R and Rmetrics – Reference Card

An Environment for Teaching
Financial Engineering and Computational Finance
with R Rmetrics Built 201.10059

R

An (uncomplete) summary of functions from R's base installation.

GETTING HELP:

```
help                documentation
?                      help topic
help.search          search system
str               object structure
args             display arguments
summary             object summary
mode             mode of an object
type             type of an object
attributes          attribute list
dim          dimension of an object
ls                        list path
dir                     show files
methods            show S3 methods
```

DATA INPUT AND OUTPUT:

```
library               load package
require               load package

data                   load data set
scan                read data values
write                write to a file
read.table           read from file
write.table           write to file
read.csv              read csv data

cat       print coerced characters
print        generic print method
sprintf          C style printing
```

DATA CREATION:

```
c                      combine data
from:to             create sequence
seq                generate sequence
rep                   replicate data
matrix                create matrix
array                  create array
list                    create list
data.frame       create data.frame
factor             encode as factor
cbind           combine by columns
rbind              combine by rows
unlist               flatten lists
as.character               convert
as.integer                 convert
as.numeric                 convert
```

DATA SELECTION & MANIPULATIONS:

```
which.max    index of the largest
which.min         of the smallest

rev                 revert elements
sort                  sort elements
cut          devide into intervals
which                 return indices
choose       compute combinations
na.omit       omit missing values
na.fail       return fail message
unique          remove duplicates
table     build contingency table
subset              return subsets
sample          resample randomly
```

ADVANCED DATA PROCESSING:

```
apply  apply function to margins
lapply      to elements of a list
tapply  to cells of ragged array

merge       merge two data frames
aggregate      split into subsets
```

DATE CLASS:
Date

Represents dates as the number of days since 1970-01-01, with negative values for earlier dates. They are always printed following the rules of the current Gregorian calendar.

```
Date                        Class
as.Date                   convert
Sys.Date             current date
Sys.timezone    time zone setting
```

S3 Methods:

```
print                       print
summary                   summary
date + number                 add
date - number            subtract
date1 lop date2        logical op
weekdays         extract weekdays
months             extract months
quarters        quarters Q1 to Q4
julian      get days since origin
seq              regular sequence
cut             convert to factor
round                 round date
trunc              truncate Date
```

Conversion Function:

```
format.Date     string conversion
```

DATE TIME CLASSES:
POSIXt, POSIXct, POSIXlt

Represent calendar dates and times to the nearest second.

```
POSIXt                     Classes
POSIXct     number representation
POSIXlt       list representation
as.POSIX[cl]t               convert
Sys.time               system time
```

S3 methods:

```
print                       print
summary                   summary
time + number                 add
time - number            subtract
time1 lop time2        logical op
weekdays         extract weekdays
months             extract months
quarters        quarters Q1 to Q4
julian      get days since origin
seq              regular sequence
cut             convert to factor
round                 round date
trunc              truncate date
```

Conversion Functions:

```
strptime                   convert
format               format string
strftime              format alias
ISOdatetime        return POSIXct
ISOdate            return POSIXct
```

NOTE: Rmetrics has its own S4 'timeDate' and 'timeSeries' classes

MATHEMATICAL FUNCTIONS:

Arithmetic and Relational Operators:

```
+   -   *   /   ^   %%   %/%..
<   >   <=   >=   ==..!=..
```

Mathematical Functions:

```
sqrt abs sign
sin cos tan
asin acos atan atan2
sinh cosh tanh
asinh acosh atanh
exp log log10 log2
```

Distributions:

```
rnorm rexp rgamma rpois
rweibull rcauchy rbeta
rt rf rchisq rbinom rgeom
rhyper rlogis rlnorm
rnbinom runif rwilcox
```

Statistical Functions:

```
min max range sum diff prod
mean median sd var cor
scale round trunc
pmin pmax
cumsum cumprod cummin cummax
union intersect
```

Complex Arithmetic:

```
complex Re Im Mod Adj Conj
```

STRING MANIPULATIONS:

```
paste    concatenate and convert
substr         extract substring
strsplit     split in substrings
grep          search for matches
gsub          substitute matches
tolower    convert to lower case
toupper            to upper case
match        positons of matches
pmatch           partial matches
nchar       number of characters
```

GRAPHS AND PLOTS:

