return a scalar constant. If users write their functions incorrectly (using ***** instead of **.***, for example), **intquad3** may not compute the expected integral, but the integral of a constant function.

To integrate over a region which is bounded by functions, rather than just scalars, use **intgrat2** or **intgrat3**.

Example

```
proc f(x,y,z);
   retp(x.*y.*z);
endp;

xl = 1|0;
yl = 1|0;
zl = { 1 2 3, 0 0 0 };

_intrec = 0;
y = intquad3(&f,xl,yl,zl);
```

This will integrate the function **f(x) = x*y*z** over 3 sets of limits, since **zl** is defined to be a 2x3 matrix.

Source

integral.src

Globals

_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8, _intrec

See also

intquad1, intquad2, intsimp, intgrat2, intgrat3

intrleav

Purpose

Interleaves the rows of two files that have been sorted on a common variable, to give a single file sorted on that variable.

Format

intrleav(*infile1*,*infile2*,*outfile*,*keyvar*,*keytyp***);**

Input

infile1	string, name of input file 1.
infile2	string, name of input file 2.
outfile	string, name of output file.
keyvar	string, name of key variable, this is the column the files are sorted on.
keytyp	scalar, data type of key variable.
1	numeric key, ascending order
2	character key, ascending order
-1	numeric key, descending order
-2	character key, descending order

Remarks

The two files MUST have exactly the same variables, i.e., the same number of columns AND the same variable names. They must both already be sorted on the key column. This procedure will combine them into one large file, sorted by the key variable.

If the inputs are null or 0, the procedure will ask for them.

Example

```
intrleav("freq.dat","freqata.dat",
      "intfile","AGE",1);
```

Source

sortd.src

intrsect

Purpose Returns the intersection of two vectors, with duplicates removed.

Format *y* **= intrsect(***v1***,***v2***,***flag***);**

Input

v1	Nx1 vector.
v2	Mx1 vector.
flag	scalar; if 1, *v1*, and *v2* are numeric, if 0, character.

Output

y	Lx1 vector containing all unique values that are in both *v1* and *v2*, sorted in ascending order.

Remarks Place smaller vector first for fastest operation.

If there are a lot of duplicates within a vector, it is faster to remove them with **unique** before calling **intrsect**.

Source intrsect.src

Example

```
let v1 = mary jane linda dawn;
let v2 = mary sally lisa ruth linda;
y = intrsect(v1,v2,0);
```

$$y = \begin{matrix} LINDA \\ MARY \end{matrix}$$

intsimp

Purpose

Integrates a specified function using Simpson's method with end correction. A single integral is computed in one function call.

Format

y **= intsimp(&***f***,***xl***,***tol***);**

Input

&*f*	pointer to the procedure containing the function to be integrated.
xl	2x1 vector, the limits of *x*. The first element is the upper limit and the second element is the lower limit.
tol	The tolerance to be used in testing for convergence.

Output

y	The estimated integral of *f*(*x*) between *xl*[*1*] and *xl*[*2*].

Example

```
proc f(x);
   retp(sin(x));
endp;

let xl = { 1,
           0 };

y = intsimp(&f,xl,1E-8);
```

y = 0.45969769

This will integrate the function between 0 and 1.

Source

intsimp.src

See also

intquad1, intquad2, intquad3, intgrat2, intgrat3

inv, invpd

Purpose

inv returns the inverse of an invertible matrix.

invpd returns the inverse of a symmetric, positive definite matrix.

Format

y **= inv(***x***);**
y **= invpd(***x***);**

Input

x NxN matrix.

Output

y NxN matrix containing the inverse of *x*.

Remarks

x can be any legitimate matrix expression that returns a matrix that is legal for the function.

For **inv**, *x* must be square and invertible.

For **invpd**, *x* must be symmetric and positive definite.

If the input matrix is not invertible by these functions, they will either terminate the program with an error message or return an error code which can be tested for with the **scalerr** function. This depends on the **trap** state as follows:

trap 1, return error code

inv	invpd
50	20

trap 0, terminate with error message

inv	invpd
Matrix singular	Matrix not positive definite

If the input to **invpd** is not symmetric, it is possible that the function will (erroneously) appear to operate successfully.

Positive definite matrices can be inverted by **inv.** However, for symmetric, positive definite matrices (such as moment matrices), **invpd** is about twice as fast as **inv**.

inv, invpd

Example

```
n = 4000;
x1 = rndn(n,1);
x = ones(n,1)~x1;
btrue = { 1, 0.5 };
y = x*btrue + rndn(n,1);
bols = invpd(x'x)*x'y;
```

bols = 1.017201 0.484244

This example simulates some data and computes the **ols** coefficient estimator using the **invpd** function. First, the number of observations is specified. Second, a vector **x1** of standard Normal random variables is generated and is concatenated with a vector of 1's (to create a constant term). The true coefficients are specified, and the dependent variable **y** is created. Then the **ols** coefficient estimates are computed.

See also

scalerr, trap, prcsn

Technical Notes

For complex matrices, **inv** uses the ZGECO, ZGEDI path in the LINPACK routines. For real matrices, it uses the **croutp** function.

The **inv** function uses the Crout decomposition. The advantage of this routine is that on some platforms it allows most of the intermediate results to be computed in extended precision.

The **invpd** function uses the Cholesky decomposition and is based upon the LINPACK routines for positive definite matrices. On OS/2 and DOS, if **prcsn** 80 is in effect, all intermediate calculations and intermediate results will be in the 80-bit extended precision of the 80x87 temporary real format. The final results will be rounded to 64-bit double precision.

The tolerance used to determine singularity is 1.0e-14. This can be changed. See "Singularity Tolerance" in the *User's Guide*.

invswp

Purpose Computes a generalized sweep inverse.

Format *y* **= invswp(***x***);**

Input

x	NxN matrix.

Output

y	NxN matrix, the generalized inverse of *x*.

Remarks This will invert any general matrix. That is, even matrices which will not invert using **inv** because they are singular will invert using **invswp**.

x and *y* will satisfy the four Moore-Penrose conditions:

1. $xyx = x$
2. $yxy = y$
3. xy is symmetric
4. yx is symmetric

The tolerance used to determine if a pivot element is zero is taken from the **crout** singularity tolerance. The corresponding row and column are zeroed out. See "Appendix C" in the *User's Guide*.

Example

```
let x[3,3] = 1 2 3 4 5 6 7 8 9;
y = invswp(x);
```

$$y = \begin{matrix} -1.6666667 & 0.66666667 & 0.0000000 \\ 1.3333333 & -0.3333333 & 0.0000000 \\ 0.0000000 & 0.0000000 & 0.0000000 \end{matrix}$$

iscplx

Purpose Returns whether a matrix is complex or real.

Format *y* **= iscplx(***x***);**

Input *x* NxK matrix.

Output *y* scalar, 1 if *x* is complex, 0 if it is real.

Example

```
x = { 1, 2i, 3 };
y = iscplx(x);
```

y = 1

See also **hasimag, iscplxf**

iscplxf

Purpose Returns whether a data set is complex or real.

Format *y* **= iscplxf(***fh***);**

Input *fh* scalar, file handle of an open file.

Output *y* scalar, 1 if the data set is complex, 0 if it is real.

See also **hasimag, iscplx**

isinfnanmiss

Purpose Returns true if the argument contains an infinity, NaN, or missing value.

Format y **= isinfnanmiss(**x**);**

Input

x	NxK matrix.

Output

y	scalar, 1 if *x* contains any infinities, NaNs, or missing values, else 0.

See Also **scalinfnanmiss, ismiss, scalmiss**

ismiss

Purpose Returns a 1 if its matrix argument contains any missing values, otherwise returns a 0.

Format *y* **= ismiss(***x***);**

Input

x	NxK matrix.

Output

y	scalar, 1 or 0.

Remarks *y* will be a scalar 1 if the matrix *x* contains any missing values, otherwise it will be a 0.

An element of *x* is considered to be a missing if and only if it contains a missing value in the real part. Thus, for *x* = 1 + .i, **ismiss**(*x*) will return a 0.

Example

```
x = { 1 6 3 4 };
y = ismiss(x);
```

y = 0

See also **scalmiss, miss, missrv**

isSparse

Purpose Tests whether a matrix is a sparse matrix.

Format *r* **= isSparse(***x***);**

Input

x	MxN sparse or dense matrix.

Output

r	scalar, 1 if *x* is sparse, 0 otherwise.

Source sparse.src

keep (dataloop)

Purpose Specifies columns (variables) to be saved to the output data set in a data loop.

Format **keep** *variable_list*;

Remarks Commas are optional in **variable_list**.

Retains only the specified variables in the output data set. Any variables referenced must already exist, either as elements of the source data set, or as the result of a previous **make**, **vector**, or **code** statement.

If neither **keep** nor **drop** is used, the output data set will contain all variables from the source data set, as well as any newly defined variables. The effects of multiple **keep** and **drop** statements are cumulative.

Example

```
keep age, pay, sex;
```

See also **drop**

key

Purpose

Returns the ASCII value of the next key available in the keyboard buffer.

Format

y **= key;**

Remarks

If you are working in terminal mode, **key** does not "see" any keystrokes until ENTER is pressed. The value returned will be zero if no key is available in the buffer or it will equal the ASCII value of the key if one is available. The key is taken from the buffer at this time and the next call to **key** will return the next key.

Here are the values returned if the key pressed is not a standard ASCII character in the range of 1-255.

1015	SHIFT+TAB
1016-1025	ALT+Q, W, E, R, T, Y, U, I, O, P
1030-1038	ALT+A, S, D, F, G, H, J, K, L
1044-1050	ALT+Z, X, C, V, B, N, M
1059-1068	F1-F10
1071	HOME
1072	CURSOR UP
1073	PAGE UP
1075	LEFT ARROW
1077	RIGHT ARROW
1079	END
1080	DOWN ARROW
1081	PAGE DOWN
1082	INSERT
1083	DELETE
1084-1093	SHIFT+F1-F10
1094-1103	CTRL+F1-F10
1104-1113	ALT+F1-F10
1114	CTRL+PRINT SCREEN
1115	CTRL+LEFT ARROW
1116	CTRL+RIGHT ARROW
1117	CTRL+END
1118	CTRL+PAGE DOWN

1119	CTRL+HOME
1120-1131	ALT+1,2,3,4,5,6,7,8,9,0,HYPHEN, EQUAL SIGN
1132	CTRL+PAGE UP

Example

```
format /rds 1,0;
kk = 0;
do until kk == 27;
   kk = key;
   if kk == 0;
      continue;
   elseif kk == vals(“ ”);
      print “space \\” kk;
   elseif kk == vals(“\r”);
      print “carriage return \\” kk;
   elseif kk ≥ vals(“0”) and kk ≤ vals(“9”);
      print “digit \\” kk chrs(kk);
   elseif vals(upper(chrs(kk))) ≥ vals(“A”) and
          vals(upper(chrs(kk))) ≤ vals(“Z”);
      print “alpha \\” kk chrs(kk);
   else;
      print “\\” kk;
   endif;
endo;
```

This is an example of a loop that processes keyboard input. This loop will continue until the ESC key (ASCII 27) is pressed.

See also

vals, chrs, upper, lower, con, cons

keyav

Purpose Check if keystroke is available.

Format *x* **= keyav;**

Output *x* scalar, value of key or 0 if no key is available.

See also **keyw, key**

keyw

Purpose Waits for and gets a key.

Format *k* **= keyw;**

Output *k* scalar, ASCII value of the key pressed.

Remarks If you are working in terminal mode, GAUSS will not see any input until you press the ENTER key. **keyw** gets the next key from the keyboard buffer. If the keyboard buffer is empty, **keyw** waits for a keystroke. For normal keys, **keyw** returns the ASCII value of the key. See **key** for a table of return values for extended and function keys.

See also key

keyword

Purpose

Begins the definition of a keyword procedure. Keywords are user-defined functions with local or global variables.

Format

keyword *name*(*str*);

Input

name literal, name of the keyword. This name will be a global symbol.

str string, a name to be used inside the keyword to refer to the argument that is passed to the keyword when the keyword is called. This will always be local to the keyword, and cannot be accessed from outside the keyword or from other keywords or procedures.

Remarks

A keyword definition begins with the **keyword** statement and ends with the **endp** statement. See "Procedures and Keywords" in *User's Guide*.

Keywords always have 1 string argument and 0 returns. GAUSS will take everything past *name*, excluding leading spaces, and pass it as a string argument to the keyword. Inside the keyword, the argument is a local string. The user is responsible to manipulate or parse the string.

An example of a keyword definition is:

```
keyword add(str);
   local tok,sum;
   sum = 0;
   do until str $== "";
      { tok, str } = token(str);
      sum = sum + stof(tok);
   endo;
   print "Sum is: " sum;
endp;
```

To use this keyword, type:

```
add 1 2 3 4 5;
```

This keyword will respond by printing:

```
Sum is: 15
```

See also **proc, local, endp**

lag (dataloop)

Purpose

Lags variables a specified number of periods.

Format

lag *nv1* **=** *var1*:*p1* [[*nv2* **=** *var2:p2*...]]**;**

Input

var	name of the variable to lag.
p	scalar constant, number of periods to lag.

Output

nv	name of the new lagged variable.

Remarks

You can specify any number of variables to lag. Each variable can be lagged a different number of periods. Both positive and negative lags are allowed.

Lagging is executed before any other transformations. If the new variable name is different from that of the variable to lag, the new variable is first created and appended to a temporary data set. This temporary data set becomes the input data set for the data loop, and is then automatically deleted.

lag1

Purpose Lags a matrix by one time period for time series analysis.

Format *y* **= lag1(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix, *x* lagged 1 period.

Remarks **lag1** lags *x* by one time period, so the first observations of *y* are missing.

Source lag.src

See also **lagn**

lagn

Purpose Lags a matrix a specified number of time periods for time series analysis.

Format *y* **= lagn(***x*,*t***);**

Input

x	NxK matrix.
t	scalar, number of time periods.

Output

y	NxK matrix, *x* lagged *t* periods.

Remarks If *t* is positive, **lagn** lags *x* back *t* time periods, so the first *t* observations of *y* are missing. If *t* is negative, **lagn** lags *x* forward *t* time periods, so the last *t* observations of *y* are missing.

Source lag.src

See also **lag1**

lapeighb

Purpose

Computes eigenvalues only of a real symmetric or complex Hermitian matrix selected by bounds.

Format

ve = **lapeighb(***x*,*vl*,*vu***);**

Input

x	NxN matrix, real symmetric or complex Hermitian.
vl	scalar, lower bound of the interval to be searched for eigenvalues.
vu	scalar, upper bound of the interval to be searched for eigenvalues; *vu* must be greater than *vl*.
abstol	scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interva [*a*,*b*] of width less than or equal to ABSTOL + EPS*max(|*a*|,|*b*|), where EPS is machine precision. If ABSTOL is less than or equal to zero, then EPS*||*T*|| will be used in its place, where *T* is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.

Output

ve	Mx1 vector, eigenvalues, where M is the number of eigenvalues on the half open interval (*vl*,*vu*]. If no eigenvalues are found then *s* is a scalar missing value.

Remarks

lapeighb computes eigenvalues only which are found on on the half open interval (*vl*,*vu*]. To find eigenvalues within a specified range of indices see **lapeighi**. For eigenvectors see **lapeighvi**, or **lapeighvb** **lapeighb** is based on the LAPACK drivers DYESVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 5   2   1,
      2   6   2,
      1   2   9 };
vl = 5;
vu = 10;
ve = lapeighi(x,il,iu,0);
```

lapeighb

```
print ve;


6.0000
```

See also **lapeighb, lapeighvi, lapeighvb**

lapeighi

Purpose

Computes eigenvalues only of a real symmetric or complex Hermitian matrix selected by index.

Format

ve **= lapeighi(***x*,*il*,*iu*,*abstol***);**

Input

x	NxN matrix, real symmetric or complex Hermitian.
il	scalar, index of the smallest desired eigenvalue ranking them from smallest to largest.
iu	scalar, index of the largest desired eigenvalue, *iu* must be greater than *il*.
abstol	scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interval [*a*,*b*] of width less than or equal to ABSTOL + EPS*max(|*a*|,|*b*|), where EPS is machine precision. If ABSTOL is less than or equal to zero, then EPS*||*T*|| will be used in its place, where *T* is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.

Output

ve	(*iu*-*il*+1)x1 vector, eigenvalues.

Remarks

lapeighi computes *iu*-*il*+1 eigenvalues only given a range of indices, i.e., the i-th to j-th eigenvalues, ranking them from smallest to largest. To find eigenvalues within a specified range see **lapeighxb**. For eigenvectors see LEIGHVX, **lapeighvi**, or **lapeighvb**. **lapeighi** is based on the LAPACK drivers DYESVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 5   2   1,
      2   6   2,
      1   2   9 };
il = 2;
iu = 3;
ve = lapeighi(x,il,iu,0);
print ve;
```

lapeighi

```
              6.0000 10.6056
```

See also **lapeighb, lapeighvi, lapeighvb**

lapeighvb

Purpose

Computes eigenvalues and eigenvectors of a real symmetric or complex Hermitian matrix selected by bounds.

Format

{ *ve*,*va* **} = lapeighvb(**x,*vl*,*vu*,*abstol***);**

Input

x	NxN matrix, real symmetric or complex Hermitian.
vl	scalar, lower bound of the interval to be searched for eigenvalues.
vu	scalar, upper bound of the interval to be searched for eigenvalues; *vu* must be greater than *vl*.
abstol	scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interval [*a*,*b*] of width less than or equal to ABSTOL + EPS*max(|*a*|,|*b*|), where EPS is machine precision. If ABSTOL is less than or equal to zero, then EPS*||*T*|| will be used in its place, where *T* is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.

Output

ve	Mx1 vector, eigenvalues, where M is the number of eigenvalues on the half open interval (*vl*,*vu*]. If no eigenvalues are found then *s* is a scalar missing value.
va	NxM matrix, eigenvectors.

Remarks

lapeighvb computes eigenvalues and eigenvectors which are found on the half open interval (*vl*,*vu*]. **lapeighvb** is based on the LAPACK drivers DYESVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 5   2   1,
      2   6   2,
      1   2   9 };
vl = 5;
vu = 10;
{ ve,va } = lapeighvb(x,il,iu,0);
```

lapeighvb

```
print ve;

6.0000
print va;
-0.5774 -0.5774
 0.5774
```

See also

lapeighvb

lapeighvi

Purpose

Computes selected eigenvalues and eigenvectors of a real symmetric or complex Hermitian matrix.

Format

{ *ve*,*va* **} = lapeighvi(***x*,*il*,*iu*,*abstol***);**

Input

x	NxN matrix, real symmetric or complex Hermitian.
il	scalar, index of the smallest desired eigenvalue ranking them from smallest to largest.
iu	calar, index of the largest desired eigenvalue, *iu* must be greater than *il*.
abstol	scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interval [*a*,*b*] of width less than or equal to ABSTOL + EPS*max(|*a*|,|*b*|), where EPS is machine precision. If ABSTOL is less than or equal to zero, then EPS*||*T*|| will be used in its place, where *T* is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.

Output

ve	(*iu*-*il*+1)x1 vector, eigenvalues.
va	Nx(*iu*-*il*+1) matrix, eigenvectors.

Remarks

lapeighvi computes *iu*-*il*+1 eigenvalues and eigenvectors given a range of indices, i.e., the i-th to j-th eigenvalues, ranking them from smallest to largest. To find eigenvalues and eigenvectors within a specified range see **lapeighvb**. **lapeighvi** is based on the LAPACK drivers DYESVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 5   2   1,
      2   6   2,
      1   2   9 };
il = 2;
iu = 3;
{ ve,va } = lapeighvi(x,il,iu,0);
```

lapeighvi

```
print ve;
6.0000 10.6056
print va;
-0.5774  0.3197  -0.5774  0.4908
 0.5774  0.8105
```

See also

lapeighvb, lapeighb

lapgeig

Purpose Computes generalized eigenvalues for a pair of real or complex general matrices.

Format **{** *va1*,*va2* **} = lapgeig(***A*,*B***);**

Input

A	NxN matrix, real or complex general matrix.
B	NxN matrix, real or complex general matrix.

Output

va1	Nx1 vector, numerator of eigenvalues.
va2	Nx1 vector, denominator of eigenvalues.

Remarks *va1* and *va2* are the vectors of the numerators and denominators respectively of the eigenvalues of the solution of the generalized symmetric eigenproblem of the form *A*w = e*B*w where *A* and *B* are real or complex general matrices and *w* = *va1* ./ *va2*. The generalized eigenvalues are not computed directly because some elements of *va2* may be zero, i.e., the eigenvalues may be infinite. This procedure calls the LAPACK routines DGEGV and ZGEGV.

See also **lapgeig, lapgeigh**

lapgeigh

Purpose Computes generalized eigenvalues for a pair of real symmetric or Hermitian matrices.

Format *ve* **= lapgeigh(***A*,*B***);**

Input

A	NxN matrix, real or complex symmetric or Hermitian matrix.
B	NxN matrix, real or complex positive definite symmetric or Hermitian matrix.

Output

ve	Nx1 vector, eigenvalues.

Remarks *ve* is the vector of eigenvalues of the solution of the generalized symmetric eigenproblem of the form $Ax = \lambda Bx$.

Example

```
A = { 3  4  5,
      2  5  2,
      3  2  4 };
B = { 4  2  2,
      2  6  1,
      2  1  8 };
ve = lapgeigh(A,B);
print ve;
-0.18577146
 0.50880165 1.1335370
```

This procedure calls the LAPACK routines DSYGV and ZHEGV.

See also **lapgeig, lapgeighv**

lapgeighv

Purpose

Computes generalized eigenvalues and eigenvectors for a pair of real symmetric or Hermitian matrices.

Format

{ *ve*,*va* **} = lapgeighv(***A*,*B***);**

Input

A	NxN matrix, real or complex symmetric or Hermitian matrix.
B	NxN matrix, real or complex positive definite symmetric or Hermitian matrix.

Output

ve	Nx1 vector, eigenvalues.
va	NxN matrix, eigenvectors.

Remarks

ve and *va* are the eigenvalues and eigenvectors of the solution of the generalized symmetric eigenproblem of the form $Ax = \lambda Bx$.

Equivalently, *va* diagonalizes $U'^{-1} A U^{-1}$ in the following way

$$vaU'^{-1}AU^{-1}va' = e$$

where $B = U'U$. This procedure calls the LAPACK routines DSYGV and ZHEGV.

Example

```
A = { 3  4  5,
      2  5  2,
      3  2  4 };
B = { 4  2  2,
      2  6  1,
      2  1  8 };
{ ve, va } = lapgeighv(A,B);
print ve;
-0.0425
 0.5082
 0.8694
```

lapgeighv

```
print va;
 0.3575   -0.0996   0.9286
-0.2594    0.9446   0.2012
-0.8972   -0.3128   0.3118
```

See also

lapgeig, lapgeigh

lapgeigv

Purpose

Computes generalized eigenvalues, left eigenvectors, and right eigenvectors for a pair of real or complex general matrices.

Format

{ *va1*,*va2*,*lve*,*rve* **} = lapgeigv(***A*,*B***);**

Input

A	NxN matrix, real or complex general matrix.
B	NxN matrix, real or complex general matrix.

Output

va1	Nx1 vector, numerator of eigenvalues.
va2	Nx1 vector, denominator of eigenvalues.
lve	NxN left eigenvectors.
rve	NxN right eigenvectors.

Remarks

va1 and *va2* are the vectors of the numerators and denominators respectively of the eigenvalues of the solution of the generalized symmetric eigenproblem of the form $A\mathrm{w} = \lambda B\mathrm{w}$ where *A* and *B* are real or complex general matrices and *w* = *va1* ./ *va2*. The generalized eigenvalues are not computed directly because some elements of *va2* may be zero, i.e., the eigenvalues may be infinite.

The left and right eigenvectors diagonalize $U'^{-1} A U^{-1}$ where B = U'U, that is,

$$lve\, U'^{-1} AU\ \ lve' = w$$

and

$$rve' U'^{-1} AU^{-1} rve = w$$

This procedure calls the LAPACK routines DGEGV and ZGEGV.

See also

lapgeig, **lapgeigh**

lapgsvds

Purpose

Compute the generalized singular value decomposition of a pair of real or complex general matrices.

Format

{ *C*,*S*,*R* **} = lapgsvds(***A*,*B***);**

Input

A	MxN real or complex matrix.
B	PxN real or complex matrix.

Output

C	Lx1 vector, singular values for *A*.
S	Lx1 vector, singular values for *B*.
R	(K+L)x(K+L) upper triangular matrix.

Remarks

(1) The generalized singular value decomposition of *A* and *B* is

$$U'AQ = D_1 Z$$

$$V'BQ = D_2 Z$$

where *U, V,* and *Q* are orthogonal matrices (see **lapgsvdcst** and **lapgsvdst**). Letting K+L = the rank of *A*|*B* then *R* is a (K+L)x(K+L) upper triangular matrix, D1 and D2 are Mx(K+L) and Px(K+L) matrices with entries on the diagonal, Z = [0 *R*], and if M-K-L >= 0

$$D_1 = \begin{array}{c} \\ K \\ L \\ M-K-L \end{array} \begin{array}{c} \begin{array}{cc} K & L \end{array} \\ \begin{bmatrix} I & O \\ O & C \\ O & O \end{bmatrix} \end{array}$$

$$D_2 = \begin{array}{c} \\ L \\ P-L \end{array} \begin{array}{c} \begin{array}{cc} K & L \end{array} \\ \begin{bmatrix} O & S \\ O & O \end{bmatrix} \end{array}$$

$$[O\ R] = \begin{array}{c} \\ K \\ L \end{array} \begin{array}{c} \begin{array}{ccc} N-K-L & K & L \end{array} \\ \begin{bmatrix} O & R_{11} & R_{12} \\ O & O & R_{22} \end{bmatrix} \end{array}$$

$$D_1 = \begin{array}{c} \\ K \\ M-K \end{array} \begin{array}{c} \begin{array}{ccc} K & M-K & K+L-M \end{array} \\ \begin{bmatrix} I & O & O \\ O & C & O \end{bmatrix} \end{array}$$

$$D_2 = \begin{array}{c} \\ M-K \\ K+L-M \\ P-L \end{array} \begin{array}{c} \begin{array}{ccc} K & M-K & K+L-M \end{array} \\ \begin{bmatrix} O & S & O \\ O & O & I \\ O & O & O \end{bmatrix} \end{array}$$

$$[O\ R] = \begin{array}{c} \\ K \\ M-K \\ K+L-M \end{array} \begin{array}{c} \begin{array}{cccc} N-K-L & K & M-K & K+L-M \end{array} \\ \begin{bmatrix} O & R_{11} & R_{12} & R_{13} \\ O & O & R_{22} & R_{23} \\ O & O & O & R_{33} \end{bmatrix} \end{array}$$

(2) Form the matrix

$$X = Q \begin{bmatrix} I & O \\ O & R^{-1} \end{bmatrix}$$

then

$$A = U'^{-1} E_1 X$$

$$B = V'^{-1} E_2 X^{-1}$$

where $E_1 = \begin{bmatrix} O & D_2 \end{bmatrix}$. $E_2 = \begin{bmatrix} O & A_2 \end{bmatrix}$

lapgsvds

(3) The generalized singular value decomposition of *A* and *B* implicitly produces the singular value decomposition of AB^{-1}:

$$AB^{-1} = UD_1D_2^{-1}V'$$

This procedure calls the LAPACK routines DGGSVD and ZGGSVD.

Also see **lapgsvdcst and lapgsvdst**

lapgsvdcst

Purpose

Compute the generalized singular value decomposition of a pair of real or complex general matrices.

Format

{ *C*,*S*,*R*,*U*,*V*,*Q* **} = lapgsvdcst(***A*,*B***);**

Input

A	MxN matrix.
B	PxN matrix.

Output

C	Lx1 vector, singular values for *A*.
S	Lx1 vector, singular values for *B*.
R	(K+L)x(K+L) upper triangular matrix.
U	MxM matrix, orthogonal transformation matrix.
V	PxP matrix, orthogonal transformation matrix.
U	NxN matrix, orthogonal transformation matrix.

Remarks

(1) The generalized singular value decomposition of *A* and *B* is

$$U'AQ = D_1 Z$$

$$V'BQ = D_2 Z$$

where *U*, *V*, and *Q* are orthogonal matrices (see **lapgsvdcst** and **lapgsvdst**). Letting K+L = the rank of *A*|*B* then *R* is a (K+L)x(K+L) upper triangular matrix, D1 and D2 are Mx(K+L) and Px(K+L) matrices with entries on the diagonal, Z = [0 *R*], and if M-K-L >= 0

$$D_1 = \begin{array}{c} \\ K \\ L \\ M-K-L \end{array} \begin{array}{c} \begin{array}{cc} K & L \end{array} \\ \begin{bmatrix} I & O \\ O & C \\ O & O \end{bmatrix} \end{array}$$

$$D_2 = \begin{array}{c} \\ L \\ P-L \end{array} \begin{array}{c} \begin{array}{cc} K & L \end{array} \\ \begin{bmatrix} O & S \\ O & O \end{bmatrix} \end{array}$$

$$[O\ R] = \begin{array}{c} \\ K \\ L \end{array} \begin{array}{c} \begin{array}{ccc} N-K-L & K & L \end{array} \\ \begin{bmatrix} O & R_{11} & R_{12} \\ O & O & R_{22} \end{bmatrix} \end{array}$$

$$D_1 = \begin{array}{c} \\ K \\ M-K \end{array} \begin{array}{c} \begin{array}{ccc} K & M-K & K+L-M \end{array} \\ \begin{bmatrix} I & O & O \\ O & C & O \end{bmatrix} \end{array}$$

$$D_2 = \begin{array}{c} \\ M-K \\ K+L-M \\ P-L \end{array} \begin{array}{c} \begin{array}{ccc} K & M-K & K+L-M \end{array} \\ \begin{bmatrix} O & S & O \\ O & O & I \\ O & O & O \end{bmatrix} \end{array}$$

$$[O\ R] = \begin{array}{c} \\ K \\ M-K \\ K+L-M \end{array} \begin{array}{c} \begin{array}{cccc} N-K-L & K & M-K & K+L-M \end{array} \\ \begin{bmatrix} O & R_{11} & R_{12} & R_{13} \\ O & O & R_{22} & R_{23} \\ O & O & O & R_{33} \end{bmatrix} \end{array}$$

(2) Form the matrix

$$X = Q \begin{bmatrix} I & O \\ O & R^{-1} \end{bmatrix}$$

then

$$A = U'^{-1} E_1 X$$

$$B = V'^{-1} E_2 X^{-1}$$

where $E_1 = \begin{bmatrix} O & D_2 \end{bmatrix}$. $E_2 = \begin{bmatrix} O & A_2 \end{bmatrix}$

(3) The generalized singular value decomposition of *A* and *B* implicitly produces the singular value decomposition of AB^{-1}:

$$AB^{-1} = UD_1D_2^{-1}V'$$

This procedure calls the LAPACK routines DGGSVD and ZGGSVD.

See also **lapgsvds and lapgsvdst**

lapgsvdst

Purpose

Compute the generalized singular value decomposition of a pair of real or complex general matrices.

Format

{ *D1*,*D2*,*Z*,*U*,*V*,*Q* **} = lapgsvdst(***A*,*B***);**

Input

A	MxN matrix.
B	PxN matrix.

Output

D1	Mx(K+L) matrix, with singular values for *A* on diagonal.
D2	Px(K+L) matrix, with singular values for *B* on diagonal.
Z	(K+L)xN matrix, partitioned matrix composed of a zero matrix and upper triangular matrix.
U	MxM matrix, orthogonal transformation matrix.
V	PxP matrix, orthogonal transformation matrix.
U	NxN matrix, orthogonal transformation matrix.

Remarks

(1) The generalized singular value decomposition of *A* and *B* is

$$U'AQ = D_1Z$$

$$V'BQ = D_2Z$$

where *U*, *V*, and *Q* are orthogonal matrices (see **lapgsvdcst** and **lapgsvdst**). Letting K+L = the rank of *A*|*B* then *R* is a (K+L)x(K+L) upper triangular matrix, D1 and D2 are Mx(K+L) and Px(K+L) matrices with entries on the diagonal, Z = [0 *R*], and if M-K-L >= 0

$$D_1 = \begin{array}{c} \\ K \\ L \\ M-K-L \end{array} \begin{array}{c} \begin{array}{cc} K & L \end{array} \\ \begin{bmatrix} I & O \\ O & C \\ O & O \end{bmatrix} \end{array}$$

$$D_2 = \begin{array}{c} \\ L \\ P-L \end{array} \begin{array}{c} \begin{array}{cc} K & L \end{array} \\ \begin{bmatrix} O & S \\ O & O \end{bmatrix} \end{array}$$

$$[O\ R] = \begin{array}{c} \\ K \\ L \end{array} \begin{array}{c} \begin{array}{ccc} N-K-L & K & L \end{array} \\ \begin{bmatrix} O & R_{11} & R_{12} \\ O & O & R_{22} \end{bmatrix} \end{array}$$

$$D_1 = \begin{array}{c} \\ K \\ M-K \end{array} \begin{array}{c} \begin{array}{ccc} K & M-K & K+L-M \end{array} \\ \begin{bmatrix} I & O & O \\ O & C & O \end{bmatrix} \end{array}$$

$$D_2 = \begin{array}{c} \\ M-K \\ K+L-M \\ P-L \end{array} \begin{array}{c} \begin{array}{ccc} K & M-K & K+L-M \end{array} \\ \begin{bmatrix} O & S & O \\ O & O & I \\ O & O & O \end{bmatrix} \end{array}$$

$$[O\ R] = \begin{array}{c} \\ K \\ M-K \\ K+L-M \end{array} \begin{array}{c} \begin{array}{cccc} N-K-L & K & M-K & K+L-M \end{array} \\ \begin{bmatrix} O & R_{11} & R_{12} & R_{13} \\ O & O & R_{22} & R_{23} \\ O & O & O & R_{33} \end{bmatrix} \end{array}$$

(2) Form the matrix

$$X = Q \begin{bmatrix} I & O \\ O & R^{-1} \end{bmatrix}$$

then

$$A = U'^{-1} E_1 X$$

$$B = V'^{-1} E_2 X^{-1}$$

where $E_1 = \begin{bmatrix} O & D_2 \end{bmatrix}$. $E_2 = \begin{bmatrix} O & A_2 \end{bmatrix}$

(3) The generalized singular value decomposition of *A* and *B* implicitly produces the singular value decomposition of AB^{-1}:

$$AB^{-1} = UD_1D_2^{-1}V'$$

This procedure calls the LAPACK routines DGGSVD and ZGGSVD.

See also lapgsvds and lapgsvdcst

lapschur

Purpose

Compute the generalized Schur form of a pair of real or complex general matrices.

Format

{ *sa*, *sb*, *q*, *z* **} = lapschur(***A*,*B***);**

Input

A	NxN matrix, real or complex general matrix.
B	NxN matrix, real or complex general matrix.

Output

sa	NxN matrix, Schur form of *A*.
sb	NxN matrix, Schur form of *B*.
q	NxN matrix, left Schur vectors.
z	NxN matrix, right Schur vectors.

Remarks

The pair of matrices *A* and *B* are in generalized real Schur form when *B* is upper triangular with non-negative diagonal, and *A* is block upper triangular with 1x1 and 2x2 blocks. The 1x1 blocks correspond to real generalized eigenvalues and the 2x2 blocks to pairs of complex conjugate eigenvalues. The real generalized eigenvalues can be computed by dividing the diagonal element of sa by the corresponding diagonal element of *sb*. The complex generalized eigenvalues are computed by first constructing two complex conjugate numbers from 2x2 block where the real parts are on the diagonal of the block and the imaginary part on the off-diagonal. The eigenvalues are then computed by dividing the two complex conjugate values by their corresponding diagonal elements of *sb*. The generalized Schur vectors q and z are orthogonal matrices that reduce *A* and *B* to Schur form:

```
sa = q' A z
sb   q' B z
```

This procedure calls the LAPACK routines DGEGS and ZGEGS.

lapsvdcusv

Purpose

Computes the singular value decomposition a real or complex rectangular matrix, returns compact u and v.

Format

{ *u*,*s*,*v* **} = lapsvdcusv(**x**);**

Input

x	MxN matrix, real or complex rectangular matrix.

Output

u	Mxmin(M,N) matrix, left singular vectors.
s	min(M,N)xN matrix, singular values.
v	NxN matrix, right singular values.

Remarks

lapsvdcusv computes the singular value decomposition of a real or complex rectangular matrix. The SVD is

```
x = usv'
```

where *v* is the matrix of right singular vectors. **lapsvdcusv** is based on the LAPACK drivers DGESVD and ZGESVD. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 2.143 4.345 6.124,
      1.244 5.124 3.412, 0.235 5.657 8.214 };
{ u,s,v }  = lapsvdusv(x);
print s;
```

```
–0.55531277  0.04904843   1.83019394
–0.43090168  1.83684123  –0.33766923
–0.71130266 –0.54524400  –0.44357356
```

```
print s;
```

```
        13.895868 0.0000000 0.0000000
        0.0000000 2.1893939 0.0000000
        0.0000000 0.0000000 1.4344261
```

```
print v;
```

```
        –0.13624432 –0.62209955 –0.77099263
         0.46497296  0.64704876 –0.60425826
         0.87477862 –0.44081748  0.20110275
```

See also **lapsvds, lapsvdusv**

lapsvds

Purpose Computes the singular values of a real or complex rectangular matrix

Format *s* **= lapsvds(***x***);**

Input

x	MxN matrix, real or complex rectangular matrix.

Output

s	MiN(M,N)x1 vector, singular values.

Remarks **lapsvd** computes the singular values of a real or complex rectangular matrix. The svd is

```
x = usv'
```

where *v* is the matrix of right singular vectors. For the computation of the singular vectors, see **lapsvdcusv** and **lapsvdusv**.

lapsvd is based on the LAPACK drivers DGESVD and ZGESVD. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 2.143 4.345 6.124,
      1.244 5.124 3.412,
      0.235 5.657 8.214 };
va = lapsvd(x); print va;
      13.895868 2.1893939 1.4344261


xi = { 4+1 3+1 2+2,
       1+2 5+3 2+2,
       1+1 2+1 6+2 };
ve = lapsvds(xi); print ve;
       10.352877 4.0190557 2.3801546
```

See also **lapsvdcusv, lapsvdusv**

lapsvdusv

Purpose

Computes the singular value decomposition a real or complex rectangular matrix.

Format

{ *u*,*s*,*v* **} = lapsvdusv(***x***);**

Input

x	MxN matrix, real or complex rectangular matrix.

Output

u	MxM matrix, left singular vectors.
s	MxN matrix, singular values.
v	NxN matrix, right singular values.

Remarks

lapsvdusv computes the singular value decomposition of a real or complex rectangular matrix. The SVD is

```
x = usv'
```

where *v* is the matrix of right singular vectors. **lapsvdusv** is based on the LAPACK drivers DGESVD and ZGESVD. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

```
x = { 2.143 4.345 6.124,
      1.244 5.124 3.412,
      0.235 5.657 8.214 };
{ u,s,v } = lapsvdusv(x);
print u;
-0.5553  0.0490  0.8302
-0.4309  0.8368 -0.3377
-0.7113 -0.5452 -0.4436
print s;
13.8959  0.0000  0.0000
 0.0000  2.1894  0.0000
 0.0000  0.0000  1.4344
```

lapsvdusv

```
print v;
-0.1362 0.4650  0.8748
 0.6221 0.6470 -0.4408  -0.7710  -0.6043  0.2011
```

See also

lapsvds, lapsvdcusv

let

Purpose

Creates a matrix from a list of numeric or character values. The result is always of type **matrix**, **string** or **string array**.

Format

let *x* **=** *constant_list*;

Remarks

Expressions and matrix names are not allowed in the **let** command. Expressions such as this:

```
let x[2,1] = 3*a b
```

are illegal. To define matrices by combining matrices and expressions, use an expression containing the concatenation operators: **~** and **|** .

Numbers can be entered in scientific notation. The syntax is *d*E±*n*, where *d* is a number and *n* is an integer (denoting the power of 10).

```
let x = 1e+10 1.1e-4 4.019e+2;
```

Complex numbers can be entered by joining the real and imaginary parts with a sign (+ or -); there should be no spaces between the numbers and the sign. Numbers with no real part can be entered by appending an "i" to the number.

```
let x = 1.2+23 8.56i 3-2.1i -4.2e+6i
1.2e-4-4.5e+3i;
```

If curly braces are used, the **let** is optional. You will need the **let** for statements that you want to protect from the beautifier using the **-l** flag on the beautifier command line.

```
let x = { 1 2 3, 4 5 6, 7 8 9 };
x = { 1 2 3, 4 5 6, 7 8 9 };
```

If indices are given, a matrix of that size will be created:

```
let x[2,2] = 1 2 3 4;
```

$$x = \begin{matrix} 1 & 2 \\ 3 & 4 \end{matrix}$$

If indices are not given, a column vector will be created:

let

```
let x = 1 2 3 4;
```

```
x =
1
2
3
4
```

You can create matrices with no elements, i.e., "empty matrices". Just use a set of empty curly braces.

```
x = {};
```

Empty matrices are chiefly used as the starting point for building up a matrix, for example in a **do** loop. For more information on empty matrices, see "Language Fundamentals" in the *User's Guide*.

Character elements are allowed in a **let** statement:

```
let x = age pay sex;
```

```
x =
AGE
PAY
SEX
```

Lowercase elements can be created if quotation marks are used. Note that each element must be quoted.

```
let x = "age" "pay" "sex";
```

```
x =
age
pay
sex
```

Example

```
let x;
```

```
x = 0
```

```
let x = { 1 2 3, 4 5 6, 7 8 9 };
```

```
     1 2 3
x =  4 5 6
     7 8 9
```

```
let x[3,3] = 1 2 3 4 5 6 7 8 9;
```

```
     1 2 3
x =  4 5 6
     7 8 9
```

```
let x[3,3] = 1;
```

```
     1 1 1
x =  1 1 1
     1 1 1
```

```
let x[3,3];
```

```
     0 0 0
x =  0 0 0
     0 0 0
```

let

```
let x = 1 2 3 4 5 6 7 8 9;
```

$x =$ 1, 2, 3, 4, 5, 6, 7, 8, 9

```
let x = dog cat;
```

$x =$ DOG, CAT

```
let x = “dog” “cat”;
```

$x =$ dog, cat

```
let string x = { “Median Income”
                 “Country”;
```

$x =$ Median Income, Country

See also **con, cons, declare, load**

lib

Purpose

Builds and updates library files.

Format

lib *library* [[*file*]] [[**-***flag* **-***flag***...**]]**;**

Input

library literal, name of library.

file optional literal, name of source file to be updated or added.

flags optional literal preceded by '-', controls operation of library update. To control handling of path information on source filenames:

-addpath	(default) add paths to entries without paths and expand relative paths.
-gausspath	reset all paths using a normal file search.
-leavepath	leave all path information untouched.
-nopath	drop all path information.

To specify a library update or a complete library build:

-update	(default) update the symbol information for the specified file only.
-build	update the symbol information for every library entry by compiling the actual source file.
-delete	delete a file from the library.
-list	list files in a library.

To control the symbol type information placed in the library file:

-strong	(default) use strongly typed symbol entries.
-weak	save no type information. This should only be used to build a library compatible with a previous version of GAUSS.

lib

To control location of temporary files for a complete library build:

-tmp	(default) use the directory pointed to by the **tmp_path** configuration variable. The directory will usually be on a RAM disk. If **tmp_path** is not defined, **lib** will look for a **tmp** environment variable.
-disk	use the same directory listed in the **lib_path** configuration variable.

Remarks

The flags can be shortened to one or two letters, as long as they remain unique — for example, **-b** to **-build** a library, **-li** to list files in a library.

If the filenames include a full path, the compilation process is faster because no unnecessary directory searching is needed during the autoloading process. The default path handling adds a path to each file listed in the library and also expands any relative paths so the system will work from any drive or subdirectory.

When a path is added to a filename containing no path information, the file is searched for on the current directory and then on each subdirectory listed in **src_path**. The first path encountered that contains the file is added to the filename in the library entry.

See also

library

library

Purpose

Sets up the list of active libraries.

Format

library [[**-l**]] *lib1*,*lib2*,*lib3*,*lib4*;
library;

Remarks

If no arguments are given, the list of current libraries will be printed out.

The **-l** option will write a file containing a listing of libraries, files, and symbols for all active libraries. This file will reside in the directory defined by the **lib_path** configuration variable. Under Windows and UNIX, the file will have a unique name beginning with `liblst_`. Under OS/2 and DOS, the file will be called `gausslib.lst`; if it already exists it will be overwritten.

For more information about the library system, see "Libraries" in the *User's Guide*.

The default extension for library files is `.lcg`.

If a list of library names is given, they will be the new set of active libraries. The two default libraries are `user.lcg` and `gauss.lcg`. Unless otherwise specified, `user.lcg` will be searched first and `gauss.lcg` will be searched last. Any other user-specified libraries will be searched after `user.lcg` in the order they were entered in the **library** statement.

If the statement:

```
y = dog(x);
```

is encountered in a program, **dog** will be searched for in the active libraries. If it is found, it will be compiled. If it cannot be found in a library, the deletion state determines how it is handled:

autodelete **on**	search for `dog.g`
autodelete **off**	return **Undefined symbol** error message

If **dog** calls **cat** and **cat** calls **bird** and they are all in separate files, they will all be found by the autoloader.