General Plots:

```
plot       generic plot function
hist              histogram plot
densityplot         density plot
barplot                 bar plot
piechart              pie chart
boxplot                 box plot
coplot            bivariate plot
pairs            bivariate plots
symbols             draw symbols
```

Time Series Plots:

```
plot.ts         time series plot
ts.plot    allow different dates
```

Quantile Plots:

```
qqnorm      normal quantile plot
qqplot    quantile-quantile plot
```

Two Dimensional Plots:

```
contour             contour plot
image                 image plot
persp           perspective plot
heatmap                heat map
```

Low Level Plot Functions:

```
points                add points
lines                  add lines
text             add text to plot
mtext     add text in the margin
abline               draw a line
rect           draw a rectangle
polygon          draw a polygon
legend        add legend to plot
title         add title/subtitle
locator       return coordinates
```

Graphical Parameters:

```
par               set parameters
  adj      control justification
  bg            background color
  box           control box type
  cex      size of text/symbbols
  col                select color
  font          select font type
  lty                 line type
  lwd               line width
  mfcol       column partitions
  mfrow         row partitions
  pchar             symbol type
```

OPTIMIZATION AND MODELLING:

```
uniroot          search for zero
optimize      search for optimum
optim  general purpose optimizer
nlm     non-linear minimizatoion
nls     non-linear least squares

approx    interpolation function
smooth.spline         spline fit
loess       local polynomial fit
lowess     scatterplot smoothing

lm              linear model fit
```

Rmetrics

fBasics

IMPORT DATA FROM INTERNET: [A1]

Functions to import financial and economic market data from the Internet.

```
download.file       WWW download

yahooImport                Yahoo
keystatsImport     KeyStatistics
economagicImport      Economagic
fredImport          St Louis FED
```

BASIC STATISTICS: [A2]
INCLUDING ROW/COLUMN STATISTICS

Functions which compute basic statistical properties. Missing functions in R to calculate skewness and kurtosis are added, a function which creates a summary statistics, and functions to calculate column and statistics.

```
mean                        Mean
median                    Median
std           Standard Deviation
var                     Variance


skewness                 Skewness
kurtosis                 Kurtosis
basicStats      Basic Statistics

rowStats          Row Statistics
  rowMeans                 Means
  rowAvgs                Averages
  rowVars               Variances
  rowStdevs         Standard Devs
  rowSkewness            Skewness
  rowKurtosis            Kurtosis
  rowCumsums              Cumsums

colStats       Column Statistics
  colMeans                 Means
  colAvgs                Averages
  colVars               Variances
  colStdevs         Standard Devs
  colSkewness            Skewness
  colKurtosis            Kurtosis
  colCumsums              Cumsums
```

SOME UTILITY FUNCTIONS: [A3]
BASIC PLOTS AND TABLES

Plotting functions and utilities for the explorative data analysis of financial and economic market data using S4 time series objects from Rmetrics. Included are also utility functions displaying tables for characters, plot symbols, and colors.

```
splusLikePlot     Set Parameters

tsPlot               Time Series
histPlot               Histogram
densityPlot              Density

logpdfPlot           Log Density
qqgaussPlot     Normal Quantiles
scalinglawPlot       Scaling Law
circlesPlot           3D Circles
perspPlot            Perspective

characterTable        Characters
plotcharacterTable    Plot Chars
colorTable           Show Colors
```

GENERALISED-HYPERBOLIC DISTRIBUTION: [B1]

Functions to compute density, distribution function, quantile function and to generate

random variates for two special cases of the generalized hyperbolic distribution: the hperbolic distribution and the normal inverse Gaussian distribution.

Generalized Hyperbolic Distribution:

```
dgh                    GH Density
pgh                  Probability
qgh                    Quantiles
rgh               Random Variates
```

Hyperbolic:

```
dhyp           Hyperbolic Density
phyp                 Probability
qhyp                   Quantiles
rhyp              Random Variates
*hyp2    Second Parameterization
*hyp3     Third Parameterization
*hyp3    Fourth Parameterization
```

Normal Inverse Gaussian:

```
dnig                   NIG Density
pnig                   Probability
qnig                     Quantiles
rnig               Random Variates
```

STABLE DISTRIBUTION: [B2]

Functions to compute density, distribution function, quantile function and to generate random variates from the stable distribution. Two different algorithms are used for the symmetric and skewed distribution.

```
dsymstb         Symmetric Density
psymstb               Probability
qsymstb                 Quantiles
rsymstb           Random Variates

dstable            Skewed Density
pstable               Probability
qstable                 Quantiles
rstable           Random Variates
  Parameterizations:     0, 1, 2
stableMode           Stable Mode
```

MLE ESTIMATES: [B3] OF DISTRIBUTIONAL PARAMETERS

Maximum likelihood estimators to fit the parameters of a distribution. Included are estimators for the Student-t, the hyperbolic and the normal inverse Gaussian distributions.

```
tFit                    Student-t
ghFit     Generalized Hyperbolic
hypFit                Hyperbolic
nigFit      Normal Inverse Gauss
```

TEST CLASS : [B4]

Class represenatation and methods for objects of class fHTEST.

Class Representation:

```
fHTEST                   S4 class
  @call                       call
  @data                       list
  @test                       list
  @title                 character
  @description           character
```

Methods:

```
show.fHTEST      S4 print method
```

ONE SAMPLE TESTS: [B5]

Functions of one sample tests mostly for testing normality of obsevations.

Normal Tests:

```
normalTest             test suite
ksnormTest    Kolmogorof-Smirnov
shapiroTest                Shapiro
jarqueberaTest        Jarque-Bera
dagoTest          D'Agostino Test
```

Functions from the nortest Package:

```
adTest           Anderson-Darling
cvmTest          Cramer von Mises
lillieTest        Lilliefors Test
pchiTest             Pearson Test
sfTest            Shapiro Francia
```

Independence Test:

```
runsTest                 Runs Test
```

TWO SAMPLE TEST: [B6]

Functions for two sample statistical tests.

Distributional Equivalence:

```
s2Test         Kolmogorov Smirnov
```

Difference in Locations:

```
tTest                       t Test
kw2test            Kruskal-Wallis
```

Difference in Variances:

```
varfTest          variance f Test
```

Difference in Scales:

```
ansariTest         Ansari-Bradley
bartlett2Test             Bartlett
fligner2Test      Fligner-Killeen
```

Correlations:

```
PearsonTest       Pearson's coeff
KendallTest         Kendall's tau
SpearmanTest       spearman's rho
```

Distributions:

```
[dpq]ansariw  Ansari W Statistic
```

STYLIZED FACTS: [B7]

Functions to plot several stylized facts of financial and economic time series. This includes fat tails, autocorrelations, cross-correlations, long memory behavior, and the Taylor effect.

```
LogpdfPlot        logarithmic PDF
qqgausPlot       Normal Quantiles
scalinglawPlot       Scaling Law
acfPlot          Autocorrelation
pacfPlot             Partial ACF
ccfPlot        Cross Correlation
lmacfPlot          Long Memory ACF
teffectPlot          Taylor Effect
```

ADDITIONAL FUNCTIONS PART OF THE DEMO SECTION:

Spline Smoothed Density:

```
dssd                       Density
pssd                   Probability
qssd                     Quantiles
rssd               Random Deviates
```

Bootstrapped Statistics:

```
bootMean        Bootstrapped Mean
```

Data Import:

```
csvImport          from CSV files
forecastsImport      forcasts.org
```

fCalendar

TIME-DATE CLASS: [C1] MANAGING DATES AND TIME

Functions for managing date and time around the globe for any financial center. The con cept allows for dealing with time zones, day light saving time and holiday calendars independent of the date and time specifications of the operating system implemented on your computer. This is an important issue especially for R running under Microsoft's Windows operating system.

```
RulesFinCenter           DST Rule
ListFinCenter        List Centers
```

Class Representation:

```
timeDate                 S4 Class
  @Data    POSIXlt date/time Slot
  @Dim                 length Slot
  @format    format specification
  @FinCenter     financial center

timeCalendar       calender atoms
timeSequence              sequence
Sys.timeDate     system date/time
```

Special Time Date Objects:

```
TimeLastDayInMonth              .
TimeNdayOnOrAfter               .
TimeNdayOnOrBefore              .
TimeNthNdayInMonth              .
TimeLastNdayInMonth             .
```

S3 Methods:

```
is.timeDate                  test
print                       print
summary                   summary
format                     format
```

TIME-DATE CLASS - METHODS: [C2]
METHODS FOR TIME-DATE OBJECTS

Methods for objects of class 'timeDate'. Included are S3 methods for mathematical operations and for transformations between different representations of date/time objects.