The source browser and the help facility will search for **dog** in exactly the same sequence as the autoloader. The file containing **dog** will be displayed in the window and you can scroll up and down and look at the code and comments.

library

Library files are simple ASCII files that you can create with the editor. Here is an example:

```
/*
** This is a GAUSS library file.
*/

eig.src
     eig       : proc
     eigsym    : proc
     _eigerr   : matrix
svd.src
     cond      : proc
     pinv      : proc
     rank      : proc
     svd       : proc
     _svdtol   : matrix
```

The lines not indented are the file names. The lines that are indented are the symbols defined in that file. As you can see, a GAUSS library is a dictionary of files and the global symbols they contain.

Any line beginning with **/***, ** ** or ***/** is considered a comment. Blank lines are okay.

Here is a debugging hint. If your program is acting strange and you suspect it is autoloading the wrong copy of a procedure, use the source browser or help facility to locate the suspected function. It will use the same search path that the autoloader uses.

See also

declare, external, lib, proc

#lineson, #linesoff

Purpose

The **#lineson** command causes GAUSS to embed line number and file name records in a program for the purpose of reporting the location where an error occurs. The **#linesoff** command causes GAUSS to stop embedding line and file records in a program.

Format

```
#lineson;
#linesoff;
```

Remarks

In the "lines on" mode, GAUSS keeps track of line numbers and file names and reports the location of an error when an execution time error occurs. In the "lines off" mode, GAUSS does not keep track of lines and files at execution time. During the compile phase, line numbers and file names will always be given when errors occur in a program stored in a disk file.

It is easier to debug a program when the locations of errors are reported, but this slows down execution. In programs with several scalar operations, the time spent tracking line numbers and file names is most significant.

These commands have no effect on interactive programs (that is, those typed in the window and run from the command line), since there are no line numbers in such programs.

Line number tracking can be turned on and off through the user interface, but the **#lineson** and **#linesoff** commands will override that.

The line numbers and file names given at run-time will reflect the last record encountered in the code. If you have a mixture of procedures that were compiled without line and file records and procedures that were compiled with line and file records, use the **trace** command to locate exactly where the error occurs.

The **Currently active call** error message will always be correct. If it states that it was executing procedure xyz at line number nnn in file ABC and xyz has no line nnn or is not in file ABC, you know that it just did not encounter any line or file records in xyz before it crashed.

When using **#include**'d files, the line number and file name will be correct for the file the error was in, within the limits stated above.

See also

trace

listwise (dataloop)

Purpose

Controls listwise deletion of missing values.

Format

listwise [[**read**]|[[**write**]];

Remarks

If **read** is specified, the deletion of all rows containing missing values happens immediately after reading the input file and before any transformations. If **write** is specified, the deletion of missing values happens after any transformations and just before writing to the output file. If no **listwise** statement is present, rows with missing values are not deleted.

The default is **read**.

ln

Purpose Computes the natural log of all elements of a matrix.

Format *y* **= ln(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the natural log values of the elements of *x*.

Remarks **ln** is defined for $x \neq 0$.

If *x* is negative, complex results are returned.

You can turn the generation of complex numbers for negative inputs on or off in the GAUSS configuration file, and with the **sysstate** function, case 8. If you turn it off, **ln** will generate an error for negative inputs.

If *x* is already complex, the complex number state doesn't matter; **ln** will compute a complex result.

x can be any expression that returns a matrix.

Example

```
y = ln(16);
```

y = 2.7725887

lncdfbvn

Purpose Computes natural log of bivariate Normal cumulative distribution function.

Format *y* **= lncdfbvn(***x1***,***x2***,***r***);**

Input

x1	NxK matrix, abscissae.
x2	LxM matrix, abscissae.
r	PxQ matrix, correlations.

Output

y	max(N,L,P) x max(K,M,Q) matrix, $ln\ Pr(X < x1, X < x2 \mid r)$.

Remarks *x1*, *x2*, and *r* must be ExE conformable.

Source lncdfn.src

See also **cdfbvn, lncdfmvn**

lncdfbvn2

Purpose

Returns log of cdfbvn of a bounded rectangle.

Format

y **= lncdfbvn2(***h*,*dh*,*k*,*dk*,*r***);**

Input

h	Nx1 vector, upper limits of integration for variable 1.
dh	Nx1 vector, increments for variable 1.
k	Nx1 vector, upper limits of integration for variable 2.
dk	Nx1 vector, increments for variable 2.
r	Nx1 vector, correlation coefficients between the two variables.

Output

y	Nx1 vector, the log of the integral from *h*,*k* to *h*+*dh*,*k*+*dk* of the standardized bivariate Normal distribution.

Remarks

Scalar input arguments are okay; they will be expanded to Nx1 vectors.

lncdfbvn2 will abort if the computed integral is negative.

lncdfbvn2 computes an error estimate for each set of inputs--the real integral is **exp**(*y*)±err. The size of the error depends on the input arguments. If **trap 2** is set, a warning message is displayed when err ≥ **exp**(*y*)/100.

For an estimate of the actual error, see **cdfbvn2e**.

Example

Example 1

```
lncdfbvn2(1,1,1,1,0.5);
```

produces:

```
-3.2180110258198771e+000
```

Example 2

```
trap 0,2;
lncdfbvn2(1,1e-15,1,1e-15,0.5);
```

produces:

```
-7.1171016046360151e+001
```

lncdfbvn2

Example 3

```
trap 2,2;
lncdfbvn2(1,-1e-45,1,1e-45,0.5);
WARNING: Dubious accuracy from lncdfbvn2:
0.000e+000 ± 2.8e-060
-INF
```

See also

cdfbvn2, cdfbvn2e

lncdfmvn

Purpose Computes natural log of multivariate Normal cumulative distribution function.

Format *y* **= lncdfmvn(***x***,***r***);**

Input

x	KxL matrix, abscissae.
r	KxK matrix, correlation matrix.

Output

y	Lx1 vector, *ln Pr*(*X* < *x* | *r*).

Remarks You can pass more than one set of abscissae at a time; each column of *x* is treated separately.

Source lncdfn.src

See also **cdfmvn, lncdfbvn**

lncdfn

Purpose Computes natural log of Normal cumulative distribution function.

Format *y* **= lncdfn(***x***);**

Input *x* NxK matrix, abscissae.

Output *y* NxK matrix, *ln Pr*(*X* < *x*).

Source lncdfn.src

lncdfn2

Purpose Computes natural log of interval of Normal cumulative distribution function.

Format *y* **= lncdfn2(***x*,*r***);**

Input

x	MxN matrix, abscissae.
r	KxL matrix, ExE conformable with *x*, intervals.

Output

y	max(M,K) x max(N,L) matrix, the log of the integral from *x* to *x*+*dx* of the Normal distribution, i.e., *ln Pr*(*x* < *X* < *x* + *dx*).

Remarks The relative error is:

$\|x\| \le 1$ and $dx \le 1$	±1*e*-14
$1 < \|x\| < 37$ and $\|dx\| < 1\|x\|$	±1*e*-13
$\min(x,x + dx) > -37$ and $y > -690$	±1*e*-11 or better

A relative error of ±1*e*-14 implies that the answer is accurate to better than ±1 in the 14th digit.

Example

```
print lncdfn2(-10,29);
   -7.6198530241605269e-24
print lncdfn2(0,1);
   -1.0748623268620716e+00
print lncdfn2(5,1);
   -1.5068446096529453e+01
```

Source lncdfn.src

See also **cdfn2**

lncdfnc

Purpose Computes natural log of complement of Normal cumulative distribution function.

Format *y* **= lncdfnc(***x***);**

Input

x	NxK matrix, abscissae.

Output

y	NxK matrix, *ln* (1 - *Pr*(*X* < *x*)).

Source lncdfn.src

lnfact

Purpose Computes the natural log of the factorial function and can be used to compute log gamma.

Format *y* **= lnfact(***x***);**

Input

x	NxK matrix, all elements must be positive.

Output

y	NxK matrix containing the natural log of the factorial of each of the elements of *x*.

Remarks For integer *x*, this is (approximately) *ln*(*x*!). However, the computation is done using a formula, and the function is defined for noninteger *x*.

In most formulae in which the factorial operator appears, it is possible to avoid computing the factorial directly, and to use **lnfact** instead. The advantage of this is that **lnfact** does not have the overflow problems that the factorial (**!**) operator has.

For $x \geq 1$, this function has at least 6 digit accuracy, for $x > 4$ it has at least 9 digit accuracy, and for $x > 10$ it has at least 12 digit accuracy. For $0 < x < 1$, accuracy is not known completely but is probably at least 6 digits.

Sometimes log gamma is required instead of log factorial. These functions are related by:

```
lngamma(x) = lnfact(x-1);
```

Example

```
let x = 100 500 1000;
y = lnfact(x);
```

```
          363.739375560
y =       2611.33045846
          5912.12817849
```

Source lnfact.src

See also **gamma**

lnfact

Technical Notes

For $x > 1$, Stirling's formula is used.

For $0 < x \leq 1$, **ln(gamma(**x**+1))** is used.

lnpdfn

Purpose Computes standard Normal log-probabilities.

Format *z* **= lnpdfn(***x***);**

Input

x NxK matrix, data.

Output

z NxK matrix, log-probabilities.

Remarks This computes the log of the scalar Normal density function for each element of *x*. *z* could be computed by the following GAUSS code:

```
y = -ln(sqrt(2*pi))-x.*x/2;
```

For multivariate log-probabilities, see **lnpdfmvn**.

Example

```
x = { .2, -1, 0, 1, 2 };
z = lnpdfn(x);
```

$$z = \begin{matrix} -2.9189385 \\ -1.4189385 \\ -0.91893853 \\ -1.4189385 \\ -2.9189385 \end{matrix}$$

lnpdfmvn

Purpose Computes multivariate Normal log-probabilities.

Format *z* **= lnpdfmvn(***x***,***s***);**

Input

x	NxK matrix, data.
s	KxK matrix, covariance matrix.

Output

z	Nx1 vector, log-probabilities.

Remarks This computes the multivariate Normal log-probability for each row of *x*.

lnpdfmvt

Purpose Computes multivariate Student's t log-probabilities.

Format *z* **= lnpdfmvt(***x***,***s***,***nu***);**

Input

x	NxK matrix, data.
s	KxK matrix, covariance matrix.
nu	scalar, degrees of freedom.

Output

z	Nx1 vector, log-probabilities.

lnpdft

Purpose

Computes Student's t log-probabilities.

Format

z **= lnpdft(***x*,*nu***);**

Input

x	NxK matrix, data.
nu	scalar, degrees of freedom.

Output

z	NxK matrix, log-probabilities.

Remarks

This does not compute the log of the joint Student's t pdf. Instead, the scalar Normal density function is computed element by element.

For multivariate probabilities with covariance matrix see lnpdfmvt.

load, loadf, loadk, loadm, loadp, loads

Purpose

Loads from a disk file.

Format

load [[**path=***path*]] *x*, *y[]*=*filename*, *z*=*filename*;

Remarks

All the **load***xx* commands use the same syntax — they only differ in the types of symbols you use them with.

load, loadm	matrix
loads	string
loadf	function (**fn**)
loadk	keyword (**keyword**)
loadp	procedure (**proc**)

If no filename is given as with *x* above, then the symbol name the file is to be loaded into is used as the filename and the proper extension is added.

If more than one item is to be loaded in a single statement, the names should be separated by commas.

The filename can be either a literal or a string. If the filename is in a string variable, then the **^** (caret) operator must precede the name of the string, as in:

```
filestr = "mydata/char";
loadm x = ^filestr;
```

If no extension is supplied, the proper extension for each type of file will be used automatically as follows:

load	.fmt - matrix file or delimited ASCII file
loadm	.fmt - matrix file or delimited ASCII file
loads	.fst - string file
loadf	.fcg - user-defined function (**fn**) file
loadk	.fcg - user-defined keyword (**keyword**) file
loadp	.fcg - user-defined procedure (**proc**) file

These commands also signal to the compiler what type of object the symbol is so that later references to it will be compiled correctly.

A dummy definition must exist in the program for each symbol that is loaded in using **loadf**, **loadk**, or **loadp**. This resolves the need to

have the symbol initialized at compile time. When the load executes, the dummy definition will be replaced with the saved definition.

```
proc corrmat; endp;
loadp corrmat;
y = corrmat;


keyword regress(x); endp;
loadk regress;
regress x on y z t from data01;


fn sqrd=;
loadf sqrd;
y = sqrd(4.5);
```

To load GAUSS files created with the **save** command, no brackets are used with the symbol name.

If you use **save** to save a scalar error code 65535 (i.e., **error(65535)**), it will be interpreted as an empty matrix when you **load** it again.

ASCII data files

To load ASCII data files, square brackets follow the name of the symbol.

Numbers in ASCII files must be delimited with spaces, commas, tabs, or newlines. If the size of the matrix to be loaded is not explicitly given, as in:

```
load x[] = data.asc;
```

GAUSS will load as many elements as possible from the file and create an Nx1 matrix. This is the preferred method of loading ASCII data from a file, especially when you want to verify if the load was successful. Your program can then see how many elements were actually loaded by testing the matrix with the **rows** command, and if that is correct, the Nx1 matrix can be reshaped to the desired form. You could, for instance, put the number of rows and columns of the matrix right in the file as the first and second elements and reshape the remainder of the vector to the desired form using those values.

If the size of the matrix is explicitly given in the **load** command, then no checking will be done. If you use:

```
load x[500,6] = data.asc;
```

GAUSS will still load as many elements as possible from the file into an Nx1 matrix and then automatically reshape it using the dimensions given.

If your file contains nine numbers (1 2 3 4 5 6 7 8 9), then the matrix *x* that was created would be as follows:

```
load x[1,9] = data.asc;

x =  1 2 3 4 5 6 7 8 9

load x[3,3] = data.asc;

     1 2 3
x =  4 5 6
     7 8 9

load x[2,2] = data.asc;

x =  1 2
     3 4

load x[2,9] = data.asc;

x =  1 2 3 4 5 6 7 8 9
     1 2 3 4 5 6 7 8 9

load x[3,5] = data.asc;

     1 2 3 4 5
x =  6 7 8 9 1
     2 3 4 5 6
```

load accepts pathnames. The following is legal:

```
loadm k = /gauss/x;
```

This will load `/gauss/x.fmt` into **k**.

If the **path=** subcommand is used with **load** and **save**, the path string will be remembered until changed in a subsequent command. This path will be used whenever none is specified. There are four separate paths for:

1. **load, loadm**
2. **loadf, loadp**
3. **loads**
4. **save**

Setting any of the four paths will not affect the others. The current path settings can be obtained (and changed) with the **sysstate** function, cases 4-7.

```
loadm path = /data;
```

This will change the **loadm** path without loading anything.

```
load path = /gauss x,y,z;
```

This will load `x.fmt`, `0y.fmt`, and `z.fmt` using `/gauss` as a path. This path will be used for the next load if none is specified.

The load path or save path can be overridden in any particular load or save by putting an explicit path on the filename given to load from or save to as follows:

```
loadm path = /miscdata;

loadm x = /data/mydata1, y, z = hisdata;
```

In the above program:

`/data/mydata1.fmt` would be loaded into a matrix called *x*.

`/miscdata/y.fmt` would be loaded into a matrix called *y*.

`/miscdata/hisdata.fmt` would be loaded into a matrix called *z*.

```
oldmpath = sysstate(5,"/data");

load x, y;

call sysstate(5,oldmpath);
```

This will get the old **loadm** path, set it to `/data`, load `x.fmt` and `y.fmt`, and reset the **loadm** path to its original setting.

See also

loadd, save, let, con, cons, sysstate

loadd

Purpose Loads a data set.

Format *y* **= loadd(***dataset***);**

Input *dataset* string, name of data set.

Output *y* NxK matrix of data.

Remarks The data set must not be larger than a single GAUSS matrix.

If *dataset* is a null string or 0, the data set `temp.dat` will be loaded. To load a matrix file, use an `.fmt` extension on *dataset*.

Source `saveload.src`

Globals **__maxvec**

loadwind

Purpose Loads a previously saved graphic panel configuration.

Library pgraph

Format *err* = loadwind(*namestr*);

Input *namestr* string, name of file to be loaded.

Output *err* scalar, 0 if successful, 1 if graphic panel matrix is invalid. Note that the current graphic panel configuration will be overwritten in either case.

Source pwindow.src

See also savewind

local

Purpose Declares variables that are to exist only inside a procedure.

Format `local` *x*`,` *y*`,` *f*`:proc;`

Remarks The statement above would place the names *x*, *y*, and *f* in the local symbol table for the current procedure being compiled. This statement is legal only between the **`proc`** statement and the **`endp`** statement of a procedure definition.

These symbols cannot be accessed outside of the procedure.

The symbol *f* in the example above will be treated as a procedure whenever it is accessed in the procedure. What is actually passed in is a pointer to a procedure.

See "Procedures and Keywords" in the *User's Guide*.

See also **`proc`**

locate

Purpose

Positions the cursor in the window.

Format

locate *m*, *n*;

Portability

Windows only

Locates the cursor in the current output window.

Remarks

m and *n* denote the row and column, respectively, at which the cursor is to be located.

The origin (1,1) is the upper left corner.

m and *n* may be any expressions that return scalars. Nonintegers will be truncated to an integer.

Example

```
r = csrlin;
c = csrcol;
cls;
locate r,c;
```

In this example the window is cleared without affecting the cursor position.

See also

csrlin, **csrcol**

loess

Purpose

Computes coefficients of locally weighted regression.

Format

{ *yhat*,*ys*,*xs* **} = loess(***depvar*,*indvars***);**

Input

depvar	NX1 vector, dependent variable.
indvars	NXK matrix, independent variables.

Global Input

_loess_Span	scalar, degree of smoothing. Must be greater than 2 / N. Default = .67777.
_loess_NumEval	scalar, number of points in *ys* and *xs*. Default = 50.
_loess_Degree	scalar, if 2, quadratic fit, otherwise linear. Default = 1.
_loess_WgtType	scalar, type of weights. If 1, robust, symmetric weights, otherwise Gaussian. Default = 1.
__output	scalar, if 1, iteration information and results are printed, otherwise nothing is printed.

Output

yhat	NX1 vector, predicted *depvar* given *indvars*.
ys	**_loess_numEval**X1 vector, ordinate values given abscissae values in *xs*.
xs	**_loess_numEval**X1 vector, equally spaced abscissae values.

Remarks

Based on Cleveland, William S. “Robust Locally Weighted Regression and Smoothing Scatterplots.” *JASA.* Vol. 74, 1979, 829-36.

Source

loess.src

log

Purpose

Computes the $\log_{10}$ of all elements of a matrix.

Format

y **= log(***x***);**

Input

x NxK matrix.

Output

y NxK matrix containing the log 10 values of the elements of *x*.

Remarks

log is defined for $x \neq 0$.

If *x* is negative, complex results are returned.

You can turn the generation of complex numbers for negative inputs on or off in the GAUSS configuration file, and with the **sysstate** function, case 8. If you turn it off, **log** will generate an error for negative inputs.

If *x* is already complex, the complex number state doesn't matter; **log** will compute a complex result.

x can be any expression that returns a matrix.

Example

```
x = round(rndu(3,3)*10+1);
y = log(x);
```

$$x = \begin{matrix} 4.0000000000 & 2.0000000000 & 1.0000000000 \\ 10.0000000000 & 4.0000000000 & 8.0000000000 \\ 7.0000000000 & 2.0000000000 & 6.0000000000 \end{matrix}$$

$$y = \begin{matrix} 0.60205999 & 0.30103 & 0.30103 \\ 1.0000000000 & 0.60205999 & 0.90308999 \\ 0.8450980400 & 0.30103 & 0.77815125 \end{matrix}$$

loglog

Purpose Graphs X vs. Y using log coordinates.

Library **pgraph**

Format **loglog(***x*,*y***);**

Input

x	Nx1 or NxM matrix. Each column contains the X values for a particular line.
y	Nx1 or NxM matrix. Each column contains the Y values for a particular line.

Source ploglog.src

See also **xy, logy, logx**

logx

Purpose Graphs X vs. Y using log coordinates for the X axis.

Library pgraph

Format logx(*x*,*y*);

Input

x	Nx1 or NxM matrix. Each column contains the X values for a particular line.
y	Nx1 or NxM matrix. Each column contains the Y values for a particular line.

Source plogx.src

See also xy, logy, loglog

logy

Purpose Graphs X vs. Y using log coordinates for the Y axis.

Library **pgraph**

Format **logy(*x*,*y*);**

Input

x	Nx1 or NxM matrix. Each column represents the X values for a particular line.
y	Nx1 or NxM matrix. Each column represents the Y values for a particular line.

Source plogy.src

See also **xy, logx, loglog**

lower

Purpose Converts a string or character matrix to lowercase.

Format *y* **= lower(***x***);**

Input

x	string or NxK matrix of character data to be converted to lowercase.

Output

y	string or NxK matrix which contains the lowercase equivalent of the data in *x*.

Remarks If *x* is a numeric matrix, *y* will contain garbage. No error message will be generated since GAUSS does not distinguish between numeric and character data in matrices.

Example

```
x = "MATH 401";
y = lower(x);
print y;
```

produces:

```
math 401
```

See also upper

lowmat, lowmat1

Purpose Returns the lower portion of a matrix. **lowmat** returns the main diagonal and every element below. **lowmat1** is the same except it replaces the main diagonal with ones.

Format
```
L = lowmat(x);
L = lowmat1(x);
```

Input

x	NxN matrix.

Output

L	NxN matrix containing the lower elements of the matrix. The upper elements are replaced with zeros. **lowmat** returns the main diagonal intact. **lowmat1** replaces the main diagonal with ones.

Example
```
x = { 1  2 -1,
      2  3 -2,
      1 -2  1 };

L = lowmat(x);
L1 = lowmat1(x);
```

The resulting matrices are:

$$L = \begin{matrix} 1 & 0 & 0 \\ 2 & 3 & 0 \\ 1 & -2 & 1 \end{matrix}$$

$$L1 = \begin{matrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ 1 & -2 & 1 \end{matrix}$$

Source diag.src

See also **upmat, upmat1, diag, diagrv, crout, croutp**

lpos

Purpose

Returns the current position of the print head within the printer buffer for the printer.

Format

y **= lpos;**

Remarks

This function is basically equivalent to function **csrcol** but this returns the current column position for the standard printer.

The value returned is the column position of the next character to be printed to the printer buffer. This does not necessarily reflect the actual physical position of the print head at the time of the call.

If this function returns a number greater than 1, there are characters in the buffer for the standard printer which have not yet been sent to the printer. This buffer can be flushed at any time by **lprint**'ing a carriage return/line feed sequence, or a form feed character.

Example

```
if lpos > 60;
   lprint;
endif;
```

In this example, if the print buffer contains 60 characters or more, a carriage return/line feed sequence will be printed.

See also

lprint, lpwidth

lprint

Purpose

Controls printing to the line printer.

Format

lprint [[*/typ*]] [[*/fmted*]] [[*/mf*]] [[*/jnt*]] [[*list of expressions separated by spaces*]] [[*;*]]**;**

Remarks

This function was originally written for line printers. It is still supported for backwards compatibility purposes, but if you're using a page-oriented printer (such as a laser or inkjet printer), it may not give you the results you're expecting.

lprint statements work in essentially the same way that **print** statements work. The main difference is that **lprint** statements cannot be directed to the auxiliary output. Also, the **locate** statement has no meaning with **lprint**.

Two semicolons following an **lprint** statement will suppress the final line feed.

See **print** for information on */typ*, */fmted*, */mf*, and */jnt*.

A list of expressions is a list of GAUSS expressions, separated by spaces. In **lprint** statements, because a space is the delimiter between expressions, no spaces are allowed inside expressions unless they are within index brackets, they are in quotes, or the whole expression is in parentheses.

Printer width can be specified by the **lpwidth** statement:

```
lpwidth 132;
```

This statement remains in effect until cancelled. The default printer width is 80. That is, GAUSS automatically sends a line feed to the printer after printing 80 characters.

lpos can be used to determine the (column) position of the next character that will be printed in the buffer.

An **lprint** statement by itself will cause a blank line to be printed:

```
lprint;
```

The printing of special characters is accomplished by the use of the backslash (\) within double quotes. The options are:

"\b"	**backspace** (ASCII 8)
"\e"	**escape** (ASCII 27)

lprint

"\f"	**form feed** (ASCII 12)
"\l"	**line feed** (ASCII 10)
"\r"	**carriage return** (ASCII 13)
" t"	**tab** (ASCII 9)
"\###"	the character whose ASCII value is "###" (decimal)

GAUSS also has an automatic line printer mode which causes the results of all global assignment statements to be printed out on the printer. This is controlled by the l**print on** and **lprint off** commands. (See **lprint on**, **lprint off**.)

Example

```
lprint 3*4 5+2;
```

See also

print, lprint on, lpos, lpwidth, format

lpwidth

Purpose

Specifies the width of the printer.

Format

lpwidth *n*;

Remarks

n is a scalar which specifies the width of the printer in columns (characters). That is, after printing *n* characters on a line, GAUSS will send a carriage return and a line feed, so that the print head will move to the beginning of the next line.

If a matrix is being printed, the line feed sequence will always be inserted between separate elements of the matrix rather than being inserted between digits of a single element.

n may be any scalar-valued expression. Nonintegers will be truncated to an integer.

The default is 80 columns.

Note: This does not send control characters to the printer to automatically switch the mode of the printer to a different character pitch because each printer is different. This only controls the frequency of carriage return/line feed sequences.

Example

```
lpwidth 132;
```

This statement will change the printer width to 132 columns.

See also

lprint, **lpos**, **outwidth**

ltrisol

Purpose

Computes the solution of $Lx = b$ where L is a lower triangular matrix.

Format

x **= ltrisol(***b***,***L***);**

Input

b	PxK matrix.
L	PxP lower triangular matrix.

Output

x	PxK matrix.

ltrisol applies a forward solve to $Lx = b$ to solve for x. If b has more than one column, each column will be solved for separately, i.e., **ltrisol** will apply a forward solve to **L * x[.,i] = b[.,i]**.

lu

Purpose Computes the LU decomposition of a square matrix with partial (row) pivoting, such that $X = LU$.

Format `{ l,u } = lu(x);`

Input

x	NxN square nonsingular matrix.

Output

l	NxN "scrambled" lower triangular matrix. This is a lower triangular matrix that has been reordered based on the row pivoting.
u	NxN upper triangular matrix.

Example

```
rndseed 13;
format /rd 10,4;
x = complex(rndn(3,3),rndn(3,3));
{ l,u } = lu(x);
x2 = l*u;
```

$$x = \begin{matrix} 0.1523 + 0.7685i & -0.8957 + 0.0342i & 2.4353 + 2.7736i \\ -1.1953 + 1.2187i & 1.2118 + 0.2571i & -0.0446 - 1.7768i \\ 0.8038 + 1.3668i & 1.2950 - 1.6929i & 1.6267 + 0.2844i \end{matrix}$$

$$l = \begin{matrix} 0.2589 - 0.3789i & -1.2417 + 0.5225i & 1.0000 \\ 1.0000 & 0.0000 & 0.0000 \\ 0.2419 - 0.8968i & 1.0000 & 0.0000 \end{matrix}$$

$$u = \begin{matrix} -1.1953 + 1.2187i & 1.2118 + 0.2571i & -0.0446 - 1.7768i \\ 0.0000 & 0.7713 - 0.6683i & 3.2309 + 0.6742i \\ 0.0000 & 0.0000 & 6.7795 + 5.7420i \end{matrix}$$

lu

$$x2 = \begin{matrix} 0.1523 + 0.7685i & -0.8957 + 0.0342i & 2.4353 + 2.7736i \\ -1.1953 + 1.2187i & 1.2118 + 0.2571i & -0.0446 - 1.7768i \\ 0.8038 + 1.3668i & 1.2950 - 1.6929i & 1.6267 + 0.2844i \end{matrix}$$

See also **crout, croutp, chol**

lusol

Purpose

Computes the solution of $LUx = b$ where L is a lower triangular matrix and U is an upper triangular matrix.

Format

x **= lusol(***b*,*L*,*U***);**

Input

b	PxK matrix.
L	PxP lower triangular matrix.
U	PxP upper triangular matrix.

Output

x	PxK matrix.

Remarks

If *b* has more than one column, each column is solved for separately, i.e., **lusol** solves $LUx[.,i] = b[.,i]$.

make (dataloop)

Purpose

Specifies the creation of a new variable within a data loop.

Format

make [[#]] *numvar* **=** *numeric_expression*;
make $ *charvar* **=** *character_expression*;

Remarks

A *numeric_expression* is any valid expression returning a numeric vector. A *character_expression* is any valid expression returning a character vector. If neither '**$**' nor '**#**' is specified, '**#**' is assumed.

The expression may contain explicit variable names and/or GAUSS commands. Any variables referenced must already exist, either as elements of the source data set, as **extern**s, or as the result of a previous **make**, **vector**, or **code** statement. The variable name must be unique. A variable cannot be made more than once, or an error is generated.

Example

```
make sqvpt = sqrt(velocity * pressure * temp);

make $ sex = lower(sex);
```

See also

vector

makevars

Purpose

Creates separate global vectors from the columns of a matrix.

Format

makevars(*x*,*vnames*,*xnames***);**

Input

x	NxK matrix whose columns will be converted into individual vectors.
vnames	string or Mx1 character vector containing names of global vectors to create. If 0, all names in *xnames* will be used.
xnames	string or Kx1 character vector containing names to be associated with the columns of the matrix *x*.

Remarks

If *xnames* = 0, the prefix X will be used to create names. Therefore, if there are 9 columns in *x*, the names will be X1-X9, if there are 10, they will be X01-X10, and so on.

If *xnames* or *vnames* is a string, the individual names must be separated by spaces or commas.

```
vnames = “age pay sex";
```

Since these new vectors are created at execution time, the compiler will not know they exist until after **makevars** has executed once. This means that you cannot access them by name unless you previously **clear** them or otherwise add them to the symbol table. (See **setvars** for a quick interactive solution to this.)

This function is the opposite of **mergevar**.

Example

```
let x[3,3] =  101 35 50000
              102 29 13000
              103 37 18000;
let xnames = id age pay;
let vnames = age pay;
makevars(x,vnames,xnames);
```

Two global vectors, called **age** and **pay**, are created from the columns of **x**.

makevars

```
let x[3,3] =  101 35 50000
              102 29 13000
              103 37 18000;
xnames = "id age pay";
vnames = "age pay";
makevars(x,vnames,xnames);
```

This is the same as the example above, except that strings are used for the variable names.

Source vars.src

Globals __vpad

See also mergevar, setvars

makewind

Purpose

Creates a graphic panel of specific size and position and add it to the list of graphic panels.

Library

pgraph

Format

makewind(*xsize***,***ysize***,***xshft***,***yshft***,***typ***);**

Input

xsize	scalar, horizontal size of the graphic panel in inches.
ysize	scalar, vertical size of the graphic panel in inches.
xshft	scalar, horizontal distance from left edge of window in inches.
yshft	scalar, vertical distance from bottom edge of window in inches.
typ	scalar, graphic panel attribute type. If this value is 1, the graphic panels will be transparent. If 0, the graphic panels will be nontransparent.

Remarks

Note that if this procedure is used when rotating the page, the passed parameters are scaled appropriately to the newly oriented page. The size and shift values will not be true inches when printed, but the graphic panel size to page size ratio remains the same. The result of this implementation automates the rotation and eliminates the required graphic panel recalculations by the user.

See the **window** command for creating tiled graphic panels. For more information on using graphic panels, see "Publication Quality Graphics" in the *User's Guide*.

Source

pwindow.src

See also

window, endwind, setwind, getwind, begwind, nextwind

margin

Purpose Sets the margins for the current graph graphic panel.

Library pgraph

Format margin(*l*,*r*,*t*,*b*);

Input

l	scalar, the left margin in inches.
r	scalar, the right margin in inches.
t	scalar, the top margin in inches.
b	scalar, the bottom margin in inches.

Remarks By default, the dimensions of the graph are the same as the graphic panel dimensions. With this function the graph dimensions may be decreased. The result will be a smaller plot area surrounded by the specified margin. This procedure takes into consideration the axes labels and numbers for correct placement.

All input inch values for this procedure are based on a full size window of 9 x 6.855 inches. If this procedure is used with a graphic panel, the values will be scaled to **window inches** automatically.

If the axes must be placed an exact distance from the edge of the page, **axmargin** should be used.

Source pgraph.src

See also axmargin

matalloc

Purpose Allocates a matrix with unspecified contents.

Format *y* **= matalloc(***r,c***);**

Input

r	scalar, rows.
c	scalar, columns.

Output

y	*r*x*c* matrix.

Remarks The contents are unspecified. This function is used to allocate a matrix that will be written to in sections using indexing or used with the Foreign Language Interface as an output matrix for a function called with **dllcall()**.

See Also **matinit, ones, zeros, eye**

matinit

Purpose Allocates a matrix with unspecified contents.

Format *y* **= matinit(***r,c,v***);**

Input

r	scalar, rows.
c	scalar, columns.
v	scalar, value to initialize.

Output

y	*r*x*c* matrix with each element equal to the value of *v*.

See Also **matalloc, ones, zeros, eye**

maxc

Purpose

Returns a column vector containing the largest element in each column of a matrix.

Format

y **= maxc(***x***);**

Input

x	NxK matrix.

Output

y	Kx1 matrix containing the largest element in each column of *x*.

Remarks

If *x* is complex, **maxc** uses the complex modulus (**abs(***x***)**) to determine the largest elements.

To find the maximum elements in each row of a matrix, transpose the matrix before applying the **maxc** function.

To find the maximum value in the whole matrix if the matrix has more than one column, nest two calls to **maxc**:

```
y = maxc(maxc(x));
```

Example

```
x = rndn(4,2);
y = maxc(x);
```

$$x = \begin{matrix} -2.124474 & 1.376765 \\ 0.348110 & 1.172391 \\ -0.027064 & 0.796867 \\ 1.421940 & -0.351313 \end{matrix}$$

$$y = \begin{matrix} 1.421940 \\ 1.376765 \end{matrix}$$

See also

minc, maxindc, minindc

maxindc

Purpose

Returns a column vector containing the index (i.e., row number) of the maximum element in each column in a matrix.

Format

y **= maxindc(***x***);**

Input

x	NxK matrix.

Output

y	Kx1 matrix containing the index of the maximum element in each column of *x*.

Remarks

If *x* is complex, **maxc** uses the complex modulus (**abs(***x***)**) to determine the largest elements.

To find the index of the maximum element in each row of a matrix, transpose the matrix before applying **maxindc**.

If there are two or more "largest" elements in a column (i.e., two or more elements equal to each other and greater than all other elements), then **maxindc** returns the index of the first one found, which will be the smallest index.

Example

```
x = round(rndn(4,4)*5);
y = maxc(x);
z = maxindc(x);
```

$$x = \begin{matrix} 1 & -11 & 0 & 5 \\ 0 & 0 & -2 & -6 \\ -8 & 0 & 3 & 2 \\ -11 & 5 & -4 & 5 \end{matrix}$$

$$y = \begin{matrix} 1 \\ 5 \\ 3 \\ 5 \end{matrix}$$

$$z = \begin{matrix} 1 \\ 4 \\ 3 \\ 1 \end{matrix}$$

See also **maxc, minindc, minc**

maxvec

Purpose Returns maximum vector length allowed.

Format *y* **= maxvec;**

Global Input **__maxvec** scalar, maximum vector length allowed.

Output *y* scalar, maximum vector length.

Remarks **maxvec** returns the value in the global scalar **__maxvec**, which can be reset in the calling program. This must never be set to 8190.

maxvec is called by Run-Time Library functions and applications when determining how many rows can be read from a data set in one call to **readr**.

On systems without virtual memory you can use 536870910. Otherwise a smaller value like 20000-30000 is necessary to prevent excessive disk thrashing. The trick is to allow the algorithm making the disk reads to execute entirely in RAM.

Example

```
y = maxvec;
print y;
```

produces:

```
20000.000
```

Source system.src

mbesseli

Purpose

Computes modified and exponentially scaled modified Bessels of the first kind of the nth order.

Format

y **= mbesseli(***x*,*n*,*alpha***);**
y **= mbesseli0(***x***);**
y **= mbesseli1(***x***);**

y **= mbesselei(***x*,*n*,*alpha***);**
y **= mbesselei0(***x***);**
y **= mbesselei1(***x***);**

Input

x	Kx1 vector, abscissae.
n	scalar, highest order.
alpha	scalar, $0 \le alpha < 1$.

Output

y	KxN matrix, evaluations of the modified Bessel or the exponentially scaled modified Bessel of the first kind of the nth orders.

Remarks

For the functions that permit you to specify the order, the returned matrix contains a sequence of modified or exponentially scaled modified Bessel values of different orders. For the ith row of y:

$$y[i,.] = I_{\alpha}(x[i])\ I_{\alpha+1}(x[i])\ \ldots\ I_{\alpha+n-1}(x[i])$$

The remaining functions generate modified Bessels of only the specified order.

The exponentially scaled modified Bessels are related to the unscaled modifed Bessels in the following way:

```
mbesselei0(x) = exp(-x) * mbesseli0(x)
```

The use of the scaled versions of the modified Bessel can improve the numerical properties of some calculations by keeping the intermediate numbers small in size.

Example

This example produces estimates for the “circular” response regression model (Fisher, N.I. *Statistical Analysis of Circular Data*. NY: Cambridge

University Press, 1993.), where the dependent variable varies between -π and π in a circular manner. The model is

$$y = \mu + G(XB)$$

where *B* is a vector of regression coefficients, *X* a matrix of independent variables with a column of 1's included for a constant, and *y* a vector of "circular" dependent variables, and where *G*() is a function mapping *XB* onto the [-π, π] interval.

The log-likelihood for this model is from Fisher, N.I. ... 1993, 159;

$$logL = -N \; x \; ln((I_0(\kappa)) + \kappa) \sum_{i}^{N} cos(y_i - \mu - G(X_i B))$$

To generate estimates it is necessary to maximize this function using an iterative method. **QNewton** is used here.

κ is required to be nonnegative and therefore in the example below, the exponential of this parameter is estimated instead. Also, the exponentially scaled modified Bessel is used to improve numerical properties of the calculations.

The **arctan** function is used in *G*()to map *XB* to the [-π, π] interval as suggested by Fisher, N.I. ... 1993, 158.

```
proc G(u);
   retp(2*atan(u));
endp;

proc lpr(b);
   local dev;
```

```
/*
** b[1] - kappa
** b[2] - mu
** b[3] - constant
** b[4:rows(b)] - coefficients
*/
   dev = y - b[2]- G(b[3] + x * b[4:rows(b)]);
   retp(rows(dev)*ln(mbesselei0(exp(b[1])) -
   sumc(exp(b[1])*(cos(dev)-1))));
endp;

loadm data;
y0 = data[.,1];
x0 = data[.,2:cols(data)];

b0 = 2*ones(cols(x),1);

{ b,fct,grd,ret } = QNewton(&lpr,b0);

cov = invpd(hessp(&lpr,b));

print “estimates   standard errors”;
print;
print b~sqrt(diag(cov));
```

Source ribesl.src

meanc

Purpose Computes the mean of every column of a matrix.

Format *y* **= meanc(***x***);**

Input *x* NxK matrix.

Output *y* Kx1 matrix containing the mean of every column of *x*.

Example

```
x = meanc(rndu(2000,4));
```

$$x = \begin{matrix} 0.492446 \\ 0.503543 \\ 0.502905 \\ 0.509283 \end{matrix}$$

In this example, 4 columns of uniform random numbers are generated in a matrix, and the mean is computed for each column.

See also **stdc**

median

Purpose Computes the medians of the columns of a matrix.

Format *m* **= median(***x***);**

Input

x	NxK matrix.

Output

m	Kx1 vector containing the medians of the respective columns of *x*.

Example

```
x = { 8 4,
      6 8,
      3 7 };
y = median(x);
```

y =
6.0000000
7.0000000

Source median.src

mergeby

Purpose

Merges two sorted files by a common variable.

Format

mergeby(*infile1*,*infile2*,*outfile*,*keytyp***);**

Input

infile1	string, name of input file 1.
infile2	string, name of input file 2.
outfile	string, name of output file.
keytyp	scalar, data type of key variable. 1 numeric 2 character

Remarks

This will combine the variables in the two files to create a single large file. The following assumptions hold:

1. Both files have the key variable in the first column.
2. All of the values of the key variable within a file are unique.
3. Each file is already sorted on that variable.

The output file will contain the key variable in its first column.

It is not necessary for the two files to have the same number of rows. For each row for which the key variables match, a row will be created in the output file. *outfile* will contain the columns from *infile1* followed by the columns of *infile2* minus the key column from the second file.

If the inputs are null or 0, the procedure will ask for them.

Example

```
mergeby("freq", "freqdata", "mergex",1);
```

Source

sortd.src

mergevar

Purpose Accepts a list of names of global matrices, and concatenates the corresponding matrices horizontally to form a single matrix.

Format *x* **= mergevar(***vnames***);**

Input

vnames string or Kx1 column vector containing the names of K global matrices.

Output

x NxM matrix that contains the concatenated matrices, where M is the sum of the columns in the K matrices specified in *vnames*.

Remarks The matrices specified in *vnames* must be globals and they must all have the same number of rows.

This function is the opposite of **makevars**.

Example

```
let vnames = age pay sex;
x = mergevar(vnames);
```

The matrices **age**, **pay**, and **sex** will be concatenated horizontally to create **x**.

Source vars.src

See also **makevars**

minc

Purpose

Returns a column vector containing the smallest element in each column in a matrix.

Format

y **= minc(***x***);**

Input

x NxK matrix.

Output

y Kx1 matrix containing the smallest element in each column of *x*.

Remarks

If *x* is complex, **minc** uses the complex modulus (**abs(***x***)**) to determine the smallest elements.

To find the minimum element in each row, transpose the matrix before applying the **minc** function.

To find the minimum value in the whole matrix, nest two calls to **minc**:

```
y = minc(minc(x));
```

Example

```
x = rndn(4,2);
y = minc(x);
```

$$x = \begin{matrix} -1.061321 & -0.729026 \\ -0.021965 & 0.184246 \\ 1.843242 & -1.847015 \\ 1.977621 & -0.532307 \end{matrix}$$

$$y = \begin{matrix} -1.061321 \\ -1.847015 \end{matrix}$$

See also

maxc, minindc, maxindc

minindc

Purpose

Returns a column vector containing the index (i.e., row number) of the smallest element in each column in a matrix.

Format

y **= minindc(***x***);**

Input

x	NxK matrix.

Output

y	Kx1 matrix containing the index of the smallest element in each column of *x*.

Remarks

If *x* is complex, **minindc** uses the complex modulus (**abs(***x***)**) to determine the smallest elements.

To find the index of the smallest element in each row, transpose the matrix before applying **minindc**.

If there are two or more "smallest" elements in a column (i.e., two or more elements equal to each other and less than all other elements), then **minindc** returns the index of the first one found, which will be the smallest index.

Example

```
x = round(rndn(5,4)*5);
y = minc(x);
z = minindc(x);
```

$$x = \begin{matrix} -5 & 6 & -4 & -1 \\ 2 & -2 & 1 & 3 \\ 6 & 0 & 1 & -7 \\ -6 & 0 & 8 & -4 \\ 7 & -4 & 8 & 3 \end{matrix}$$

$$y = \begin{matrix} -6 \\ -4 \\ -4 \\ -7 \end{matrix}$$

minindc

$$x = \begin{matrix} 4 \\ 5 \\ 1 \\ 3 \end{matrix}$$

See also **maxindc, minc, maxc**

miss, missrv

Purpose

miss converts specified elements in a matrix to GAUSS's missing value code. **missrv** is the reverse of this, and converts missing values into specified values.

Format

y **= miss(***x*,*v***);**
y **= missrv(***x*,*v***);**

Input

x	NxK matrix.
v	LxM matrix, ExE conformable with *x*.

Output

y	max(N,L) by max(K,M) matrix.

Remarks

For **miss**, elements in *x* that are equal to the corresponding elements in *v* will be replaced with the GAUSS missing value code.

For **missrv**, elements in *x* that are equal to the GAUSS missing value code will be replaced with the corresponding element of *v*.

For complex matrices, the missing value code is defined as a missing value entry in the real part of the matrix. For complex *x*, then, **miss** replaces elements with a ". + 0i" value, and **missrv** examines only the real part of *x* for missing values. If, for example, an element of *x* = 1 + .i, **missrv** will not replace it.

These functions act like element-by-element operators. If *v* is a scalar, for instance -1, then all -1's in *x* are converted to missing. If *v* is a row (column) vector with the same number of columns (rows) as *x*, then each column (row) in *x* is transformed to missings according to the corresponding element in *v*. If *v* is a matrix of the same size as *x*, then the transformation is done corresponding element by corresponding element.

Missing values are given special treatment in the following functions and operators: *b/a* (matrix division when *a* is not square and neither *a* nor *b* is scalar), **counts**, **ismiss**, **maxc**, **maxindc**, **minc**, **minindc**, **miss**, **missex**, **missrv**, **moment**, **packr**, **scalmiss**, **sortc**.

As long as you know a matrix contains no missings to begin with, **miss** and **missrv** can be used to convert one set of numbers into another. For example:

```
y=missrv(miss(x,0),1);
```

will convert 0's to 1's.

miss, missrv

Example

```
v = -1~4~5;

y = miss(x,v);
```

If **x** has 3 columns, all -1's in the first column will be changed to missings, along with all 4's in the second column and 5's in the third column.