S3 Methods:

[.timeDate	subset
+.timeDate	add
-.timeDate	subtract
Ops.timeDate	math operations
diff.timeDate	difference
difftimeDate	another diff
c.timeDate	concatenate
rep.timeDate	repeat
round.timeDate	round
trunc.timeDate	truncate
start.timeDate	first
end.timeDate	last
sort.timeDate	sort
rev.timeDate	revert

Transformations:

as.character.timeDate	.
as.data.frame.timeDate	.
as.POSIXct.timeDate	.
as.POSIXlt.timeDate	.
julian.POSIXt	.
julian.timeDate	.
atoms.timeDate	.
months.timeDate	.

DAYLIGHT SAVING TIME RULES: [C3]

Functions for about 100 cities and regions, which return the daylight saving time tables. The functions are:

```
Adelaide Algiers Amsterdam
  Anchorage Andorra Athens
  Auckland
Bahrain Bangkok Beirut
  Belfast Belgrade Berlin
  BogotaBratislava Brisbane
  Brussels Bucharest Budapest
  BuenosAires
Cairo Calcutta Caracas
  Casablanca Cayman Chicago
  Copenhagen
Darwin Denver Detroit
  Dubai Dublin Eastern
Edmonton Frankfurt Helsinki
HongKong Honolulu
Indianapolis Istanbul
Jakarta Jerusalem
  Johannesburg
Kiev KualaLumpur Kuwait
Lagos Lisbon Ljubljana London
  LosAngeles Luxembourg
Madrid Manila Melbourne
  MexicoCity Monaco Montreal
  Moscow
Nairobi Nassau NewYork Nicosia
Oslo
Pacific Paris Perth Prague
Riga Riyadh Rome
Seoul Shanghai Singapore Sofia
  Stockholm Sydney
Taipei Tallinn Tehran Tokyo
  Tunis
Vaduz Vancouver Vienna Vilnius
Warsaw Winnipeg
Zagreb Zurich
```

TIME SERIES CLASS: [C4]

Functions and methods dealing with regul-ar and irregular 'timeSeries' objects. Dates and times are implemented as 'timeDate' objects. Included are functions and methods for the generation and representation of 'timeSeries' objects, and for mathematical operations.

Class Representation:

timeSeries	S4 Class
@Data	matrix slot
@positions	character
@format	character
@FinCenter	character
@units	character
@title	character
@documentation	character
seriesData	get data
seriesPositions	get positions
read.timeSeries	Spreadsheet

S3 Methods:

as.timeSeries	convert
is.timeSeries	check
print	print
plot	plot
lines	lines
Ops	math operations
[	indexing
head	head of data
tail	tail of data
start	first date
end	last date

Format Conversions:

as.vector	convert
as.matrix	convert
as.data.fram	convert

Math Operations:

applySeries	apply
cutSeries	cut
diffSeries	difference
lagSeries	lagged
mergeSeries	merge
returnSeries	returns
revSeries	revert

HOLIDAY CALENDARS: [C5]
MANAGEMENT OF CALENDAR DATES

easter	Easter
holiday	holidays
holiday.NYSE	NYSE holidays

Conditioned N-Days Dates:

on.or.after	get date
on.or.before	get date
nth.of.nday	get date
last.of.nday	get date

ISO-8601 CCYYMMDD Format:

sjulian	Julian day counter
sdate	Gregorian date
sday.of.week	day of the week
sleap.year	leap year
print.sdate	print method

HOLIDAY DATES: [C6]

Functions and methods dealing with holiday calendars.

```
  Septuagesima Quinquagesima
  AshWednesday PalmSunday
  GoodFriday Easter
  EasterSunday EasterMonday
  RogationSunday Ascension
  Pentecost PentecostMonday
  TrinitySunday CorpusChristi
  ChristTheKing Advent1st
  Advent2nd Advent3rd Advent4th
  ChristmasEve ChristmasDay
  BoxingDay NewYearsDay
  SolemnityOfMary Epiphany
  PresentationOfLord
  Annunciation
  TransfigurationOfLord
  AssumptionOfMary
  BirthOfVirginMary
  CelebrationOfHolyCross
  MassOfArchangels AllSaints
  AllSouls LaborDay
```