See also **counts, ismiss, maxc, maxindc, minc, minindc, missex, moment, packr, scalmiss, sortc**

missex

Purpose

Converts numeric values to the missing value code according to the values given in a logical expression.

Format

y **= missex(***x*,*e***);**

Input

x	NxK matrix.
e	NxK logical matrix (matrix of 0's and 1's) that serves as a "mask" for *x*; the 1's in *e* correspond to the values in *x* that are to be converted into missing values.

Output

y	NxK matrix that equals *x*, but with those elements that correspond to the 1's in *e* converted to missing.

Remarks

The matrix *e* will usually be created by a logical expression. For instance, to convert all numbers between 10 and 15 in *x* to missing, the following code could be used:

```
y = missex(x, (x .> 10) .and (x .< 15));
```

Note that "dot" operators MUST be used in constructing the logical expressions.

For complex matrices, the missing value code is defined as a missing value entry in the real part of the matrix. For complex *x*, then, **missex** replaces elements with a ". + 0i" value.

This function is like **miss**, but is more general in that a range of values can be converted into missings.

Example

```
x = rndu(3,2);

/* logical expression */

e = (x .> .10) .and (x .< .20);

y = missex(x,e);
```

A 3x2 matrix of uniform random numbers is created. All values in the interval (0.10, 0.20) are converted to missing.

Source

datatran.src

See also

miss, missrv

moment

Purpose

Computes a cross-product matrix. This is the same as $x'x$.

Format

y **= moment(***x***,***d***);**

Input

x NxK matrix.

d scalar, controls handling of missing values.

- 0 missing values will not be checked for. This is the fastest option.
- 1 "listwise deletion" is used. Any row that contains a missing value in any of its elements is excluded from the computation of the moment matrix. If every row in *x* contains missing values, then **moment(***x***,1)** will return a scalar zero.
- 2 "pairwise deletion" is used. Any element of *x* that is missing is excluded from the computation of the moment matrix. Note that this is seldom a satisfactory method of handling missing values, and special care must be taken in computing the relevant number of observations and degrees of freedom.

Output

y KxK matrix which equals $x'x$.

Remarks

The fact that the moment matrix is symmetric is taken into account to cut execution time almost in half.

If there is no missing data then $d = 0$ should be used because it will be faster.

The **/** operator (matrix division) will automatically form a moment matrix (performing pairwise deletions if **trap** 2 is set) and will compute the **ols** coefficients of a regression. However, it can only be used for data sets that are small enough to fit into a single matrix. In addition, the moment matrix and its inverse cannot be recovered if the **/** operator is used.

Example

```
xx = moment(x,2);

ixx = invpd(xx);

b = ixx*missrv(x,0)'y;
```

In this example, the regression of *y* on *x* is computed. The moment matrix **xx** is formed using the **moment** command (with pairwise deletion, since the second parameter is 2). Then **xx** is inverted using the **invpd** function. Finally, the **ols** coefficients are computed. **missrv** is used to emulate pairwise deletion by setting missing values to 0.

momentd

Purpose

Computes a moment (X′X) matrix from a GAUSS data set.

Format

m **= momentd(***dataset*,*vars*);

Input

dataset string, name of data set.

vars Kx1 character vector, names of variables.

or

Kx1 numeric vector, indices of columns.

These can be any size subset of the variables in the data set, and can be in any order. If a scalar 0 is passed, all columns of the data set will be used.

Defaults are provided for the following global input variables so they can be ignored unless you need control over the other options provided by this procedure.

Global Input

__con scalar, default 1.

- 1 a constant term will be added.
- 0 no constant term will be added.

__miss scalar, default 0.

- 0 there are no missing values (fastest).
- 1 do listwise deletion, drop an observation if any missings occur in it.
- 2 do pairwise deletion. This is equivalent to setting missings to 0 when calculating *m*.

__row scalar, default 0, the number of rows to read per iteration of the read loop.

If 0, the number of rows will be calculated internally.

If you get an **Insufficient memory** error message, or you want the rounding to be exactly the same between runs, you can set the number of rows to read before calling **momentd**.

Output

m MxM matrix, where M = K + **__con**, the moment matrix constructed by calculating X′X where X is the data, with or without a constant vector of ones.

Error handling is controlled by the low order bit of the trap flag.

trap 0	terminate with error message	
trap 1	return scalar error code in *m*	
	33	too many missings
	34	file not found

Example

```
z = { age, pay, sex };
m = momentd(“freq”,z);
```

Source momentd.src

Globals **__con, __miss, __row**

msym

Purpose

Allows the user to set the symbol that GAUSS uses when missing values are converted to ASCII and vice versa.

Format

msym *str*;

Input

str literal or ^string (up to 8 letters) which, if not surrounded by quotes, is forced to uppercase. This is the string to be printed for missing values. The default is '**.**'.

Remarks

The entire string will be printed out when converting to ASCII in **print**, **lprint**, and **printfm** statements.

When converting ASCII to binary in **loadm** and **let** statements, only the first character is significant. In other words,

```
msym HAT;
```

will cause '**H**' to be converted to missing on input.

This does not affect **writer** which outputs data in binary format.

See also

print, lprint, printfm

nametype

Purpose

Provides support for programs following the upper/lowercase convention in GAUSS data sets. (See "File I/O" in the *User's Guide*.) Returns a vector of names of the correct case and a 1/0 vector of type information.

Format

{ *vname*,*vtype* **} = nametype(***vname*,*vtype***);**

Input

vname Nx1 character vector of variable names.

vtype scalar or Nx1 vector of 1's and 0's to determine the type and therefore the case of the output *vname*. If this is scalar 0 or 1 it will be expanded to Nx1. If -1, **nametype** will assume that *vname* follows the upper/lowercase convention.

Output

vname Nx1 character vector of variable names of the correct case, uppercase if numeric, lowercase if character.

vtype Nx1 vector of ones and zeros, 1 if variable is numeric, 0 if character.

Example

```
vn = { age, pay, sex };
vt = { 1, 1, 0 };
{ vn, vt } = nametype(vn,vt);
print $vn;
```

```
      AGE
vn =  PAY
      sex
```

Source

nametype.src

Globals

vartype

.

new

Purpose

Erases everything in memory including the symbol table; closes all open files, the auxiliary output, and turns the window on if it was off; also allows the size of the new symbol table and the main program space to be specified.

Format

new [[*nos* [[**,** *mps*]]]**;**

Input

nos scalar, which indicates the maximum number of global symbols allowed. See your platform supplement for the maximum number of globals allowed in this implementation.

mps scalar, which indicates the number of bytes of main program space to be allocated. See your platform supplement for the maximum amount allowed in this implementation.

Remarks

Procedures, user-defined functions, and global matrices strings and string arrays are all global symbols.

The main program space is the amount of memory available for nonprocedure, nonfunction program code.

This command can be used with arguments as the first statement in a program to clear the symbol table and to allocate only as much space for program code as your program actually needs. When used in this manner, the auxiliary output will not be closed. This will allow you to open the auxiliary output from command level and run a program without having to remove the **new** at the beginning of the program. If this command is not the first statement in your program, it will cause the program to terminate.

Example

```
new;            /*  clear global symbols. */

new 300;        /*  clear global symbols, set */
                /*  maximum number of global */
                /*  symbols to 300, and leave */
                /*  program space unchanged. */

new             /*  clear global symbols, set */
200,100000;     /*  maximum number of global */
                /*  symbols to 200, and allocate */
                /*  100000 bytes for main */
                /*  program code. */

 new ,100000;   /*  clear global symbols, */
                /*  allocate 100000 bytes for */
                /*  main program code, and leave */
                /*  maximum number of globals */
                /*  unchanged. */
```

See also

clear, delete, output

nextn, nextnevn

Purpose

Returns allowable matrix dimensions for computing FFT's.

Format

n **= nextn(***n0***);**
n **= nextnevn(***n0***);**

Input

n0 scalar, the length of a vector or the number of rows or columns in a matrix.

Output

n scalar, the next allowable size for the given dimension for computing an FFT or RFFT. $n \geq n0$.

Remarks

nextn and **nextnevn** determine allowable matrix dimensions for computing FFT's. The Temperton FFT routines (see table below) can handle any matrix whose dimensions can be expressed as:

$2^p \times 3^q \times 5^r \times 7^s$, *p,q,r* nonnegative integers
$s = 0$ or 1

with one restriction: the vector length or matrix column size must be even (*p* must be positive) when computing RFFT's.

fftn, etc., automatically pad matrices (with zeros) to the next allowable dimensions; **nextn** and **nextnevn** are provided in case you want to check or fix matrix sizes yourself.

Use the following table to determine what to call for a given function and matrix:

FFT Function	Vector Length	Matrix Rows	Matrix Columns
fftn	**nextn**	**nextn**	**nextn**
rfftn	**nextnevn**	**nextn**	**nextnevn**
rfftnp	**nextnevn**	**nextn**	**nextnevn**

Example

```
n = nextn(456);
```

n = 480

Source optim.src

See also **fftn, optn, optnevn, rfftn, rfftnp**

nextwind

Purpose Sets the current graphic panel to the next available graphic panel.

Library pgraph

Format nextwind;

Remarks This function selects the next available graphic panel to be the current graphic panel. This is the graphic panel in which the next graph will be drawn.

See the discussion on using graphic panels in "Publication Quality Graphics" in the *User's Guide*.

Source pwindow.src

See also endwind, begwind, setwind, getwind, makewind, window

null

Purpose

Computes an orthonormal basis for the (right) null space of a matrix.

Format

b **= null(***x***);**

Input

x	NxM matrix.

Output

b MxK matrix, where K is the nullity of X, such that:

$x*b = 0$ (NxK matrix of zeros)

and

$b'b = I$ (MxM identity matrix)

The error returns are returned in *b*:

error code	reason
1	there is no null space
2	b is too large to return in a single matrix

Use **scalerr** to test for error returns.

Remarks

The orthogonal complement of the column space of x' is computed using the QR decomposition. This provides an orthonormal basis for the null space of *x*.

Example

```
let x[2,4] = 2 1 3 -1
             3 5 1  2;

b = null(x);
z = x*b;
i = b'b;
```

Source

null.src

Globals

_qrdc, _qrsl

null1

Purpose

Computes an orthonormal basis for the (right) null space of a matrix.

Format

nu **= null1(***x*,*dataset*);

Input

x	NxM matrix.
dataset	string, the name of a data set **null1** will write.

Output

nu	scalar, the nullity of *x*.

Remarks

null1 computes an MxK matrix *b*, where K is the nullity of *x*, such that:

$x*b = 0$ (NxK matrix of zeros)

and

$b'b = I$ (MxM identity matrix)

The transpose of *b* is written to the data set named by *dataset*, unless the nullity of *x* is zero. If *nu* is zero, the data set is not written.

Source

null.src

Globals

_qrdc, _qrsl

ols

Purpose

Computes a least squares regression.

Format

```
{ vnam,m,b,stb,vc,stderr,sigma,cx,rsq,resid,dwstat }
= ols(dataset,depvar,indvars);
```

Input

dataset string, name of data set or null string.

If *dataset* is a null string, the procedure assumes that the actual data has been passed in the next two arguments.

depvar If *dataset* contains a string:

string, name of dependent variable.

scalar, index of dependent variable. If scalar 0, the last column of the data set will be used.

If *dataset* is a null string or 0:

NX1 vector, the dependent variable.

indvars If *dataset* contains a string:

KX1 character vector, names of independent variables.

KX1 numeric vector, indices of independent variables.

These can be any size subset of the variables in the data set and can be in any order. If a scalar 0 is passed, all columns of the data set will be used except for the one used for the dependent variable.

If *dataset* is a null string or 0:

NXK matrix, the independent variables.

Global Input

Defaults are provided for the following global input variables, so they can be ignored unless you need control over the other options provided by this procedure.

__altnam global vector, default 0.

This can be a (K+1)X1 or (K+2)X1 character vector of alternate variable names for the output. If **__con** is 1, this must be (K+2)X1. The name of the dependent variable is the last element.

__con global scalar, default 1.

1 a constant term will be added, D = K+1.

0 no constant term will be added, D = K.

A constant term will always be used in constructing the moment matrix m.

__miss global scalar, default 0.

- 0 there are no missing values (fastest).
- 1 listwise deletion, drop any cases in which missings occur.
- 2 pairwise deletion, this is equivalent to setting missings to 0 when calculating *m*. The number of cases computed is equal to the total number of cases in the data set.

__output global scalar, default 1.

- 1 print the statistics.
- 0 do not print statistics.

__row global scalar, the number of rows to read per iteration of the read loop. Default 0.

If 0, the number of rows will be calculated internally. If you get an **Insufficient memory** error message while executing **ols**, you can supply a value for **__row** that works on your system.

The answers may vary slightly due to rounding error differences when a different number of rows is read per iteration. You can use **__row** to control this if you want to get exactly the same rounding effects between several runs.

_olsres global scalar, default 0.

- 1 compute residuals (*resid*) and Durbin-Watson statistic(*dwstat*).
- 0 *resid* = 0, *dwstat* = 0.

Output

vnam (K+2)x1 or (K+1)x1 character vector, the variable names used in the regression. If a constant term is used, this vector will be (K+2)x1, and the first name will be "CONSTANT". The last name will be the name of the dependent variable.

m MxM matrix, where M = K+2, the moment matrix constructed by calculating **X′X** where **X** is a matrix containing all useable observations and having columns in the order:

1.0	*indvars*	*depvar*
(constant)	(independent variables)	(dependent variable)

A constant term is always used in computing *m*.

b Dx1 vector, the least squares estimates of parameters.

Error handling is controlled by the low order bit of the trap flag.

trap 0 terminate with error message

trap 1 return scalar error code in *b*

- **30** system singular
- **31** system underdetermined
- **32** same number of columns as rows
- **33** too many missings
- **34** file not found
- **35** no variance in an independent variable

The system can become underdetermined if you use listwise deletion and have missing values. In that case, it is possible to skip so many cases that there are fewer useable rows than columns in the data set.

stb Kx1 vector, the standardized coefficients.

vc DxD matrix, the variance-covariance matrix of estimates.

stderr Dx1 vector, the standard errors of the estimated parameters.

sigma scalar, standard deviation of residual.

cx (K+1)x(K+1) matrix, correlation matrix of variables with the dependent variable as the last column.

rsq scalar, R square, coefficient of determination.

resid residuals, *resid = y - x * b*.

If **_olsres** = 1, the residuals will be computed.

If the data is taken from a data set, a new data set will be created for the residuals, using the name in the global string variable **_olsrnam**. The residuals will be saved in this data set as an Nx1 column. The *resid* return value will be a string containing the name of the new data set containing the residuals.

If the data is passed in as a matrix, the *resid* return value will be the Nx1 vector of residuals.

dwstat scalar, Durbin-Watson statistic.

Remarks

No output file is modified, opened, or closed by this procedure. If you want output to be placed in a file, you need to open an output file before calling **ols**.

ols

Example

```
y = { 2,
      3,
      1,
      7,
      5 };

x = { 1 3 2,
      2 3 1,
      7 1 7,
      5 3 1,
      3 5 5 };


output file = ols.out reset;
call ols(0,y,x);
output off;
```

In this example, the output from **ols** was put into a file called `ols.out` as well as being printed in the window. This example will compute a least squares regression of **y** on **x**. The return values were discarded by using a **call** statement.

```
data = "olsdat";
depvar = { score };
indvars = { region,age,marstat };
_olsres = 1;
output file = lpt1 on;
{ nam,m,b,stb,vc,std,sig,cx,rsq,resid,dbw } =
    ols(data,depvar,indvars);
output off;
```

In this example, the data set `olsdat.dat` was used to compute a regression. The dependent variable is **score**. The independent variables are **region**, **age**, and **marstat**. The residuals and Durbin-Watson statistic will be computed. The output will be sent to the printer as well as the window and the returned values are assigned to variables.

Source ols.src

Globals **_olsres, _olsrnam, __altnam, __con, __miss, __output, __row, __vpad**

See also **olsqr**

olsqr

Purpose

Computes OLS coefficients using QR decomposition.

Format

b **= olsqr(***y*,*x***);**

Input

y	Nx1 vector containing dependent variable.
x	NxP matrix containing independent variables.

Global Input

_olsqtol global scalar, the tolerance for testing if diagonal elements are approaching zero. The default value is 10*e*-14.

Output

b Px1 vector of least squares estimates of regression of *y* on *x*. If *x* does not have full rank, then the coefficients that cannot be estimated will be zero.

Remarks

This provides an alternative to *y*/*x* for computing least squares coefficients.

This procedure is slower than the **/** operator. However, for near singular matrices it may produce better results.

olsqr handles matrices that do not have full rank by returning zeros for the coefficients that cannot be estimated.

Source

olsqr.src

Globals

_olsqtol

See also

ols, olsqr2, orth, qqr

olsqr2

Purpose

Computes OLS coefficients, residuals, and predicted values using the QR decomposition.

Format

{ *b*,*r*,*p* **} = olsqr2(***y*,*x***);**

Input

y	Nx1 vector containing dependent variable.
x	NxP matrix containing independent variables.

Global Input

_olsqtol global scalar, the tolerance for testing if diagonal elements are approaching zero. The default value is 10*e*-14.

Output

b	Px1 vector of least squares estimates of regression of *y* on *x*. If *x* does not have full rank, then the coefficients that cannot be estimated will be zero.
r	Px1 vector of residuals. (*r* = *y* - *x***b*)
p	Px1 vector of predicted values. (*p* = *x***b*)

Remarks

This provides an alternative to *y*/*x* for computing least squares coefficients.

This procedure is slower than the / operator. However, for near singular matrices, it may produce better results.

olsqr2 handles matrices that do not have full rank by returning zeros for the coefficients that cannot be estimated.

Source

olsqr.src

Globals

_olsqtol

See also

olsqr, orth, qqr

ones

Purpose Creates a matrix of ones.

Format *y* **= ones(***r***,***c***);**

Input

r	scalar, number of rows.
c	scalar, number of columns.

Output

y	RxC matrix of ones.

Remarks Noninteger arguments will be truncated to an integer.

Example

```
x = ones(3,2);
```

$$x = \begin{matrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \end{matrix}$$

See also **zeros, eye**

open

Purpose

Opens an existing GAUSS data file.

Format

open *fh*=*filename* [[**for** *mode*]] [[**varindxi** [[*offs*]]]];

Input

filename literal or ^string.

filename is the name of the file on the disk. The name can include a path if the directory to be used is not the current directory. This filename will automatically be given the extension `.dat`. If an extension is specified, the `.dat` will be overridden. If the file is an `.fmt` matrix file, the extension must be explicitly given. If the name of the file is to be taken from a string variable, the name of the string must be preceded by the ^ (caret) operator.

mode [[**read**]], **append**, **update**

The modes supported with the optional **for** subcommand are:

read This is the default file opening mode and will be the one used if none is specified. Files opened in this mode cannot be written to. The pointer is set to the beginning of the file and the **writer** function is disabled for files opened in this way. This is the only mode available for matrix files (`.fmt`), which are always written in one piece with the **save** command.

append Files opened in this mode cannot be read. The pointer will be set to the end of the file so that a subsequent write to the file with the **writer** function will add data to the end of the file without overwriting any of the existing data in the file. The **readr** function is disabled for files opened in this way. This mode is used to add additional rows to the end of a file.

update Files opened in this mode can be read from and written to. The pointer will be set to the beginning of the file. This mode is used to make changes in a file.

offs scalar.

The optional **varindxi** subcommand tells GAUSS to create a set of global scalars that contain the index (column position) of the variables in a GAUSS data file. These "index variables" will have the same names as the corresponding variables in the data file but with "**i**" added as a prefix. They can be used inside index brackets, and with functions like **submat** to access specific columns of a matrix without having to remember the column position.

The optional *offs* is an offset that will be added to the index variables. This is useful if data from multiple files are concatenated horizontally in one matrix. It can be any scalar expression. The default is 0.

The index variables are useful for creating submatrices of specific variables without requiring that the positions of the variables be known. For instance, if there are two variables, **xvar** and **yvar** in the data set, the index variables will have the names **ixvar**, **iyvar**. If **xvar** is the first column in the data file, and **yvar** is the second, and if no offset, *offs*, has been specified, then **ixvar** and **iyvar** will equal 1 and 2, respectively. If an offset of 3 had been specified, then these variables would be assigned the values 4 and 5, respectively.

The **varindxi** and **varindx** options cannot be used with `.fmt` matrix files because no column names are stored with them.

If **varindxi** is used, GAUSS will ignore the **Undefined symbol** error message for global symbols that start with "i". This makes it much more convenient to use index variables because they don't have to be cleared before they are accessed in the program. Clearing is otherwise necessary because the index variables do not exist until execution time when the data file is actually opened and the names are read in from the header of the file. At compile time a statement like: **y=x[.,ixvar];** will be illegal if the compiler has never heard of **ixvar**. If **varindxi** is used, this error will be ignored for symbols beginning with "**i**". Any symbols that are accessed before they have been initialized with a real value will be trapped at execution time with a **Variable not initialized** error message.

Output

fh scalar.

fh is the file handle which will be used by most commands to refer to the file within GAUSS. This file handle is actually a scalar containing an integer value that uniquely identifies each file. This value is assigned by GAUSS when the **open** command is executed. If the file was not successfully opened, the file handle will be set to -1.

Remarks

The file must exist before it can be opened with the **open** command. (To create a new file, see **create** or **save**.)

A file can be opened simultaneously under more than one handle. See the second example following.

If the value that is in the file handle when the **open** command begins to execute matches that of an already open file, the process will be aborted and a **File already open** error message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happens, you would no longer be able to access the first file.

It is important to set unused file handles to zero because both **open** and **create** check the value that is in a file handle to see if it matches that of an open file before they proceed with the process of opening a file. This should be done with **close** or **closeall**.

Example

```
fname = "/data/rawdat";

open dt = ^fname for append;

if dt == -1;
   print "File not found";
   end;
endif;

y = writer(dt,x);

if y /= rows(x);
   print "Disk Full";
   end;
endif;

dt = close(dt);
```

In the example above, the existing data set `/data/rawdat.dat` is opened for appending new data. The name of the file was in the string variable **fname**. In this example the file handle is tested to see if the file was opened successfully. The matrix **x** is written to this data set. The number of columns in **x** must be the same as the number of columns in the existing data set. The first row in **x** will be placed after the last row in the existing data set. The **writer** function will return the number of rows actually written. If this does not equal the number of rows that were attempted, then the disk is probably full.

```
open fin = mydata for read;
open fout = mydata for update;
do until eof(fin);
   x = readr(fin,100);
   x[.,1 3] = ln(x[.,1 3]);
   call writer(fout,x);
endo;
closeall fin,fout;
```

In the above example, the same file, `mydata.dat`, is opened twice with two different file handles. It is opened for read with the handle **fin**, and it is opened for update with the handle **fout**. This will allow the file to be transformed in place without taking up the extra space necessary for a separate output file. Notice that **fin** is used as the input handle and **fout** is used as the output handle. The loop will terminate as soon as the input handle has reached the end of the file. Inside the loop the file is read into a matrix called **x** using the input handle, the data are transformed (columns 1 and 3 are replaced with their natural logs), and the transformed data is written back out using the output handle. This type of operation works well as long as the total number of rows and columns does not change.

The following example assumes a data file named `dat1.dat` that has the variables: **visc**, **temp**, **lub**, **rpm**.

```
open f1 = dat1 varindxi;
dtx = readr(f1,100);
x = dtx[.,irpm ilub ivisc];
y = dtx[.,itemp];
call seekr(f1,1);
```

In this example, the data set `dat1.dat` is opened for reading (the `.dat` and the **`for read`** are implicit). **`varindxi`** is specified with no constant. Thus, index variables are created that give the positions of the variables in the data set. The first 100 rows of the data set are read into the matrix **`dtx`**. Then, specified variables in a specified order are assigned to the matrices **`x`** and **`y`** using the index variables. The last line uses the **`seekr`** function to reset the pointer to the beginning of the file.

```
open q1 = dat1 varindx;
open q2 = dat2 varindx colsf(q1);
nr = 100;
y = readr(q1,nr)~readr(q2,nr);
closeall q1,q2;
```

In this example, two data sets are opened for reading and index variables are created for each. A constant is added to the indices for the second data set (**`q2`**), equal to the number of variables (columns) in the first data set (**`q1`**). Thus, if there are three variables **`x1`**, **`x2`**, **`x3`** in **`q1`**, and three variables **`y1`**, **`y2`**, **`y3`** in **`q2`**, the index variables that were created when the files were opened would be **`ix1`**, **`ix2`**, **`ix3`**, **`iy1`**, **`iy2`**, **`iy3`**. The values of these index variables would be 1, 2, 3, 4, 5, 6, respectively. The first 100 rows of the two data sets are read in and concatenated to give the matrix **`y`**. The index variables will thus give the correct positions of the variables in **`y`**.

```
open fx = x.fmt;
i = 1; rf = rowsf(fx);
sampsize = round(rf*0.1);
rndsmpx = zeros(sampsize,colsf(fx));
do until i > sampsize;
   r = ceil(rndu(1,1)*rf);
   call seekr(fx,r);
   rndsmpx[i,.] = readr(fx,1);
   i = i+1;
endo;
fx = close(fx);
```

In this example, a 10% random sample of rows is drawn from the matrix file `x.fmt` and put into the matrix **rndsmpx**. Note that the extension `.fmt` must be specified explicitly in the **open** statement. The **rowsf** command is used to obtain the number of rows in `x.fmt`. This number is multiplied by 0.10 and the result is rounded to the nearest integer; this yields desired sample size. Then random integers (**r**) in the range 1 to **rf** are generated. **seekr** is used to locate to the appropriate row in the matrix, and the row is read with **readr** and placed in the matrix **rndsmpx**. This is continued until the complete sample has been obtained.

See also

create, close, closeall, readr, writer, seekr, eof

optn, optnevn

Purpose

Returns optimal matrix dimensions for computing FFT's.

Format

n **= optn(***n0***);**
n **= optnevn(***n0***);**

Input

n0 scalar, the length of a vector or the number of rows or columns in a matrix.

Output

n scalar, the next optimal size for the given dimension for computing an FFT or RFFT. $n \geq n0$.

Remarks

optn and **optnevn** determine optimal matrix dimensions for computing FFT's. The Temperton FFT routines (see table following) can handle any matrix whose dimensions can be expressed as:

$$2^p \times 3^q \times 5^r \times 7^s, \qquad p, q, r \text{ nonnegative integers}, \quad s = 0 \text{ or } 1$$

with one restriction: the vector length or matrix column size must be even (p must be positive) when computing RFFT's.

fftn, etc., pad matrices to the next allowable dimensions; however, they generally run faster for matrices whose dimensions are highly composite numbers, that is, products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20 percent faster than a 32768x1 vector, because 33600 is a highly composite number, $2^6 \times 3 \times 5^2 \times 7$, whereas 32768 is a simple power of 2, 2^{15}. **optn** and **optnevn** are provided so you can take advantage of this fact by hand-sizing matrices to optimal dimensions before computing the FFT.

optn, optnevn

Use the following table to determine what to call for a given function and matrix:

FFT Function	Vector Length	Matrix Rows	Matrix Columns
fftn	**optn**	**optn**	**optn**
rfftn	**optnevn**	**optn**	**optnevn**
rfftnp	**optnevn**	**optn**	**optnevn**

Example

```
n = optn(231);
```

n = 240.00000

See also

fftn, nextn, nextnevn, rfftn, rfftnp

orth

Purpose Computes an orthonormal basis for the column space of a matrix.

Format *y* **= orth(***x***);**

Input

x	NxK matrix.

Global Input

_orthtol	global scalar, the tolerance for testing if diagonal elements are approaching zero. The default is 1.0*e*-14.

Output

y	NxL matrix such that *y*′*y* = **eye**(L) and whose columns span the same space as the columns of *x*; L is the rank of *x*.

Example

```
x = { 6 5 4,
      2 7 5 };
y = orth(x);
```

$$y = \begin{matrix} -0.58123819 & -0.81373347 \\ -0.81373347 & 0.58123819 \end{matrix}$$

Source qqr.src

Globals **_orthtol**

See also **qqr, olsqr**

output

Purpose

This command makes it possible to direct the output of **print** statements to two different places simultaneously. One output device is always the window or standard output. The other can be selected by the user to be any disk file or other suitable output device such as a printer.

Format

output [[**file=***filename*]] [[**on**|**off**|**reset**]];

Input

filename literal or ^string.

The **file=***filename* subcommand selects the file or device to which output is to be sent.

If the name of the file is to be taken from a string variable, the name of the string must be preceded by the ^ (caret) operator.

The default file name is `output.out`.

on, off, reset literal, mode flag

on opens the auxiliary output file or device and causes the results of all **print** statements to be sent to that file or device. If the file already exists, it will be opened for appending. If the file does not already exist, it will be created.

off closes the auxiliary output file and turns off the auxiliary output.

reset similar to the **on** subcommand, except that it always creates a new file. If the file already exists, it will be destroyed and a new file by that name will be created. If it does not exist, it will be created.

Remarks

After you have written to an output file you have to close the file before you can print it or edit it with the GAUSS editor. Use **output off**.

The selection of the auxiliary output file or device remains in effect until a new selection is made, or until you exit GAUSS. Thus, if a file is named as the output device in one program, it will remain the output device in subsequent programs until a new **file=***filename* subcommand is encountered.

The command **output file=***filename*; will select the file or device but will not open it. A subsequent **output on;** or **output reset;** will open it and turn on the auxiliary output.

The command **output off** will close the file and turn off the auxiliary output. The filename will remain the same. A subsequent **output on** will cause the file to be opened again for appending. A subsequent **output reset** will cause the existing file to be destroyed and then recreated and will turn on the auxiliary output.

The command **output** by itself will cause the name and status (i.e., open or closed) of the current auxiliary output file to be printed in the window.

The output to the console can be turned off and on using the **screen off** and **screen on** commands. Output to the auxiliary file or device can be turned off or on using the **output off** or **output on** command. The defaults are **screen on** and **output off**.

The auxiliary file or device can be closed by an explicit **output off** statement, by an **end** statement, or by an interactive **new** statement. However, a **new** statement at the beginning of a program will not close the file. This allows programs with **new** statements in them to be run without reopening the auxiliary output file.

If a program sends data to a disk file, it will execute much faster if the window is off.

The **outwidth** command will set the line width of the output file. The default is 80.

output

Example

```
output file = out1.out on;
```

This statement will open the file `out1.out` and will cause the results of all subsequent **print** statements to be sent to that file. If `out1.out` already exists, the new output will be appended.

```
output file = out2.out;
output on;
```

This is equivalent to the previous example.

```
output reset;
```

This statement will create a new output file using the current filename. If the file already exists, any data in it will be lost.

```
output file = mydata.asc reset;
screen off;
format /m1/rz 1,8;
open fp = mydata;
do until eof(fp);
   print readr(fp,200);;
endo;
fp = close(fp);
end;
```

The program above will write the contents of the GAUSS file `mydata.dat` into an ASCII file called `mydata.asc`. If there had been an existing file by the name of `mydata.asc`, it would have been overwritten.

The **/m1** parameter in the **format** statement in combination with the **;;** at the end of the **print** statement will cause one carriage return/line feed pair to be written at the beginning of each row of the output file. There will not be an extra line feed added at the end of each 200 row block.

The **end** statement above will automatically perform **output off** and **screen on**.

See also

outwidth, screen, end, new

outtyp (dataloop)

Purpose Specifies the precision of the output data set.

Format **outtyp** *num_constant*;

Remarks *num_constant* must be 2, 4, or 8, to specify integer, single precision, or double precision, respectively.

If **outtyp** is not specified, the precison of the output data set will be that of the input data set. If character data is present in the data set, the precision will be forced to double.

Example

```
outtyp 8;
```

outwidth

Purpose Specifies the width of the auxiliary output.

Format **outwidth** *n*;

Remarks *n* specifies the width of the auxiliary output in columns (characters). After printing *n* characters on a line, GAUSS will output a line feed.

If a matrix is being printed, the line feed sequence will always be inserted between separate elements of the matrix rather than being inserted between digits of a single element.

n may be any scalar-valued expression in the range of 2-256. Nonintegers will be truncated to an integer. If 256 is used, no additional lines will be inserted.

The default is 80 columns.

Example

```
outwidth 132;
```

This statement will change the auxiliary output width to 132 columns.

See also **lpwidth, output, print**

pacf

Purpose Computes sample partial autocorrelations.

Format *rkk* **= pacf(***y*,*k*,*d***);**

Input

y	Nx1 vector, data.
k	scalar, maximum number of partial autocorrelations to compute.
d	scalar, order of differencing.

Output

rkk	Kx1 vector, sample partial autocorrelations.

Example

```
proc pacf(y,k,d);
   local a,l,j,r,t;
   r = acf(y,k,d);
   a = zeros(k,k);
   a[1,1] = r[1];
   t = 1;
   l = 2;
   do while l le k;
      a[l,l] = (r[l]-a[l-1,1:t]*rev(r[1:l-1]))/
      (1-a[l-1,1:t]*r[1:t]);
      j = 1;
      do while j <= t;
         a[l,j] = a[l-1,j] - a[l,l]*a[l-1,l-j];
         j = j+1;
      endo;
      t = t+1;
      l = l+1;
   endo;
```

pacf

```
            retp(diag(a));
        endp;
```

Source tsutil.src

packr

Purpose Deletes the rows of a matrix that contain any missing values.

Format *y* **= packr(***x***);**

Input

x NxK matrix.

Output

y LxK submatrix of *x* containing only those rows that do not have missing values in any of their elements.

Remarks This function is useful for handling missing values by "listwise deletion," particularly prior to using the **/** operator to compute least squares coefficients.

If all rows of a matrix contain missing values, **packr** returns a scalar missing value. This can be tested for quickly with the **scalmiss** function.

Example

```
x = miss(ceil(rndu(3,3)*10),1);
y = packr(x);
```

```
      . 9 10
x =   4 2  .
      3 4  9

y =   3 4  9
```

In this example, the matrix **x** is formed with random integers and missing values. **packr** is used to delete rows with missing values.

packr

```
open fp = mydata;
obs = 0;
sum = 0;
do until eof(fp);
   x = packr(readr(fp,100));
   if not scalmiss(x);
      obs = obs+rows(x);
      sum = sum+sumc(x);
   endif;
endo;
mean = sum/obs;
```

In this example, the sums of each column in a data file are computed as well as a count of the rows that do not contain any missing values. **packr** is used to delete rows that contain missings and **scalmiss** is used to skip the two sum steps if all the rows are deleted for a particular iteration of the read loop. Then the sums are divided by the number of observations to obtain the means.

See also

scalmiss, miss, missrv

parse

Purpose Parses a string, returning a character vector of tokens.

Format *tok* **= parse(***str***,***delim***);**

Input

str	string consisting of a series of tokens and/or delimiters.
delim	NxK character matrix of delimiters that might be found in *str*.

Output

tok	Mx1 character vector consisting of the tokens contained in *str*. All tokens are returned; any delimiters found in *str* are ignored.

Remarks The tokens in *str* must be 8 characters or less in size. If they are longer, the contents of *tok* is unpredictable.

See also **token**

pause

Purpose Pauses for a specified number of seconds.

Format **pause(***sec***);**

Input *sec* seconds to pause.

Source pause.src

See also **wait**

pdfn

Purpose Computes the standard Normal (scalar) probability density function.

Format *y* **= pdfn(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the standard Normal probability density function of *x*.

Remarks This does not compute the joint Normal density function. Instead, the scalar Normal density function is computed element-by-element. *y* could be computed by the following GAUSS code:

```
y = (1/sqrt(2*pi))*exp(-(x.*x)/2);
```

Example

```
x = rndn(2,2);
y = pdfn(x);
```

$$x = \begin{matrix} -1.828915 & 0.514485 \\ -0.550219 & -0.275229 \end{matrix}$$

$$y = \begin{matrix} 0.074915 & 0.349488 \\ 0.342903 & 0.384115 \end{matrix}$$

pi

Purpose Returns the mathematical constant π.

Format *y* **= pi;**

Example

```
format /rdn 16,14;
print pi;
```

produces:

```
3.14159265358979
```

pinv

Purpose

Computes the Moore-Penrose pseudo-inverse of a matrix, using the singular value decomposition.

This pseudo-inverse is one particular type of generalized inverse.

Format

y **= pinv(***x***);**

Input

x NxM matrix.

Global Input

_svdtol global scalar, any singular values less than **_svdtol** are treated as zero in determining the rank of the input matrix. The default value for **_svdtol** is 1.0*e*-13.

Output

y MxN matrix that satisfies the 4 Moore-Penrose conditions:

XYX = *X*

YXY = *Y*

XY is symmetric

YX is symmetric

Global Output

_svderr global scalar, if not all of the singular values can be computed **_svderr** will be nonzero.

Example

```
x = { 6 5 4, 2 7 5 } ;
y = pinv(x);
```

$$y = \begin{matrix} 0.22017139 & -0.16348055 \\ -0.05207647 & 0.13447594 \\ -0.0151615 & 0.07712591 \end{matrix}$$

Source

svd.src

Globals

_svdtol, _svderr

polar

Purpose Graphs data using polar coordinates.

Library pgraph

Format **polar(***radius*,*theta*);

Input

radius	NX1 or NXM matrix. Each column contains the magnitude for a particular line.
theta	NX1 or NXM matrix. Each column represents the angle values for a particular line.

Source polar.src

See also xy, logx, logy, loglog, scale, xtics, ytics

polychar

Purpose Computes the characteristic polynomial of a square matrix.

Format *c* **= polychar(***x***);**

Input

x NxN matrix.

Output

c (N+1)x1 vector of coefficients of the N^{th} order characteristic polynomial of *x*:

$$p(z)=c[1]*z^n + c[2]*z^{(n-1)} + ... + c[n]*z + c[n+1];$$

Remarks The coefficient of z^n is set to unity ($c[1]=1$).

Source poly.src

See also **polymake, polymult, polyroot, polyeval**

polyeval

Purpose Evaluates polynomials. Can either be 1 or more scalar polynomials or a single matrix polynomial.

Format *y* **= polyeval(***x***,***c***);**

Input

x 1xK or NxN; that is, *x* can either represent K separate scalar values at which to evaluate the (scalar) polynomial(s), or it can represent a single NxN matrix.

c (P+1)xK or (P+1)x1 matrix of coefficients of polynomials to evaluate. If *x* is 1xK, then *c* must be (P+1)xK. If *x* is NxN, *c* must be (P+1)x1. That is, if *x* is a matrix, it can only be evaluated at a single set of coefficients.

Output

y Kx1 vector (if *c* is (P+1)xK) or NxN matrix (if *c* is (P+1)x1 and x is NxN):

$$y = (c[1,.].*x^{p} + c[2,.].*x^{(p-1)} + ... + c[p+1,.])';$$

Remarks In both the scalar and the matrix case, Horner's rule is used to do the evaluation. In the scalar case, the function **recsercp** is called (this implements an elaboration of Horner's rule).

Example

```
x = 2;

let c = 1 1 0 1 1;

y = polyeval(x,c);
```

The result is 27. Note that this is the decimal value of the binary number 11011.

```
y = polyeval(x,1|zeros(n,1));
```

This will raise the matrix *x* to the n^{th} power (e.g: *x***x***x***x**...**x*).

Source poly.src

See also **polymake, polychar, polymult, polyroot**

polyint

Purpose

Calculates an N^{th} order polynomial interpolation.

Format

y **= polyint(***xa*,*ya*,*x***);**

Input

xa	Nx1 vector, *X* values.
ya	Nx1 vector, *Y* values.
x	scalar, *X* value to solve for.

Global Input

_poldeg	global scalar, the degree of polynomial required, default 6.

Output

y	result of interpolation or extrapolation.

Global Output

_polerr	global scalar, interpolation error.

Remarks

Calculates an N^{th} order polynomial interpolation or extrapolation of X on Y given the vectors *xa* and *ya* and the scalar *x*. The procedure uses Neville's algorithm to determine an up to N^{th} order polynomial and an error estimate.

Polynomials above degree 6 are not likely to increase the accuracy for most data. Test **_polerr** to determine the required **_poldeg** for your problem.

Source

polyint.src

Technical Notes

Press, W.P., B.P. Flannery, S.A. Tevkolsky, and W.T. Vettering. *Numerical Recipes: The Art of Scientific Computing*. NY: Cambridge Press, 1986.

polymake

Purpose Computes the coefficients of a polynomial given the roots.

Format *c* **= polymake(***r***);**

Input

r Nx1 vector containing roots of the desired polynomial.

Output

c (N+1)x1 vector containing the coefficients of the N^{th} order polynomial with roots *r*:

$$p(z)=c[1]*z^n+ c[2]*z^{(n-1)} + ...+ c[n]*z + c[n+1];$$

Remarks The coefficient of z^n is set to unity ($c[1]=1$).

Example

```
r = { 2, 1, 3 };
c = polymake(r);
```

$$c = \begin{matrix} -1.0000000 \\ -6.0000000 \\ 11.000000 \\ -6.0000000 \end{matrix}$$

Source poly.src

See also **polychar, polymult, polyroot, polyeval**

polymat

Purpose Returns a matrix containing the powers of the elements of *x* from 1 to *p*.

Format *y* **= polymat(***x***,***p***);**

Input

x	NxK matrix.
p	scalar, positive integer.

Output

y	Nx(*p**K) matrix containing powers of the elements of *x* from 1 to *p*. The first K columns will contain first powers, the second K columns contain the second powers, and so on.

Remarks To do polynomial regression use **ols**:

```
{ vnam,m,b,stb,vc,stderr,sigma,cx,rsq,resid,
dwstat } = ols(0,y,polymat(x,p));
```

Source polymat.src

polymroot

Purpose Computes the roots of the determinant of a matrix polynomial

Format *r* **= polymroot(***c***);**

Input

c (N+1)*KxK matrix of coefficients of an Nth order polynomial of rank K.

Output

r K*N vector containing the roots of the determinantal equation.

Remarks *c* is constructed of N+1 KxK coefficient matrices stacked vertically with the coefficient matrix of the t^n at the top, t^(n-1) next, down to the t^0 matrix at the bottom.

Note that this procedure solves the scalar problem as well, that is, the one that POLYROOT solves.

Example Solve det(A2*t^2 + A1*t + A0) = 0 where:

```
A2 = [ 1  2 ]
     [ 2  1 ]
A1 = [ 5  8 ]
     [10  7 ]
A0 = [ 3  4 ]
     [ 6  5 ]
a2 = { 1 2, 2 1 };
a1 = { 5 8, 10 7 };
a0 = { 3 4, 6 5 };
print polymroot(a2|a1|a0);
   -4.3027756
   -.69722436
   -2.6180340
   -.38196601
```

polymult

Purpose Multiplies polynomials.

Format *c* **= polymult(***c1***,***c2***);**

Input

c1	(D1+1)x1 vector containing the coefficients of the first polynomial.
c2	(D2+1)x1 vector containing the coefficients of the second polynomial.

Output

c	(D1+D2)x1 vector containing the coefficients of the product of the two polynomials.

Example

```
c1 = { 2, 1 };
c2 = { 2, 0, 1 };
c = polymult(c1,c2);
```

```
c =  4.0000000
     2.0000000
     2.0000000
     1.0000000
```

Source poly.src

See also **polymake, polychar, polyroot, polyeval**

Technical Notes If the degree of *c1* is *D1* (e.g., if *D1*=3, then the polynomial corresponding to *c1* is cubic), then there must be *D1+1* elements in *c1* (e.g., 4 elements for a cubic). Thus, for instance the coefficients for the polynomial $5*x^3 + 6*x + 3$ would be: *c1*=5|0|6|3. (Note that zeros must be explicitly given if there are powers of *x* missing.)

polyroot

Purpose Computes the roots of a polynomial given the coefficients.

Format *y* **= polyroot(***c***);**

Input

c (N+1)x1 vector of coefficients of an N^{th} order polynomial:

$$p(z)=c[1]*z^n + c[2]*z^{(n-1)}+ ...+c[n]*z + c[n+1]$$

Zero leading terms will be stripped from *c*. When that occurs the order of *y* will be the order of the polynomial after the leading zeros have been stripped.

c[1] need not be normalized to unity.

Output

y Nx1 vector, the roots of *c*.

Source poly.src

See also **polymake, polychar, polymult, polyeval**

pop

Purpose Provides access to a last-in, first-out stack for matrices.

Format **pop** *b*; **pop** *a*;

Remarks This is used with **gosub**, **goto**, and **return** statements with parameters. It permits passing parameters to subroutines or labels, and returning parameters from subroutines.

The **gosub** syntax allows an implicit **push** statement. This syntax is almost the same as that of a standard **gosub**, except that the matrices to be **push**'ed "into the subroutine" are in parentheses following the label name. The matrices to be **push**'ed back to the main body of the program are in parentheses following the **return** statement. The only limit on the number of matrices that can be passed to and from subroutines in this way is the amount of room on the stack.

No matrix expressions can be executed between the (implicit) **push** and the **pop**. Execution of such expressions will alter what is on the stack.

Matrices must be **pop**'ped in the reverse order that they are **push**'ed, therefore the statements:

```
goto label(x,y,z);
   .
   .
   .
label:
   pop c;
   pop b;
   pop a;
```

$c = z$ $b = y$ $a = x$

Note that matrices are **pop**'ped in reverse order, and that there is a separate **pop** statement for each matrix popped.

See also **gosub, goto, return**

pqgwin

Purpose Sets the graphics viewer mode.

Library pgraph

Format **pqgwin** *arg*;

Input

arg string literal.

"one"	Use only one viewer.
"many"	Use a new viewer for each graph.

Remarks If "one" is set, the viewer executable will be vwr.exe.

"manual" and "auto" are supported for backwards compatibility, manual=one, auto=many.

Example:

```
pqgwin one;
pqgwin many;
```

Source pgraph.src

See also setvwrmode

setvwrmode

prcsn

Purpose

Sets the computational precision of some of the matrix operators.

Format

prcsn *n*;

Input

n scalar, 64 or 80.

Portability

UNIX, Windows

This function has no effect under UNIX or Windows. All computations are done in 64-bit precision.

Remarks

n is a scalar containing either 64 or 80. The operators affected by this command are **chol**, **solpd**, **invpd**, and *b/a* (when neither *a* nor *b* is scalar and *a* is not square).

prcsn 80 is the default. Precision is set to 80 bits (10 bytes), which corresponds to about 19 digits of precision.

prcsn 64 sets the precision to 64 bits (8 bytes), which is standard IEEE double precision. This corresponds to 15-16 digits of precision. 80-bit precision is still maintained within the 80x87 math coprocessor so that actual precision is better than double precision.

When **prcsn** 80 is in effect, all temporary storage and all computations for the operators listed above are done in 80 bits. When the operator is finished, the final result is rounded to 64-bit double precision.

See also

chol, solpd, invpd

princomp

Purpose

Computes principal components of a data matrix.

Format

{*p*,*v*,*a***} = princomp(***x*,*j***);**

Input

x	NxK data matrix, N > K, full rank.
j	scalar, number of principal components to be computed (J ≤ K).

Output

p	NxJ matrix of the first *j* principal components of *x* in descending order of amount of variance explained.
v	Jx1 vector of fractions of variance explained.
a	JxK matrix of factor loadings, such that *x* = *p***a* +error.

Remarks

Adapted from a program written by Mico Loretan.

The algorithm is based on Theil, Henri “Principles of Econometrics.” Wiley, NY, 1971, 46-56.

print

Purpose

Prints matrices or strings to the window and/or auxiliary output.

Format

print [[**/flush**]] [[*/typ*]] [[*/fmted*]] [[*/mf*]] [[*/jnt*]]
list_of_expressions[[**;**]]**;**

Input

/typ literal, symbol type flag.

/mat, /sa, /str	Indicate which symbol types you are setting the output format for: matrices (**/mat**), string arrays (**/sa)**, and/or strings (**/str**). You can specify more than one */typ* flag; the format will be set for all types indicated. If no */typ* flag is listed, **print** assumes **/mat**.

/fmted literal, enable formatting flag.

/on, /off	Enable/disable formatting. When formatting is disabled, the contents of a variable are dumped to the window in a "raw" format.

/mf literal, matrix format. It controls the way rows of a matrix are separated from one another. The possibilities are:

/m0	no delimiters before or after rows when printing out matrices.
/m1 or /mb1	print 1 carriage return/line feed pair before each row of a matrix with more than 1 row.
/m2 or /mb2	print 2 carriage return/line feed pairs before each row of a matrix with more than 1 row.
/m3 or /mb3	print "Row 1", "Row 2"... before each row of a matrix with more than one row.
/ma1	print 1 carriage return/line feed pair after each row of a matrix with more than 1 row.
/ma2	print 2 carriage return/line feed pairs after each row of a matrix with more than 1 row.

	/a1	print 1 carriage return/line feed pair after each row of a matrix.
	/a2	print 2 carriage return/line feed pairs after each row of a matrix.
	/b1	print 1 carriage return/line feed pair before each row of a matrix.
	/b2	print 2 carriage return/line feed pairs before each row of a matrix.
	/b3	print "Row 1", "Row 2"... before each row of a matrix.

/jnt literal, controls justification, notation, and the trailing character.

Right-Justified

/rd	Signed decimal number in the form [-] ####.#### where #### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed.
/re	Signed number in the form [-]#.##E±###, where # is one decimal digit, ## is one or more decimal digits depending on the precision, and ### is three decimal digits. If precision is 0, the form will be [-]#E±### with no decimal point printed.
/ro	This will give a format like **/rd** or **/re** depending on which is most compact for the number being printed. A format like **/re** will be used only if the exponent value is less than -4 or greater than the precision. If a **/re** format is used a decimal point will always appear. The precision signifies the number of significant digits displayed.

/rz This will give a format like **/rd** or **/re** depending on which is most compact for the number being printed. A format like **/re** will be used only if the exponent value is less than -4 or greater than the precision. If a **/re** format is used, trailing zeros will be supressed and a decimal point will appear only if one or more digits follow it. The precision signifies the number of significant digits displayed.

Left-Justified

/ld Signed decimal number in the form [-]####.####, where #### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed. If the number is positive, a space character will replace the leading minus sign.

/le Signed number in the form [-]#.##E±###, where # is one decimal digit, ## is one or more decimal digits depending on the precision, and ### is three decimal digits. If precision is 0, the form will be [-]#E±### with no decimal point printed. If the number is positive, a space character will replace the leading minus sign.

/lo This will give a format like **/ld** or **/le** depending on which is most compact for the number being printed. A format like **/le** will be used only if the exponent value is less than -4 or greater than the precision. If a **/le** format is used a decimal point will always appear. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.

/lz	This will give a format like **/ld** or **/le** depending on which is most compact for the number being printed. A format like **/le** will be used only if the exponent value is less than -4 or greater than the precision. If a **/le** format is used, trailing zeros will be supressed and a decimal point will appear only if one or more digits follow it. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.

Trailing Character

The following characters can be added to the */jnt* parameters above to control the trailing character if any:

```
format /rdn 1,3;
```

s	The number will be followed immediately by a space character. This is the default.
c	The number will be followed immediately with a comma.
t	The number will be followed immediately with a tab character.
n	No trailing character.

The default when GAUSS is first started is:

```
format /m1 /r0 16,8;
```

;;	Double semicolons following a **print** statement will suppress the final carriage return/line feed.

Remarks

The list of expressions MUST be separated by spaces. In **print** statements, because a space is the delimiter between expressions, NO SPACES are allowed inside expressions unless they are within index brackets, quotes, or parentheses.

The printing of special characters is accomplished by the use of the backslash (****) within double quotes. The options are:

\b	backspace (ASCII 8)
\e	escape (ASCII 27)
\f	form feed (ASCII 12)
\g	beep (ASCII 7)
\l	line feed (ASCII 10)
\r	carriage return (ASCII 13)
\t	tab (ASCII 9)
\###	the character whose ASCII value is "###" (decimal).

Thus, **\13\10** is a carriage return/line feed sequence. The first three digits will be picked up here. So if the character to follow a special character is a digit, be sure to use three digits in the escape sequence. For example: **\0074** will be interpreted as 2 characters (ASCII 7 followed by the character "4").

An expression with no assignment operator is an implicit **print** statement.

If **output on** has been specified, then all subsequent **print** statements will be directed to the auxiliary output as well as the window. (See **output**.) The **locate** statement has no effect on what will be sent to the auxiliary output, so all formatting must be accomplished using tab characters or some other form of serial output.

If the name of the symbol to be printed is prefixed with a '**$**', it is assumed that the symbol is a matrix of characters.

```
print $x;
```

Note that GAUSS makes no distinction between matrices containing character data and those containing numeric data, so it is the responsibility of the user to use functions which operate on character matrices only on those matrices containing character data.

These matrices of character strings have a maximum of 8 characters per element. A precision of 8 or more should be set when printing out character matrices or the elements will be truncated.

print

Complex numbers are printed with the sign of the imaginary half separating them and an "i" appended to the imaginary half. Also, the current field width setting (see **format**) refers to the width of field for each half of the number, so a complex number printed with a field of 8 will actually take (at least) 20 spaces to print.

A **print** statement by itself will cause a blank line to be printed:

```
print;
```

GAUSS also has an *automatic print mode* which causes the results of all global assignment statements to be printed out. This is controlled by the **print on** and **print off** commands. (See **print on**.)

Example

```
x = rndn(3,3);
format /rd 16,8;
   print x;
format /re 12,2;
   print x;
   print /rd/m3 x;
```

```
  0.14357994  –1.39272762  –0.91942414
  0.51061645  –0.02332207  –0.02511298
 –1.54675893  –1.04988540   0.07992059

  1.44E-001  –1.39E+000  –9.19E-001
  5.11E-001  –2.33E-002  –2.51E-002
 –1.55E+000  –1.05E+000   7.99E-002

Row 1
         0.14    -1.39    -0.92
Row 2
         0.51    -0.02    -0.03
Row 3
        -1.55    -1.05     0.08
```

In this example, a 3x3 random matrix is printed using 3 different formats. Notice that in the last statement the format is overridden in the **print** statement itself but the field and precision remain the same.

```
let x = AGE PAY SEX;

format /m1 8,8;

print $x;
```

produces:

```
   AGE

   PAY

   SEX
```

See also **lprint, print on, lprint on, printfm, printdos**

printdos

Purpose Prints a string to the standard output.

Format **printdos** *s*;

Input

s string, containing the string to be printed to the standard output.

Remarks This function is useful for printing messages to the window when **screen off** is in effect. The output of this function will not go to the auxiliary output.

This function can also be used to send escape sequences to the `ansi.sys` device driver.

Example

```
printdos "\27[7m"; /* set for reverse video */
printdos "\27[0m"; /* set for normal text */
```

See the DOS manuals for more complete information.

See also **print, lprint, printfm, screen**

printfm

Purpose

Prints a matrix using a different format for each column of the matrix.

Format

y **= printfm(***x*,*mask*,*fmt***);**

Input

x	NxK matrix which is to be printed and which may contain both character and numeric data.
mask	LxM matrix, ExE conformable with *x*, containing ones and zeros which is used to specify whether the particular row, column, or element is to be printed as a string (0) or numeric (1) value.
fmt	Kx3 or 1x3 matrix where each row specifies the format for the respective column of *x*.

Output

y	scalar, 1 if the function is successful and 0 if it fails.

Remarks

The mask is applied to the matrix *x* following the rules of standard element-by-element operations. If the corresponding element of mask is 0, then that element of *x* is printed as a character string of up to 8 characters. If mask contains a 1, then that element of *x* is assumed to be a double precision floating point number.

The contents of *fmt* are as follows:

[K,1]	format string,	a string 8 characters maximum.
[K,2]	field width,	a number < 80.
[K,3]	precision,	a number < 17.

The format strings correspond to the **format** slash commands as follows:

```
/rdn    "*.*lf"
/ren    "*.*lE"
/ron    "#*.*lG"
/rzn    "*.*lG"
/ldn     "-*.*lf"
/len    "-*.*lE"
/lon    "-#*.*lG"
/lzn    "-*.*lG"
```

Complex numbers are printed with the sign of the imaginary half separating them and an "**i**" appended to the imaginary half. The field width refers to the width of field for each half of the number, so a complex number printed with a field of 8 will actually take (at least) 20 spaces to print.

If the precision = 0, the decimal point will be suppressed.

The format string can be a maximum of 8 characters and is appended to a **%** sign and passed directly to the **fprintf** function in the standard C language I/O library. The **lf**, etc., are case sensitive. If you know C, you will easily be able to use this.

If you want special characters to be printed after *x*, then include them as the last characters of the format string. For example:

"*.*lf,"	right-justified decimal followed by a comma.
"-*.*s"	left-justified string followed by a space.
"*.*lf"	right-justified decimal followed by nothing.

If you want the beginning of the field padded with zeros, then put a "**0**" before the first "*****" in the format string:

"0*.*lf"	right-justified decimal

Example

Here is an example of **printfm** being used to print a mixed numeric and character matrix:

```
let x[4,3] =
"AGE" 5.12345564 2.23456788
"PAY" 1.23456677 1.23456789
"SEX" 1.14454345 3.44718234
"JOB" 4.11429432 8.55649341;

let mask[1,3] = 0 1 1; /* character numeric */
                       /* numeric */

let fmt[3,3] =
"-*.*s" 8 8 /* first column format */
"*.*lf," 10 3 /* second column format */
```

```
"*.*le" 12 4; /* third column format */


d = printfm(x,mask,fmt);
```

The output looks like this:

```
AGE 5.123, 2.2346E+000
PAY 1.235, 1.2346E+000
SEX 1.145, 3.4471E+000
JOB 4.114, 8.5564E+000
```

When the column of *x* to be printed contains all string elements, use a format string of **"*.*s"** if you want it right-justified, or **"-*.*s"** if you want it left-justified. If the column is mixed string and numeric elements, then use the correct numeric format and **printfm** will substitute a default format string for those elements in the column that are strings.

Remember, the mask value controls whether an element will be printed as a number or a string.

See also

print, lprint, printdos

printfmt

Purpose Prints character, numeric, or mixed matrix using a default format controlled by the functions **formatcv** and **formatnv**.

Format *y* **= printfmt(***x*,*mask***);**

Input

x	NxK matrix which is to be printed.
mask	scalar, 1 if *x* is numeric or 0 if *x* is character. or 1xK vector of 1's and 0's. The corresponding column of *x* will be printed as numeric where *mask* = 1 and as character where *mask* = 0.

Output

y	scalar, 1 if the function is successful and 0 if it fails.

Remarks Default format for numeric data is: **"*.*lg" 16 8**

Default format for character data is: **"*.*s" 8 8**

Example

```
x = rndn(5,4);
call printfmt(x,1);
```

Source gauss.src

Globals **__fmtcv, __fmtnv**

See also **formatcv, formatnv**

proc

Purpose

Begins the definition of a multi-line recursive procedure. Procedures are user-defined functions with local or global variables.

Format

proc [[**(***nrets***) =**]] *name***(***arglist***);**

Input

nrets constant, number of objects returned by the procedure. If *nrets* is not explicitly given, the default is 1. Legal values are 0 to 1023. The **retp** statement is used to return values from a procedure.

name literal, name of the procedure. This name will be a global symbol.

arglist a list of names, separated by commas, to be used inside the procedure to refer to the arguments that are passed to the procedure when the procedure is called. These will always be local to the procedure, and cannot be accessed from outside the procedure or from other procedures.

Remarks

A procedure definition begins with the **proc** statement and ends with the **endp** statement.

An example of a procedure definition is:

```
proc dog(x,y,z); /* procedure declaration */
   local a,b; /* local variable declarations */
   a = x .* x;
   b = y .* y;
   a = a ./ x;
   b = b ./ y;
   z = z .* z;
   z = inv(z);
   retp(a'b*z); /* return with value of */
                /* a'b*z */
endp; /* end of procedure definition */
```

proc

Procedures can be used just as if they were functions intrinsic to the language. Below are the possible variations depending on the number of items the procedure returns.

Returns 1 item:

```
y = dog(i,j,k);
```

Returns multiple items:

```
{ x,y,z } = cat(i,j,k);
```

Returns no items:

```
fish(i,j,k);
```

If the procedure does not return any items or you want to discard the returned items:

```
call dog(i,j,k);
```

Procedure definitions may not be nested.

For more details on writing procedures, see “Procedures and Keywords” in the *User’s Guide*.

See also

keyword, call, endp, local, retp

prodc

Purpose Computes the products of all elements in each column of a matrix.

Format *y* **= prodc(***x***);**

Input

x NxK matrix.

Output

y Kx1 matrix containing the products of all elements in each column of *x*.

Remarks To find the products of the elements in each row of a matrix, transpose before applying **prodc**. If *x* is complex, use the bookkeeping transpose (.′).

To find the products of all of the elements in a matrix, use the **vecr** function before applying **prodc**.

Example

```
let x[3,3] = 1 2 3
             4 5 6
             7 8 9;
y = prodc(x);
```

```
      28
y =   80
     162
```

See also **sumc, meanc, stdc**

putf

Purpose

Writes the contents of a string to a file.

Format

ret **= putf(***filename*,*str*,*start*,*len*,*mode*,*append***);**

Input

filename	string, name of output file.
str	string to be written to *filename*. All or part of *str* may be written out.
start	scalar, beginning position in *str* of output string.
len	scalar, length of output string.
mode	scalar, output mode, (0) ASCII or (1) binary.
append	scalar, file write mode, (0) overwrite or (1) append.

Output

ret scalar, return code.

Remarks

If *mode* is set to (1) binary, a string of length *len* will be written to *filename*. If *mode* is set to (0) ASCII, the string will be output up to length *len* or until **putf** encounters a ^Z (ASCII 26) in *str.* The ^Z will not be written to *filename*.

If *append* is set to (0) overwrite, the current contents of *filename* will be destroyed. If *append* is set to (1) append, *filename* will be created if it does not already exist.

If an error occurs, **putf** will either return an error code or terminate the program with an error message, depending on the **trap** state. If bit 2 (the 4's bit) of the trap flag is 0, **putf** will terminate with an error message. If bit 2 of the trap flag is 1, **putf** will return an error code. The value of the trap flag can be tested with **trapchk**.

ret can have the following values:

0	normal return
1	null file name
2	file open error
3	file write error
4	output string too long
5	null output string, or illegal *mode* value
6	illegal *append* value
16	append specified but file did not exist; file was created (warning only)

Source `putf.src`

See also **getf**

QNewton

Purpose

Optimizes a function using the BFGS descent algorithm.

Format

{ *x*,*f*,*g*,*ret* } **= QNewton(** &*fct*,*start* **);**

Input

&*fct*	pointer to a procedure that computes the function to be minimized. This procedure must have one input argument, a vector of parameter values, and one output argument, the value of the function evaluated at the input vector of parameter values.
start	Kx1 vector, start values.

Global Input

_qn_RelGradTol	scalar, convergence tolerance for relative gradient of estimated coefficients. Default = 1e-5.
_qn_GradProc	scalar, pointer to a procedure that computes the gradient of the function with respect to the parameters. This procedure must have a single input argument, a Kx1 vector of parameter values, and a single output argument, a Kx1 vector of gradients of the function with respect to the parameters evaluated at the vector of parameter values. If **_qn_GradProc** is 0, **QNewton** uses **gradp**.
_qn_MaxIters	scalar, maximum number of iterations. Default = 1e+5. Termination can be forced by pressing C on the keyboard.
_qn_PrintIters	scalar, if 1, print iteration information. Default = 0. Can be toggled during iterations by pressing P on the keyboard.
_qn_ParNames	Kx1 vector, labels for parameters.
_qn_PrintResults	scalar, if 1, results are printed.

Output

x	Kx1 vector, coefficients at the minimum of the function.
f	scalar, value of function at minimum.
g	Kx1 vector, gradient at the minimum of the function.
ret	scalar, return code.
	0 normal convergence

1	forced termination
2	max iterations exceeded
3	function calculation failed
4	gradient calculation failed
5	step length calculation failed
6	function cannot be evaluated at initial parameter values

Remarks

If you are running in terminal mode, GAUSS will not see any input until you press ENTER. Pressing C on the keyboard will terminate iterations, and pressing P will toggle iteration output.

To reset global variables for this function to their default values, call **qnewtonset**.

Example

This example computes maximum likelihood coefficients and standard errors for a Tobit model:

```
/*
** qnewton.e - a Tobit model
*/

z = loadd("tobit"); /* get data */
b0 = { 1, 1, 1, 1 };
{b,f,g,retcode} = qnewton(&lpr,b0);


/*
** covariance matrix of parameters
*/

h = hessp(&lpr,b);

output file = qnewton.out reset;

print "Tobit Model";
print;
```

```
print “coefficients standard errors”;
print b~sqrt(diag(invpd(h)));

output off;

/*
** log-likelihood proc
*/

proc lpr(b);
   local s,m,u;
   s = b[4];
   if s ≤ 1e-4;
      retp(error(0));
   endif;
   m = z[.,2:4]*b[1:3,.];
   u = z[.,1] ./= 0;
   retp(-sumc(u.*lnpdfn2(z[.,1]-m,s) +
                    (1-u).*(ln(cdfnc(m/sqrt(s))))));
endp;
```

produces:

```
Tobit Model
coefficients standard errors

     0.010417884   0.080220019
     -0.20805753   0.094551107
    -0.099749592   0.080006676
      0.65223067   0.099827309
```

Source

qnewton.src

QProg

Purpose

Solves the quadratic programming problem.

Format

{ *x,u1,u2,u3,u4,ret* } **= QProg(** *start,q,r,a,b,c,d,bnds* **);**

Input

start	Kx1 vector, start values.
q	KxK matrix, symmetric model matrix.
r	Kx1 vector, model constant vector.
a	MxK matrix, equality constraint coefficient matrix, or scalar 0, no equality constraints.
b	Mx1 vector, equality constraint constant vector, or scalar 0, will be expanded to Mx1 vector of zeros.
c	NxK matrix, inequality constraint coefficient matrix, or scalar 0, no inequality constraints.
d	Nx1 vector, inequality constraint constant vector, or scalar 0, will be expanded to Nx1 vector of zeros.
bnds	Kx2 matrix, bounds on *x*, the first column contains the lower bounds on *x*, and the second column the upper bounds. If scalar 0, the bounds for all elements will default to $\pm 1e200$.

Global Input

_qprog_maxit	scalar, maximum number of iterations. Default = 1000.

Output

x	Kx1 vector, coefficients at the minimum of the function.
u1	Mx1 vector, Lagrangian coefficients of equality constraints.
u2	Nx1 vector, Lagrangian coefficients of inequality constraints.
u3	Kx1 vector, Lagrangian coefficients of lower bounds.
u4	Kx1 vector, Lagrangian coefficients of upper bounds.
ret	scalar, return code.

0	successful termination
1	max iterations exceeded
2	machine accuracy is insufficient to maintain decreasing function values
3	model matrices not conformable
<0	active constraints inconsistent

QProg

Remarks

QProg solves the standard quadratic programming problem:

$$min\frac{1}{2}x'Qx - x'R$$

subject to constraints,

$$Ax = B$$
$$Cx \geq D$$

and bounds,

$$x_{low} \leq x \leq x_{up}$$

Source

qprog.src

qqr

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X*, such that:

$$X = Q_1 R$$

Format

{ *q1,r* } **= qqr(**x**);**

Input

x	NxP matrix.

Output

q1	NxK unitary matrix, K = min(N,P).
r	KxP upper triangular matrix.

Remarks

Given *X*, there is an orthogonal matrix *Q* such that *Q′X* is zero below its diagonal, i.e.,

$$Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X = Q_1 R$$

is the QR decomposition of *X*. If *X* has linearly independent columns, *R* is also the Cholesky factorization of the moment matrix of *X*, i.e., of *X'X*.

If you want only the *R* matrix, see the function **qr**. Not computing Q_1 can produce significant improvements in computing time and memory usage.

An unpivoted *R* matrix can also be generated using **cholup**:

```
r = cholup(zeros(cols(x),cols(x)),x);
```

For linear equation or least squares problems, which require Q_2 for computing residuals and residual sums of squares, see **olsqr** and **qtyr**.

qqr

For most problems an explicit copy of Q_1 or Q_2 is not required. Instead one of the following, $Q'Y$, QY, $Q_1'Y$, Q_1Y, $Q_2'Y$, or Q_2Y, for some Y, is required. These cases are all handled by **qtyr** and **qyr**. These functions are available because Q and Q_1 are typically very large matrices while their products with Y are more manageable.

If N < P the factorization assumes the form:

$$Q'X = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px(N – P). Thus Q is a PxP matrix and R is a PxN matrix containing R_1 and R_2. This type of factorization is useful for the solution of underdetermined systems. However, unless the linearly independent columns happen to be the initial rows, such an analysis also requires pivoting (see **qre** and **qrep**).

Source

qqr.src

See also

qre, qrep, qtyr, qtyre, qtyrep, qyr, qyre, qyrep, olsqr

qqre

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X*, such that:

$$X[.,E] = Q_1 R$$

Format

{ *q1,r,e* } **= qqre(***x***);**

Input

x	NxP matrix.

Output

q1	NxK unitary matrix, K = min(N,P).
r	KxP upper triangular matrix.
e	Px1 permutation vector.

Remarks

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q'X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[.,E] = Q_1 R$$

is the QR decomposition of *X*[.,*E*].

If you want only the *R* matrix, see **qre**. Not computing Q_1 can produce significant improvements in computing time and memory usage.

If *X* has rank P, then the columns of *X* will not be permuted. If *X* has rank M < P, then the M linearly independent columns are permuted to the front of *X* by *E*. Partition the permuted X in the following way:

$$X[.,E] = \begin{bmatrix} X_1 & X_2 \end{bmatrix}$$

where X_1 is NxM and X_2 is Nx(P – M). Further partition R in the following way:

$$R = \begin{bmatrix} R_{11} & R_{12} \\ 0 & 0 \end{bmatrix}$$

where R_{11} is MxM and R_{12} is Mx(P – M). Then

$$A = R_{11}^{-1} R_{12}$$

and

$$X_2 = X_1 A$$

that is, A is an Mx(P – N) matrix defining the linear combinations of X_2 with respect to X_1.

If N < P the factorization assumes the form:

$$Q'X = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px (N – P). Thus Q is a PxP matrix and R is a PxN matrix containing R_1 and R_2. This type of factorization is useful for the solution of underdetermined systems. For the solution of

$$X[., E]b = Y$$

it can be shown that

```
b = qrsol(Q'Y,R1) | zeros(N-P,1);
```

The explicit formation here of Q, which can be a very large matrix, can be avoided by using the function **qtyre**.

For further discussion of QR factorizations see the remarks under **qqr**.

Source qqr.src

See also **qqr, qtyre, olsqr**

qqrep

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X*, such that:

$$X[\,.\,, E] = Q_1 R$$

Format

{ *q1,r,e* } **= qqrep(***x,pvt***);**

Input

x NxP matrix.

pvt Px1 vector, controls the selection of the pivot columns:

if *pvt*[*i*] > 0, *x*[*i*] is an initial column

if *pvt*[*i*] = 0, *x*[*i*] is a free column

if *pvt*[*i*] < 0, *x*[*i*] is a final column

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

Output

q1 NxK unitary matrix, K = min(N,P).

r KxP upper triangular matrix.

e Px1 permutation vector.

Remarks

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q′X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.\,, E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.\,, E] = \begin{bmatrix} Q_1 & R \end{bmatrix}$$

is the QR decomposition of *X*[.,*E*].

qqrep

qqrep allows you to control the pivoting. For example, suppose that *X* is a data set with a column of ones in the first column. If there are linear dependencies among the columns of *X*, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using *pvt*.

If you want only the *R* matrix, see **qrep**. Not computing Q_1 can produce significant improvements in computing time and memory usage.

Source qqr.src

See also **qqr, qre, olsqr**

qr

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X*, such that:

$$X = Q_1 R$$

Format

r **= qr(***x***);**

Input

x	NxP matrix.

Output

r	KxP upper triangular matrix, K = min(N,P).

Remarks

qr is the same as **qqr** but doesn't return the Q_1 matrix. If Q_1 is not wanted, **qr** will save a significant amount of time and memory usage, especially for large problems.

Given *X*, there is an orthogonal matrix *Q* such that *Q′X* is zero below its diagonal, i.e.,

$$Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X = Q_1 R$$

is the QR decomposition of *X*. If *X* has linearly independent columns, *R* is also the Cholesky factorization of the moment matrix of *X*, i.e., of *X′X*.

qr does not return the Q_1 matrix because in most cases it is not required and can be very large. If you need the Q_1 matrix see the function **qqr**. If you need the entire *Q* matrix call **qyr** with *Y* set to a conformable identity matrix.

For most problems *Q′Y*, $Q_1'Y$, or *Q Y*, $Q_1 Y$, for some *Y*, are required. For these cases see **qtyr** and **qyr**.

qr

For linear equation or least squares problems, which require Q_2 for computing residuals and residual sums of squares, see **olsqr**.

If N < P the factorization assumes the form:

$$Q'X = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px(N – P). Thus Q is a PxP matrix and R is a PxN matrix containing R_1 and R_2. This type of factorization is useful for the solution of underdetermined systems. However, unless the linearly independent columns happen to be the initial rows, such an analysis also requires pivoting (see **qre** and **qrep**).

Source qr.src

See also **qqr, qrep, qtyre**

qre

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X*, such that:

$$X[\,.,E] = Q_1 R$$

Format

{ *r*,*e* } **= qre(***x***);**

Input

x	NxP matrix.

Output

r	KxP upper triangular matrix, K = min(N,P).
e	Px1 permutation vector.

Remarks

qre is the same as **qqre** but doesn't return the Q_1 matrix. If Q_1 is not wanted, **qre** will save a significant amount of time and memory usage, especially for large problems.

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q'X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.,E] = Q_1 R$$

is the QR decomposition of *X*[.,*E*].

qre does not return the Q_1 matrix because in most cases it is not required and can be very large. If you need the Q_1 matrix see the function **qqre**. If you need the entire *Q* matrix call **qyre** with *Y* set to a conformable identity matrix. For most problems *Q'Y*, $Q_1'Y$, or *QY*, $Q_1 Y$, for some *Y*, are required. For these cases see **qtyre** and **qyre**.

If X has rank P, then the columns of X will not be permuted. If X has rank M < P, then the M linearly independent columns are permuted to the front of X by E. Partition the permuted X in the following way:

$$X[., E] = \begin{bmatrix} X_1 & X_2 \end{bmatrix}$$

where X_1 is NxM and X_2 is Nx(P – M). Further partition R in the following way:

$$R = \begin{bmatrix} R_{11} & R_{12} \\ 0 & 0 \end{bmatrix}$$

where R_{11} is MxM and R_{12} is Mx(P – M). Then

$$A = R_{11}^{-1} R_{12}$$

and

$$X_2 = X_1 A$$

that is, A is an Mx(P – N) matrix defining the linear combinations of X_2 with respect to X_1.

If N < P the factorization assumes the form:

$$Q'X = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px(N – P). Thus Q is a PxP matrix and R is a PxN matrix containing R_1 and R_2. This type of factorization is useful for the solution of underdetermined systems. For the solution of

$$X[., E]b = Y$$

it can be shown that

```
b = qrsol(Q'Y,R1) | zeros(N-P,1);
```

The explicit formation here of Q, which can be a very large matrix, can be avoided by using the function **qtyre**.

For further discussion of QR factorizations see the remarks under **qqr**.

Source qr.src

See also **qqr, olsqr**

qrep

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X*, such that:

$$X[\,.,E\,] = Q_1 R$$

Format

{ *r*,*e* } **= qrep(***x*,*pvt***);**

Input

x NxP matrix.

pvt Px1 vector, controls the selection of the pivot columns:

if *pvt*[*i*] > 0, *x*[*i*] is an initial column

if *pvt*[*i*] = 0, *x*[*i*] is a free column

if *pvt*[*i*] < 0, *x*[*i*] is a final column

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

Output

r KxP upper triangular matrix, K = min(N,P).

e Px1 permutation vector.

Remarks

qrep is the same as **qqrep** but doesn't return the Q_1 matrix. If Q_1 is not wanted, **qrep** will save a significant amount of time and memory usage, especially for large problems.

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q'X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.,E\,] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.,E\,] = Q_1 R$$

qrep

is the QR decomposition of X[.,E].

qrep does not return the Q_1 matrix because in most cases it is not required and can be very large. If you need the Q_1 matrix see the function **qqrep**. If you need the entire Q matrix call **qyrep** with Y set to a conformable identity matrix. For most problems $Q'Y$, $Q_1'Y$, or QY, Q_1Y, for some Y, are required. For these cases see **qtyrep** and **qyrep**.

qrep allows you to control the pivoting. For example, suppose that X is a data set with a column of ones in the first column. If there are linear dependencies among the columns of X, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using *pvt*.

Source qr.src

See also **qr, qre, qqrep**

qrsol

Purpose Computes the solution of $Rx = b$ where R is an upper triangular matrix.

Format *x* **= qrsol(***b*,*R***);**

Input

b	PxL matrix.
R	PxP upper triangular matrix.

Output

x	PxL matrix.

Remarks **qrsol** applies a backsolve to $Rx = b$ to solve for x. Generally R will be the R matrix from a QR factorization. **qrsol** may be used, however, in any situation where R is upper triangular.

Source qrsol.src

See also **qqr, qr, qtyr, qrtsol**

qrtsol

Purpose Computes the solution of $R'x = b$ where R is an upper triangular matrix.

Format *x* **= qrtsol(***b,R***);**

Input

b	PxL matrix.
R	PxP upper triangular matrix.

Output

x	PxL matrix.

Remarks **qrtsol** applies a forward solve to $R'x = b$ to solve for *x*. Generally *R* will be the *R* matrix from a QR factorization. **qrtsol** may be used, however, in any situation where *R* is upper triangular. If *R* is lower triangular, transpose before calling **qrtsol**.

If *R* is not transposed, use **qrsol**.

Source qrsol.src

See also **qqr, qr, qtyr, qrsol**

qtyr

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X* and returns *Q′Y* and *R*.

Format

{ *qty,r* } **= qtyr(***y,x***);**

Input

y	NxL matrix.
x	NxP matrix.

Output

qty	NxL unitary matrix.
r	KxP upper triangular matrix, K = min(N,P).

Remarks

Given *X*, there is an orthogonal matrix *Q* such that *Q′X* is zero below its diagonal, i.e.,

$$Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X = Q_1 R$$

is the QR decomposition of *X*. If *X* has linearly independent columns, *R* is also the Cholesky factorization of the moment matrix of *X*, i.e., of *X′X*. For most problems *Q* or Q_1 is not what is required. Rather, we require *Q′Y* or $Q_1'Y$ where *Y* is an NxL matrix (if either *QY* or $Q_1 Y$ are required, see **qyr**). Since *Q* can be a very large matrix, **qtyr** has been provided for the calculation of *Q′Y* which will be a much smaller matrix. $Q_1'Y$ will be a submatrix of *Q′Y*. In particular,

$$G = Q_1'Y = qty[1 : P, .]$$

and $Q_2'Y$ is the remaining submatrix:

qtyr

$$H = Q_2' Y = qty[P + 1 : N, .]$$

Suppose that *X* is an NxK data set of independent variables, and *v* is an Nx1 vector of dependent variables. Then it can be shown that

$$b = R^{-1} G$$

and

$$s_j = \sum_{i=1}^{N-P} H_{i,j}, j = 1, 2, \ldots L$$

where *b* is a PxL matrix of least squares coefficients and *s* is a 1xL vector of residual sums of squares. Rather than invert *R* directly, however, it is better to apply **qrsol** to

$$Rb = Q_1' Y$$

For rank deficient least squares problems, see **qtyre** and **qtyrep**.

Example

The QR algorithm is the superior numerical method for the solution of least squares problems:

```
loadm x, y;
{ qty, r } = qtyr(y,x);
q1ty = qty[1:rows(r),.];
q2ty = qty[rows(r)+1:rows(qty),.];
b = qrsol(q1ty,r);  /* LS coefficients */
s2 = sumc(q2ty^2);  /* residual sums of squares */
```

Source

qtyr.src

See also

qqr, qtyre, qtyrep, olsqr

qtyre

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X* and returns *Q'Y* and *R*.

Format

{ *qty,r,e* } **= qtyre(***y,x***);**

Input

y	NxL matrix.
x	NxP matrix.

Output

qty	NxL unitary matrix.
r	KxP upper triangular matrix, K = min(N,P).
e	Px1 permutation vector.

Remarks

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q'X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.\,,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.\,,E] = Q_1 R$$

is the QR decomposition of *X*[.,*E*].

If *X* has rank P, then the columns of *X* will not be permuted. If *X* has rank M < P, then the M linearly independent columns are permuted to the front of *X* by *E*. Partition the permuted *X* in the following way:

$$X[\,.\,,E] = \begin{bmatrix} X_1 & X_2 \end{bmatrix}$$

where X_1 is NxM and X_2 is Nx(P – M). Further partition *R* in the following way:

$$R = \begin{bmatrix} R_{11} & R_{12} \\ 0 & 0 \end{bmatrix}$$

where R_{11} is MxM and R_{12} is Mx(P – M). Then

$$A = R_{11}^{-1} R_{12}$$

and

$$X_2 = X_1 A$$

that is, A is an Mx(P – N) matrix defining the linear combinations of X_2 with respect to X_1.

For most problems Q or Q_1 is not what is required. Rather, we require $Q'Y$ or $Q_1'Y$ where Y is an NxL matrix. Since Q can be a very large matrix, **qtyre** has been provided for the calculation of $Q'Y$ which will be a much smaller matrix. $Q_1'Y$ will be a submatrix of $Q'Y$. In particular,

$$Q_1'Y = qty[1{:}P, .]$$

and $Q_2'Y$ is the remaining submatrix:

$$Q_2'Y = qty[P + 1 : N, .]$$

Suppose that X is an NxK data set of independent variables and Y is an Nx1 vector of dependent variables. Suppose further that X contains linearly dependent columns, i.e., X has rank M < P. Then define

$$C = Q_2'Y \ [1 : M, .]$$

$$A = R[1{:}M, 1{:}M]$$

and the vector (or matrix of L > 1) of least squares coefficients of the reduced, linearly independent problem is the solution of

$$Ab = C$$

To solve for b use **qrsol**:

```
b = qrsol(C,A);
```

If N < P the factorization assumes the form:

$$Q'X[.,E] = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px(N – P). Thus Q is a PxP matrix and R is a PxN matrix containing R_1 and R_2. This type of factorization is useful for the solution of underdetermined systems. For the solution of

$$X[.,E]b = Y$$

it can be shown that

```
b = qrsol(Q'Y,R1) | zeros(N-P,1);
```

Source qtyr.src

See also **qqr, qre, qtyr**

qtyrep

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X* using a pivot vector and returns *Q′Y* and *R*.

Format

{ *qty,r,e* } **= qtyrep(***y,x,pvt***);**

Input

y	NxL matrix.
x	NxP matrix.
pvt	Px1 vector, controls the selection of the pivot columns:

if *pvt*[*i*] > 0, *x*[*i*] is an initial column

if *pvt*[*i*] = 0, *x*[*i*] is a free column

if *pvt*[*i*] < 0, *x*[*i*] is a final column

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

Output

qty	NxL unitary matrix.
r	KxP upper triangular matrix, K = min(N,P).
e	Px1 permutation vector.

Remarks

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q′X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.\,,E\,] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.\,,E\,] = Q_1 R$$

is the QR decomposition of *X*[.,*E*].

qtyrep allows you to control the pivoting. For example, suppose that *X* is a data set with a column of ones in the first column. If there are linear dependencies among the columns of *X*, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using *pvt*.

Example

```
y = { 4 7 2,
      5 9 1,
      6 3 3 };
x = { 12 9 5,
      4 3 5,
      4 2 7 };
pvt = { 11, 10, 3 };
{ qty, r, e } = qtyrep(y,x,pvt);
```

qty =

–6.9347609	–9.9498744	–3.0151134
4.0998891	3.5527137e – 15	2.1929640
3.4785054	6.3245553	0.31622777

r =

–13.266499	–9.6483630	–8.1408063
0.0000000	–0.95346259	4.7673129
0.0000000	0.0000000	3.1622777

e =

1.0000000
2.0000000
3.0000000

Source

qtyr.src

See also

qrep, qtyre

quantile

Purpose

Computes quantiles from data in a matrix, given specified probabilities.

Format

y **= quantile(***x*,*e***)**

Input

x	NxK matrix of data.
e	Lx1 vector, quantile levels or probabilities.

Output

y	LxK matrix, quantiles.

Remarks

quantile will not succeed if N***minc**(*e*) is less than 1, or N***maxc**(*e*) is greater than N - 1. In other words, to produce a quantile for a level of .001, the input matrix must have more than 1000 rows.

Example

```
rndseed 345567;
x = rndn(1000,4);  /* data */
e = { .025, .5, .975 };  /* quantile levels */
y = quantile(x,e);

print "medians";
print y[2,.];
print;
print "95 percentiles";
print y[1,.];
print y[3,.];
```

produces:

```
medians
-0.0020     -0.0408     -0.0380     -0.0247
95 percentiles
-1.8677     -1.9894     -2.1474     -1.8747
```

```
          1.9687       2.0899       1.8576       2.0545
```

Source quantile.src

quantiled

Purpose

Computes quantiles from data in a data set, given specified probabilities.

Format

y **= quantiled(***dataset*,*e*,*var***);**

Input

dataset	string, data set name, or NxM matrix of data.
e	Lx1 vector, quantile levels or probabilities.
var	Kx1 vector or scalar zero. If Kx1, character vector of labels selected for analysis, or numeric vector of column numbers in data set of variables selected for analysis. If scalar zero, all columns are selected. If *dataset* is a matrix *var* cannot be a character vector.

Output

y	LxK matrix, quantiles.

Remarks

quantiled will not succeed if N***minc**(*e*) is less than 1, or N***maxc**(*e*) is greater than N - 1. In other words, to produce a quantile for a level of .001, the input matrix must have more than 1000 rows.

Example

```
y = quantiled("tobit",e,0);


print "medians";
print y[2,.];
print;
print "95 percentiles";
print y[1,.];
print y[3,.];
```

produces:

```
medians
0.0000     1.0000    -0.0021    -0.1228
95 percentiles
-1.1198     1.0000    -1.8139    -2.3143
```

```
    2.3066      1.0000      1.4590      1.6954
```

Source quantile.src

qyr

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X* and returns *QY* and *R*.

Format

{ *qy*,*r* } **= qyr(***y*,*x***);**

Input

y	NxL matrix.
x	NxP matrix.

Output

qy	NxL unitary matrix.
r	KxP upper triangular matrix, K = min(N,P).

Remarks

Given *X*, there is an orthogonal matrix *Q* such that *Q′X* is zero below its diagonal, i.e.,

$$Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X = Q_1 R$$

is the QR decomposition of *X*. If *X* has linearly independent columns, *R* is also the Cholesky factorization of the moment matrix of *X*, i.e., of *X′X*.

For most problems *Q* or Q_1 is not what is required. Since *Q* can be a very large matrix, **qyr** has been provided for the calculation of *QY*, where *Y* is some NxL matrix, which will be a much smaller matrix.

If either *Q′Y* or $Q_1'Y$ are required, see **qtyr**.

Example

```
x = { 1 11, 7 3, 2 1 };
y = { 2 6, 5 10, 4 3 };
{ qy, r } = qyr(y,x);
```

$$qy = \begin{matrix} 4.6288991 & 9.0506281 \\ -3.6692823 & -7.8788202 \\ 3.1795692 & 1.0051489 \end{matrix}$$

$$r = \begin{matrix} -7.3484692 & -4.6268140 \\ 0.0000000 & 10.468648 \end{matrix}$$

Source `qyr.src`

See also **qqr, qyre, qyrep, olsqr**

qyre

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X* and returns *QY* and *R*.

Format

{ *qy*,*r*,*e* } **= qyre(***y*,*x***);**

Input

y	NxL matrix.
x	NxP matrix.

Output

qy	NxL unitary matrix.
r	KxP upper triangular matrix, K = min(N,P).
e	Px1 permutation vector.

Remarks

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q'X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.\,,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.\,,E] = Q_1 R$$

is the QR decomposition of *X*[.,*E*].

For most problems *Q* or Q_1 is not what is required. Since *Q* can be a very large matrix, **qyre** has been provided for the calculation of *QY*, where *Y* is some NxL matrix, which will be a much smaller matrix.

If either *Q'Y* or $Q_1'Y$ are required, see **qtyre**.

If N < P the factorization assumes the form:

$$Q'X[\,.\,,E] = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px(N – P). Thus Q is a PxP matrix and R is a PxN matrix containing R_1 and R_2.

Example

```
x = { 1 11, 7 3, 2 1 };
y = { 2 6, 5 10, 4 3 };
{ qy, r, e } = qyre(y,x);
```

$$qy = \begin{matrix} -0.5942276 & -3.0456088 \\ -6.2442636 & -11.647846 \\ 2.3782485 & -0.22790230 \end{matrix}$$

$$r = \begin{matrix} -11.445523 & -2.9705938 \\ 0.0000000 & -6.7212776 \end{matrix}$$

$$e = \begin{matrix} 2.0000000 \\ 1.0000000 \end{matrix}$$

Source qyr.src

See also **qqr, qre, qyr**

qyrep

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix *X* using a pivot vector and returns *QY* and *R*.

Format

{ *qy,r,e* } **= qyrep(***y,x,pvt***);**

Input

y NxL matrix.

x NxP matrix.

pvt Px1 vector, controls the selection of the pivot columns:

if *pvt*[*i*] > 0, *x*[*i*] is an initial column

if *pvt*[*i*] = 0, *x*[*i*] is a free column

if *pvt*[*i*] < 0, *x*[*i*] is a final column

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

Output

qy NxL unitary matrix.

r KxP upper triangular matrix, K = min(N,P).

e Px1 permutation vector.

Remarks

Given *X*[.,*E*], where *E* is a permutation vector that permutes the columns of *X*, there is an orthogonal matrix *Q* such that *Q′X*[.,*E*] is zero below its diagonal, i.e.,

$$Q'X[\,.\,,E\,] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where *R* is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}$$

where Q_1 has P columns, then

$$X[\,.\,,E\,] = Q_1 R$$

is the QR decomposition of *X*[.,*E*].

qyrep allows you to control the pivoting. For example, suppose that *X* is a data set with a column of ones in the first column. If there are linear dependencies among the columns of *X*, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using *pvt*.

For most problems *Q* or Q_1 is not what is required. Since *Q* can be a very large matrix, **qyrep** has been provided for the calculation of *QY*, where *Y* is some NxL matrix, which will be a much smaller matrix.

If either $Q'Y$ or $Q_1'Y$ are required, see **qtyrep**.