Switzerland:

```
  CHBerchtoldsDay
  CHSechselaeuten
  CHAscension
  CHConfederationDay
  CHKnabenschiessen
```

Great Britain:

```
  GBMayDay
  GBBankHoliday
  GBSummerBankHoliday
  GBMilleniumDay
```

Germany:

```
  DEAscension
  DECorpusChristi
  DEGermanUnity
  DEChristmasEve
  DENewYearsEve
```

France:

```
  FRFetDeLaVictoire1945
  FRAscension
  FRBastilleDay
  FRAssumptionVirginMary
  FRAllSaints
  FRArmisticeDay
```

Italy:

```
  ITEpiphany
  ITLiberationDay
  ITAssumptionOfVirginMary
  ITAllSaints
  ITStAmrose
  ITImmaculateConception
```

United States:

```
USDecorationMemorialDay
USPresidentsDay
USNewYearsDay
USInaugurationDay
USMLKingsBirthday
USLincolnsBirthday
USWashingtonsBirthday
USMemorialDay
USIndependenceDay
USLaborDay
USColumbusDay
USElectionDay
USVeteransDay
USThanksgivingDay
USChristmasDay
USCPulaskisBirthday
USGoodFriday
```

Canada:

```
CAVictoriaDay
CACanadaDay
CACivicProvincialHoliday
CALabourDay
CAThanksgivingDay
CaRemembranceDay
```

Japan:

```
JPNewYearsDay
JPGantan
JPBankHolidayJan2
JPBankHolidayJan3
JPComingOfAgeDay
JPSeijinNoHi
JPNatFoundationDay
JPKenkokuKinenNoHi
JPGreeneryDay JPMidoriNoHi
JPConstitutionDay
JPKenpouKinenBi
JPNationHoliday
JPKokuminNoKyujitu
JPChildrensDay
JPKodomoNoHi
JPMarineDay
JPUmiNoHi
JPRespectForTheAgedDay
JPKeirouNOhi
JPAutumnalEquinox
JPShuubunNoHi
JPHealthandSportsDay
JPTaiikuNoHi
JPNationalCultureDay
JPBunkaNoHi
JPThanksgivingDay
JPKinrouKanshaNoHi
JPEmperorsBirthday
JPTennouTanjyouBi
JPBankHolidayDec31
```

FX HIGH FREQUENCY DATA / [D1]
FILTERING / BUSINESS TIME SCALES
ISO-8601 CCYYMMDDhhmm:

Functions for the management of high frequency financial market time series, especially for FX series collected from a Reuters data feed. The collection includes functions for the management of dates and times formatted in the ISO-8601 string CCYYMMDDhhmm, functions for filter and outlier detection of high frequency FX data records as collected from a Reuters data feed, and functions which can be used to calculate log-prices, log-returns, to extract subsamples, to interpolate in time, to build business time scales, and to de-seasonalize and de-volatilize high frequency financial market data.

```
xjulian             Julian timer
xdate        Gregorian Date/Time
xday.of.week     day of the week

xleap.year             leap year
fxdata.                  FX Data
fxdata.parser             parser
fxdata.filter             filter
fxdata.varmin     var min format

xts.log                 take log
xts.diff              difference
xts.cut                      cut
xts.interp           interpolate
xts.map                 time map
xts.upsilon         Upsilon time
xts.dvs        de-volatilization
xts.dwh      day/week histograms
```

ADDITIONAL FUNCTIONS
PART OF THE DEMO SECTION:

S3 chron Methods:

```
print.chron          print patch
print.dates          print patch
seq.chron        sequence method
```

Time/Date Functions:

```
is.weekday    check for weekdays
is.weekend      for weekend days
is.bizday      for business days
holidayZurich        Holiday Cal
summary.timeSeries     S3 Method
```

fSeries

LINEAR TIME SERIES MODELLING: [A1]
AR-ARMA-ARIMA-FRACDIFF MODELS

Functions to model univariate autoregressive moving average time series processes, including time series simulation, parameter estimation, diagnostic analysis of the fit, and predictions of future values.