If N < P the factorization assumes the form:

$$Q'X[.,E] = \begin{bmatrix} R_1 & R_2 \end{bmatrix}$$

where R_1 is a PxP upper triangular matrix and R_2 is Px(N – P). Thus *Q* is a PxP matrix and *R* is a PxN matrix containing R_1 and R_2.

Source qyr.src

See also **qr, qqrep, qrep, qtyrep**

rank

Purpose Computes the rank of a matrix, using the singular value decomposition.

Format *k* **= rank(***x***);**

Input

x	NxP matrix.

Global Input

_svdtol	global scalar, the tolerance used in determining if any of the singular values are effectively 0. The default value is 10*e*-13. This can be changed before calling the procedure.

Output

k	an estimate of the rank of *x*. This equals the number of singular values of *x* that exceed a prespecified tolerance in absolute value.

Global Output

_svderr	global scalar, if not all of the singular values can be computed **_svderr** will be nonzero.

Source svd.src

rankindx

Purpose Returns the vector of ranks of a vector.

Format *y* **= rankindx(***x*,*flag***);**

Input

x	Nx1 vector.
flag	scalar, 1 for numeric data or 0 for character data.

Output

y	Nx1 vector containing the ranks of *x*. That is, the rank of the largest element is N and the rank of the smallest is 1. (To get ranks in descending order, subtract *y* from N+1).

Remarks **rankindx** assigns different ranks to elements that have equal values (ties). Missing values are assigned the lowest ranks.

Example

```
let x = 12 4 15 7 8;
r = rankindx(x,1);
```

```
     4
     1
r =  5
     2
     3
```

readr

Purpose

Reads a specified number of rows of data from a GAUSS data set (`.dat`) file or a GAUSS matrix (`.fmt`) file.

Format

y **= readr(***f1,r***);**

Input

fl	scalar, file handle of an open file.
r	scalar, number of rows to read.

Output

y	NxK matrix, the data read from the file.

Remarks

The first time a **readr** statement is encountered, the first *r* rows will be read. The next time it is encountered, the next *r* rows will be read in, and so on. If the end of the data set is reached before *r* rows can be read, then only those rows remaining will be read.

After the last row has been read, the pointer is placed immediately after the end of the file. An attempt to read the file in these circumstances will cause an error message.

To move the pointer to a specific place in the file use **seekr**.

Example

```
open dt = dat1.dat;

m = 0;

do until eof(dt);

   x = readr(dt,400);

   m = m+moment(x,0);

endo;

dt = close(dt);
```

This code reads data from a data set 400 rows at a time. The moment matrix for each set of rows is computed and added to the sum of the previous moment matrices. The result is the moment matrix for the entire data set. **eof(dt)** returns 1 when the end of the data set is encountered.

See also

open, create, writer, seekr, eof

real

Purpose Returns the real part of a matrix.

Format *zr* **= real(***x***);**

Input

x	NxK matrix.

Output

zr	NxK matrix, the real part of *x*.

Remarks If *x* is not complex, *zr* will be equal to *x*.

Example

```
x = { 1 11,
      7i 3,
      2+i 1 };
zr = real(x);
```

```
zr =  1.0000000 11.0000000
      0.0000000  3.0000000
      2.0000000  1.0000000
```

See also **complex, imag**

recode

Purpose

Changes the values of an existing vector from a vector of new values. Used in data transformations.

Format

y **= recode(***x,e,v***);**

Input

x	Nx1 vector to be recoded (changed).
e	NxK matrix of 1's and 0's.
v	Kx1 vector containing the new values to be assigned to the recoded variable.

Output

y	Nx1 vector containing the recoded values of *x*.

Remarks

There should be no more than a single 1 in any row of *e*.

For any given row *N* of *x* and *e*, if the K^{th} column of *e* is 1, the K^{th} element of *v* will replace the original element of *x*.

If every column of *e* contains a 0, the original value of *x* will be unchanged.

Example

```
x =  { 20,
       45,
       32,
       63,
       29 };
e1 = (20 .lt x) .and (x .le 30);
e2 = (30 .lt x) .and (x .le 40);
e3 = (40 .lt x) .and (x .le 50);
e4 = (50 .lt x) .and (x .le 60);
e = e1~e2~e3~e4;
```

```
v = { 1,
      2,
      3,
      4 };

y = recode(x,e,v);
```

x =

```
20
45
32
63
29
```

e =

```
0 0 0 0
0 0 1 0
0 1 0 0
0 0 0 0
1 0 0 0
```

v =

```
1
2
3
4
```

y =

```
20
 3
 2
63
 1
```

Source datatran.src

See also **code, substute**

recode (dataloop)

Purpose

Changes the value of a variable with different values based on a set of logical expressions.

Format

```
recode [#] [$] var with
val_1 for expression_1,
val_2 for expression_2,
      .
      .
      .
val_n for expression_n;
```

Input

var	literal, the new variable name.
val	scalar, value to be used if corresponding expression is true.
expression	logical scalar-returning expression that returns nonzero *TRUE* or zero *FALSE*.

Remarks

If '**$**' is specified, the variable will be considered a character variable. If '**#**' is specified, the variable will be considered numeric. If neither is specified, the type of the variable will be left unchanged.

The logical expressions must be mutually exclusive, that is only one may return *TRUE* for a given row (observation).

If none of the expressions is *TRUE* for a given row (observation), its value will remain unchanged.

Any variables referenced must already exist, either as elements of the source data set, as **extern**s, or as the result of a previous **make**, **vector**, or **code** statement.

Example

```
recode age with
      1 for age < 21,
      2 for age ≥ 21 and age < 35,
      3 for age ≥ 35 and age < 50,
      4 for age ≥ 50 and age < 65,
      5 for age ≥ 65;

recode $ sex with
      “MALE” for sex == 1,
      “FEMALE” for sex == 0;

recode # sex with
      1 for sex $== “MALE”,
      0 for sex $== “FEMALE”;
```

See also

code

recserar

Purpose

Computes a vector of autoregressive recursive series.

Format

y **= recserar(***x,y0,a***);**

Input

x	NxK matrix
y0	PxK matrix.
a	PxK matrix.

Output

y	NxK matrix containing the series.

Remarks

recserar is particularly useful in dealing with time series.

Typically, the result would be thought of as *K* vectors of length *N*.

y0 contains the first *P* values of each of these vectors (thus, these are prespecified). The remaining elements are constructed by computing a P^{th} order "autoregressive" recursion, with weights given by a, and then by adding the result to the corresponding elements of *x*. That is, the t^{th} row of *y* is given by:

$$y[t, .] = x[t, .] + a[1, .] * y[t - 1,.] + \ldots + a[P, .] * y[t - P,.], t = P + 1, \ldots, N$$

and

$$y[t, .] = y0[t, .], t = 1, \ldots, P$$

Note that the first *P* rows of *x* are not used.

Example

```
n = 10;
fn multnorm(n,sigma) =
     rndn(n,rows(sigma))*chol(sigma);
let sig[2,2] = { 1 -.3, -.3 1 };
rho = 0.5~0.3;
y0 = 0~0;
e = multnorm(n,sig);
x = ones(n,1)~rndn(n,3);
b = 1|2|3|4;
```

```
y = recserar(x*b+e,y0,rho);
```

In this example, two autoregressive series are formed using simulated data. The general form of the series can be written:

```
y[1,t] = rho[1,1]*y[1,t-1] + x[t,.]*b + e[1,t]
y[2,t] = rho[2,1]*y[2,t-1] + x[t,.]*b + e[2,t]
```

The error terms (**e[1,t]** and **e[2,t]**) are not individually serially correlated, but they are contemporaneously correlated with each other. The variance-covariance matrix is **sig**.

See also

recsercp, recserrc

recsercp

Purpose

Computes a recursive series involving products. Can be used to compute cumulative products, to evaluate polynomials using Horner's rule, and to convert from base *b* representations of numbers to decimal representations among other things.

Format

y **= recsercp(***x,z***);**

Input

x	NxK or 1xK matrix
z	NxK or 1xK matrix.

Output

y NxK matrix in which each column is a series generated by a recursion of the form:

$$y(1) = x(1) + z(1)$$

$$y(t) = y(t-1) \times x(t) + z(t),\ t = 2, \ldots N$$

Remarks

The following GAUSS code could be used to emulate **recsercp** when the number of rows in *x* and *z* is the same:

```
n = rows(x);  /* assume here that rows(z) */
              /* is also n */
y = zeros(n,1);
y[1,.] = x[1,.] + z[1,.];
i = 2;

do until i > n;
   y[i,.] = y[i-1,.] .* x[i,.] + z[i,.];
   i = i +1;
endo;
```

Note that K series can be computed simultaneously, since *x* and *z* can have K columns (they must both have the same number of columns).

recsercp allows either *x* or *z* to have only 1 row.

recsercp(*x,0*) will produce the cumulative products of the elements in *x*.

Example

```
c1 = c[1,.];
n = rows(c) - 1;
y = recsercp(x,trim(c ./ c1,1,0));
p = c1 .* y[n,.];
```

If **x** is a scalar and **c** is an (N+1)x1 vector, the result **p** will contain the value of the polynomial whose coefficients are given in **c**. That is:

$$p = c[1,.] \times x^{n} + c[2,.] \times x^{(n-1)} + ... + c[n+1,.]$$

Note that both **x** and **c** could contain more than 1 column, and then this code would evaluate the entire set of polynomials at the same time. Note also that if **x** = 2, and if **c** contains the digits of the binary representation of a number, then **p** will be the decimal representation of that number.

See also

recserar, recserrc

recserrc

Purpose Computes a recursive series involving division.

Format *y* **= recserrc(***x,z***);**

Input

x	1xK or Kx1 vector.
z	NxK matrix.

Output

y NxK matrix in which each column is a series generated by a recursion of the form:

y[1] = x mod z[1], x = trunc(x / z[1])
y[2] = x mod z[2], x = trunc(x / z[2])
y[3] = x mod z[3], x = trunc(x / z[3])
. . .
y[n] = x mod z[n]

Remarks Can be used to convert from decimal to other number systems (radix conversion).

Example

```
x = 2|8|10;
b = 2;
n = maxc( log(x)./log(b) ) + 1;
z = reshape( b, n, rows(x) );
y = rev( recserrc(x, z) )' ;
```

The result, **y**, will contain in its rows (note that it is transposed in the last step) the digits representing the decimal numbers 2, 8, and 10 in base 2:

```
0 0 1 0
1 0 0 0
1 0 1 0
```

Source recserrc.src

See also **recserar, recsercp**

rerun

Purpose Displays the most recently created graphics file.

Library **pgraph**

Format **rerun;**

Portability **DOS only**

rerun invokes the graphics utility pqgrun.exe.

Remarks **rerun** is used by the **endwind** function.

Source pcart.src

Globals **_pcmdlin, _pnotify, _psilent, _ptek, _pzoom**

reshape

Purpose

Reshapes a matrix.

Format

y **= reshape(***x,r,c***);**

Input

x	NxK matrix.
r	scalar, new row dimension.
c	scalar, new column dimension.

Output

y	RxC matrix created from the elements of *x*.

Remarks

Matrices are stored in row major order.

The first *c* elements are put into the first row of *y*, the second in the second row, and so on. If there are more elements in *x* than in *y*, the remaining elements are discarded. If there are not enough elements in *x* to fill *y*, then when **reshape** runs out of elements, it goes back to the first element of *x* and starts getting additional elements from there.

Example

```
y = reshape(x,2,6);
```

If $x = \begin{matrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{matrix}$ then $y = \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 7 & 8 & 9 & 10 & 11 & 12 \end{matrix}$

If $x = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{matrix}$ then $y = \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 7 & 8 & 9 & 1 & 2 & 3 \end{matrix}$

If $x = \begin{matrix} 1 & 2 & 3 & 4 & 5 \\ 6 & 7 & 8 & 9 & 10 \\ 11 & 12 & 13 & 14 & 15 \end{matrix}$ then $y = \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 7 & 8 & 9 & 10 & 11 & 12 \end{matrix}$

If $x = \begin{matrix} 1 & 2 \\ 3 & 4 \end{matrix}$ then $y = \begin{matrix} 1 & 2 & 3 & 4 & 1 & 2 \\ 3 & 4 & 1 & 2 & 3 & 4 \end{matrix}$

If $x = 1$ then $y = \begin{matrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{matrix}$

See also `submat, vec`

retp

Purpose Returns from a procedure or keyword.

Format
```
retp;
retp(x,y,...);
```

Remarks For more details, see "Procedures and Keywords" in the *User's Guide*.

In a **retp** statement 0-1023 items may be returned. The items may be expressions. Items are separated by commas.

It is legal to return with no arguments, as long as the procedure is defined to return 0 arguments.

See also **proc, keyword, endp**

return

Purpose Returns from a subroutine.

Format
```
return;
return(x,y,...);
```

Remarks The number of items that may be returned from a subroutine in a **return** statement is limited only by stack space. The items may be expressions. Items are separated by commas.

It is legal to return with no arguments and therefore return nothing.

See also **gosub, pop**

rev

Purpose Reverses the order of the rows in a matrix.

Format *y* **= rev(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the reversed rows of *x*.

Remarks The first row of *y* will be where the last row of *x* was and the last row will be where the first was and so on. This can be used to put a sorted matrix in descending order.

Example

```
x = round(rndn(5,3)*10);
y = rev(x);
```

$$x = \begin{matrix} 10 & 7 & 8 \\ 7 & 4 & -9 \\ -11 & 0 & -3 \\ 3 & 18 & 0 \\ 9 & -1 & 20 \end{matrix}$$

$$y = \begin{matrix} 9 & -1 & 20 \\ 3 & 18 & 0 \\ -11 & 0 & -3 \\ 7 & 4 & -9 \\ 10 & 7 & 8 \end{matrix}$$

See also sortc

rfft

Purpose Computes a real 1- or 2-D Fast Fourier transform.

Format *y* **= rfft(***x***);**

Input

x	NxK real matrix.

Output

y	LxM matrix, where L and M are the smallest powers of 2 greater than or equal to N and K, respectively.

Remarks Computes the RFFT of *x*, scaled by 1/(L*M).

This uses a Temperton Fast Fourier algorithm.

If N or K is not a power of 2, *x* will be padded out with zeros before computing the transform.

Example

```
x = { 6 9, 8 1 };
y = rfft(x);
```

$$y = \begin{matrix} 6.0000000 & 1.0000000 \\ 1.5000000 & -2.5000000 \end{matrix}$$

See also **rffti, fft, ffti, fftm, fftmi**

rffti

Purpose Computes inverse real 1- or 2-D Fast Fourier transform.

Format *y* **= rffti(***x***);**

Input

x	NxK matrix.

Output

y	LxM real matrix, where L and M are the smallest prime factor products greater than or equal to N and K.

Remarks It is up to the user to guarantee that the input will return a real result. If in doubt, use **ffti**.

Example

```
x = { 6 1, 1.5 -2.5 };
y = rffti(x);
```

$$y = \begin{matrix} 6.0000000 & 9.0000000 \\ 8.0000000 & 1.0000000 \end{matrix}$$

See also **rfft, fft, ffti, fftm, fftmi**

rfftip

Purpose

Computes an inverse real 1- or 2-D FFT. Takes a packed format FFT as input.

Format

y **= rfftip(***x***);**

Input

x NxK matrix or K-length vector.

Output

y LxM real matrix or M-length vector.

Remarks

rfftip assumes that its input is of the same form as that output by **rfftp** and **rfftnp**.

rfftip uses the Temperton prime factor FFT algorithm. This algorithm can compute the inverse FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. GAUSS implements the Temperton algorithm for any integer power of 2, 3, and 5, and one factor of 7. Thus, **rfftip** can handle any matrix whose dimensions can be expressed as:

$$2^p \times 3^q \times 5^r \times 7^s, \qquad p, q, r \geq 0$$
$$s = 0 \text{ or } 1$$

If a dimension of *x* does not meet this requirement, it will be padded with zeros to the next allowable size before the inverse FFT is computed. Note that **rfftip** assumes the length (for vectors) or column dimension (for matrices) of *x* is K-1 rather than K, since the last element or column does not hold FFT information, but the Nyquist frequencies.

The sizes of *x* and *y* are related as follows: L will be the smallest prime factor product greater than or equal to N, and M will be twice the smallest prime factor product greater than or equal to K-1. This takes into account the fact that *x* contains both positive and negative frequencies in the row dimension (matrices only), but only positive frequencies, and those only in the first K-1 elements or columns, in the length or column dimension.

It is up to the user to guarantee that the input will return a real result. If in doubt, use **ffti**. Note, however, that **ffti** expects a full FFT, including negative frequency information, for input.

Do not pass **rfftip** the output from **rfft** or **rfftn**—it will return incorrect results. Use **rffti** with those routines.

rfftip

See also **fft, ffti, fftm, fftmi, fftn, rfft, rffti, rfftn, rfftnp, rfftp**

rfftn

Purpose

Computes a real 1- or 2-D FFT.

Format

y **= rfftn(***x***);**

Input

x	NxK real matrix.

Output

y	LxM matrix, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.

Remarks

rfftn uses the Temperton prime factor FFT algorithm. This algorithm can compute the FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. GAUSS implements the Temperton algorithm for any power of 2, 3, and 5, and one factor of 7. Thus, **rfftn** can handle any matrix whose dimensions can be expressed as:

$$2^p \times 3^q \times 5^r \times 7^s, \quad \begin{array}{ll} p, q, r \geq 0 & \text{for rows of matrix} \\ p > 0, q, r \geq 0 & \text{for columns of matrix} \\ p > 0, q, r \geq 0 & \text{for length of vector} \\ s = 0 \text{ or } 1 & \text{for all dimensions} \end{array}$$

If a dimension of *x* does not meet these requirements, it will be padded with zeros to the next allowable size before the FFT is computed.

rfftn pads matrices to the next allowable size; however, it generally runs faster for matrices whose dimensions are highly composite numbers, i.e., products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20 percent faster than a 32768x1 vector, because 33600 is a highly composite number, 2^6 x 3 x 5^2 x 7, whereas 32768 is a simple power of 2, 2^{15}. For this reason, you may want to hand-pad matrices to optimum dimensions before passing them to **rfftn**. The Run-Time Library includes two routines, **optn** and **optnevn**, for determining optimum dimensions. Use **optn** to determine optimum rows for matrices, and **optnevn** to determine optimum columns for matrices and optimum lengths for vectors.

The Run-Time Library also includes the **nextn** and **nextnevn** routines, for determining allowable dimensions for matrices and vectors.

(You can use these to see the dimensions to which **rfftn** would pad a matrix or vector.)

rfftn scales the computed FFT by 1/(L*M).

See also

fft, ffti, fftm, fftmi, fftn, rfft, rffti, rfftip, rfftnp, rfftp

rfftnp

Purpose

Computes a real 1- or 2-D FFT. Returns the results in a packed format.

Format

y **= rfftnp(***x***);**

Input

x	NxK real matrix or K-length real vector.

Output

y	Lx(M/2+1) matrix or (M/2+1)-length vector, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.

Remarks

For 1-D FFT's, **rfftnp** returns the positive frequencies in ascending order in the first M/2 elements, and the Nyquist frequency in the last element. For 2-D FFT's, **rfftnp** returns the positive and negative frequencies for the row dimension, and for the column dimension it returns the positive frequencies in ascending order in the first M/2 columns, and the Nyquist frequencies in the last column. Usually the FFT of a real function is calculated to find the power density spectrum or to perform filtering on the waveform. In both these cases only the positive frequencies are required. (See also **rfft** and **rfftn** for routines that return the negative frequencies as well.)

rfftnp uses the Temperton prime factor FFT algorithm. This algorithm can compute the FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. GAUSS implements the Temperton algorithm for any power of 2, 3, and 5, and one factor of 7. Thus, **rfftnp** can handle any matrix whose dimensions can be expressed as:

$$2^p \times 3^q \times 5^r \times 7^s, \quad \begin{array}{ll} p, q, r \geq 0 & \text{for rows of matrix} \\ p > 0, q, r \geq 0 & \text{for columns of matrix} \\ p > 0, q, r \geq 0 & \text{for length of vector} \\ s = 0 \text{ or } 1 & \text{for all dimensions} \end{array}$$

If a dimension of *x* does not meet these requirements, it will be padded with zeros to the next allowable size before the FFT is computed.

rfftnp pads matrices to the next allowable size; however, it generally runs faster for matrices whose dimensions are highly composite numbers, i.e., products of several factors (to various powers), rather than powers of

a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20 percent faster than a 32768x1 vector, because 33600 is a highly composite number, $2^6 \times 3 \times 5^2 \times 7$, whereas 32768 is a simple power of 2, 2^{15}. For this reason, you may want to hand-pad matrices to optimum dimensions before passing them to **rfftnp**. The Run-Time Library includes two routines, **optn** and **optnevn**, for determining optimum dimensions. Use **optn** to determine optimum rows for matrices, and **optnevn** to determine optimum columns for matrices and optimum lengths for vectors.

The Run-Time Library also includes the **nextn** and **nextnevn** routines, for determining allowable dimensions for matrices and vectors. (You can use these to see the dimensions to which **rfftnp** would pad a matrix or vector.)

rfftnp scales the computed FFT by 1/(L*M).

See also

fft, ffti, fftm, fftmi, fftn, rfft, rffti, rfftip, rfftn, rfftp

rfftp

Purpose Computes a real 1- or 2-D FFT. Returns the results in a packed format.

Format *y* **= rfftp(***x***);**

Input

x	NxK real matrix or K-length real vector.

Output

y	Lx(M/2+1) matrix or (M/2+1)-length vector, where L and M are the smallest powers of 2 greater than or equal to N and K, respectively.

Remarks If a dimension of *x* is not a power of 2, it will be padded with zeros to the next allowable size before the FFT is computed.

For 1-D FFT's, **rfftp** returns the positive frequencies in ascending order in the first M/2 elements, and the Nyquist frequency in the last element. For 2-D FFT's, **rfftp** returns the positive and negative frequencies for the row dimension, and for the column dimension it returns the positive frequencies in ascending order in the first M/2 columns, and the Nyquist frequencies in the last column. Usually the FFT of a real function is calculated to find the power density spectrum or to perform filtering on the waveform. In both these cases only the positive frequencies are required. (See also **rfft** and **rfftn** for routines that return the negative frequencies as well.)

rfftp scales the computed FFT by 1/(L*M).

rfftp uses the Temperton FFT algorithm.

See also **fft, ffti, fftm, fftmi, fftn, rfft, rffti, rfftip, rfftn, rfftnp**

rndbeta

Purpose

Computes pseudo-random numbers with beta distribution.

Format

x **= rndbeta(***r,c,a,b***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
a	MxN matrix, ExE conformable with RxC resulting matrix, shape parameters for beta distribution.
b	KxL matrix, ExE conformable with RxC resulting matrix, shape parameters for beta distribution.

Output

x	RxC matrix, beta distributed pseudo-random numbers.

Remarks

The properties of the pseudo-random numbers in *x* are:

$$E(x) = a / (a + b)$$

$$Var(x) = a \times b / (a + b + 1) \times (a + b)^2$$

$$x > 0$$

$$x < 1$$

$$a > 0$$

$$b > 0$$

Source

random.src

rndcon, rndmult, rndseed

Purpose

Resets the parameters of the linear congruential random number generator that is the basis for **rndu**, **rndi** and **rndn**.

Format

rndcon *c*;
rndmult *a*;
rndseed *seed*;

Portability

Windows, **UNIX**, **OS/2**

Parameter default values and ranges:

seed	time(0),	0 < seed < 2^32
a	1664525	0 < a < 2^32
c	1013904223	0 ≤ c < 2^32

Remarks

A linear congruential uniform random number generator is used by **rndu**, and is also called by **rndn**. These statements allow the parameters of this generator to be changed.

The procedure used to generate the uniform random numbers is as follows. First, the current "seed" is used to generate a new seed:

$$\mathbf{new\_seed} = (((a * seed) \ \%\ 2^{32}) + c) \ \%\ 2^{32}$$

(where % is the mod operator). Then a number between 0 and 1 is created by dividing the new seed by 2^{32}:

$$x = \mathbf{new\_seed} / 2^{32}$$

rndcon resets *c*.

rndmult resets *a*.

rndseed resets *seed*. This is the initial seed for the generator. The default is that GAUSS uses the clock to generate an initial seed when GAUSS is invoked.

GAUSS goes to the clock to seed the generator only when it is first started up. Therefore, if GAUSS is allowed to run for a long time, and if large numbers of random numbers are generated, there is a possibility of recycling (that is, the sequence of "random numbers" will repeat itself). However, the generator used has an extremely long cycle, and so that should not usually be a problem.

rndcon, rndmult, rndseed

The parameters set by these commands remain in effect until new commands are encountered, or until GAUSS is restarted.

See also **rndu, rndn, rndi, rndLCi, rndKMi**

rndgam

Purpose

Computes pseudo-random numbers with gamma distribution.

Format

x **= rndgam(***r,c,alpha***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
alpha	MxN matrix, ExE conformable with RxC resulting matrix, shape parameters for gamma distribution.

Output

x	RxC matrix, gamma distributed pseudo-random numbers.

Remarks

The properties of the pseudo-random numbers in *x* are:

$$\begin{aligned} E(x) &= alpha \\ Var(x) &= alpha \\ x &> 0 \\ alpha &> 0 \end{aligned}$$

To generate **gamma (***alpha***,** *theta***)** pseudo-random numbers where *theta* is a scale parameter, multiply the result of **rndgam** by *theta*. Thus:

z = theta * **rndgam(1**,**1**,*alpha***)**

has the properties

$$\begin{aligned} E(z) &= alpha \times theta \\ Var(z) &= alpha \times theta^2 \\ z &> 0 \\ alpha &> 0 \\ theta &> 0 \end{aligned}$$

Source

random.src

rndi

Purpose

Returns a matrix of random integers, 0 <= *y* < 2^32.

Format

y **= rndi(***r*,*c***);**

Input

r	scalar, row dimension.
c	scalar, column dimension.

Output

y	*r*x*c* matrix of random integers between 0 and 2^32 - 1, inclusive.

Remarks

r and *c* will be truncated to integers if necessary.

This generator is automatically seeded using the system clock when GAUSS first starts. However, that can be overridden using the **rndseed** statement or using **rndus**.

Each seed is generated from the preceding seed, using the formula

$$\textbf{new\_seed} = (((a * seed) \ \% \ 2^{32}) + c) \ \% \ 2^{32}$$

where % is the mod operator. The new seeds are the values returned. The muliplicative constant and the additive constant may be changed using **rndmult** and **rndcon** respectively.

See also

rndu, rndus, rndn, rndcon, rndmult

rndKMbeta

Purpose

Computes beta pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndKMbeta(**r,c,a,b,*state***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
a	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, first shape argument for beta distribution.
b	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, second shape argument for beta distribution.
state	scalar or 500x1 vector.
	Scalar case:
	state = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.
	500x1 vector case:
	state = the state vector returned from a previous call to one of the **rndKM** random number functions.

Output

x	*r*x*c* matrix, beta distributed random numbers.
newstate	500x1 vector, the updated state.

Remarks

The properties of the pseudo-random numbers in *x* are:

$$E(x) = \frac{a}{a+b}, Var(x) = \frac{(a*b)}{(a+b+1)*(a+b)^2}$$

$0 < x < 1$, $a > 0$, $b > 0$

r and *c* will be truncated to integers if necessary.

Source

randkm.src

Technical Notes

rndKMbeta uses the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes.

rndKMgam

Purpose

Computes Gamma pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndKMgam(***r*,*c*,*alpha*,*state***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
alpha	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, shape argument for gamma distribution.
state	scalar or 500x1 vector. **Scalar case:** *state* = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock. **500x1 vector case:** *state* = the state vector returned from a previous call to one of the **rndKM** random number functions.

Output

x	*r*x*c* matrix, gamma distributed random numbers.
newstate	500x1 vector, the updated state.

Remarks

The properties of the pseudo-random numbers in *x* are:

E(*x*) = *alpha*, Var(*x*) = *alpha*

x > 0, *alpha* > 0.

To generate gamma(*alpha*, *theta*) pseudo-random numbers where *theta* is a scale parameter, multiply the result of **rndgam** by *theta*.

Thus

z = *theta* * **rndgam**(1,1,*alpha*);

has the properties

E(*z*) = *alpha* * *theta*, Var(*z*) = *alpha* * *theta* ^ 2

z > 0, *alpha* > 0, *theta* > 0.

r and *c* will be truncated to integers if necessary.

Source

randkm.src

Technical Notes

rndKMgam uses the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes.

rndKMi

Purpose

Returns a matrix of random integers, 0 <= *y* < 2^32, and the state of the random number generator.

Format

{ *y*, *newstate* **} = rndKMi(***r*, *c*, *state***);**

Input

r	scalar, row dimension.
c	scalar, column dimension.
state	scalar or 500x1 vector.
	Scalar case:
	state = starting seed value. If -1, GAUSS computes the starting seed based on the system clock.
	500x1 vector case:
	state = the *state* vector returned from a previous call to one of the **rndKM** random number generators**.**

Output

y	*r*x*c* matrix of random integers between 0 and 2^32 - 1, inclusive.
newstate	500x1 vector, the updated state.

Remarks

r and *c* will be truncated to integers if necessary.

Example

This example generates two thousand vectors of random integers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

```
state = 13;
n = 2000;
k = 1000000;
c = 0;
min = 2^32+1;
max = -1;
```

```
do while c < n;
   { y,state } = rndKMi(k,1,state);
   min = minc(min | minc(y));
   max = maxc(max | maxc(y));
   c = c + k;
endo;

print "min " min;
print "max " max;
```

See also

rndKMn, rndKMu

Technical Notes

rndKMi generates random integers using a KISS+Monster algorithm developed by George Marsaglia. KISS initializes the sequence used in the recur-with-carry Monster random number generator. For more information on this generator see http://www.Aptech.com/random.

rndKMn

Purpose

Returns a matrix of standard normal (pseudo) random variables and the state of the random number generator.

Format

{ *y*, *newstate* **} = rndKMn(***r*, *c*, *state***);**

Input

r	scalar, row dimension.
c	scalar, column dimension.
state	scalar or 500x1 vector.
	Scalar case:
	state = starting seed value. If -1, GAUSS computes the starting seed based on the system clock.
	500x1 vector case:
	state = the *state* vector returned from a previous call to one of the **rndKM** random number generators.

Output

y	*r*x*c* matrix of standard normal random numbers.
newstate	500x1 vector, the updated state.

Remarks

r and *c* will be truncated to integers if necessary.

Example

This example generates two thousand vectors of standard normal random numbers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

```
state = 13;
n = 2000;
k = 1000000;
c = 0;
submean = {};
```

```
do while c < n;
   { y,state } = rndKMn(k,1,state);
   submean = submean | meanc(y);
   c = c + k;
endo;

mean = meanc(submean);
print mean;
```

See also

rndKMu, rndKMi

Technical Notes

rndKMn calls the uniform random number generator that is the basis for **rndKMu** multiple times for each normal random number generated. This is the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes. Potential normal random numbers are filtered using the fast acceptance-rejection algorithm proposed by Kinderman, A.J. and J.G. Ramage, "Computer Generation of Normal Random Numbers," Journal of the American Statistical Association, December 1976, Volume 71, Number 356, pp. 893-896.

rndKMnb

Purpose

Computes negative binomial pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndKMnb(***r*,*c*,*k*,*p*,*state***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
k	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, "event" argument for negative binomial distribution.
p	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, "probability" argument for negative binomial distribution.
state	scalar or 500x1 vector.
	Scalar case:
	state = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.
	500x1 vector case:
	state = the state vector returned from a previous call to one of the **rndKM** random number functions.

Output

x	*r*x*c* matrix, negative binomial distributed random numbers.
newstate	500x1 vector, the updated state.

Remarks

The properties of the pseudo-random numbers in *x* are:

$$E(x) = \frac{k*p}{(1-p)}, Var(x) = \frac{k*p}{(1-p)^2}$$

$x = 0, 1, ..., k > 0, 0 < p < 1$

r and *c* will be truncated to integers if necessary.

Source

randkm.src

Technical Notes

rndKMnb uses the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes.

rndKMp

Purpose

Computes Poisson pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndKMp(***r*,*c*,*lambda*,*state***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
lambda	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, shape argument for Poisson distribution.
state	scalar or 500x1 vector. **Scalar case:** *state* = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock. **500x1 vector case:** *state* = the state vector returned from a previous call to one of the **rndKM** random number functions.

Output

x	*r*x*c* matrix, Poisson distributed random numbers.
newstate	500x1 vector, the updated state.

Remarks

The properties of the pseudo-random numbers in *x* are:

E(*x*) = *lambda*, Var(*x*) = *lambda*

x = 0, 1, ..., *lambda* > 0.

r and *c* will be truncated to integers if necessary.

Source

randkm.src

Technical Notes

rndKMp uses the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes.

rndKMu

Purpose

Returns a matrix of uniform (pseudo) random variables and the state of the random number generator.

Format

{ *y*, *newstate* **} = rndKMu(***r*, *c*, *state***);**

Input

r	scalar, row dimension.
c	scalar, column dimension.
state	scalar, 2x1 vector, or 500x1 vector.

Scalar case:

state = starting seed value. If -1, GAUSS computes the starting seed based on the system clock.

2x1 vector case:

[1]	the starting seed, uses the system clock if -1
[2]	0 for 0 <= *y* < 1
	1 for 0 <= *y* <= 1

500x1 vector case:

state = the *state* vector returned from a previous call to one of the **rndKM** random number generators.

Output

y	*r*x*c* matrix of uniform random numbers, 0 <= *y* < 1.
newstate	500x1 vector, the updated state.

Remarks

r and *c* will be truncated to integers if necessary.

Example

This example generates two thousand vectors of uniform random numbers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

```
state = 13;

n = 2000;

k = 1000000;

c = 0;

submean = {};
```

```
do while c < n;
   { y,state } = rndKMu(k,1,state);
   submean = submean | meanc(y);
   c = c + k;
endo;

mean = meanc(submean);
print 0.5-mean;
```

See also

rndKMn, rndKMi

Technical Notes

rndKMu uses the recur-with-carry KISS-Monster algorithm described in the **rndKMi** Technical Notes. Random integer seeds from 0 to 2^32-1 are generated. Each integer is divided by 2^32 or 2^32-1.

rndKMvm

Purpose

Computes von Mises pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndKMvm(***r*,*c*,*m*,*k*,*state***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
m	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, means for vm distribution.
k	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, shape argument for vm distribution.
state	scalar or 500x1 vector. **Scalar case:** *state* = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock. **500x1 vector case:** *state* = the state vector returned from a previous call to one of the **rndKM** random number functions.

Output

x	*r*x*c* matrix, von Mises distributed random numbers.
newstate	500x1 vector, the updated state.

Remarks

r and *c* will be truncated to integers if necessary.

Source

randkm.src

Technical Notes

rndKMvm uses the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes.

rndLCbeta

Purpose

Computes beta pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndLCbeta(***r*,*c*,*a*,*b*,*state***);**

Input

r scalar, number of rows of resulting matrix.

c scalar, number of columns of resulting matrix.

a *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, first shape argument for beta distribution.

b *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, second shape argument for beta distribution.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = -1, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if -1

[2] the multiplicative constant

[3] the additive constant

Output

x *r*x*c* matrix, beta distributed random numbers.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks:

The properties of the pseudo-random numbers in *x* are:

$$E(x) = \frac{a}{a+b}, Var(x) = \frac{(a*b)}{(a+b+1)*(a+b)^2}$$

rndLCbeta

$0 < x < 1, a > 0, b > 0$

r and *c* will be truncated to integers if necessary.

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, Statistical Computing, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

new_seed = (((*a* ***** *seed***) % 2^{32})+** *c***) % 2^{32}**

where % is the mod operator and where a is the multiplicative constant and c is the additive constant.

rndLCgam

Purpose

Computes Gamma pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndLCgam(***r*,*c*,*alpha*,*state***);**

Input

r scalar, number of rows of resulting matrix.

c scalar, number of columns of resulting matrix.

alpha *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, shape argument for gamma distribution.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = -1, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if -1

[2] the multiplicative constant

[3] the additive constant

Output

x *r*x*c* matrix, gamma distributed random numbers.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks

The properties of the pseudo-random numbers in *x* are:

E(*x*) = *alpha*, Var(*x*) = *alpha*

x > 0, *alpha* > 0.

To generate gamma (*alpha*, *theta*) pseudo-random numbers where *theta* is a scale parameter, multiply the result of **rndgam** by *theta*.

Thus

z = *theta* * **rndgam**(1,1,*alpha*);

has the properties

E(*z*) = *alpha* * *theta*, Var(*z*) = *alpha* * *theta* ^ 2

z > 0, *alpha* > 0, *theta* > 0.

r and *c* will be truncated to integers if necessary.

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, Statistical Computing, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

new_seed = (((*a* * *seed***) % 2**^{32}**)+***c***) % 2**^{32}

where % is the mod operator and where a is the multiplicative constant and c is the additive constant.

rndLCi

Purpose

Returns a matrix of random integers, 0 <= *y* < 2^32, and the state of the random number generator.

Format

{ *y*, *newstate* **} = rndLCi(***r*, *c*, *state***);**

Input

r scalar, row dimension.

c scalar, column dimension.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = 0, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if 0

[2] the multiplicative constant

[3] the additive constant

Output

y *r*x*c* matrix of random integers between 0 and 2^32 - 1, inclusive.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks

r and *c* will be truncated to integers if necessary.

Each seed is generated from the preceding seed, using the formula

$$\mathbf{new\_seed} = (((a * seed) \ \%\ 2^{32}) + c) \ \%\ 2^{32}$$

where % is the mod operator and where a is the multiplicative constant and c is the additive constant. The new seeds are the values returned.

rndLCi

Example

```
state = 13;
n = 2000000000;
k = 1000000;
c = 0;
min = 2^32+1;
max = -1;

do while c < n;
   { y,state } = rndLCi(k,1,state);
   min = minc(min | minc(y));
   max = maxc(max | maxc(y));
   c = c + k;
endo;

print "min " min;
print "max " max;
```

See also

rndLCn, **rndLCu**, **rndcon**, **rndmult**

rndLCn

Purpose

Returns a matrix of standard normal (pseudo) random variables and the state of the random number generator.

Format

{ *y*, *newstate* **} = rndLCn(***r*, *c*, *state***);**

Input

r scalar, row dimension.

c scalar, column dimension.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = 0, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if 0

[2] the multiplicative constant

[3] the additive constant

Output

y *rxc* matrix of standard normal random numbers.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks

r and *c* will be truncated to integers if necessary.

Example

```
state = 13;
n = 2000000000;
k = 1000000;
c = 0;
```

rndLCn

```
submean = {};

do while c < n;
   { y,state } = rndLCn(k,1,state);
   submean = submean | meanc(y);
   c = c + k;
endo;

mean = meanc(submean);
print mean;
```

See also

rndLCu, rndLCi, rndcon, rndmult

Technical Notes

The normal random number generator is based on the uniform random number generator, using the fast acceptance-rejection algorithm proposed by Kinderman, A.J. and J.G. Ramage, "Computer Generation of Normal Random Numbers," Journal of the American Statistical Association, December 1976, Volume 71, Number 356, pp. 893-896. This algorithm calls the linear congruential uniform random number generator multiple times for each normal random number generated. See **rndLCu** for a description of the uniform random number generator algorithm.

rndLCnb

Purpose

Computes negative binomial pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndLCnb(***r*,*c*,*k*,*p*,*state***);**

Input

r scalar, number of rows of resulting matrix.

c scalar, number of columns of resulting matrix.

k *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, "event" argument for negative binomial distribution.

p *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, "probability" argument for negative binomial distribution.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = -1, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if -1

[2] the multiplicative constant

[3] the additive constant

Output

x *r*x*c* matrix, negative binomial distributed random numbers.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks

The properties of the pseudo-random numbers in *x* are:

$$E(x) = \frac{k*p}{(1-p)}, Var(x) = \frac{k*p}{(1-p)^2}$$

$x = 0, 1, ..., k > 0, 0 < p < 1$

r and *c* will be truncated to integers if necessary.

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, Statistical Computing, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

new_seed = (((*a* ***** *seed***) % 2^{32})+** *c***) % 2^{32}**

where % is the mod operator and where a is the multiplicative constant and c is the additive constant.

rndLCp

Purpose

Computes Poisson pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndLCp(***r*,*c*,*lambda*,*state***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
lambda	*r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, shape argument for Poisson distribution.
state	scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = -1, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1]	the starting seed, uses the system clock if -1
[2]	the multiplicative constant
[3]	the additive constant

Output

x	*r*x*c* matrix, Poisson distributed random numbers.
newstate	4x1 vector:

[1]	the updated seed
[2]	the multiplicative constant
[3]	the additive constant
[4]	the original initialization seed

Remarks

The properties of the pseudo-random numbers in *x* are:

E(*x*) = *lambda*, Var(*x*) = *lambda*

x = 0, 1, ..., *lambda* > 0.

r and *c* will be truncated to integers if necessary.

rndLCp

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, Statistical Computing, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

$$\mathbf{new\_seed} = (((a * seed) \ \% \ 2^{32}) + c) \ \% \ 2^{32}$$

where % is the mod operator and where a is the multiplicative constant and c is the additive constant.

rndLCu

Purpose

Returns a matrix of uniform (pseudo) random variables and the state of the random number generator.

Format

{ *y*, *newstate* **} = rndLCu(***r*, *c*, *state***);**

Input

r scalar, row dimension.

c scalar, column dimension.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = 0, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if 0

[2] the multiplicative constant

[3] the additive constant

Output

y *r*x*c* matrix of uniform random numbers, 0 <= *y* < 1.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks

r and *c* will be truncated to integers if necessary.

Each seed is generated from the preceding seed, using the formula

$$\texttt{new\_seed} = (((a * seed) \ \% \ 2^{32}) + c) \ \% \ 2^{32}$$

where % is the mod operator and where a is the multiplicative constant and c is the additive constant. A number between 0 and 1 is created by dividing new_seed by 2^32.

rndLCu

Example

```
state = 13;
n = 2000000000;
k = 1000000;
c = 0;
submean = {};

do while c < n;
   { y,state } = rndLCu(k,1,state);
   submean = submean | meanc(y);
   c = c + k;
endo;

mean = meanc(submean);
print 0.5-mean;
```

See also

rndLCn, rndLCi, rndcon, rndmult

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W. J. Jr., and J. E. Gentle, Statistical Computing, Marcel Dekker, Inc., 1980, pp. 136-147.

rndLCvm

Purpose

Computes von Mises pseudo-random numbers.

Format

{ *x*, *newstate* **} = rndLCvm(***r*,*c*,*m*,*k*,*state***);**

Input

r scalar, number of rows of resulting matrix.

c scalar, number of columns of resulting matrix.

m *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, means for vm distribution.

k *r*x*c* matrix, or *r*x1 vector, or 1x*c* vector, or scalar, shape argument for vm distribution.

state scalar, 3x1 vector, or a 4x1 state vector from a previous call to the function.

Scalar case:

state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with **rndcon** and **rndmult**.

if *state* = -1, GAUSS computes the starting seed based on the system clock.

3x1 vector case:

[1] the starting seed, uses the system clock if -1

[2] the multiplicative constant

[3] the additive constant

Output

x *r*x*c* matrix, von Mises distributed random numbers.

newstate 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed

Remarks

r and *c* will be truncated to integers if necessary.

Source

randlc.src

rndLCvm

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, Statistical Computing, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

$$\texttt{new\_seed} = (((a * seed) \ \% \ 2^{32}) + c) \ \% \ 2^{32}$$

where % is the mod operator and where a is the multiplicative constant and c is the additive constant.

rndn

Purpose

Creates a matrix of standard Normal (pseudo) random numbers.

Format

y **= rndn(***r*,*c***);**

Input

r	scalar, row dimension.
c	scalar, column dimension.

Output

y	RxC matrix of Normal random numbers having a mean of 0 and standard deviation of 1.

Remarks

r and *c* will be truncated to integers if necessary.

The Normal random number generator is based upon the uniform random number generator. To reseed them both, use the **rndseed** statement. The other parameters of the uniform generator can be changed using **rndcon**, **rndmod**, and **rndmult**.

Example

```
x = rndn(8100,1);
m = meanc(x);
s = stdc(x);
```

m = 0.002810

s = 0.997087

In this example, a sample of 8100 Normal random numbers is drawn, and the mean and standard deviation are computed for the sample.

See also

rndu, rndcon

Technical Notes

This function uses the fast acceptance-rejection algorithm proposed by Kinderman, A. J., and J. G. Ramage. “Computer Generation of Normal Random Numbers.” *Journal of the American Statistical Association.* Vol. 71 No. 356, Dec. 1976, 893-96.

rndnb

Purpose

Computes pseudo-random numbers with negative binomial distribution.

Format

x **= rndnb(***r,c,k,p***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
k	MxN matrix, ExE conformable with RxC resulting matrix, "event" parameters for negative binomial distribution.
p	KxL matrix, ExE conformable with RxC resulting matrix, probability parameters for negative binomial distribution.

Output

x	RxC matrix, negative binomial distributed pseudo-random numbers.

Remarks

The properties of the pseudo-random numbers in *x* are:

$$E(x) = k \times p / (1 - p)$$
$$Var(x) = k \times p / (1 - p)^2$$
$$x = 0, 1, 2, \ldots, k$$
$$k > 0$$
$$p > 0$$
$$p < 1$$

Source

random.src

rndp

Purpose Computes pseudo-random numbers with Poisson distribution.