Class Representation:

```
fARMA                    S4 Class
  @call                      call
  @formula                formula
  @method               character
  @parameter                 list
  @data                 data.frame
  @fit                       list
  @residuals              numeric
  @fitted.values          numeric
  @title                character
  @description          character
```

Simulation and Estimation:

```
armaSim                Simulation
armaFit                Estimation
```

fARMA S3-Methods:

```
predict                  forecast
print                       print
plot                         plot
summary                   summary
print.summary
fitted.values       fitted values
residuals               residuals
```

True ARMA Process:

```
armaTrueacf              True ACF
armaRoots     Characteristic Pol
```

HETEROSKEDASTIC TS MODELING : [A2]
GARCH-APARCH MODELS :

Functions to simulate artificial ARCH time series processes, to fit the parameters of univariate time series to ARCH models, to perform a diagnostic analysis of the fit, and to predict future values of the time series.

Class Representation:

```
fGARCH                   S3 Class
```

Simulation and Estimation:

```
garchSim       GARCH  Simulation
garchFit        GARCH Estimation
aparchSim      APARCH Simulation
aparchFit      APARCH Estimation
```

fGARCH S3-Methods:

```
predict                  forecast
print                       print
summary                   summary
```

LONG MEMORY MODELLING: [A3]

Functions to investigate the long memory behavior time series processes. Included are functions to simulate fractional Gaussian noise and fractional ARIMA processes, functions to model true autocorrelations and spectrum of these processes, and functions to compute the Hurst exponent by several different methods.

Fractional Gaussian Noise:

```
FbmSim                 Simulation
        from Stochastic Integral
     from Choleski Decomposition
         using Levinson's Method
        using Wood-chan's Method
         using Wavelet Sybthesis
```

Fractional Gaussian Noise:

```
fgnSim                 Simulation
                 Durbin's Method
                  Paxon's Method
                  Beran's Method
```

True ACF and Spectrum:

```
ckFGN0       True FGN covariance
gkFGN0     True FGARIMA spectrum
ckFAIRMA0    True FGN covariance
gkFARIMA0   True FARIMA spectrum
```

Estimation of the Hurst Exponent:

```
aggvarFit          Aggregated Var
diffvarFit        Differenced Var
absvalFit        Absolute Moments
higuchiFit       Higuchi's Method
pengFit            Peng's Mmethod
rsFit        R/S Statistic Method
perFit         Periodogram Method
boxperFit       Boxed Periodogram
whittleFit      Whittle Estimator
```

Wavelet Synthesis:

```
WaveletFit     Wavelet Estimator
```

CHAOTIC TIME SERIES: [A4]

Functions to investigate the chaotic behavior of time series processes.

```
henonSim               Henon Map
ikedaSim               Ikeda Map
logisticSim         Logistic Map
lorentzSim     Lorentz Attractor
roesslerSim   Roessler Attractor
```

RANDOM INNOVATION: [A5] PORTABLE RANDOM GENERATOR

Functions to generate portable random innovations. The functions run under R and SPlus and generates the same sequence of random numbers. Supported are uniform, normal and Student-t distributed random numbers.

```
set.lcgseed             Set Seed
get.lcgseed             Get Seed
runif.lcg                Uniform
rnorm.lcg                 Normal
rt.lcg                 Student-t
```

TIME SERIES TESTS: [B1]

Functions for testing various aspects of time series, including independence, and neg-lected nonlinearities.

Tests from 'tseries' Package:

```
bdsTest   BrockDechertScheinkman
tnnTest      Teraesvirta NN test
wnnTest            White NN test
```

UNIT ROOT DISTRIBUTION: [B2]

Functions to compute distribution function and quantile function for the unit root test statistics.

```
punitroot            Probability
qunitroot              Quantiles
```

UNIT ROOT TESTS: [B3[

Functions for unit root testing. The family of tests includes ADF tests based on Baner-jee's et al. tables and on J.G. McKinnons' numerical distribution functions. In addition we have included functions from the 'urca' packages.

```
unitrootTest        ADF/McKinnon
adfTest                 ADF Test
```

Tests from 'urca' Package:

```
urersTest   Elliott-Rothbg-Stock
urkpssTest     KPSS Stationarity
urppTest         Philipps-Perron
urspTest        Schmidt-Philipps
urzaTest           Zivot-Andrews
```

HEAVISIDE AND RELATED FUNCTIONS: [C1]

Functions which compute the Heaviside and related functions, the sign function, the delta function, the boxcar function, and the ramp function.

```
H             Unit Step Function
Sign              Another Signum
Delta             Delta Function
Boxcar           Boxcar Function
Ramp               Ramp Function
```

GARCH DISTRIBUTIONS [C2]

SkewNormal Distribution:
Functions to compute density, distribution function, quantile function and to generate random variates for the skew normal distribution.

```
dsnorm                   Density
psnorm               Probability
qsnorm                 Quantiles
rsnorm           Random Deviates
```

Skew Student Distribution:
Functions to compute density, distribution function, quantile function and to generate random variates for the symmetric and skew Sudent-t distribution with unit variance.