Format *x* **= rndp(***r,c,lambda***);**

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
lambda	MxN matrix, ExE conformable with RxC resulting matrix, shape parameters for Poisson distribution.

Output

x	RxC matrix, Poisson distributed pseudo-random numbers.

Remarks The properties of the pseudo-random numbers in *x* are:

Ex = lambda

$Var(x)$= lambda

x = 0, 1, 2, ...

lambda > 0

Source random.src

rndu

Purpose

Creates a matrix of uniform (pseudo) random variables.

Format

y **= rndu(***r*,*c***);**

Input

r	scalar, row dimension.
c	scalar, column dimension.

Output

y	RxC matrix of uniform random variables between 0 and 1.

Remarks

r and *c* will be truncated to integers if necessary.

This generator is automatically seeded using the clock when GAUSS is first started. However, that can be overridden using the **rndseed** statement or by using **rndus**.

The seed is automatically updated as a random number is generated (see above under **rndcon**). Thus, if GAUSS is allowed to run for a long time, and if large numbers of random numbers are generated, there is a possibility of recycling. This is a 32-bit generator, though, so the range is sufficient for most applications.

Example

```
x = rndu(8100,1);
y = meanc(x);
z = stdc(x);
```

y = 0.500205

z = 0.289197

In this example, a sample of 8100 uniform random numbers is generated, and the mean and standard deviation are computed for the sample.

See also

rndn, rndcon, rndmod, rndmult, rndseed

Technical Notes

This function uses a multiplicative-congruential method. This method is discussed in Kennedy, W.J., Jr., and J.E. Gentle. *Statistical Computing*. Marcel Dekker, Inc., NY, 1980, 136-147.

rndvm

Purpose Computes von Mises pseudo-random numbers.

Format *x* = **rndvm**(*r*,*c*,*m*,*k*);

Input

r	scalar, number of rows of resulting matrix.
c	scalar, number of columns of resulting matrix.
m	NxK matrix, ExE conformable with *r*x*c*, means for von Mises distribution.
k	LxM matrix, ExE conformable with *r*x*c*, shape arrgument for von Mises distribution.

Output

x	*r*x*c* matrix, von Mises distributed random numbers.

Source random.src

rotater

Purpose

Rotates the rows of a matrix.

Format

y **= rotater(***x*,*r***);**

Input

x	NxK matrix to be rotated.
r	Nx1 or 1x1 matrix specifying the amount of rotation.

Output

y	NxK rotated matrix.

Remarks

The rotation is performed horizontally within each row of the matrix. A positive rotation value will cause the elements to move to the right. A negative rotation value will cause the elements to move to the left. In either case, the elements that are pushed off the end of the row will wrap around to the opposite end of the same row.

If the rotation value is greater than or equal to the number of columns in *x*, then the rotation value will be calculated using (*r* % **cols**(*x*)).

Example

```
y = rotater(x,r);
```

If $x = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{matrix}$ and $r = \begin{matrix} 1 \\ -1 \end{matrix}$ Then $y = \begin{matrix} 3 & 1 & 2 \\ 5 & 6 & 4 \end{matrix}$

If $x = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \\ 10 & 11 & 12 \end{matrix}$ and $r = \begin{matrix} 0 \\ 1 \\ 2 \\ 3 \end{matrix}$ Then $y = \begin{matrix} 1 & 2 & 3 \\ 6 & 4 & 5 \\ 8 & 9 & 7 \\ 10 & 11 & 12 \end{matrix}$

See also

shiftr

round

Purpose Rounds to the nearest integer.

Format *y* **= round(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix containing the rounded elements of *x*.

Example

```
let x = { 77.68   -14.10,
          4.73   -158.88 };
y = round(x);
```

$$y = \begin{matrix} 78 & -14 \\ 5 & -159 \end{matrix}$$

See also **trunc, floor, ceil**

rows

Purpose Returns the number of rows in a matrix.

Format *y* **= rows(***x***);**

Input

x NxK matrix.

Output

y scalar, number of rows in the specified matrix.

Remarks If *x* is an empty matrix, **rows**(*x*) and **cols**(*x*) return 0.

Example

```
x = ones(3,5);
y = rows(x);
```

$$x = \begin{matrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{matrix}$$

$y = 3$

See also **cols, show**

rowsf

Purpose Returns the number of rows in a GAUSS data set (`.dat`) file or GAUSS matrix (`.fmt`) file.

Format *y* **= rowsf(***f***);**

Input

f	file handle of an open file.

Output

y	scalar, number of rows in the specified file.

Example

```
open fp = myfile;
r = rowsf(fp);
c = colsf(fp);
```

See also **colsf, open, typef**

rref

Purpose

Computes the reduced row echelon form of a matrix.

Format

y **= rref(***x***);**

Input

x MxN matrix.

Output

y MxN matrix containing reduced row echelon form of *x*.

Remarks

The tolerance used for zeroing elements is computed inside the procedure using:

```
tol = maxc(m|n) * eps * maxc(abs(sumc(x′)));
```

where **eps** = 2.24e–16;

This procedure can be used to find the rank of a matrix. It is not as stable numerically as the singular value decomposition (which is used in the **rank** function), but it is faster for large matrices.

There is some speed advantage in having the number of rows be greater than the number of columns, so you may want to transpose if all you care about is the rank.

The following code can be used to compute the rank of a matrix:

```
r = sumc(sumc(abs(y′)) .> tol);
```

where *y* is the output from **rref**, and **tol** is the tolerance used. This finds the number of rows with any nonzero elements, which gives the rank of the matrix, disregarding numeric problems.

Example

```
let x[3,3] =  1  2  3
              4  5  6
              7  8  9;
y = rref(x);
```

$$y = \begin{matrix} 1 & 0 & -1 \\ 0 & 1 & 2 \\ 0 & 0 & 0 \end{matrix}$$

Source

rref.src

run

Purpose

Runs a source code or compiled code program.

Format

run *filename*;

Input

filename literal or ^string, name of file to run.

Remarks

The filename can be any legal file name. Filename extensions can be whatever you want, except for the compiled file extension, `.gcg`. Pathnames are okay. If the name is to be taken from a string variable, then the name of the string variable must be preceded by the ^ (caret) operator.

The **run** statement can be used both from the command line and within a program. If used in a program, once control is given to another program through the **run** statement there is no return to the original program.

If you specify a filename without an extension, GAUSS will first look for a compiled code program (i.e., a `.gcg` file) by that name, then a source code program by that name. For example, if you enter

```
run dog;
```

GAUSS will first look for the compiled code file `dog.gcg`, and run that if it finds it. If GAUSS cannot find `dog.gcg`, it will then look for the source code file dog with no extension.

If a path is specified for the file, then no additional searching will be attempted if the file is not found.

If a path is not specified the current directory will be searched first, then each directory listed in **src_path**. The first instance found is run. **src_path** is defined in `gauss.cfg`.

`run /gauss/myprog.prc;`	No additional search will be made if the file is not found.
`run myprog.prc;`	The directories listed in **src_path** will be searched for `myprog.prc` if the file is not found in the current directory.

Programs can also be run by typing the filename on the OS command line when starting GAUSS.

Example

Example 1

```
run myprog.prg;
```

run

Example 2

```
name = “myprog.prg”;
run ^name;
```

See also

#include

save

Purpose

Saves matrices, strings, or procedures to a disk file.

Format

save [[*vflag*]] [[**path=***path*]] *x*, [[*lpath***=**]]*y*;

Input

vflag version flag.

- **-v89** supported on DOS, OS/2, Windows
- **-v92** supported on UNIX, Windows
- **-v96** supported on all platforms

See also "File I/O" in the *User's Guide* for details on the various versions. The default format can be specified in `gauss.cfg` by setting the **dat_fmt_version** configuration variable. If **dat_fmt_version** is not set, the default is **v96**.

path literal or ^string, a default path to use for this and subsequent **save**s.

x a symbol name, the name of the file the symbol will be saved in is the same as this with the proper extension added for the type of the symbol.

lpath literal or ^string, a local path and filename to be used for a particular symbol. This path will override the path previously set and the filename will override the name of the symbol being saved. The extension cannot be overridden.

y the symbol to be saved to *lpath*.

Remarks

save can be used to save matrices, strings, procedures, and functions. Procedures and functions must be compiled and resident in memory before they can be **save**'d.

The following extensions will be given to files that are saved:

matrix	`.fmt`
string	`.fst`
procedure	`.fcg`
function	`.fcg`
keyword	`.fcg`

if the **path=** subcommand is used with **save**, the path string will be remembered until changed in a subsequent command. This path will be

used whenever none is specified. The save path can be overridden in any particular save by specifying an explicit path and filename.

Example

```
spath = "/gauss";
save path = ^spath x,y,z;
```

Save **x**, **y**, and **z** using **/gauss** as a path. This path will be used for the next save if none is specified.

```
svp = "/gauss/data";
save path = ^svp n, k, /gauss/quad1=quad;
```

n and **k** will be saved using **/gauss/data** as the save path, **quad** will be saved in **/gauss** with the name `quad1.fmt`. On platforms that use the backslash as the path separator, the double backslash is required inside double quotes to get a backslash, because it is the escape character in quoted strings. It is not required when specifying literals.

```
save path=/procs;
```

Changes save path to /procs.

```
save path = /miscdata;
save /data/mydata1 = x, y, hisdata = z;
```

In the above program:

x would be saved in `/data/mydata1.fmt`

y would be saved in `/miscdata/y.fmt`

z would be saved in `/miscdata/hisdata.fmt`

See also

load, saveall, saved

saveall

Purpose

Saves the current state of the machine to a compiled file. All procedures, global matrices and strings will be saved.

Format

saveall *fname*;

Input

fname literal or ^string, the path and filename of the compiled file to be created.

Remarks

The file extension will be `.gcg`.

A file will be created containing all your matrices, strings, and procedures. No main code segment will be saved. This just means it will be a `.gcg` file with no main program code (see **compile**). The rest of the contents of memory will be saved including all global matrices, strings, functions and procedures. Local variables are not saved. This can be used inside a program to take a snapshot of the state of your global variables and procedures. To reload the compiled image use **run** or **use**.

```
library pgraph;
external proc xy,logx,logy,loglog,hist;
saveall pgraph;
```

This would create a file called `pgraph.gcg` containing all the procedures, strings and matrices needed to run Publication Quality Graphics programs. Other programs could be compiled very quickly with the following statement at the top of each:

```
use pgraph;
```

See also

compile, run, use

saved

Purpose

Writes a matrix in memory to a GAUSS data set on disk.

Format

y **= saved(***x,dataset,vnames***);**

Input

x	NxK matrix to save in `.dat` file.
dataset	string, name of data set.
vnames	string or Kx1 character vector, names for the columns of the data set.

Output

y	scalar, 1 if successful, 0 if fail.

Remarks

If *dataset* is null or 0, the data set name will be `temp.dat`.

if *vnames* is a null or 0, the variable names will begin with "X" and be numbered 1-K.

If *vnames* is a string or has fewer elements than *x* has columns, it will be expanded as explained under **create**.

The output data type is double precision.

Example

```
x = rndn(100,3);
dataset = "mydata";
vnames = { height, weight, age };
if not saved(x,dataset,vnames);
   errorlog "Write error";
   end;
endif;
```

Source

saveload.src

See also

loadd, writer, create

savewind

Purpose Saves the current graphic panel configuration to a file.

Library **pgraph**

Format *err* **= savewind(***filename***);**

Input

filename	Name of file.

Output

err	scalar, 0 if successful, 1 if graphic panel matrix is invalid. Note that the file is written in either case.

Remarks See the discussion on using graphic panels in "Publication Quality Graphics" in the *User's Guide.*

Source pwindow.src

See also **loadwind**

scale

Purpose

Fixes the scaling for subsequent graphs. The axes endpoints and increments are computed as a best guess based on the data passed to it.

Library

pgraph

Format

scale(*x*,*y***);**

Input

x	matrix, the X axis data.
y	matrix, the Y axis data.

Remarks

x and *y* must each have at least 2 elements. Only the minimum and maximum values are necessary.

This routine fixes the scaling for all subsequent graphs until **graphset** is called. This also clears **xtics** and **ytics** whenever it is called.

If either of the arguments is a scalar missing, the main graphics function will set the scaling for that axis using the actual data.

If an argument has 2 elements, the first will be used for the minimum and the last will be used for the maximum.

If an argument has 2 elements, and contains a missing value, that end of the axis will be scaled from the data by the main graphics function.

If you want direct control over the axes endpoints and tick marks, use **xtics** or **ytics**. If **xtics** or **ytics** have been called after **scale**, they will override **scale**.

Source

pscale.src

See also

xtics, ytics, ztics, scale3d

scale3d

Purpose

Fixes the scaling for subsequent graphs. The axes endpoints and increments are computed as a best guess based on the data passed to it.

Library

pgraph

Format

scale3d(*x,y,z***);**

Input

x	matrix, the X axis data.
y	matrix, the Y axis data.
z	matrix, the Z axis data.

Remarks

x, *y* and *z* must each have at least 2 elements. Only the minimum and maximum values are necessary.

This routine fixes the scaling for all subsequent graphs until **graphset** is called. This also clears **xtics**, **ytics** and **ztics** whenever it is called.

If any of the arguments is a scalar missing, the main graphics function will set the scaling for that axis using the actual data.

If an argument has 2 elements, the first will be used for the minimum and the last will be used for the maximum.

If an argument has 2 elements, and contains a missing value, that end of the axis will be scaled from the data by the main graphics function.

If you want direct control over the axes endpoints and tick marks, use **xtics**, **ytics**, or **ztics**. If one of these functions have been called, they will override **scale3d**.

Source

pscale.src

See also

scale, xtics, ytics, ztics

scalerr

Purpose

Tests for a scalar error code.

Format

y **= scalerr(***c***);**

Input

c NxK matrix, generally the return argument of a function or procedure call.

Output

y scalar, which is returned as a 0 if its argument is not a scalar error code. If the argument is an error code, then scalerr returns the value of the error code as an integer.

Remarks

Error codes in GAUSS are NaN's (Not A Number). These are not just scalar integer values. They are special floating point encodings that the math chip recognizes as not representing a valid number. See also **error**.

scalerr can be used to test for either those error codes which are predefined in GAUSS or an error code which the user has defined using **error**.

If *c* is an empty matrix, **scalerr** will return 65535.

Certain functions will either return an error code or terminate a program with an error message, depending on the trap state. The **trap** command is used to set the trap state. The error code that will be returned will appear to most commands as a missing value code, but the **scalerr** function can distinguish between missing values and error codes and will return the value of the error code.

Following are some of the functions affected by the trap state:

function	**trap 1** error code	**trap 0** error message
chol	10	**Matrix not positive definite**
invpd	20	**Matrix not positive definite**
solpd	30	**Matrix not positive definite**
/	40	**Matrix not positive definite** (*second argument not square*)
	41	**Matrix singular** (*second argument is square*)
inv	50	**Matrix singular**

Example

```
trap 1;
cm = invpd(x);
trap 0;
if scalerr(cm);
   cm = inv(x);
endif;
```

In this example **invpd** will return a scalar error code if the matrix **x** is not positive definite. If **scalerr** returns with a nonzero value, the program will use the **inv** function, which is slower, to compute the inverse. Since the trap state has been turned off, if **inv** fails the program will terminate with a **Matrix singular** error message.

See also

error, trap, trapchk

scalinfnanmiss

Purpose Returns true if the argument is a scalar infinity, NaN, or missing value.

Format *y* **= scalinfnanmiss(***x***);**

Input

x	NxK matrix.

Output

y	scalar, 1 if *x* is a scalar, infinity, NaN, or missing value, else 0.

See Also **isinfnanmiss, ismiss, scalmiss**

scalmiss

Purpose

Tests to see if its argument is a scalar missing value.

Format

y **= scalmiss(**x**);**

Input

x	NxK matrix.

Output

y	scalar, 1 if argument is a scalar missing value, 0 if not.

Remarks

scalmiss first tests to see if the argument is a scalar. If it is not scalar, **scalmiss** returns a 0 without testing any of the elements.

The **ismiss** function will test each element of the matrix and return 1 if it encounters any missing values. **scalmiss** will execute much faster if the argument is a large matrix since it will not test each element of the matrix but will simply return a 0.

An element of *x* is considered to be a missing if and only if it contains a missing value in the real part. Thus, **scalmiss** and **ismiss** would return a 1 for complex *x* = . + 1i, , a 0 for *x* = 1 + .i.

Example

```
clear s;
do until eof(fp);
   y = readr(fp,nr);
   y = packr(y);
   if scalmiss(y);
      continue;
   endif;
   s = s+sumc(y);
endo;
```

In this example the **packr** function will return a scalar missing if every row of its argument contains missing values, otherwise it will return a matrix that contains no missing values. **scalmiss** is used here to test for a scalar missing returned from **packr**. If that is true, then the sum step will be skipped for that iteration of the read loop because there were no rows left after the rows containing missings were packed out.

schtoc

Purpose

To reduce any 2x2 blocks on the diagional of the real Schur matrix returned from **schur**. The transformation matrix is also updated.

Format

{ *schc, transc* **} = schtoc(***sch,trans***);**

Input

sch	real NxN matrix in Real Schur form, i.e., upper triangular except for possibly 2x2 blocks on the diagonal.
trans	real NxN matrix, the associated transformation matrix.

Output

schc	NxN matrix, possibly complex, strictly upper triangular. The diagonal entries are the eigenvalues.
transc	NxN matrix, possibly complex, the associated transformation matrix.

Remarks

Other than checking that the inputs are strictly real matrices, no other checks are made. If the input matrix *sch* is already upper triangular it is not changed. Small off-diagional elements are considered to be zero. See the source code for the test used.

Example

```
{ schc, transc } = schtoc(schur(a));
```

This example calculates the complex Schur form for a real matrix **a**.

Source

schtoc.src

See also

schur

schur

Purpose

Computes the Schur form of a square matrix.

Format

{ *s,z* **} = schur(**x**)**

Input

x	KxK matrix.

Output

s	KxK matrix, Schur form.
z	KxK matrix, transformation matrix.

Remarks

schur computes the real Schur form of a square matrix. The real Schur form is an upper quasi-triangular matrix, that is, it is block triangular where the blocks are 2x2 submatrices which correspond to complex eigenvalues of x. If x has no complex eigenvalues, s will be strictly upper triangular. To convert s to the complex Schur form, use the Run-Time Library function **schtoc**.

x is first reduced to upper Hessenberg form using orthogonal similiarity transformations, then reduced to Schur form through a sequence of QR decompositions.

schur uses the ORTRAN, ORTHES and HQR2 functions from EISPACK.

z is an orthogonal matrix that transforms x into s and vice versa. Thus

$$s = z'xz$$

and since z is orthogonal,

$$x = zsz'$$

Example

```
let x[3,3] = 1  2  3
             4  5  6
             7  8  9;
{ s, z } = schur(x);
```

$$s = \begin{matrix} 16.11684397 & 4.89897949 & 0.0000000 \\ -0.0000000 & -1.11684397 & -0.0000000 \\ 0.0000000 & 0.0000000 & 0.0000000 \end{matrix}$$

schur

$$z = \begin{matrix} 0.23197069 & 0.88290596 & 0.40824829 \\ 0.52532209 & 0.23952042 & -0.81649658 \\ 0.81867350 & -0.40386512 & 0.40824829 \end{matrix}$$

See also

hess

screen

Purpose Controls output to the screen.

Format

```
screen on;
screen off;
screen;
```

Remarks When this is **on**, the results of all print statements will be directed to the window. When this is **off**, print statements will not be sent to the window. This is independent of the statement **output on**, which will cause the results of all print statements to be routed to the current auxiliary output file.

If you are sending a lot of output to the auxiliary output file on a disk drive, turning the window off will speed things up.

The **end** statement will automatically do **output off** and **screen on**.

screen with no arguments will print "**Screen is on**" or "**Screen is off**" on the console.

screen

Example

```
output file = mydata.asc reset;
screen off;
format /m1/rz 1,8;
open fp = mydata;
do until eof(fp);
   print readr(fp,200);;
endo;
fp = close(fp);
end;
```

The program above will write the contents of the GAUSS file `mydata.dat` into an ASCII file called `mydata.asc`. If `mydata.asc` already exists, it will be overwritten.

Turning the window off will speed up execution. The **end** statement above will automatically perform **output off** and **screen on**.

See also

output, end, new

scroll

Purpose Scrolls a section of the window.

Format **scroll** *v*;

Input *v* 6x1 vector

Portability **Windows**

Remarks This command is intended to be used in the DOS compatibility window to support legacy programs.

The elements of *v* are defined as:

[1]	coordinate of upper left row.
[2]	coordinate of upper left column.
[3]	coordinate of lower right row.
[4]	coordinate of lower right column.
[5]	number of lines to scroll.
[6]	value of attribute.

This assumes the origin at (1,1) in the upper left just like the **locate** command. The window will be scrolled the number of lines up or down (positive or negative 5^{th} element) and the value of the 6^{th} element will be used as the attribute as follows:

7	regular text
112	reverse video
0	graphics black

If the number of lines (element 5) is 0, the entire window will be blanked.

scroll

Example

```
let v = 1 1 12 80 5 7;
scroll v;
```

This call would scroll a graphic panel 80 columns wide covering the upper twelve rows of the window. The graphic panel would be scrolled up 5 lines and the new lines would be displayed in regular text mode.

See also **locate, printdos**

seekr

Purpose Moves the pointer in a `.dat` or `.fmt` file to a particular row.

Format *y* **= seekr(***fh*,*r***);**

Input

fh	scalar, file handle of an open file.
r	scalar, the row number to which the pointer is to be moved.

Output

y	scalar, the row number to which the pointer has been moved.

Remarks If $r = -1$, the current row number will be returned.

If $r = 0$, the pointer will be moved to the end of the file, just past the end of the last row.

rowsf returns the number of rows in a file.

```
seekr(fh,0) == rowsf(fh) + 1;
```

Do NOT try to seek beyond the end of a file.

See also **open, readr, rowsf**

select (dataloop)

Purpose Selects specific rows (observations) in a data loop based on a logical expression.

Format **select** *logical_expression*;

Remarks Selects only those rows for which *logical_expression* is *TRUE*. Any variables referenced must already exist, either as elements of the source data set, as **extern**s, or as the result of a previous **make**, **vector**, or **code** statement.

Example

```
select age > 40 AND sex $== 'MALE';
```

See also **delete**

selif

Purpose Selects rows from a matrix. Those selected are the rows for which there is a 1 in the corresponding row of *e*.

Format *y* **= selif(***x*,*e***);**

Input

x	NxK matrix.
e	Nx1 vector of 1's and 0's.

Output

y	MxK matrix consisting of the rows of *x* for which there is a 1 in the corresponding row of *e*.

Remarks The argument *e* will usually be generated by a logical expression using "dot" operators.

y will be a scalar missing if no rows are selected.

Example

```
y = selif(x,x[.,2] .gt 100);
```

selects all rows of *x* in which the second column is greater than 100.

```
let x[3,3] =   0     10     20
              30     40     50
              60     70     80;

e = (x[.,1] .gt 0) .and (x[.,3] .lt 100);

y = selif(x,e);
```

The resulting matrix *y* is:

```
30 40 50
60 70 80
```

All rows for which the element in column 1 is greater than 0 and the element in column 3 is less than 100 are placed into the matrix **y**.

Source datatran.src

See also **delif, scalmiss**

seqa, seqm

Purpose

seqa creates an additive sequence. **seqm** creates a multiplicative sequence.

Format

y = **seqa(***start,inc,n***);**
y = **seqm(***start,inc,n***);**

Input

start	scalar specifying the first element.
inc	scalar specifying increment.
n	scalar specifying the number of elements in the sequence.

Output

y	Nx1 vector containing the specified sequence.

Remarks

For **seqa**, *y* will contain a first element equal to *start*, the second equal to *start+inc*, and the last equal to *start+inc*(n-1)*.

For instance,

```
seqa(1,1,10)
```

will create a column vector containing the numbers 1, 2, … 10.

For **seqm**, *y* will contain a first element equal to *start*, the second equal to *start*inc*, and the last equal to $start*inc^{(n-1)}$.

For instance,

```
seqm(10,10,10)
```

will create a column vector containing the numbers 10, 100, … 10^{10}.

Example

```
a = seqa(2,2,10)';
m = seqm(2,2,10)';
```

a = 2 4 6 8 10 12 14 16 18 20

m = 2 4 8 16 32 64 128 256 512 1024

Note that the results have been transposed in this example. Both functions return Nx1 (column) vectors.

See also

recserar, recsercp

setdif

Purpose

Returns the unique elements in one vector that are not present in a second vector.

Format

y **= setdif(***v1*,*v2*,*flag***);**

Input

v1	Nx1 vector.	
v2	Mx1 vector.	
flag	scalar,	if 0, case-sensitive character comparison. if 1, numeric comparison. if 2, case-insensitive character comparison.

Output

y Lx1 sorted vector containing all unique values that are in *v1* and are not in *v2*, or a scalar missing.

Example

```
let v1 = mary jane linda john;
let v2 = mary sally;
flag = 0;
y = setdif(v1,v2,flag);
```

```
      JANE
y =   JOHN
     LINDA
```

Source

setdif.src

setvars

Purpose Reads the variable names from a data set header and creates global matrices with the same names.

Format *nvec* **= setvars(***dataset***);**

Input

dataset string, the name of the GAUSS data set. Do not use a file extension.

Output

nvec Nx1 character vector, containing the variable names defined in the data set.

Remarks **setvars** is designed to be used interactively.

Example

```
nvec = setvars("freq");
```

Source vars.src

See also **makevars**

setvwrmode

Purpose Sets the graphics viewer mode.

Library **pgraph**

Format *oldmode* **= setvwrmode(***mode***);**

Input

mode string, new mode or null string.

"one"	Use only one viewer.
"many"	Use a new viewer for each graph.

Output *oldmode* string, previous mode.

Remarks If mode is a null string, the current mode will be returned with no changes made.

If "one" is set, the viewer executable will be `vwr.exe`.

Example

```
oldmode = setvwrmode("one");
call setvwrmode(oldmode);
```

Source `pgraph.src`

See also **pqgwin**

setwind

Purpose Sets the current graphic panel to a previously created graphic panel number.

Library **pgraph**

Format **setwind(*n*);**

Input *n* scalar, graphic panel number.

Remarks This function selects the specified graphic panel to be the current graphic panel. This is the graphic panel in which the next graph will be drawn.

See the discussion on using graphic panels in "Publication Quality Graphics in the *User's Guide.*

Source pwindow.src

See also **begwind, endwind, getwind, nextwind, makewind, window**

shell

Purpose Executes an operating system command.

Format **shell** [[*s*]];

Input

s literal or ^string, the command to be executed.

Remarks **shell** lets you run shell commands and programs from inside GAUSS. If a command is specified, it is executed; when it finishes, you automatically return to GAUSS. If no command is specified, the shell is executed and control passes to it, so you can issue commands interactively. You have to type **exit** to get back to GAUSS in that case.

If you specify a command in a string variable, precede it with the (caret) **^** .

Example

```
comstr = "ls ./src";
shell ^comstr;
```

This lists the contents of the `./src` subdirectory, then returns to GAUSS.

```
shell cmp n1.fmt n1.fmt.old;
```

This compares the matrix file `n1.fmt` to an older version of itself, `n1.fmt.old`, to see if it has changed. When **cmp** finishes, control is returned to GAUSS.

```
shell;
```

This executes an interactive shell. The OS prompt will appear and OS commands or other programs can be executed. To return to GAUSS, type **exit**.

See also **exec**

shiftr

Purpose

Shifts the rows of a matrix.

Format

y **= shiftr(***x,s,f***);**

Input

x	NxK matrix to be shifted.
s	scalar or Nx1 vector specifying the amount of shift.
f	scalar or Nx1 vector specifying the value to fill in.

Output

y	NxK shifted matrix.

Remarks

The shift is performed within each row of the matrix, horizontally. If the shift value is positive, the elements in the row will be moved to the right. A negative shift value causes the elements to be moved to the left. The elements that are pushed off the end of the row are lost, and the fill value will be used for the new elements on the other end.

Example

```
y = shiftr(x,s,f);
```

If $x = \begin{matrix} 1 & 2 \\ 3 & 4 \end{matrix}$ and $s = \begin{matrix} 1 \\ -1 \end{matrix}$ and $f = \begin{matrix} 99 \\ 999 \end{matrix}$

Then $y = \begin{matrix} 99 & 1 \\ 4 & 999 \end{matrix}$

If $x = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{matrix}$ and $s = \begin{matrix} 0 \\ 1 \\ 2 \end{matrix}$ and $f = 0$

Then $y = \begin{matrix} 1 & 2 & 3 \\ 0 & 4 & 5 \\ 0 & 0 & 7 \end{matrix}$

See also

rotater

show, lshow

Purpose

Displays the global symbol table. The output from **lshow** is sent to the printer.

Format

show [[**-***flags*]] [[*symbol*]]**;**
lshow [[**-***flags*]] [[*symbol*]]**;**

Input

flags flags to specify the symbol type that is shown.

- **k** keywords
- **p** procedures
- **f** **fn** functions
- **m** matrices
- **s** strings
- **g** show only symbols with global references
- **l** show only symbols with all local references
- **n** no pause

symbol the name of the symbol to be shown. If the last character is an asterisk (*****), all symbols beginning with the supplied characters will be shown.

Remarks

If there are no arguments, the entire symbol table will be displayed.

show is directed to the auxiliary output if it is open.

Here is an example listing with an explanation of the columns:

```
Memory used   Address    Name     Info   Cplx Type       References
  32 bytes at [00081b74] AREA     1=1         FUNCTION   local refs
  32 bytes at [00081a14] dotfeq   1=2         PROCEDURE  global refs
1144 bytes at [0007f1b4] indices2 4=3         PROCEDURE  local refs
 144 bytes at [0007f874] X        3,3    C    MATRIX
 352 bytes at [0007f6ec] _IXCAT   44,1        MATRIX
   8 bytes at [0007f6dc] _olsrnam 7 char      STRING

32000 bytes program space, 0% used
4336375 bytes workspace, 4325655 bytes free
53 global symbols, 1500 maximum, 6 shown
```

The "Memory used" column is the amount of memory used by the item.

The "Address" column is the address where the item is stored (hexadecimal format). This will change as matrices and strings change in size.

The "Name" column is the name of the symbol.

The "Info" column depends on the type of the symbol. If the symbol is a procedure or a function, it gives the number of values that the function or procedure returns and the number of arguments that need to be passed to it when it is called. If the symbol is a matrix, then the Info column gives the number of rows and columns. If the symbol is a string, then the Info column gives the number of characters in the string. As follows:

Rets=Args	if procedure or function
Row,Col	if matrix
Length	if string

The "Cplx" column contains a "C" if the symbol is a complex matrix.

The "Type" column specifies the symbol table type of the symbol. It can be **function**, **keyword**, **matrix**, **procedure**, or **string**.

If the symbol is a procedure, keyword or function, the "References" column will show if it makes any global references. If it makes only local references, the procedure or function can be saved to disk in an `.fcg` file with the **save** command. If the function or procedure makes any global references, it cannot be saved in an `.fcg` file.

The program space is the area of space reserved for all nonprocedure, nonfunction program code. It can be changed in size with the **new** command. The workspace is the memory used to store matrices, strings, procedures, and functions.

Example

```
show /fpg eig*;
```

This command will show all functions and procedures that have global references and begin with **eig**.

```
show /mn;
```

This command will show all matrices without pausing when the window is full.

See also

new, delete

sin

Purpose Returns the sine of its argument.

Format *y* **= sin(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix containing sine of *x*.

Remarks For real matrices, *x* should contain angles measured in radians.

To convert degrees to radians, multiply the degrees by $\frac{\pi}{180}$.

Example

```
let x = { 0, .5, 1, 1.5 };
y = sin(x);
```

$$y = \begin{matrix} 0.00000000 \\ 0.47942554 \\ 0.84147098 \\ 0.99749499 \end{matrix}$$

See also **atan, cos, sinh, pi**

sinh

Purpose Computes the hyperbolic sine.

Format *y* **= sinh(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix containing the hyperbolic sines of the elements of *x*.

Example

```
let x = { -0.5, -0.25, 0, 0.25, 0.5, 1 };
x = x * pi;
y = sinh(x);
```

$$x = \begin{matrix} -1.570796 \\ -0.785398 \\ 0.000000 \\ 0.785398 \\ 1.570796 \\ 3.141593 \end{matrix}$$

$$y = \begin{matrix} -2.301299 \\ -0.868671 \\ 0.000000 \\ 0.868671 \\ 2.301299 \\ 11.548739 \end{matrix}$$

Source trig.src

sleep

Purpose Sleeps for a specified number of seconds.

Format *unslept* **= sleep(***secs***);**

Input *secs* scalar, number of seconds to sleep.

Output *unslept* scalar, number of seconds not slept.

Remarks *secs* does not have to be an integer. If your system does not permit sleeping for a fractional number of seconds, *secs* will be rounded to the nearest integer, with a minimum value of 1.

If a program sleeps for the full number of secs specified, **sleep** returns 0; otherwise, if the program is awakened early (e.g., by a signal), **sleep** returns the amount of time not slept. The DOS version always sleeps the full number of seconds, so it always returns 0.

A program may sleep for longer than *secs* seconds, due to system scheduling.

solpd

Purpose

Solves a set of positive definite linear equations.

Format

x **= solpd(***b*,*A***);**

Input

b	NxK matrix.
A	NxN symmetric positive definite matrix.

Output

x	NxK matrix, the solutions for the system of equations, $Ax=b$.

Remarks

b can have more than one column. If so, the system of equations is solved for each column, i.e., *A***x*[.,*i*] = b[.,*i*].

This function uses the Cholesky decomposition to solve the system directly. Therefore it is more efficient than using **inv(***A***)*b**.

solpd does not check to see that the matrix *A* is symmetric. **solpd** will look only at the upper half of the matrix including the principal diagonal.

If the *A* matrix is not positive definite:

trap 1	return scalar error code 30.
trap 0	terminate with an error message.

One obvious use for this function is to solve for least squares coefficients. The effect of this function is thus similar to that of the **/** operator.

If *X* is a matrix of independent variables, and *Y* is a vector containing the dependent variable, then the following code will compute the least squares coefficients of the regression of *Y* on *X*:

```
b = solpd(X'Y,X'X);
```

Example

```
n = 5; format 20,8;
A = rndn(n,n);
A = A'A;
x = rndn(n,1);
b = A*x;
x2 = solpd(b,A);
print "   X     solpd(b,A)     Difference";
print x~x2~x-x2;
```

Produces:

```
        X      solpd(b,A)        Difference
-0.36334089    -0.36334089    0.00000000
 0.19683330     0.19683330    8.32667268E-017
 0.99361330     0.99361330    2.22044605E-016
-1.84167681    -1.84167681    0.00000000
-0.88455829    -0.88455829    1.11022302E-016
```

See also

scalerr, chol, invpd, trap

sortc, sortcc

Purpose

Sorts a matrix of numeric or character data.

Format

y **= sortc(***x*,*c***);**
y **= sortcc(***x*,*c***);**

Input

x	NxK matrix.
c	scalar specifying one column of *x* to sort on.

Output

y	NxK matrix equal to *x* and sorted on the column *c*.

Remarks

These functions will sort the rows of a matrix with respect to a specified column. That is, they will sort the elements of a column and will arrange all rows of the matrix in the same order as the sorted column.

sortc assumes the column to sort on is numeric. **sortcc** assumes that the column to sort on contains character data.

The matrix may contain both character and numeric data, but the sort column must be all of one type. Missing values will sort as if their value is below $-\infty$.

The sort will be in ascending order. This function uses the Quicksort algorithm.

If you need to obtain the matrix sorted in descending order, you can use:

```
rev(sortc(x,c))
```

Example

```
let x[3,3]= 4 7 3
            1 3 2
            3 4 8;
y = sortc(x,1);
```

$$x = \begin{matrix} 4 & 7 & 3 \\ 1 & 3 & 2 \\ 3 & 4 & 8 \end{matrix}$$

$$y = \begin{matrix} 1 & 3 & 2 \\ 3 & 4 & 8 \\ 4 & 7 & 3 \end{matrix}$$

See also

`rev`

sortd

Purpose

Sorts a data file on disk with respect to a specified variable.

Format

sortd(*infile,outfile,keyvar,keytyp***);**

Input

infile string, name of input file.

outfile string, name of output file, must be different.

keyvar string, name of key variable.

keytyp scalar, type of key variable.

1	numeric key, ascending order.
2	character key, ascending order.
-1	numeric key, descending order.
-2	character key, descending order.

Remarks

The data set *infile* will be sorted on the variable *keyvar*, and will be placed in *outfile*.

If the inputs are null or 0, the procedure will ask for them.

Source

sortd.src

sorthc, sorthcc

Purpose

Sorts a matrix of numeric or character data.

Format

y **= sorthc(***x*,*c***);**
y **= sorthcc(***x*,*c***);**

Input

x	NxK matrix.
c	scalar specifying one column of *x* to sort on.

Output

y	NxK matrix equal to *x* and sorted on the column *c*.

Remarks

These functions will sort the rows of a matrix with respect to a specified column. That is, they will sort the elements of a column and will arrange all rows of the matrix in the same order as the sorted column.

sorthc assumes that the column to sort on is numeric. **sorthcc** assumes that the column to sort on contains character data.

The matrix may contain both character and numeric data, but the sort column must be all of one type. Missing values will sort as if their value is below $-\infty$.

The sort is in ascending order. This function uses the heap sort algorithm.

If you need to obtain the matrix sorted in descending order, you can use:

```
rev(sorthc(x,c))
```

Example

```
let x[3,3]= 4 7 3
            1 3 2
            3 4 8;
y = sorthc(x,1);
```

```
    4 7 3
x = 1 3 2
    3 4 8
```

sorthc, sorthcc

$$y = \begin{matrix} 1 & 3 & 2 \\ 3 & 4 & 8 \\ 4 & 7 & 3 \end{matrix}$$

See also sortc, rev

sortind, sortindc

Purpose

Returns the sorted index of *x*.

Format

ind **= sortind(***x***);**
ind **= sortindc(***x***);**

Input

x	Nx1 column vector.

Output

ind	Nx1 vector representing sorted index of *x*.

Remarks

sortind assumes *x* contains numeric data. **sortindc** assumes *x* contains character data.

This function can be used to sort several matrices in the same way that some other reference matrix is sorted. To do this, create the index of the reference matrix, then use **submat** to rearrange the other matrices in the same way.

Example

```
let x = 5 4 4 3 3 2 1;
ind = sortind(x);
y = x[ind];
```

sortmc

Purpose Sorts a matrix on multiple columns.

Format *y* **= sortmc(***x*,*v***);**

Input

x	NxK matrix to be sorted.
v	Lx1 vector containing integers specifying the columns, in order, that are to be sorted. If an element is negative, that column will be interpreted as character data.

Output

y	NxK sorted matrix.

Remarks The function works recursively and the number of sort columns is limited by the available workspace.

Source sortmc.src

sparseCols

Purpose Returns the number of columns in a sparse matrix.

Format *c* **= sparseCols(***x***);**

Input *x* MxN sparse matrix.

Output c scalar, number of columns.

Source sparse.src

sparseEye

Purpose Returns a sparse identity matrix.

Format *y* **= sparseEye(***n***);**

Input

n		scalar, order of identity matrix.

Output

y		NxN sparse identity matrix.

Example

```
y = sparseEye(3);
d = denseSubmat(y,0,0);
```

d =

```
1.0000000 0.0000000 0.0000000
0.0000000 1.0000000 0.0000000
0.0000000 0.0000000 1.0000000
```

sparseFD

Purpose Converts dense matrix gto sparse matrix.

Format *y* **= sparseFD(***x,eps***);**

Input

x	MxN dense matrix.
eps	scalar, elements of *x* less than *eps* will be treated as zero.

Output

y	MxN sparse matrix.

Remarks A dense matrix is just a normal format matrix.

Source sparse.src

sparseFP

Purpose Converts packed matrix to sparse matrix.

Format *y* **= sparseFP(***x,r,c***);**

Input

x	MX3 packed matrix, see remarks for format.
r	scalar, rows of output matrix.
c	scalar, columns of output matrix.

Output

y	RXC sparse matrix.

Remarks *x* contains the nonzero elements of the sparse matrix. The first column of *x* contains the element value, the second column the row number, and the third column the column number.

Source sparse.src

sparseHConcat

Purpose Horizontally concatenates two sparse matrices.

Format *z* **= sparseHConcat(***y,x***);**

Input

y	MxN sparse matrix, left hand matrix.
x	MxL sparse matrix, right hand matrix.

Output

z	Mx(N+L) sparse matrix.

Source sparse.src

sparseNZE

Purpose Returns the number of nonzero elements in a sparse matrix.

Format *r* **= sparseNZE(***x***);**

Input

x	MxN sparse matrix.

Output

r	scalar, number of nonzero elements in *x*.

Source sparse.src

sparseOnes

Purpose Generates sparse matrix of ones and zeros

Format *y* **= sparseOnes(***x,r,c***);**

Input

x	Mx2 matrix, first column contains row numbers of the ones, and the second column contains column numbers.
r	scalar, rows of full matrix.
c	scalar, columns of full matrix.

Output

y	sparse matrix of ones.

Source sparse.src

sparseRows

Purpose Returns the number of rows in a sparse matrix.

Format *r* **= sparseRows(***x***);**

Input

x	MxN sparse matrix.

Output

r	scalar, number of rows.

Source sparse.src

sparseSet

Purpose Resets sparse library global matrices to default values.

Format **sparseSet;**

Globals **_sparse_ARnorm, _sparse_Acond, _sparse_Anorm, _sparse_Atol, _sparse_Btol, _sparse_CondLimit, _sparse_Damping, _sparse_NumIters, _sparse_RetCode, _sparse_Rnorm, _sparse_Xnorm**

Source sparse.src

sparseSolve

Purpose

Solves $Ax = B$ for x when A is a sparse matrix.

Format

x **= sparseSolve(***A,B***);**

Input

A	MxN sparse matrix.
B	Nx1 vector.

Global Input

_sparse_Damping	scalar, if nonzero, damping coefficient for damped least squares solve, i.e., $\begin{bmatrix} A \\ dI \end{bmatrix} = \begin{bmatrix} B \\ 0 \end{bmatrix}$ is solved for *X* where d =**_sparse_Damping**, *I* is a conformable identity matrix, and 0 a conformable matrix of zeros.
_sparse_Atol	scalar, an estimate of the relative error in *A*. If zero, **_sparse_Atol** is assumed to be machine precision. Default = 0.
_sparse_Btol	an estimate of the relative error in *B*. If zero, **_sparse_Btol** is assumed to be machine precision. Default = 0.
_sparse_CondLimit	upper limit on condition of *A*. Iterations will be terminated if a computed estimate of the condition of *A* exceeds **_sparse_CondLimit**. If zero, set to 1 / machine precision.
_sparse_NumIters	maximum number of iterations.

Output

x	Nx1 vector, solution of $Ax = B$.

Global Output

_sparse_RetCode scalar, termination condition.

0	*x* is the exact solution, no iterations performed.
1	solution is nearly exact with accuracy on the order of **_sparse_Atol and_sparse_Btol**.
2	solution is not exact and a least squares solution has been found with accuracy on the order of **_sparse_Atol**.
3	the estimate of the condition of *A* has exceeded **_sparse_CondLimit**. The system appears to be ill-conditioned.
4	solution is nearly exact with reasonable accuracy.
5	solution is not exact and a least squares solution has been found with reasonable accuracy.
6	iterations halted due to poor condition given machine precision.
7	**_sparse_NumIters** exceeded.

_sparse_Anorm scalar, estimate of Frobenius norm of

$$\begin{bmatrix} A \\ dI \end{bmatrix}$$

_sparse_Acond estimate of condition of *A*.

_sparse_Rnorm estimate of norm of

$$\begin{bmatrix} A \\ dI \end{bmatrix} x - \begin{bmatrix} B \\ 0 \end{bmatrix}$$

_sparse_ARnorm estimate of norm of

$$\begin{bmatrix} A \\ dI \end{bmatrix}' \begin{bmatrix} A \\ dI \end{bmatrix}$$

_sparse_XAnorm estimate of norm of *x*.

Source

sparse.src

sparseSubmat

Purpose Returns (sparse) submatrix of sparse matrix.

Format *e* **= sparseSubmat(***x,r,c***);**

Input

x	MxN sparse matrix.
r	Kx1 vector, row indices.
c	Lx1 vector, column indices.

Output

e	KxL sparse matrix.

Remarks If *r* or *c* are scalar zeros, all rows or columns will be returned.

Source sparse.src

sparseTD

Purpose Multiplies sparse matrix by dense matrix.

Format *z* **= sparseTD(***s*,*d***);**

Input

s	MxN sparse matrix.
d	NxL dense matrix.

Output

z	MxL dense matrix, the result of *s* x *d*.

Source sparse.src

sparseTrTD

Purpose Multiplies sparse matrix transposed by dense matrix.

Format *z* **= sparseTrTD(***s*,*d***);**

Input

s	NxM sparse matrix.
d	NxL dense matrix.

Output

z	MxL dense matrix, the result of *s'd*.

Source sparse.src

sparseVConcat

Purpose Vertically concatenates two sparse matrices.

Format *z* **= sparseVConcat(***y,x***);**

Input

y	MxN sparse matrix, top matrix.
x	LxN sparse matrix, bottom matrix.

Output

z	(M+L)xN sparse matrix.

Source sparse.src

spline

Purpose

Computes a two-dimensional interpolatory spline.

Format

{ *u,v,w* **} = spline(***x,y,z,sigma,g***);**

Input

x	1xK vector, x-abscissae (x-axis values).
y	Nx1 vector, y-abscissae (y-axis values).
z	KxN matrix, ordinates (z-axis values).
sigma	scalar, tension factor.
g	scalar, grid size factor.

Output

u	1xK*G vector, x-abscissae, regularly spaced.
v	N*Gx1 vector, y-abscissae, regularly spaced.
w	K*G x N*G matrix, interpolated ordinates.

Remarks

sigma contains the tension factor. This value indicates the curviness desired. If *sigma* is nearly zero (e.g., .001), the resulting surface is approximately the tensor product of cubic splines. If *sigma* is large (e.g., 50.0), the resulting surface is approximately bi-linear. If *sigma* equals zero, tensor products of cubic splines result. A standard value for *sigma* is approximately 1.

g is the grid size factor. It determines the fineness of the output grid. For $g = 1$, the output matrices are identical to the input matrices. For $g = 2$, the output grid is twice as fine as the input grid, i.e., *u* will have twice as many columns as *x*, *v* will have twice as many rows as *y*, and *w* will have twice as many rows and columns as *z*.

Source

spline.src

spline1D

Purpose

Computes a smoothing spline for a curve.

Format

{ *u,v* **} = spline1D(***x,y,d,s,sigma,g***);**

Input

x	Kx1 vector, x-abscissae (x-axis values).
y	Kx1 vector, y-ordinates (y-axis values).
d	Kx1 vector or scalar, observation weights.
s	scalar, smoothing parameter, if *s* = 0, curve performs an interpolation. If *d* contains standard deviation estimates, a reasonable value for *s* is K.
sigma	scalar, tension factor.
G	scalar, grid size factor.

Output

u	K*Gx1vector, x-abscissae, regularly spaced.
v	N*Gx1 vector, interpolated ordinates, regularly spaced.

Remarks

sigma contains the tension factor. This value indicates the curviness desired. If *sigma* is nearly zero (e.g. 0.001), the resulting curve is approximately the tensor product of cubic splines. If *sigma* is large (e.g. 50), the resulting curve is approximately bi-linear. If *sigma* equals zero, tensor products of cubic splines result. A standard value for *sigma* is approximately 1.

G is the grid size factor. It determines the fineness of the output grid. For *G* = 1, the output matrices are identical to the input matrices. For *G* = 2, the output grid is twice as fine as the input grid, i.e., *u* will have twice as many columns as *x*, and *v* will have twice as many rows as *y*.

spline2D

Purpose

Computes a smoothing spline for a surface.

Format

{ *u,v,w* **} = spline2D(***x,y,z,sigma,g***);**

Input

x	Kx1 vector, x-abscissae (x-axis values).
y	Nx1 vector, y-abscissae (y-axis values).
z	KxN matrix, ordinates (z-axis values).
sigma	scalar, tension factor.
G	scalar, grid size factor.

Output

u	1xK*G vector, x-abscissae, regularly spaced.
v	N*Gx1 vector, y-abscissae, regularly spaced.
w	K*GxN*G matrix, interpolated ordinates.

Remarks

sigma contains the tension factor. This value indicates the curviness desired. If *sigma* is nearly zero (e.g. 0.001), the resulting surface is approximately the tensor product of cubic splines. If *sigma* is large (e.g. 50.), the resulting surface is approximately bi-linear. If *sigma* equals zero, tensor products of cubic splines result. A standard value for *sigma* is approximately 1.

G is the grid size factor. It determines the fineness of the output grid. For *G* = 1, the output matrices are identical to the input matrices. For *G* = 2, the output grid is twice as fine as the input grid, i.e., *u* will have twice as many columns as *x*, and *v* will have twice as many rows as *y*.

sqpSolve

Purpose

Solves the nonlinear programming problem using a sequential quadratic programming method.

Format

{ *x,f,lagr,retcode* **} = sqpSolve(&***fct,start***);**

Input

&*fct*	pointer to a procedure that computes the function to be minimized. This procedure must have one input argument, a vector of parameter values, and one output argument, the value of the function evaluated at the input vector of parameter values.
start	Kx1 vector of start values.

Global Input

_sqp_A	MxK matrix, linear equality constraint coefficients.
_sqp_B	Mx1 vector, linear equality constraint constants.

These globals are used to specify linear equality constraints of the following type:

```
_sqp_A * X = _sqp_B
```

where X is the Kx1 unknown parameter vector.

sqpSolve

_sqp_EqProc scalar, pointer to a procedure that computes the nonlinear equality constraints. For example, the statement:

```
_sqp_EqProc = eqproc;
```

tells **sqpSolve** that nonlinear equality constraints are to be placed on the parameters and where the procedure computing them is to be found. The procedure must have one input argument, the Kx1 vector of parameters, and one output argument, the Rx1 vector of computed constraints that are to be equal to zero. For example, suppose that you wish to place the following constraint:

```
P[1] * P[2] = P[3]
```

The procedure for this is:

```
proc eqproc(p);
   retp(p[1]*[2]-p[3]);
endp;
```

_sqp_C MxK matrix, linear inequality constraint coefficients.

_sqp_D Mx1 vector, linear inequality constraint constants.

These globals are used to specify linear inequality constraints of the following type:

```
_sqp_C * X ≥ _sqp_D
```

where X is the Kx1 unknown parameter vector.

_sqp_IneqProc

scalar, pointer to a procedure that computes the nonlinear inequality constraints. For example the statement:

```
_sqp_EqProc = &ineqproc;
```

tells **sqpSolve** that nonlinear equality constraints are to be placed on the parameters and where the procedure computing them is to be found. The procedure must have one input argument, the Kx1 vector of parameters, and one output argument, the Rx1 vector of computed constraints that are to be equal to zero. For example, suppose that you wish to place the following constraint:

```
P[1] * P[2] ≥ P[3]
```

The procedure for this is:

```
proc ineqproc(p);
   retp(p[1]*[2]-p[3]);
endp;
```

_sqp_Bounds

Kx2 matrix, bounds on parameters. The first column contains the lower bounds, and the second column the upper bounds. If the bounds for all the coefficients are the same, a 1x2 matrix may be used. Default is:

```
[1] -1e256
[2] 1e256
```

sqpSolve

_sqp_GradProc scalar, pointer to a procedure that computes the gradient of the function with respect to the parameters. For example, the statement:

```
_sqp_GradProc = &gradproc;
```

tells **sqpSolve** that a gradient procedure exists and where to find it. The user-provided procedure has two input arguments, a KX1 vector of parameter values and an NXP matrix of data. The procedure returns a single output argument, an NXK matrix of gradients of the log-likelihood function with respect to the parameters evaluated at the vector of parameter values.

Default = 0, i.e., no gradient procedure has been provided.

_sqp_HessProc scalar, pointer to a procedure that computes the Hessian, i.e., the matrix of second order partial derivatives of the function with respect to the parameters. For example, the instruction:

```
_sqp_HessProc = &hessproc;
```

will tell **sqpSolve** that a procedure has been provided for the computation of the Hessian and where to find it. The procedure that is provided by the user must have two input arguments, a PX1 vector of parameter values and an NXK data matrix. The procedure returns a single output argument, the PXP symmetric matrix of second order derivatives of the function evaluated at the parameter values.

_sqp_MaxIters scalar, maximum number of iterations. Default = 1e+5. Termination can be forced by pressing C on the keyboard.

_sqp_DirTol scalar, convergence tolerance for gradient of estimated coefficients. Default = 1e-5. When this criterion has been satisifed **sqpSolve** will exit the iterations.

_sqp_ParNames KX1 character vector, parameter names.

_sqp_PrintIters	scalar, if nonzero, prints iteration information. Default = 0. Can be toggled during iterations by pressing P on the keyboard.
_sqp_FeasibleTest	scalar, if nonzero, parameters are tested for feasibility before computing function in line search. If function is defined outside inequality boundaries, then this test can be turned off.
_sqp_RandRadius	scalar, If zero, no random search is attempted. If nonzero it is the radius of random search which is invoked whenever the usual line search fails. Default = .01.
__output	scalar, if nonzero, results are printed. Default = 0.

Output

x Kx1 vector of parameters at minimum.

f scalar, function evaluated at *x*.

lagr vector, created using **vput**. Contains the Lagrangean for the constraints. They may be extracted with the **vread** command using the following strings:

"lineq"	Lagrangeans of linear equality constraints
"nlineq"	Lagrangeans of nonlinear equality constraints
"linineq"	Lagrangeans of linear inequality constraints
"nlinineq"	Lagrangeans of nonlinear inequality constraints
"bounds"	Lagrangeans of bounds

Whenever a constraint is active, its associated Lagrangean will be nonzero.

retcode return code:

0	normal convergence
1	forced exit
2	maximum number of iterations exceeded
3	function calculation failed
4	gradient calculation failed
5	Hessian calculation failed
6	line search failed
7	error with constraints

sqpSolve

Remarks

Pressing C on the keyboard will terminate iterations, and pressing P will toggle iteration output.

sqpSolve is recursive, that is, it can call itself with another function and set of global variables.

To reset global variables for this function to their default values, call **sqpSolveSet**.

Example

```
sqpSolveSet;

proc fct(x);
   retp( (x[1] + 3*x[2] + x[3])^2 + 4*(x[1] -
   x[2])^2 );
endp;

proc ineqp(x);
   retp(6*x[2] + 4*x[3] - x[1]^3 - 3);
endp;

proc eqp(x);
   retp(1-sumc(x));
endp;

_sqp_Bounds = { 0 1e256 };

start = { .1, .7, .2 };

_sqp_IneqProc = &ineqp;

_sqp_EqProc = &eqp;

{ x,f,lagr,ret } = sqpSolve( &fct,start );
```

Source

sqpsolve.src

sqrt

Purpose Computes the square root of every element in a matrix.

Format *y* **= sqrt(***x***);**

Input

x NxK matrix.

Output

y NxK matrix, the square roots of each element of *x*.

Remarks If *x* is negative, complex results are returned.

You can turn the generation of complex numbers for negative inputs on or off in the GAUSS configuration file, and with the **sysstate** function, case 8. If you turn it off, **sqrt** will generate an error for negative inputs.

If *x* is already complex, the complex number state doesn't matter; **sqrt** will compute a complex result.

Example

```
let x[2,2] = 1 2 3 4;
y = sqrt(x);
```

```
x =  1.00000000 2.00000000
     3.00000000 4.00000000

y =  1.00000000 1.41421356
     1.73205081 2.00000000
```

stdc

Purpose

Computes the standard deviation of the elements in each column of a matrix.

Format

y **= stdc(***x***);**

Input

x NxK matrix.

Output

y Kx1 vector, the standard deviation of each column of *x*.

Remarks

This function essentially computes:

```
sqrt(1/(N-1)*sumc((x-meanc(x)')^2))
```

Thus, the divisor is N-1 rather than N, where N is the number of elements being summed. To convert to the alternate definition, multiply by

```
sqrt((N-1)/N)
```

Example

```
y = rndn(8100,1);
std = stdc(y);
```

std = 1.008377

In this example, 8100 standard Normal random variables are generated, and their standard deviation is computed.

See also

meanc

stocv

Purpose Converts a string to a character vector.

Format *v* **= stocv(***s***);**

Input

s	string, to be converted to character vector.

Output

v	Nx1 character vector, contains the contents of *s*.

Remarks **stocv** breaks *s* up into a vector of 8-character length matrix elements. Note that the character information in the vector is not guaranteed to be null-terminated.

Example

```
s = "Now is the time for all good men";
v = stocv(s);
```

$$= \begin{matrix} \text{"Now is t"} \\ \text{"he time "} \\ \text{"for all "} \\ \text{"good men"} \end{matrix}$$

See also **cvtos, vget, vlist, vput, vread**

stof

Purpose Converts a string to floating point.

Format *y* **= stof(***x***);**

Input

x		string, or NxK matrix containing character elements to be converted.

Output

y		matrix, the floating point equivalents of the ASCII numbers in *x*.

Remarks If *x* is a string containing "1 2 3", then **stof** will return a 3x1 matrix containing the numbers 1, 2, and 3.

If *x* is a null string, **stof** will return a 0.

This uses the same input conversion routine as **loadm** and **let**. It will convert character elements and missing values. **stof** also converts complex numbers in the same manner as **let**.

See also **ftos, ftocv, chrs**

stop

Purpose Stops a program and returns to the command prompt. Does not close files.

Format `stop;`

Remarks This command has the same effect as **end**, except it does not close files or the auxiliary output.

It is not necessary to put a **stop** or an **end** statement at the end of a program. If neither is found, an implicit **stop** is executed.

See also `end, new, system`

strindx

Purpose

Finds the index of one string within another string.

Format

y **= strindx(***where,what,start***);**

Input

where	string or scalar, the data to be searched.
what	string or scalar, the substring to be searched for in *where*.
start	scalar, the starting point of the search in *where* for an occurrence of *what*. The index of the first character in a string is 1.

Output

y	scalar containing the index of the first occurrence of *what*, within *where*, which is greater than or equal to *start*. If no occurrence is found, it will be 0.

Remarks

An example of the use of this function is the location of a name within a string of names:

```
z = “Whatchmacallit”;
x = “call”;
y = strindx(z,x,1);
```

y = 9

This function is used with **strsect** for extracting substrings.

See also

strrindx, strlen, strsect, strput

strlen

Purpose Returns the length of a string.

Format *y* **= strlen(***x***);**

Input

x	string or NxK matrix of character data.

Output

y	scalar containing the exact length of the string *x* or NxK matrix of the lengths of the elements in the matrix *x*.

Remarks The null character (ASCII 0) is a legal character within strings and so embedded nulls will be counted in the length of strings. The final terminating null byte is not counted, though.

For character matrices, the length is computed by counting the characters (maximum of 8) up to the first null in each element of the matrix. The null character, therefore, is not a valid character in matrices containing character data and is not counted in the lengths of the elements of those matrices.

Example

```
x = "How long?";
y = strlen(x);
```

y = 9

See also **strsect, strindx, strrindx**

strput

Purpose Lays a substring over a string.

Format *y* **= strput(***substr,str,off***);**

Input

substr	string, the substring to be laid over the other string.
str	string, the string to receive the substring.
off	scalar, the offset in *str* to place *substr*. The offset of the first byte is 1.

Output

y	string, the new string.

Example

```
str = “max”;
sub = “imum”;
f = 4;
y = strput(sub,str,f);
print y;
```

Produces:

```
maximum
```

Source strput.src

strrindx

Purpose

Finds the index of one string within another string. Searches from the end of the string to the beginning.

Format

y **= strrindx(***where,what,start***);**

Input

where	string or scalar, the data to be searched.
what	string or scalar, the substring to be searched for in *where*.
start	scalar, the starting point of the search in *where* for an occurrence of *what*. *where* will be searched from this point backward for *what*.

Output

y	scalar containing the index of the last occurrence of *what*, within *where*, which is less than or equal to *start*. If no occurrence is found, it will be 0.

Remarks

A negative value for *start* causes the search to begin at the end of the string. An example of the use of **strrindx** is extracting a file name from a complete path specification:

```
path = "/gauss/src/ols.src";
ps = "/";
pos = strrindx(path,ps,-1);
if pos;
   name = strsect(path,pos+1,strlen(path));
else;
   name = "";
endif;
```

pos = 11

name = "ols.src"

strrindx can be used with **strsect** for extracting substrings.

See also

strindx, strlen, strsect, strput

strsect

Purpose

Extracts a substring of a string.

Format

y **= strsect(***str,start,len***);**

Input

str	string or scalar from which the segment is to be obtained.
start	scalar, the index of the substring in *str.* The index of the first character is 1.
len	scalar, the length of the substring.

Output

y	string, the extracted substring, or a null string if *start* is greater than the length of *str.*

Remarks

If there are not enough characters in a string for the defined substring to be extracted, then a short string or a null string will be returned.

If *str* is a matrix containing character data, it must be scalar.

Example

```
strng = “This is an example string.”
y = strsect(strng,12,7);
```

y = example

See also

strlen, strindx, strrindx

strsplit

Purpose

Splits an Nx1 string vector into an NxK string array of the individual tokens.

Format

sa **= strsplit(***sv***);**

Input

sv Nx1 string array.

Output

sa NxK string array.

Remarks

Each row of *sv* must contain the same number of tokens. The following characters are considered delimiters between tokens:

space	ASCII 32
tab	ASCII 9
comma	ASCII 44
newline	ASCII 10
carriage return	ASCII 13

Tokens containing delimiters must be enclosed in single or double quotes or parentheses. Tokens enclosed in single or double quotes will NOT retain the quotes upon translation. Tokens enclosed in parentheses WILL retain the parentheses after translation. Parentheses cannot be nested.

Example

```
let string sv = {
"dog 'cat fish' moose",
"lion, zebra, elk",
"seal owl whale"
};

sa = strsplit(sv);
```

strsplit

```
                ’dog’   ’cat fish’   ’moose’
sa = ’lion’   ’zebra’      ’elk’
     ’seal’   ’owl’        ’whale’
```

See also

strsplitPad

strsplitPad

Purpose

Splits a string vector into a string array of the individual tokens. Pads on the right with null strings.

Format

sa **= strsplitPad(***sv*, *cols***);**

Input

sv	Nx1 string array.
cols	scalar, number of columns of output string array.

Output

sa	Nxcols string array.

Remarks

Rows containing more than *cols* tokens are truncated and rows containing fewer than *cols* tokens are padded on the right with null strings. The following characters are considered delimiters between tokens:

space	ASCII 32
tab	ASCII 9
comma	ASCII 44
newline	ASCII 10
carriage return	ASCII 13

Tokens containing delimiters must be enclosed in single or double quotes or parentheses. Tokens enclosed in single or double quotes will NOT retain the quotes upon translation. Tokens enclosed in parentheses WILL retain the parentheses after translation. Parentheses cannot be nested.

Example

```
let string sv = {
"dog 'cat fish' moose",
"lion, zebra, elk, bird",
"seal owl whale"
};

sa = strsplitPad(sv, 4);
```

strsplitPad

```
                  'dog'   'cat fish'   'moose'   ''
sa = 'lion'  'zebra'      'elk'     'bird'
     'seal'  'owl'        'whale'   ''
```

See also

strsplit

strtodt

Purpose

Converts a string array of dates to a matrix in DT scalar format.

Format

x **= strtodt(***sa*, *fmt***);**

Input

sa	NxK string array containing dates.
fmt	string containing date/time format characters.

Output

x	NxK matrix of dates in DT scalar format.

Remarks

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

20010421183207

represents 18:32:07 or 6:32:07 PM on April 21, 2001.

The following formats are supported:

YYYY	4 digit year
YR	Last two digits of year
MO	Number of month, 01-12
DD	Day of month, 01-31
HH	Hour of day, 00-23
MI	Minute of hour, 00-59
SS	Second of minute, 00-59

Example

```
x = strtodt("2001-03-25 14:58:49",
      "YYYY-MO-DD HH:MI:SS");
print x;
```

produces:

```
20010325145849.0
```

strtodt

```
x = strtodt("2001-03-25 14:58:49", "YYYY-MO-DD");
print x;
```

produces:

```
20010325000000.0
```

```
x = strtodt("14:58:49", "HH:MI:SS");
print x;
```

produces:

```
145849.0
```

```
x = strtodt("04-15-00", "MO-DD-YR");
print x;
```

produces:

```
20000415000000.0
```

See also **dttostr, dttoutc, utctodt**

strtof

Purpose Converts a string array to a numeric matrix.

Format *x* **= strtof(***sa***);**

Input

sa	NxK string array containing numeric data.

Output

x	NxK matrix.

Remarks This function supports real matrices only. Use **strtofcplx** for complex data.

See also **strtofcplx, ftostrC**

strtofcplx

Purpose Converts a string array to a complex numeric matrix.

Format *x* **= strtofcplx(***sa***);**

Input

sa	NxK string array containing numeric data.

Output

x	NxK complex matrix.

Remarks **strtofcplx** supports both real and complex data. It is slower than **strtof** for real matrices. **strtofcplx** requires the presence of the real part. The imaginary part can be absent.

See also **strtof, ftostrC**

submat

Purpose Extracts a submatrix of a matrix, with the appropriate rows and columns given by the elements of vectors.

Format *y* **= submat(***x,r,c***);**

Input

x	NxK matrix.
r	LxM matrix of row indices.
c	PxQ matrix of column indices.

Output *y* (L*M)x(P*Q) submatrix of *x*, *y* may be larger than *x*.

Remarks If *r* = 0, then all rows of *x* will be used. If *c* = 0, then all columns of *x* will be used.

Example

```
let x[3,4] = 1 2 3 4 5 6 7 8 9 10 11 12;
let v1 = 1 3;
let v2 = 2 4;
y = submat(x,v1,v2);
z = submat(x,0,v2);
```

x =

```
 1  2  3  4
 5  6  7  8
 9 10 11 12
```

y =

```
 2  4
10 12
```

z =

```
 2  4
 6  8
10 12
```

See also **diag, vec, reshape**

subscat

Purpose

Changes the values in a vector depending on the category a particular element falls in.

Format

y **= subscat(***x*,*v*,*s***);**

Input

x Nx1 vector.

v Px1 numeric vector, containing breakpoints specifying the ranges within which substitution is to be made. This MUST be sorted in ascending order.

v can contain a missing value as a separate category if the missing value is the first element in *v*.

If *v* is a scalar, all matches must be exact for a substitution to be made.

s Px1 vector, containing values to be substituted.

Output

y Nx1 vector, with the elements in *s* substituted for the original elements of *x* according to which of the regions the elements of *x* fall into:

$$
\begin{array}{rll}
v[1] < & x \le v[1] \rightarrow & s[1] \\
 & x \le v[2] \rightarrow & s[2] \\
 & \cdots & \\
v[p-1] < & x \le v[p] \rightarrow & s[p] \\
 & x > v[p] \rightarrow & \text{the original value of } x
\end{array}
$$

If missing is not a category specified in *v*, missings in *x* are passed through without change.

Example

```
let x = 1 2 3 4 5 6 7 8 9 10;
let v = 4 5 8;
let s = 10 5 0;
y = subscat(x,v,s);
```

```
y =
    10
    10
    10
    10
     5
     0
     0
     0
     9
    10
```

substute

Purpose

Substitutes new values for old values in a matrix, depending on the outcome of a logical expression.

Format

y **= substute(***x,e,v***);**

Input

x NXK matrix containing the data to be changed.

e LXM matrix, EXE conformable with *x* containing 1's and 0's.

Elements of *x* will be changed if the corresponding element of *e* is 1.

v PXQ matrix, EXE conformable with *x* and *e*, containing the values to be substituted for the original values of *x* when the corresponding element of *e* is 1.

Output

y max(N,L,P) by max(K,M,Q) matrix.

Remarks

The *e* matrix is usually the result of an expression or set of expressions using dot conditional and boolean operators.

Example

```
x = { Y  55  30,
      N  57  18,
      Y  24   3,
      N  63  38,
      Y  55  32,
      N  37  11 };

e = x[.,1] .$== "Y" .and x[.,2] .≥ 55 .and x[.,3] .≥
     30;
x[.,1] = substute(x[.,1],e,0$+"R");
```

$$e = \begin{matrix} 1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{matrix}$$

Here is what *x* looks like after substitution:

$$y = \begin{matrix} \text{R } 55 & 30 \\ \text{N } 57 & 18 \\ \text{Y } 24 & 3 \\ \text{N } 63 & 38 \\ \text{R } 55 & 32 \\ \text{N } 37 & 11 \end{matrix}$$

Source `datatran.src`

See also **`code, recode`**

sumc

Purpose Computes the sum of each column of a matrix.

Format *y* **= sumc(***x***);**

Input

x	NxK matrix.

Output

y	Kx1 vector, the sums of each column of *x*.

Remarks To find the sums of the elements in each row of a matrix, transpose before applying **sumc**. If *x* is complex, use the bookkeeping transpose (**.'**).

To find the sums of all of the elements in a matrix, use the **vecr** function before applying **sumc**.

Example

```
x = round(rndu(5,3)*5);
y = sumc(x);
```

$$x = \begin{matrix} 2 & 4 & 3 \\ 2 & 1 & 2 \\ 5 & 1 & 3 \\ 5 & 1 & 1 \\ 3 & 3 & 4 \end{matrix}$$

$$y = \begin{matrix} 17 \\ 10 \\ 13 \end{matrix}$$

See also **cumsumc, meanc, stdc**

surface

Purpose

Graphs a 3-D surface.

Library

pgraph

Format

surface(*x,y,z***);**

Input

x	1xK vector, the X axis data.
y	Nx1 vector, the Y axis data.
z	NxK matrix, the matrix of height data to be plotted.

Global Input

_psurf 2x1 vector, controls 3-D surface characteristics.

[1] if 1, show hidden lines. Default 0.

[2] color for base (default 7). The base is an outline of the X-Y plane with a line connecting each corner to the surface. If 0, no base is drawn.

_pticout scalar, if 0 (default), tick marks point inward, if 1, tick marks point outward.

_pzclr Z level color control.

There are 3 ways to set colors for the Z levels of a surface graph.

1. To specify a single color for the entire surface plot, set the color control variable to a scalar value 1–15. Example:

```
_pzclr = 15;
```

2. To specify multiple colors distributed evenly over the entire Z range, set the color control variable to a vector containing the desired colors only. GAUSS will automatically calculate the required corresponding Z values for you. The following example will produce a three color surface plot, the Z ranges being lowest=blue, middle=light blue, highest=white:

```
_pzclr = { 1, 10, 15 };
```

3. To specify multiple colors distributed over selected ranges, the Z ranges as well as the colors must be manually input by the user. The following example assumes -0.2 to be the minimum value in the *z* matrix:

```
_pzclr = {-0.2 1, /* z ≥ -0.2 */
                  /* blue */
0.0 10,  /* z ≥ 0.0 light blue */
0.2 15 }; /* z ≥ 0.2 white */
```

Since a Z level is required for each selected color, the user must be responsible to compute the minimum value of the *z* matrix as the first Z range element. This may be most easily accomplished by setting the **_pzclr** matrix as shown above (the first element being an arbitrary value), then reset the first element to the minimum *z* value as follows:

```
_pzclr = { -0.0  1,
           0.0 10,
           0.2 15 };
_pzclr [1,1] = minc(minc(z));
```

0	Black	8	Dark Grey
1	Blue	9	Light Blue
2	Green	10	Light Green
3	Cyan	11	Light Cyan
4	Red	12	Light Red
5	Magenta	13	Light Magenta
6	Brown	14	Yellow
7	Grey	15	White

Source psurface.src

See also **volume, view**

svd

Purpose Computes the singular values of a matrix.

Format *s* **= svd(***x***);**

Input

x	NxP matrix whose singular values are to be computed.

Output

s	Mx1 vector, where M = min(N,P), containing the singular values of *x* arranged in descending order.

Global Output

_svderr	global scalar, if not all of the singular values can be computed **_svderr** will be nonzero. The singular values in *s[_***svderr***+1], … s[M]* will be correct.

Remarks Error handling is controlled with the low bit of the trap flag.

trap 0	set **_svderr** and terminate with message
trap 1	set **_svderr** and continue execution

Example

```
x = { 4 3 6 7,
      8 2 9 5 },
y = svd(x);
```

y =
16.521787
3.3212254

Source svd.src

See also **svd1, svd2, svds**

svd1

Purpose Computes the singular value decomposition of a matrix so that: $x = u * s * v'$.

Format **{** *u,s,v* **} = svd1(**x**);**

Input

x	NxP matrix whose singular values are to be computed.

Output

u	NxN matrix, the left singular vectors of *x*.
s	NxP diagonal matrix, containing the singular values of *x* arranged in descending order on the principal diagonal.
v	PxP matrix, the right singular vectors of *x*.

Global Output

_svderr	global scalar, if all of the singular values are correct, **_svderr** is 0. If not all of the singular values can be computed, **_svderr** is set and the diagonal elements of *s* with indices greater than **_svderr** are correct.

Remarks Error handling is controlled with the low bit of the trap flag.

trap 0	set **_svderr** and terminate with message
trap 1	set **_svderr** and continue execution

Example

```
x = rndu(3,3);
{ u, s, v } = svd1(x);
```

$$x = \begin{matrix} 0.97847012 & 0.20538614 & 0.59906497 \\ 0.85474208 & 0.79673540 & 0.22482095 \\ 0.33340653 & 0.74443792 & 0.75698778 \end{matrix}$$

$$u = \begin{matrix} -0.57955818 & 0.65204491 & 1.48882486 \\ -0.61005618 & 0.05056673 & -0.79074298 \\ -0.54031821 & -0.75649219 & 0.36847767 \end{matrix}$$

$$s = \begin{matrix} 1.84994646 & 0.00000000 & 0.00000000 \\ 0.00000000 & 0.60370542 & 0.00000000 \\ 0.00000000 & 0.00000000 & 0.47539239 \end{matrix}$$

$$v = \begin{matrix} -0.68578561 & 0.71062560 & -0.15719208 \\ -0.54451302 & -0.64427479 & -0.53704336 \\ -0.48291165 & -0.28270348 & 0.82877927 \end{matrix}$$

Source `svd.src`

See also **svd, svd2, svdusv**

svd2

Purpose Computes the singular value decomposition of a matrix so that: *x* = *u* * *s* * *v*' (compact *u*).

Format **{** *u,s,v* **} = svd2(***x***);**

Input

x	NxP matrix whose singular values are to be computed.

Output

u	NxN or NxP matrix, the left singular vectors of *x*. If N > P, then *u* will be NxP containing only the P left singular vectors of *x*.
s	NxP or PxP diagonal matrix, containing the singular values of *x* arranged in descending order on the principal diagonal. If N > P, then *s* will be PxP.
v	PxP matrix, the right singular vectors of *x*.

Global Output

_svderr	global scalar, if all of the singular values are correct, **_svderr** is 0. If not all of the singular values can be computed, **_svderr** is set and the diagonal elements of *s* with indices greater than **_svderr** are correct.

Remarks Error handling is controlled with the low bit of the trap flag.

trap 0	set **_svderr** and terminate with message
trap 1	set **_svderr** and continue execution

Source svd.src

Globals **_svderr**

See also **svd, svd1, svdcusv**

svdcusv

Purpose Computes the singular value decomposition of a matrix so that: $x = u * s * v'$ (compact u).

Format `{` *u,s,v* `} = svdcusv(`*x*`);`

Input

x	NxP matrix whose singular values are to be computed.

Output

u	NxN or NxP matrix, the left singular vectors of *x*. If N > P, *u* is NxP containing only the P left singular vectors of *x*.
s	NxP or PxP diagonal matrix, the singular values of *x* arranged in descending order on the principal diagonal. If N > P, *s* is PxP.
v	PxP matrix, the right singular vectors of *x*.

Remarks If not all the singular values can be computed, *s[1,1]* is set to a scalar error code. Use **scalerr** to convert this to an integer. The diagonal elements of *s* with indices greater than **scalerr(***s[1,1]***)** are correct. If **scalerr(***s[1,1]***)** returns a 0, all the singular values have been computed.

See also **svd2, svds, svdusv**

svds

Purpose Computes the singular values of a matrix.

Format *s* **= svds(***x***);**

Input

x	NxP matrix whose singular values are to be computed.

Output

s	min(N,P)x1 vector, the singular values of *x* arranged in descending order.

Remarks If not all the singular values can be computed, *s[1]* is set to a scalar error code. Use **scalerr** to convert this to an integer. The elements of *s* with indices greater than **scalerr(***s[1]***)** are correct. If **scalerr(***s[1]***)** returns a 0, all the singular values have been computed.

See also **svd, svdcusv, svdusv**

svdusv

Purpose

Computes the singular value decomposition of a matrix so that: *x = u * s * v'*.

Format

{ *u,s,v* **} = svdusv(***x***);**

Input

x	NxP matrix whose singular values are to be computed.

Output

u	NxN matrix, the left singular vectors of *x*.
s	NxP diagonal matrix, the singular values of *x* arranged in descending order on the principal diagonal.
v	PxP matrix, the right singular vectors of *x*.

Remarks

If not all the singular values can be computed, *s[1,1]* is set to a scalar error code. Use **scalerr** to convert this to an integer. The diagonal elements of *s* with indices greater than **scalerr(***s[1,1]***)** are correct. If **scalerr(***s[1,1]***)** returns a 0, all the singular values have been computed.

See also

svd1, svdcusv, svds

sysstate

Purpose

Gets or sets general system parameters.

Format

{ *rets...* **} = sysstate(***case,y***);**

Input

Case 1 **Version Information**

Returns the current GAUSS version information in an 8-element numeric vector.

Cases 2 through 7 **GAUSS System Paths**

Get or set GAUSS system path.

Case 8 **Complex Number Toggle**

Controls automatic generation of complex numbers in **sqrt**, **ln**, and **log** for negative arguments.

Case 9 **Complex Trailing Character**

Get and set trailing character for the imaginary part of a complex number.

Case 10 **Printer Width**

Get and set **lprint** width.

Case 11 **Auxiliary Output Width**

Get and set the auxiliary output width.

Case 12 **Precision**

Get and set precision for positive definite matrix routines.

Case 13 **LU Tolerance**

Get and set singularity tolerance for LU decomposition.

Case 14 **Cholesky Tolerance**

Get and set singularity tolerance for Cholesky decomposition.

Case 15 **Screen State**

Get and set window state as controlled by **screen** command.

Case 16 **Automatic print Mode**

Get and set automatic **print** mode.

Case 17 **Automatic lprint Mode**

Get and set automatic **lprint** mode.

Case 18 **Auxiliary Output**

Get auxiliary output parameters.

Case 19 **Get/Set Format**

Get and set format parameters.

Case 21 **Imaginary Tolerance**

Get and set the imaginary tolerance.

Case 22 **Source Path**

Get and set the path the compiler will search for source files.

Case 24 **Dynamic Library Directory**

Get and set the path for the default dynamic library directory.

Case 25 **Temporary File Path**

Case 26 **Interface Mode**

Returns the current interface mode.

Case 28 **Random Number Generator Parameters**

Case 30 **Base Year Toggle**

Specifies whether year value returned by **date** is to include base year (1900) or not.

Case 1: Version Information

Returns the current GAUSS version information in an 8-element numeric vector.

Format

vi **= sysstate(***1,0***);**

Output

vi 8x1 numeric vector containing version information:

[1] Major version number.
[2] Minor version number.
[3] Revision.
[4] Machine type.
[5] Operating system.
[6] Runtime module.
[7] Light version.
[8] Always 0.

vi[4] indicates the type of machine on which GAUSS is running:

1 Intel x86
2 Sun SPARC
3 IBM RS/6000
4 HP 9000
5 SGI MIPS
6 DEC Alpha

vi[5] indicates the operating system on which GAUSS is running:

1 DOS
2 SunOS 4.1.x
3 Solaris 2.x
4 AIX
5 HP-UX
6 IRIX
7 OSF/1
8 OS/2
9 Windows

Cases 2 through 7:

GAUSS System Paths

Get or set GAUSS system path.

Format

oldpath **= sysstate(***case,path***);**

Input

case scalar 2-7, path to set.

2 `.exe` file location.
3 **loadexe** path.
4 **save** path.
5 **load**, **loadm** path.
6 **loadf**, **loadp** path.
7 **loads** path.

path scalar 0 to get path, or string containing the new path.

Output

oldpath string, original path.

Remarks

If *path* is of type matrix, the path will be returned but not modified.

Case 8: **Complex Number Toggle**

Controls automatic generation of complex numbers in **sqrt**, **ln** and **log** for negative arguments.

Format *oldstate* **= sysstate(***8,state***);**

Input *state* scalar, 1, 0, or -1.

Output *oldstate* scalar, the original state.

Remarks If *state* = 1, **log**, **ln**, and **sqrt** will return complex numbers for negative arguments. If *state* = 0, the program will terminate with an error message when negative numbers are passed to **log**, **ln**, and **sqrt**. If *state* = -1, the current state is returned and left unchanged. The default state is 1.

Case 9: **Complex Trailing Character**

Get and set trailing character for the imaginary part of a complex number.

Format *oldtrail* **= sysstate(***9,trail***);**

Input *trail* scalar 0 to get character, or string containing the new trailing character.

Output *oldtrail* string, the original trailing character.

Remarks The default character is “i”.

Case 10: **Printer Width**

Get and set **lprint** width.

Format *oldwidth* **= sysstate(***10,width***);**

Input *width* scalar, new printer width.

Output *oldwidth* scalar, the current original width.

Remarks If *width* is 0, the printer width will not be changed.

This may also be set with the **lpwidth** command.

See also **lpwidth**

sysstate

Case 11: Auxiliary Output Width

Get and set the auxiliary output width.

Format *oldwidth* **= sysstate(***11*,*width***);**

Input *width* scalar, new output width.

Output *oldwidth* scalar, the original output width.

Remarks If *width* is 0 then the output width will not be changed.

This may also be set with the **outwidth** command.

See also **outwidth**

Case 12: Precision

Get and set precision for positive definite matrix routines.

Format *oldprec* **= sysstate(***12*,*prec***);**

Input *prec* scalar, 64 or 80.

Output *oldprec* scalar, the original value.

Portability **Windows**, **UNIX**

This function has no effect under Windows or UNIX. All computations are done in 64-bit precision (except for operations done entirely within the 80x87 on Intel machines).

Remarks The precision will be changed if *prec* is either 64 or 80. Any other number will leave the precision unchanged.

See also **prcsn**

Case 13: LU Tolerance

Get and set singularity tolerance for LU decomposition.

Format *oldtol* **= sysstate(***13*,*tol***);**

Input *tol* scalar, new tolerance.

Output *oldtol* scalar, the original tolerance.

Remarks The tolerance must be >= 0. If *tol* is negative, the tolerance is returned and left unchanged.

See also **croutp, inv**

Case 14: Cholesky Tolerance

Get and set singularity tolerance for Cholesky decomposition.

Format *oldtol* **= sysstate(***14,tol***);**

Input *tol* scalar, new tolerance.

Output *oldtol* scalar, the original tolerance.

Remarks The tolerance must be >= 0. If *tol* is negative, the tolerance is returned and left unchanged.

See also **chol, invpd, solpd**

Case 15: Screen State

Get and set window state as controlled by **screen** command.

Format *oldstate* **= sysstate(***15,state***);**

Input *state* scalar, new window state.

Output *oldstate* scalar, the original window state.

Remarks If *state* = 1, window output is turned on. If *state* = 0, window output is turned off. If *state* = -1, the state is returned unchanged.

See also **screen**

Case 16: Automatic print Mode

Get and set automatic **print** mode.

Format *oldmode* **= sysstate(***16,mode***);**

Input *mode* scalar, mode.

sysstate

Output *oldmode* scalar, original mode.

Remarks If *mode* = 1, automatic **print** mode is turned on. If *mode* = 0, it is turned off. If *mode* = -1, the mode is returned unchanged.

See also **print on/off**

Case 17: Automatic lprint Mode

Get and set automatic **lprint** mode.

Format *oldmode* **= sysstate(***17,mode***);**

Input *mode* scalar, mode.

Output *oldmode* scalar, original mode.

Remarks If *mode* = 1, automatic **lprint** mode is turned on. If *mode* = 0, it is turned off. If *mode* = -1, the mode is returned unchanged.

See also **lprint on/off**

Case 18: Auxiliary Output

Get auxiliary output parameters.

Format **{** *state,name* **} = sysstate(***18,dummy***);**

Input *dummy* scalar, a dummy argument.

Output *state* scalar, auxiliary output state, 1 - on, 0 - off.
name string, auxiliary output filename.

See also **output**

Case 19: Get/Set Format

Get and set format parameters.

Format *oldfmt* **= sysstate(***19,fmt***);**

Input *fmt* scalar or 11x1 column vector containing the new format parameters. Usually this will have come from a previous sysstate(19,0) call. See Output for description of matrix.

Output *oldfmt* 11x1 vector containing the current format parameters:

[1]	format type.
[2]	justification.
[3]	sign.
[4]	leading zero.
[5]	trailing character.
[6]	row delimiter.
[7]	carriage line feed position.
[8]	automatic line feed for row vectors.
[9]	field.
[10]	precision.
[11]	formatted flag

Remarks If *fmt* is scalar 0, then the format parameters will be left unchanged.

See also `format`

Case 21: Imaginary Tolerance

Get and set the imaginary tolerance.

Format *oldtol* `= sysstate(`*21,tol*`);`

Input *tol* scalar, the new tolerance.

Output *oldtol* scalar, the original tolerance.

Remarks The imaginary tolerance is used to test whether the imaginary part of a complex matrix can be treated as zero or not. Functions that are not defined for complex matrices check the imaginary part to see if it can be ignored. The default tolerance is 2.23e–16, or machine epsilon.

If *tol* < 0, the current tolerance is returned.

See also `hasimag`

sysstate

Case 22: Source Path

Get and set the path the compiler will search for source files.

Format *oldpath* **= sysstate(***22,path***);**

Input

path scalar 0 to get path, or string containing the new path.

Output

oldpath string, original path.

Remarks

If *path* is a matrix, the current source path is returned.

This resets the **src_path** configuration variable. **src_path** is initially defined in the GAUSS configuration file, `gauss.cfg`.

path can list a sequence of directories, separated by semicolons.

Resetting **src_path** affects the path used for subsequent **run** and **compile** statements.

Case 24: Dynamic Library Directory

Get and set the path for the default dynamic library directory.

Format *oldpath* **= sysstate(***24,path***);**

Input

path scalar 0 to get path, or string containing the new path.

Output

oldpath string, original path.

Remarks

If *path* is a matrix, the current path is returned.

path should list a single directory, not a sequence of directories.

Changing the dynamic library path does not affect the state of any DLL's currently linked to GAUSS. Rather, it determines the directory that will be searched the next time **dlibrary** is called.

UNIX

Changing the path has no effect on GAUSS's default DLL, `libgauss.so`. `libgauss.so` must always be located in the GAUSSHOME directory.

Windows

Changing the path has no effect on GAUSS' default DLL, `gauss.dll`. `gauss.dll` must always be located in the GAUSSHOME directory.

OS/2

Changing the path has no effect on GAUSS's default DLL, `gauss.dll`. `gauss.dll` must always be located in the same directory as the GAUSS executable, `gauss.exe`.

DOS

sysstate 24 has no effect, as **dlibrary** and **dllcall** are not supported.

See also **dlibrary, dllcall**

Case 25: Temporary File Path

Get or set the path GAUSS will use for temporary files..

Format *oldpath* = **sysstate**(*25*,*path*);

Input path scalar 0 to get path, or string containing the new path.

Output oldpath string, original path.

Remarks If path is of type matrix, the path will be returned but not modified.

Case 26: Interface Mode

Returns the current interface mode.

Format *mode* **= sysstate(***26,0***);**

Output

mode scalar, interface mode flag

0	non-X mode
1	terminal (-v) mode
2	X Windows mode

Remarks A mode of 0 indicates that you're running a non-X version of GAUSS; i.e., a version that has no X Windows capabilities. A mode of 1 indicates that you're running an X Windows version of GAUSS, but in terminal mode; i.e., you started GAUSS with the **-v** flag. A mode of 2 indicates that you're running GAUSS in X Windows mode.

Case 28: Random Number Generator Parameters

Get and set the random number generator (RNG) parameters.

sysstate

Format

oldprms = **sysstate**(*28*,*prms*);

Input

prms	scalar 0 to get parameters, or 3x1 matrix of new parameters.	
	[1] seed,	0 < seed < 2^32
	[2] multiplier,	0 < mult < 2^32
	[3] constant,	0 ≤ const < 2^32

Output

oldprms 3x1 matrix, current parameters.

Portability

Not supported for DOS.

Remarks

If *prms* is a scalar 0, the current parameters will be returned without being changed.

The modulus of the RNG cannot be changed; it is fixed at 2^32.

See also

rndcon, **rndmult**, **rndseed**, **rndns**, **rndus**, **rndn**, **rndu**

Case 30: Base Year Toggle

Specifies whether year value returned by date is to include base year (1900) or not.

Format

oldstate = **sysstate**(*30*,*state*);

Input

state scalar, 1, 0, or missing value.

Output

oldstate scalar, the original state.

Portability

DOS

sysstate 30 has no effect. It always returns a 4-digit year.

Remarks

Internally, **date** acquires the number of years since 1900. **sysstate** 30 specifies whether **date** should add the base year to that value or not. If *state* = 1, **date** adds 1900, returning a fully-qualified 4-digit year.

If **state =** 0, date returns the number of years since 1900. If *state* is a missing value, the current state is returned. The default state is 1.

system

Purpose Quits GAUSS and returns to the operating system.

Format

```
system;
system c;
```

Input

c scalar, an optional exit code that can be recovered by the program that invoked GAUSS. The default is 0. Valid arguments are 0-255.

Remarks The system command always returns an exit code to the operating system or invoking program. If you don't supply one, it returns 0. This is usually interpreted as indicating success.

See also **exec**

tab

Purpose

Tabs the cursor to a specified text column.

Format

tab(*col***);**
print expr1 expr2 tab(*col1***) expr3 tab(***col2***) expr4 ...;**

Input

col scalar, the column position to tab to.

Remarks

col specifies an absolute column position. If *col* is not an integer, it will be truncated.

tab can be called alone or embedded in a **print** statement. You cannot embed it within a parenthesized expression in a **print** statement, though. For example:

```
print (tab(20) c + d * e);
```

will not give the results you expect. If you have to use parenthesized expressions, write it like this instead:

```
print tab(20) (c + d * e);
```

tan

Purpose Returns the tangent of its argument.

Format *y* **= tan(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix.

Remarks For real matrices, *x* should contain angles measured in radians.

To convert degrees to radians, multiply the degrees by $\frac{\pi}{180}$.

Example

```
let x = 0 .5 1 1.5;
y = tan(x);
```

$$y = \begin{matrix} 0.00000000 \\ 0.54630249 \\ 1.55740772 \\ 14.10141995 \end{matrix}$$

See also **atan, pi**

tanh

Purpose Computes the hyperbolic tangent.

Format *y* **= tanh(***x***);**

Input

x	NxK matrix.

Output

y	NxK matrix containing the hyperbolic tangents of the elements of *x*.

Example

```
let x = -0.5 -0.25 0 0.25 0.5 1;
x = x * pi;
y = tanh(x);
```

$$x = \begin{matrix} -1.570796 \\ -0.785398 \\ 0.000000 \\ 0.785398 \\ 1.570796 \\ 3.141593 \end{matrix}$$

$$y = \begin{matrix} -0.917152 \\ -0.655794 \\ 0.000000 \\ 0.655794 \\ 0.917152 \\ 0.996272 \end{matrix}$$

Source trig.src

tempname

Purpose Creates a temporary file with a unique name.

Format *tname* **= tempname(***path***,***pre***,***suf***);**

Input

path	string, path where the file will reside.
pre	string, a prefix to begin the file name with.
suf	string, a suffix to end the file name with.

Output

tname	string, unique temporary file name of the form *path/pre*XXXXnnnnn*suf*, where XXXX are 4 letters, and nnnnn is the process id of the calling process.

Remarks Any or all of the inputs may be a null string or 0. If *path* is not specified, the current working directory is used.

If unable to create a unique file name of the form requested, **tempname** returns a null string.

WARNING: GAUSS does not remove temporary files created by **tempname**. It is left to the user to remove them when they are no longer needed.

time

Purpose Returns the current system time.

Format *y* **= time;**

Output *y* 4x1 numeric vector, the current time in the order: hours, minutes, seconds, and hundredths of a second.

Example

```
print time;
```

```
  7.000000
 31.000000
 46.000000
 33.000000
```

See also **date, datestr, datestring, datestrymd, hsec, timestr**

timedt

Purpose Returns system date and time in DT scalar format.

Format *dt* **= timedt;**

Output *dt* scalar, system date and time in DT scalar format.

Remarks The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

20010421183207

represents 18:32:07 or 6:32:07 PM on April 21, 2001.

Source time.src

See also **todaydt, timeutc, dtdate**

timestr

Purpose Formats a time in a vector to a string.

Format *ts* **= timestr(***t***);**

Input

t 4x1 vector from the **time** function, or a zero. If the input is 0, the time function will be called to return the current system time.

Output

ts 8 character string containing current time in the format hr:mn:sc

Example

```
t = { 7, 31, 46, 33 };
ts = timestr(t);
print ts;
```

Produces:

```
   7:31:46
```

Source time.src

See also **date, datestr, datestring, datestrymd, ethsec, etstr, time**

timeutc

Purpose Returns the number of seconds since January 1, 1970 Greenwich Mean Time.

Format *tc* **= timeutc;**

Output

tc scalar, number of seconds since January 1, 1970 Greenwich Mean Time.

Example

```
tc = timeutc;
utv = utctodtv(tc);
```

tc = 939235033

utv = 1999 10 6 11 37 13 3 278

See also **dtvnormal, utctodtv**

title

Purpose Sets the title for the graph.

Library pgraph

Format title(*str*);

Input *str* string, the title to display above the graph.

Global Output _ptitle

Remarks Up to three lines of title may be produced by embedding a line feed character ("\L") in the title string.

Example

```
title("First title line\L Second title line\L
      Third title line");
```

Fonts may be specified in the title string. For instructions on using fonts, see "Publication Quality Graphics" in the *User Guide*.

Source pgraph.src

See also xlabel, ylabel, fonts

tkf2eps

Purpose Converts a **.tkf** file to an Encapsulated PostScript file.

Library **pgraph**

Format *ret* **= tkf2eps(***tekfile, epsfile***);**

Input

tekfile	string, name of **.tkf** file
epsfile	string, name of Encapsulated PostScript file

Output

ret	scalar, 0 if successful

Remarks The conversion is done using the global parameters in **peps.dec**. You can modify these globally by editing the **.dec** file, or locally by setting them in your program before calling **tkf2eps**.

See the header of the output Encapsulated PostScript file and a PostScript manual if you want to modify these parameters.

tkf2ps

Purpose

Converts a **.tkf** file to a PostScript file.

Library

pgraph

Format

ret **= tkf2ps(***tekfile, psfile***);**

Input

tekfile	string, name of **.tkf** file
epsfile	string, name of Encapsulated PostScript file

Output

ret	scalar, 0 if successful

Remarks

The conversion is done using the global parameters in **peps.dec**. You can modify these globally by editing the **.dec** file, or locally by setting them in your program before calling **tkf2ps**.

See the header of the output Encapsulated PostScript file and a PostScript manual if you want to modify these parameters.

tocart

Purpose Converts from polar to cartesian coordinates.

Format *xy* **= tocart(***r,theta***);**

Input

r	NxK real matrix, radius.
theta	LxM real matrix, ExE conformable with *r*, angle in radians.

Output

xy	max(N,L) by max(K,M) complex matrix containing the *X* coordinate in the real part and the *Y* coordinate in the imaginary part.

Source coord.src

todaydt

Purpose Returns system date in DT scalar format. The time returned is always midnight (00:00:00), the beginning of the returned day.

Format *dt* **= todaydt;**

Output *dt* scalar, system date in DT scalar format.

Remarks The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

20010421183207

represents 18:32:07 or 6:32:07 PM on April 21, 2001.

Source time.src

See also **timedt, timeutc, dtdate**

toeplitz

Purpose Creates a Toeplitz matrix from a column vector.

Format *t* **= toeplitz(***x***);**

Input *x* Kx1 vector.

Output *t* KxK Toeplitz matrix.

Example

```
x = seqa(1,1,5);
y = toeplitz(x);
```

$$x = \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix}$$

$$y = \begin{matrix} 1 & 2 & 3 & 4 & 5 \\ 2 & 1 & 2 & 3 & 4 \\ 3 & 2 & 1 & 2 & 3 \\ 4 & 3 & 2 & 1 & 2 \\ 5 & 4 & 3 & 2 & 1 \end{matrix}$$

Source toeplitz.src

token

Purpose

Extracts the leading token from a string.

Format

{ *token*,*str_left* **} = token(**_str_**);**

Input

str	string, the string to parse.

Output

token	string, the first token in *str*.
str_left	string, str minus *token*.

Remarks

str can be delimited with commas or spaces.

The advantage of **token** over **parse** is that **parse** is limited to tokens of 8 characters or less; **token** can extract tokens of any length.

Example

Here is a keyword that uses token to parse its string parameter.

```
keyword add(s);
   local tok,sum;
   sum = 0;
   do until s $== "";
      { tok, s } = token(s);
      sum = sum + stof(tok);
   endo;
   format /rd 1,2;
   print "Sum is: " sum;
endp;
```

If you type:

```
add 1 2 3 4 5 6;
```

add will respond:

```
Sum is: 21.00
```

Source

token.src

See also `parse`

topolar

Purpose Converts from cartesian to polar coordinates.

Format `{` *r,theta* `} = topolar(`*xy*`);`

Input

xy	NxK complex matrix containing the *X* coordinate in the real part and the *Y* coordinate in the imaginary part.

Output

r	NxK real matrix, radius.
theta	NxK real matrix, angle in radians.

Source coord.src

trace

Purpose

Allows the user to trace program execution for debugging purposes.

Format

trace *new*;
trace *new*, *mask*;

Input

new scalar, new value for trace flag.

mask scalar, optional mask to allow leaving some bits of the trace flag unchanged.

Remarks

The **trace** command has no effect unless you are running your program under GAUSS's source level debugger. Setting the **trace** flag will not generate any debugging output during normal execution of a program.

The argument is converted to a binary integer with the following meanings:

bit	decimal	meaning
ones	1	trace calls/returns
twos	2	trace line numbers
fours	4	verbose trace
eights	8	output to window
sixteens	16	output to print
thirty-twos	32	output to auxiliary output
sixty-fours	64	output to error log

You must set one or more of the output bits to get any output from **trace**. If you set **trace** to 4, you'll be doing a verbose trace of your program, but the output won't be displayed anywhere.

The trace output as a program executes will be as follows:

(+GRAD)	calling function or procedure GRAD
(-GRAD)	returning from GRAD
[47]	executing line 47

Note that the line number trace will only produce output if the program was compiled with line number records.

trace

To set a single bit use two arguments:

trace 16,16; turn on output to printer
trace 0,16; turn off output to printer

Example

```
trace 1+8;      trace fn/proc calls/returns to
                      standard output
trace 2+8;      trace line numbers to standard
                      output
trace 1+2+8;    trace line numbers and fn/proc
                      calls/returns to standard
                      output
trace 1+16;     trace fn/proc calls/returns to
                      printer
trace 2+16;     trace line numbers to printer
trace 1+2+16;   trace line numbers and fn/proc
                      calls/returns to printer
trace 4+8;      verbose trace to screen
```

See also

#lineson

trap

Purpose

Sets the trap flag to enable or disable trapping of numerical errors.

Format

trap *new*;
trap *new*, *mask*;

Input

new	scalar, new trap value.
mask	scalar, optional mask to allow leaving some bits of the trap flag unchanged.

Remarks

The trap flag is examined by some functions to control error handling. There are 16 bits in the trap flag, but most GAUSS functions will examine only the lowest order bit:

trap 1;	turn trapping on
trap 0;	turn trapping off

If we extend the use of the trap flag, we will use the lower order bits of the trap flag. It would be wise for you to use the highest 8 bits of the trap flag if you create some sort of user-defined trap mechanism for use in your programs. (See the function **trapchk** for detailed instructions on testing the state of the trap flag; see **error** for generating user-defined error codes.)

To set only one bit and leave the others unchanged use two arguments:

trap 1,1;	set the ones bit
trap 0,1;	clear the ones bit

Example

```
x = eye(3);

oldval = trapchk(1);

trap 1,1;

y = inv(x);

trap oldval,1;
```

trap

```
if scalerr(y);
   errorlog “WARNING: x is singular”;
else;
   print “y” y;
endif;
```

In this example the result of **inv** is trapped in case **x** is singular. The trap state is reset to the original value after the call to **inv**.

Run the example

```
x = eye(3);
```

It is inverted.

Now try

```
ones(3,3);
```

It isn’t.

See also

scalerr, trapchk, error

trapchk

Purpose

Tests the value of the trap flag.

Format

y **= trapchk(***m***);**

Input

m scalar mask value.

Output

y scalar which is the result of the bitwise logical AND of the trap flag and the mask.

Remarks

To check the various bits in the trap flag, add the decimal values for the bits you wish to check according to the chart below and pass the sum in as the argument to the **trapchk** function:

bit	decimal value
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096
13	8192
14	16384
15	32768

If you want to test if either bit 0 or bit 8 is set, then pass an argument of 1+256 or 257 to **trapchk**. The following table demonstrates values that will be returned for:

```
y=trapchk(257);
```

trapchk

	0	1	value of bit 0 in trap flag
0	0	1	
1	256	257	
value of bit 8 in trap flag			

GAUSS functions that test the trap flag currently test only bits 0 and 1.

See also

scalerr, trap, error

trimr

Purpose Trims rows from the top and/or bottom of a matrix.

Format *y* **= trimr(***x,t,b***);**

Input

x	NxK matrix from which rows are to be trimmed.
t	scalar containing the number of rows which are to be removed from the top of *x*.
b	scalar containing the number of rows which are to be removed from the bottom of *x*.

Output

y	RxK matrix where R=N–(*t*+*b*) containing the rows left after the trim.

Remarks If either *t* or *b* is zero, then no rows will be trimmed from that end of the matrix.

Example

```
x = rndu(5,3);
y = trimr(x,2,1);
```

x =

0.76042751	0.33841579	0.01844780
0.05334503	0.38939785	0.65029973
0.93077511	0.06961078	0.04207563
0.53640701	0.06640062	0.07222560
0.14084669	0.06033813	0.69449247

y =

0.93077511	0.06961078	0.04207563
0.53640701	0.06640062	0.07222560

See also **submat, rotater, shiftr**

trunc

Purpose Converts numbers to integers by truncating the fractional portion.

Format *y* **= trunc(***x***);**

Input *x* NxK matrix.

Output *y* NxK matrix containing the truncated elements of *x*.

Example

```
x = 100*rndn(2,2);
```

$$x = \begin{matrix} 77.68 & -14.10 \\ 4.73 & -158.88 \end{matrix}$$

```
y = trunc(x);
```

$$y = \begin{matrix} 77.00 & -14.00 \\ 4.00 & -158.00 \end{matrix}$$

See also **ceil, floor, round**

type

Purpose Returns the symbol table type of the argument.

Format *t* **= type(***x***);**

Input

x matrix or string, can be an expression.

Output

t scalar.

6	matrix
13	string
15	string array

Remarks **type** returns the type of a single symbol. The related function **typecv** will take a character vector of symbol names and return a vector of either their types or the missing value code for any that are undefined. **type** works for matrices, strings, and string arrays; **typecv** works for user-defined procedures, keywords and functions as well. **type** works for global or local symbols; **typecv** works only for global symbols.

Example

```
k = {“CHARS”};
print k;
if type(k) == 6;
   k = “”$+k;
endif;
print k;
```

produces

```
+DEN
CHARS
```

See also **typecv, typef**

typecv

Purpose

Returns the symbol table type of objects whose names are given as a string or as elements of a character vector.

Format

y **= typecv(***x***);**

Input

x string or Nx1 character vector which contains the names of variables whose type is to be determined.

Output

y scalar or Nx1 vector containing the types of the respective symbols in *x*.

Remarks

The values returned by **typecv** for the various variable types are as follows:

6	Matrix (Numeric, Character, or Mixed)
8	Procedure (**proc**)
9	Function (**fn**)
5	Keyword (**keyword**)
13	String
15	String Array

It will return the GAUSS missing value code if the symbol is not found, so **typecv** may be used to determine if a symbol is defined or not.

Example

```
xvar = sqrt(5);
yvar = "Montana";
fn area(r) = pi*r*r;
let names = xvar yvar area;
y = typecv(names);
```

```
names =  XVAR
         YVAR
         AREA
```

$$y = \begin{matrix} 6 \\ 13 \\ 9 \end{matrix}$$

See also **type, typef, varput, varget**

typef

Purpose

Returns the type of data (the number of bytes per element) in a GAUSS data set.

Format

y **= typef(***fp***);**

Input

fp scalar, file handle of an open file.

Output

y scalar, type of data in GAUSS data set.

Remarks

If *fp* is a valid GAUSS file handle, then *y* will be set to the type of the data in the file as follows:

2	2-byte signed integer
4	4-byte IEEE floating point
8	8-byte IEEE floating point

Example

```
infile = “dat1”;
outfile = “dat2”;
open fin = ^infile;
names = getname(infile);
create fout = ^outfile with ^names,0,typef(fin);
```

In this example a file `dat2.dat` is created which has the same variables and variable type as the input file, `dat1.dat`. **`typef`** is used to return the type of the input file for the **`create`** statement.

See also

colsf, rowsf

union

Purpose Returns the union of two vectors with duplicates removed.

Format *y* **= union(***v1,v2,flag***);**

Input

v1	Nx1 vector.
v2	Mx1 vector.
flag	scalar, 1 if numeric data, 0 if character.

Output

y	Lx1 vector containing all unique values that are in *v1* and *v2*, sorted in ascending order.

Remarks The combined elements of *v1* and *v2* must fit into a single vector.

Example

```
let v1 = mary jane linda john;
let v2 = mary sally;
x = union(v1,v2,0);
```

```
      JANE
      JOHN
x =   LINDA
      MARY
     SALLY
```

uniqindx

Purpose

Computes the sorted index of *x*, leaving out duplicate elements.

Format

index **= uniqindx(***x*,*flag***);**

Input

x	Nx1 or 1xN vector.
flag	scalar, 1 if numeric data, 0 if character.

Output

index	Mx1 vector, indices corresponding to the elements of *x* sorted in ascending order with duplicates removed.

Remarks

Among sets of duplicates it is unpredictable which elements will be indexed.

Example

```
let x = 5 4 4 3 3 2 1;
ind = uniqindx(x,1);
y = x[ind];
```

```
ind =
7
6
5
2
1

y =
1
2
3
4
5
```

unique

Purpose Sorts and removes duplicate elements from a vector.

Format *y* **= unique(***x*,*flag***);**

Input

x	Nx1 or 1xN vector.
flag	scalar, 1 if numeric data, 0 if character.

Output

y	Mx1 vector, sorted *x* with the duplicates removed.

Example

```
let x = 5 4 4 3 3 2 1;
y = unique(x,1);
```

```
      1
      2
y =   3
      4
      5
```

upmat, upmat1

Purpose

Returns the upper portion of a matrix. **upmat** returns the main diagonal and every element above. **upmat1** is the same except it replaces the main diagonal with ones.

Format

u **= upmat(***x***);**
u **= upmat1(***x***);**

Input

x NxK matrix.

Output

u NxK matrix containing the upper elements of the matrix. The lower elements are replaced with zeros. **upmat** returns the main diagonal intact. **upmat1** replaces the main diagonal with ones.

Example

```
x = { 1   2  -1,
      2   3  -2,
      1  -2   1 };

u = upmat(x);

u1 = upmat1(x);
```

The resulting matrices are

$$u = \begin{matrix} 1 & 2 & -1 \\ 0 & 3 & -2 \\ 0 & 0 & 1 \end{matrix}$$

$$u1 = \begin{matrix} 1 & 2 & -1 \\ 0 & 1 & -2 \\ 0 & 0 & 1 \end{matrix}$$

Source

diag.src

See also

lowmat, lowmat1, diag, diagrv, crout

upper

Purpose Converts a string or matrix of character data to uppercase.

Format *y* **= upper(***x***);**

Input

x string or NxK matrix containing the character data to be converted to uppercase.

Output

y string or NxK matrix containing the uppercase equivalent of data in *x*.

Remarks If *x* is a numeric matrix, *y* will contain garbage. No error message will be generated since GAUSS does not distinguish between numeric and character data in matrices.

Example

```
x = "uppercase";
y = upper(x);
```

y = UPPERCASE

See also **lower**

use

Purpose

Loads a compiled file at the beginning of the compilation of a source program.

Format

use *fname*;

Input

fname literal or ^string, the name of a compiled file created using the **compile** or the **saveall** command.

Remarks

The **use** command can be used ONCE at the TOP of a program to load in a compiled file which the rest of the program will be added to. In other words, if `xy.e` had the following lines:

```
library pgraph;
external proc xy;
x = seqa(0.1,0.1,100);
```

It could be compiled to `xy.gcg`. Then the following program could be run:

```
use xy;
xy(x,sin(x));
```

Which would be equivalent to:

```
new;
x = seqa(0.1,0.1,100);
xy(x,sin(x));
```

The **use** command can be used at the top of files that are to be compiled with the **compile** command. This can greatly shorten compile time for a set of closely related programs. For example:

```
library pgraph;
external proc xy,logx,logy,loglog,hist;
saveall pgraph;
```

This would create a file called `pgraph.gcg` containing all the procedures, strings and matrices needed to run PQG programs. Other

programs could be compiled very quickly with the following statement at the top of each:

```
use pgraph;
```

or the same statement could be executed once, for instance from the command prompt, to instantly load all the procedures for PQG.

When the compiled file is loaded with **use**, all previous symbols and procedures are deleted before the program is loaded. It is therefore unnecessary to execute a **new** before **use**'ing a compiled file.

use can appear only ONCE at the TOP of a program.

See also

compile, run, saveall

utctodt

Purpose Converts UTC scalar format to DT scalar format.

Format *dt* **= utctodt(***utc***);**

Input

utc Nx1 vector, UTC scalar format.

Output

dt Nx1 matrix, DT scalar format.

Remarks A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time. In DT scalar format, 11:06:47 on March 15, 2001 is 20010315110647.

Example

```
tc = 985633642;
print "tc = " tc;
dt = utctodt(tc);
print "dt = " dt;
```

produces:

```
tc = 985633642
dt = 20010326110722
```

Source time.src

See also **dtvnormal, timeutc, utctodtv, dttodtv, dtvtodt, dttoutc, dtvtodt, strtodt, dttostr**

utctodtv

Purpose Converts UTC scalar format to DTV vector format.

Format *dtv* **= utctodtv(***utc***);**

Input

utc Nx1 vector, UTC scalar format.

Output

dtv Nx8 matrix, DTV vector format.

Remarks A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time.

Each row of *dtv*, in DTV vector format, contains:

[N,1] Year
[N,2] Month in Year, 1-12
[N,3] Day of month, 1-31
[N,4] Hours since midnight, 0-23
[N,5] Minutes, 0-59
[N,6] Seconds, 0-59
[N,7] Day of week, 0-6, 0 = Sunday
[N,8] Days since Jan 1 of current year, 0-365

Example

```
tc = timeutc;
print "tc = " tc;
dtv = utctodtv(tc);
print "dtv = " dtv;
```

produces:

```
tc = 985633642
dtv = 2001 3 26 11 7 22 1 84
```

Source time.src

See also **dtvnormal, timeutc, utctodt, dttodtv, dttoutc, dtvtodt, dtvtoutc, strtodt, dttostr**

utrisol

Purpose

Computes the solution of Ux = b where U is an upper triangular matrix.

Format

x **= utrisol(***b*,*U***);**

Input

b	PxK matrix.
U	PxP upper triangular matrix.

Output

x	PxK matrix.

Remarks

utrisol applies a back solve to Ux = b to solve for *x*. If *b* has more than one column, each column is solved for separately, i.e., **utrisol** applies a back solve to Ux[.,i] = b[.,i] .

vals

Purpose Converts a string into a matrix of its ASCII values.

Format *y* **= vals(***s***);**

Input

s	string of length N where N > 0.

Output

y	Nx1 matrix containing the ASCII values of the characters in the string *s*.

Remarks If the string is null, the function will fail and an error message will be given.

Example

```
k0:
   k = key;
   if not k;
      goto k0;
   endif;
   if k == vals("Y") or k == vals("y");
      goto doit;
   else;
      end;
   endif;
doit:
```

In this example the **key** function is used to read the keyboard. When **key** returns a nonzero value, meaning a key has been pressed, the ASCII value it returns is tested to see if it is an uppercase or lowercase "Y". If it is, the program will jump to the label **doit**, otherwise the program will end.

See also **chrs, ftos, stof**

varget

Purpose

Accesses a global variable whose name is given as a string argument.

Format

y **= varget(***s***);**

Input

s		string containing the name of the global symbol you wish to access.

Output

y		contents of the matrix or string whose name is in *s*.

Remarks

This function searches the global symbol table for the symbol whose name is in *s* and returns the contents of the variable if it exists. If the symbol does not exist, the function will terminate with an **Undefined symbol** error message. If you want to check to see if a variable exists before using this function, use **typecv**.

Example

```
dog = rndn(2,2);
y = varget("dog");
```

$$dog = \begin{matrix} -0.83429985 & 0.34782433 \\ 0.91032546 & 1.75446391 \end{matrix}$$

$$y = \begin{matrix} -0.83429985 & 0.34782433 \\ 0.91032546 & 1.75446391 \end{matrix}$$

See also

typecv, varput

vargetl

Purpose Accesses a local variable whose name is given as a string argument.

Format *y* **= vargetl(***s***);**

Input

s	string containing the name of the local symbol you wish to access.

Output

y	contents of the matrix or string whose name is in *s*.

Remarks This function searches the local symbol list for the symbol whose name is in *s* and returns the contents of the variable if it exists. If the symbol does not exist, the function will terminate with an **Undefined symbol** error message.

Example

```
proc dog;
   local x,y;
   x = rndn(2,2);
   y = vargetl("x");
   print "x" x;
   print "y" y;
   retp(y);
endp;
z = dog;
print "z" z;
```

vargetl

Produces:

```
x
     -0.543851     -0.181701
     -0.108873    0.0648738
y
     -0.543851     -0.181701
     -0.108873    0.0648738
z
     -0.543851     -0.181701
     -0.108873    0.0648738
```

See also

varputl

varmall

Purpose

Computes log-likelihood of a Vector ARMA model.

Format

res **= varmall(***w, phi, theta, vc***);**

Input

w	NxK matrix, time series.
phi	K*PxK matrix, AR coefficient matrices.
theta	K*QxK matrix, MA coefficient matrices.
vc	KxK matrix, covariance matrix.

Output

ll scalar, log-likelihood. If the calculation fails *res* is set to missing value with error code:

Error Code	Reason for Failure
1	M < 1
2	N < 1
3	P < 0
4	Q < 0
5	P = 0 and Q = 0
7	floating point work space too small
8	integer work space too small
9	qq is not positive definite
10	AR parameters too close to stationarity boundary
11	model not stationary
12	model not invertible
13	I+M'H'HM not positive definite

Remarks

varmall is adapted from code developed by Jose Alberto Mauricio of the Universidad Complutense de Madrid. It was published as Algorithm AS311 in Applied Statistics. Also described in "Exact Maximum Likelihood Estimation of Stationary Vector ARMA Models," JASA, 90:282-264.

varmares

Purpose

Computes residuals of a Vector ARMA model.

Format

res **= varmares(***w, phi, theta***);**

Input

w	NxK matrix, time series.
phi	K*PxK matrix, AR coefficient matrices.
theta	K*QxK matrix, MA coefficient matrices.

Output

res NxK matrix, residuals. If the calculation fails *res* is set to missing value with error code:

Error Code	Reason for Failure
1	M < 1
2	N < 1
3	P < 0
4	Q < 0
5	P = 0 and Q = 0
7	floating point work space too small
8	integer work space too small
9	qq is not positive definite
10	AR parameters too close to stationarity boundary
11	model not stationary
12	model not invertible
13	I+M'H'HM not positive definite

Remarks

varmares is adapted from code developed by Jose Alberto Mauricio of the Universidad Complutense de Madrid. It was published as Algorithm AS311 in Applied Statistics. Also described in “Exact Maximum Likelihood Estimation of Stationary Vector ARMA Models,” JASA, 90:282-264.

varput

Purpose Allows a matrix or string to be assigned to a global symbol whose name is given as a string argument.

Format *y* **= varput(***x*,*n***);**

Input

x	NxK matrix or string which is to be assigned to the target variable.
n	string containing the name of the global symbol which will be the target variable.

Output

y	scalar, 1 if the operation is successful and 0 if the operation fails.

Remarks *x* and *n* may be global or local. The variable, whose name is in *n*, that *x* is assigned to is always a global.

If the function fails, it will be because the global symbol table is full.

This function is useful for returning values generated in local variables within a procedure to the global symbol table.

Example

```
source = rndn(2,2);
targname = “target”;
if not varput(source,targname);
   print “Symbol table full”;
   end;
endif;
```

```
source =  -0.93519984   0.40642598
          -0.36867581   2.57623519

target =  -0.93519984   0.40642598
          -0.36867581   2.57623519
```

See also **varget, typecv**

varputl

Purpose Allows a matrix or string to be assigned to a local symbol whose name is given as a string argument.

Format *y* **= varputl(***x,n***);**

Input

x	NxK matrix or string which is to be assigned to the target variable.
n	string containing the name of the local symbol which will be the target variable.

Output

y	scalar, 1 if the operation is successful and 0 if the operation fails.

Remarks *x* and *n* may be global or local. The variable, whose name is in *n*, that *x* is assigned to is always a local.

Example

```
proc dog(x);
   local a,b,c,d,e,vars,putvar;
   a=1;b=2;c=3;d=5;e=7;
   vars = { a b c d e };
   putvar = 0;
   do while putvar $/= vars;
      print “Assign x (“ $vars ”): ” ;;
      putvar = upper(cons);
      print;
   endo;
   call varputl(x,putvar);
   retp(a+b*c-d/e);
endp;
format /rds 2,1;
i = 0;
```

```
do until i ≥ 5;
   z = dog(17);
   print " z is " z;
   i = i + 1;
endo;
```

Produces:

```
Assign x ( A B C D E ): a
   z is 22.3
Assign x ( A B C D E ): b
   z is 51.3
Assign x ( A B C D E ): c
   z is 34.3
Assign x ( A B C D E ): d
   z is 4.6
Assign x ( A B C D E ): e
   z is 6.7
```

See also

vargetl

vartype

Purpose

Returns a vector of ones and zeros that indicate whether variables in a data set are character or numeric.

Format

y **= vartype(***names***);**

Input

names Nx1 character vector of variable names retrieved from a data set header file with the **getname** function.

Output

y Nx1 vector of ones and zeros, 1 if variable is numeric, 0 if character.

Remarks

This function is being obsoleted. See **vartypef**.

If a variable name in *names* is lowercase, a 0 will be returned in the corresponding element of the returned vector.

Example

```
names = getname("freq");
y = vartype(names);
print $names;
print y;
```

```
AGE
PAY
sex
WT

1.0000000
1.0000000
0.0000000
1.0000000
```

Source

vartype.src

vartypef

Purpose Returns a vector of ones and zeros that indicate whether variables in a data set are character or numeric.

Format *y* **= vartypef(***f***);**

Input

f	file handle of an open file.

Output

y	Nx1 vector of ones and zeros, 1 if variable is numeric, 0 if character.

Remarks This function should be used in place of older functions that are based on the case of the variable names. You should also use the **v96** data set format.

vcm, vcx

Purpose Computes a variance-covariance matrix.

Format
vc **= vcm(***m***);**
vc **= vcx(***x***);**

Input

m	KxK moment (x′x) matrix. A constant term MUST have been the first variable when the moment matrix was computed.
x	NxK matrix of data.

Output

vc	KxK variance-covariance matrix.

Source corr.src

See also momentd

vec, vecr

Purpose Creates a column vector by appending the columns/rows of a matrix to each other.

Format
yc **= vec(***x***);**
yr **= vecr(***x***);**

Input
x NxK matrix.

Output
yc (N*K)x1 vector, the columns of *x* appended to each other.
yr (N*K)x1 vector, the rows of *x* appended to each other and the result transposed.

Remarks **vecr** is much faster.

Example

```
x = { 1  2,
      3  4 };
yc = vec(x);
yr = vecr(x);
```

x =
1.000000 2.000000
3.000000 4.000000

yc =
1.000000
3.000000
2.000000
4.000000

yr =
1.000000
2.000000
3.000000
4.000000

vech

Purpose

Vectorizes a symmetric matrix by retaining only the lower triangular portion of the matrix.

Format

v **= vech(***x***);**

Input

x	NxN symmetric matrix.

Output

v	(N*(N+1)/2)x1 vector, the lower triangular portion of the matrix *x*.

Remarks

As you can see from the example below, **vech** will not check to see if *x* is symmetric. It just packs the lower triangular portion of the matrix into a column vector in row-wise order.

Example

```
x = seqa(10,10,3) + seqa(1,1,3)';
v = vech(x);
sx = xpnd(v);
```

```
x =  11 12 13
     21 22 23
     31 32 33

v =  11
     21
     22
     31
     32
     33

sx =  11 21 31
      21 22 32
      31 32 33
```

See also

xpnd

vector (dataloop)

Purpose Specifies the creation of a new variable within a data loop.

Format

vector [[#]] *numvar* **=** *numeric_expression*;
vector $ *charvar* **=** *character_expression*;

Remarks A *numeric_expression* is any valid expression returning a numeric value. A *character_expression* is any valid expression returning a character value. If neither '**$**' nor '**#**' is specified, '**#**' is assumed.

vector is used in place of **make** when the expression returns a scalar rather than a vector. **vector** forces the result of such an expression to a vector of the correct length. **vector** could actually be used anywhere that **make** is used, but would generate slower code for expressions that already return vectors.

Any variables referenced must already exist, either as elements of the source data set, as **extern**s, or as the result of a previous **make**, **vector**, or **code** statement.

Example

```
vector const = 1;
```

See also **make**

vget

Purpose Extracts a matrix or string from a data buffer constructed with **vput**.

Format **{** *x,dbufnew* **} = vget(***dbuf,name***);**

Input

dbuf	NX1 vector, a data buffer containing various strings and matrices.
name	string, the name of the string or matrix to extract from *dbuf*.

Output

x	LXM matrix or string, the item extracted from *dbuf*.
dbufnew	KX1 vector, the remainder of *dbuf* after *x* has been extracted.

Source vpack.src

See also **vlist, vput, vread**

view

Purpose Sets the position of the observer in workbox units for 3-D plots.

Library **pgraph**

Format **view(***x,y,z***);**

Input

x	scalar, the X position in workbox units.
y	scalar, the Y position in workbox units.
z	scalar, the Z position in workbox units.

Remarks The size of the workbox is set with **volume**. The viewer must be outside of the workbox. The closer the position of the observer, the more perspective distortion there will be. If $x = y = z$, the projection will be isometric.

If **view** is not called, a default position will be calculated.

Use **viewxyz** to locate the observer in plot coordinates.

Source pgraph.src

See also **volume, viewxyz**

viewxyz

Purpose Sets the position of the observer in plot coordinates for 3-D plots.

Library pgraph

Format **viewxyz(***x,y,z***);**

Input

x	scalar, the X position in plot coordinates.
y	scalar, the Y position in plot coordinates.
z	scalar, the Z position in plot coordinates.

Remarks The viewer must be outside of the workbox. The closer the observer, the more perspective distortion there will be.

If **viewxyz** is not called, a default position will be calculated.

Use **view** to locate the observer in workbox units.

Source pgraph.src

See also **volume, view**

vlist

Purpose Lists the contents of a data buffer constructed with **vput**.

Format **vlist(***dbuf***);**

Input

dbuf Nx1 vector, a data buffer containing various strings and matrices.

Remarks **vlist** lists the names of all the strings and matrices stored in *dbuf*.

Source vpack.src

See also **vget, vput, vread**

vnamecv

Purpose Returns the names of the elements of a data buffer constructed with **vput**.

Format *cv* **= vnamecv(***dbuf***);**

Input

dbuf Nx1 vector, a data buffer containing various strings and matrices.

Output

cv Kx1 character vector containing the names of the elements of *dbuf*.

See also **vget, vput, vread, vtypecv**

volume

Purpose Sets the length, width, and height ratios of the 3-D workbox.

Library **pgraph**

Format **volume(***x,y,z***);**

Input

x	scalar, the X length of the 3-D workbox.
y	scalar, the Y length of the 3-D workbox.
z	scalar, the Z length of the 3-D workbox.

Remarks The ratio between these values is what is important. If **volume** is not called, a default workbox will be calculated.

Source pgraph.src

See also **view**

vput

Purpose Inserts a matrix or string into a data buffer.

Format *dbufnew* **= vput(***dbuf,x,xname***);**

Input

dbuf	Nx1 vector, a data buffer containing various strings and matrices. If *dbuf* is a scalar 0, a new data buffer will be created.
x	LxM matrix or string, item to be inserted into *dbuf*.
xname	string, the name of *x*, will be inserted with *x* into *dbuf*.

Output

dbufnew	Kx1 vector, the data buffer after *x* and *xname* have been inserted.

Remarks If *dbuf* already contains *x*, the new value of *x* will replace the old one.

Source vpack.src

See also **vget, vlist, vread**

vread

Purpose Reads a string or matrix from a data buffer constructed with **vput**.

Format *x* **= vread(***dbuf*,*xname***);**

Input

dbuf	Nx1 vector, a data buffer containing various strings and matrices.
xname	string, the name of the matrix or string to read from *dbuf*.

Output

x	LxM matrix or string, the item read from *dbuf*.

Remarks **vread**, unlike **vget**, does not change the contents of *dbuf*. Reading *x* from *dbuf* does not remove it from *dbuf*.

Source vpack.src

See also **vget, vlist, vput**

vtypecv

Purpose Returns the types of the elements of a data buffer constructed with **vput**.

Format *cv* **= vtypecv(***dbuf***);**

Input

dbuf Nx1 vector, a data buffer containing various strings and matrices.

Output

cv Kx1 character vector containing the types of the elements of *dbuf*.

See also **vget, vput, vread, vnamecv**

wait, waitc

Purpose Waits until any key is pressed.

Format
```
wait;
waitc;
```

Remarks If you are working in terminal mode, they don't "see" any keystrokes until ENTER is pressed. **waitc** clears any pending keystrokes before waiting until another key is pressed.

Source wait.src, waitc.src

See also **pause**

window

Purpose Partitions the window into tiled regions of equal size.

Library pgraph

Format **window(***row,col,typ***);**

Input

row	scalar, number of rows of graphic panels.
col	scalar, number of columns of graphic panels.
typ	scalar, graphic panel attribute type. If 1, the graphic panels will be transparent, if 0, the graphic panels will be nontransparent (blanked).

Remarks The graphic panels will be numbered from 1 to (*row*)x(*col*) starting from the left topmost graphic panel and moving right.

See **makewind** for creating graphic panels of a specific size and position. (For more information, see "Publication Quality Graphics" in the *User Guide*.

Source pwindow.src

See also **endwind, begwind, setwind, nextwind, getwind, makewind**

writer

Purpose

Writes a matrix to a GAUSS data set.

Format

y **= writer(***fh*,*x***);**

Input

fh	handle of the file that data is to be written to.
x	NxK matrix.

Output

y	scalar specifying the number of rows of data actually written to the data set.

Remarks

The file must have been opened with **create**, **open for append**, or **open for update**.

The data in *x* will be written to the data set whose handle is *fh* starting at the current pointer position in the file. The pointer position in the file will be updated so the next call to **writer** will put the next block of data after the first block. (See **open** and **create** for the initial pointer positions in the file for reading and writing.)

x must have the same number of columns as the data set. **colsf** returns the number of columns in a data set.

writer returns the number of rows actually written to the data set. If *y* does not equal **rows(***x***)**, the disk is probably full.

If the data set is not double precision, the data will be rounded to nearest as it is written out.

If the data contain character elements, the file must be double precision or the character information will be lost.

If the file being written to is the 2-byte integer data type, then missing values will be written out as -32768. These will not automatically be converted to missings on input. They can be converted with the **miss** function:

```
x = miss(x,-32768);
```

Trying to write complex data to a data set that was originally created to store real data will cause a program to abort with an error message. (See **create** for details on creating a complex data set.)

writer

Example

```
create fp = data with x,10,8;
if fp == -1;
   errorlog “Can’t create output file”;
   end;
endif;
c = 0;
do until c ≥ 10000;
   y = rndn(100,10);
   k = writer(fp,y);
   if k /= rows(y);
      errorlog “Disk Full”;
      fp = close(fp);
      end;
   endif;
   c = c+k;
endo;
fp = close(fp);
```

In this example, a 10000x10 data set of Normal random numbers is written to a data set called `data.dat`. The variable names are X01-X10.

See also **open, close, create, readr, saved, seekr**

xlabel

Purpose Sets a label for the X axis.

Library **pgraph**

Format **xlabel(***str***);**

Input *str* string, the label for the X axis.

Source pgraph.src

See also **title, ylabel, zlabel**

xpnd

Purpose

Expands a column vector into a symmetric matrix.

Format

x **= xpnd(***v***);**

Input

v Kx1 vector, to be expanded into a symmetric matrix.

Output

x MxM matrix, the results of taking *v* and filling in a symmetric matrix with its elements.

$$M = ((-1 + \text{sqrt}(1+8*K))/2)$$

Remarks

If *v* does not contain the right number of elements, (that is, if **sqrt(1 + 8*K)** is not integral), then an error message is generated.

This function is particularly useful for hard-coding symmetric matrices, because only about half of the matrix needs to be entered.

Example

```
x = {  1,
       2,  3,
       4,  5,  6,
       7,  8,  9,  10 };
y = xpnd(x);
```

```
      1
      2
      3
      4
x =   5
      6
      7
      8
      9
     10
```

$$y = \begin{matrix} 1 & 2 & 4 & 7 \\ 2 & 3 & 5 & 8 \\ 4 & 5 & 6 & 9 \\ 7 & 8 & 9 & 10 \end{matrix}$$

See also **vech**

xtics

Purpose

Sets and fixes scaling, axes numbering and tick marks for the X axis.

Library

pgraph

Format

xtics(*min,max,step,minordiv***);**

Input

min	scalar, the minimum value.
max	scalar, the maximum value.
step	scalar, the value between major tick marks.
minordiv	scalar, the number of minor subdivisions.

Remarks

This routine fixes the scaling for all subsequent graphs until **graphset** is called.

This gives you direct control over the axes endpoints and tick marks. If **xtics** is called after a call to **scale**, it will override **scale**.

X and Y axes numbering may be reversed for **xy**, **logx**, **logy**, and **loglog** graphs. This may be accomplished by using a negative step value in the **xtics** and **ytics** functions.

Source

pscale.src

See also

scale, ytics, ztics

xy

Purpose Graphs X vs. Y using Cartesian coordinates.

Library pgraph

Format xy(*x*,*y*);

Input

x	Nx1 or NxM matrix. Each column contains the X values for a particular line.
y	Nx1 or NxM matrix. Each column contains the Y values for a particular line.

Remarks Missing values are ignored when plotting symbols. If missing values are encountered while plotting a curve, the curve will end and a new curve will begin plotting at the next non-missing value.

Source pxy.src

See also xyz, logx, logy, loglog

xyz

Purpose Graphs X vs. Y vs. Z using Cartesian coordinates.

Library pgraph

Format xyz(*x*,*y*,*z*);

Input

x	Nx1 or NxK matrix. Each column contains the X values for a particular line.
y	Nx1 or NxK matrix. Each column contains the Y values for a particular line.
z	Nx1 or NxK matrix. Each column contains the Z values for a particular line.

Remarks Missing values are ignored when plotting symbols. If missing values are encountered while plotting a curve, the curve will end and a new curve will begin plotting at the next non-missing value.

Source pxyz.src

See also xy, surface, volume, view

ylabel

Purpose Sets a label for the Y axis.

Library **pgraph**

Format **ylabel(***str***);**

Input *str* string, the label for the Y axis.

Source pgraph.src

See also **title, xlabel, zlabel**

ytics

Purpose

Sets and fixes scaling, axes numbering and tick marks for the Y axis.

Library

pgraph

Format

ytics(*min,max,step,minordiv***);**

Input

min	scalar, the minimum value.
max	scalar, the maximum value.
step	scalar, the value between major tick marks.
minordiv	scalar, the number of minor subdivisions.

Remarks

This routine fixes the scaling for all subsequent graphs until **graphset** is called.

This gives you direct control over the axes endpoints and tick marks. If **ytics** is called after a call to **scale**, it will override **scale**.

X and Y axes numbering may be reversed for **xy**, **logx**, **logy** and **loglog** graphs. This may be accomplished by using a negative step value in the **xtics** and **ytics** functions.

Source

pscale.src

See also

scale, xtics, ztics

zeros

Purpose Creates a matrix of zeros.

Format *y* **= zeros(***r*,*c***);**

Input

r	scalar, the number of rows.
c	scalar, the number of columns.

Output

y	RxC matrix of zeros.

Remarks This is faster than **ones**.

Noninteger arguments will be truncated to an integer.

Example

```
y = zeros(3,2);
```

```
y =  0.000000  0.000000
     0.000000  0.000000
     0.000000   0.00000
```

See also **ones, eye**

zlabel

Purpose Sets a label for the Z axis.

Library pgraph

Format zlabel(*str*);

Input *str* string, the label for the Z axis.

Source pgraph.src

See also title, xlabel, ylabel

ztics

Purpose Sets and fixes scaling, axes numbering and tick marks for the Z axis.

Library **pgraph**

Format **ztics(***min,max,step,minordiv***);**

Input

min	scalar, the minimum value.
max	scalar, the maximum value.
step	scalar, the value between major tick marks.
minordiv	scalar, the number of minor subdivisions. If this function is used with **contour**, contour labels will be placed every *minordiv* levels. If 0, there will be no labels.

Remarks This routine fixes the scaling for all subsequent graphs until **graphset** is called.

This gives you direct control over the axes endpoints and tick marks. If **ztics** is called after a call to **scale3d**, it will override **scale3d**.

Source pscale.src

See also **scale3d, xtics, ytics, contour**

ztics

Obsolete Commands A

The following commands will no longer be supported, therefore should not be used when creating new programs.

disable
editm
enable
files
font
FontLoad
FontUnload
FontUnloadAll
graph
line
lprint on/off
medit
ndpchk
ndpclex
ndpcntrl
plot
plotsym
print on/off
rndmod
rndns/rndus
setvmode
WinClear
WinClearArea
WinClearTTYlog
WinClose
WinCloseAll
WinGetActive
WinGetAttributes
WinGetColorCells
WinGetCursor
WinMove
WinOpenPQG
WinOpenText
WinOpenTTY
WinPan
WinPrint
WinPrintPQG
WinRefresh
WinRefreshArea
WinResize

Obsolete Commands

WinSetActive

WinSetBackground

WinSetColorCells

WinSetColormap

WinSetCursor

WinSetForeground

WinSetRefresh

WinSetTextWrap

WinZoomPQG

Colors Appendix B

0 Black	8 Dark Grey
1 Blue	9 Light Blue
2 Green	10 Light Green
3 Cyan	11 Light Cyan
4 Red	12 Light Red
5 Magenta	13 Light Magenta
6 Brown	14 Yellow
7 Grey	15 White