Normalized Sudent-t:

```
dst                      Density
pst                  Probability
qst                    Quantiles
rst              Random Deviates
```

Skew Normalized Sudent-t:

```
dsst                     Density
psst                 Probability
qsst                   Quantiles
rsst             Random Deviates
```

Skew Generalized Error Distribution:
Functions to compute density, distribution function, quantile function and to generate random variates for the symmetric and skew generalized error distribution.

GED:

```
dged                     Density
pged                 Probability
qged                   Quantiles
rged             Random Deviates
```

Skew GED:

```
ssged                    Density
psged                Probability
qsged                  Quantiles
rsged            Random Deviates
```

GARCH DISTRIBUTION FITS: [C3]

Maximum likelihood estimators to fit the parameters of a distribution and to compute basic statistical properties. Included are estimators for the symmetric and skew normal, the Student-t, and the generalized error distributions.

```
normFit                Normal Fit
snormFit          Skew Normal Fit
gedFit                    GED Fit
sged                 Skew GED Fit
stdFit               Sudent-t Fit
sstdFit         Skew Sudent-t Fit
```

ADDITIONAL FUNCTIONS PART OF THE DEMO SECTION:

APARCH Simulation:

```
.aparchSim        another Sim Fun
```

Distributional Statistics:

```
absMoments       absolute Moments
```

GARCH OX Interface:

```
garchOxFit          Parameter Fit
print.garchOX     S3 Print Method
plot.garchOx       S3 Plot method
```

OLS Regression Analysis:

```
OLS                 Parameter Fit
print.OLS         S3 Print Method
plot.OLS           S3 Plot Method
summary.OLS     S3 Summary Method
```

Moving Averages:

```
SMA          Simple Moving Average
EWMA       Exponentially Weighted
```

Time Series Filter:

```
hpFilter         Hodrick-Prescott
```

Additional Trading Indicators:

```
accelTA              Acceleration
adiTA                AD Indicator
adoscillatorTA     AD Oscillator
bollingerTA       Bollinger Bands
chaikinoTA     Chaikin Oscillator
chaikinvTA     Chaikin Volatility
garmanKlassTA  Garman-Klass Vola
macdTA             MACD Indicator
medpriceTA           Median Price
```

```
momentumTA              Momentum
nviTA         Negative Volume Idx
obvTA           On Balance Volume
pvTA          Positive Volume Idx
pvtrendTA      Price-Volume Trend
rocTA               RateOfChange
rsiTA       Relative Strength Idx
stochasticTA       Stochastic Osc
typicalPrice        Typical Price
wcloseTA           Weighted Close
williamsadTA          Williams AD
williamsrTA           Williams R%
```

fMultivar

REGRESSION MODELLING: [A1[EASY TO USE FUNCTION WRAPPERS

A collection and description of easy to use functions to perform a univariate regression analysis from several methods, to analyse and summarize the fit, and to predict for new data records. This wrapper was mainly build for multivariate financial time series analysis.

Class Representation:

```
fREG                      S4 Class
  @call                       call

  @formula                 formula
  @family                character
  @data                  data.frame
  @method                character
  @fit                        list
  @title                 character
  @description            characte
```

Estimation:

```
regFit              Fit Parameters
  LM              Linear Modelling
  GLM               Generalized LM
  PPR      Projection Pursuit Reg
  MARS    Multiv Adap Reg Splines
  POLYMARS     Polytochomous MARS
  NNET     Feedforward Neural Net
```

fREG S3 Methods:

```
print                       print
plot.                        plot
summary                   summary
predict                   predict
fitted.values      fitted values
residuals              residuals
```

LINEAR REGRESSION TESTS: [A2]

Functions to test linear regression models, including tests for higher serial correlations, for heteroskedasticity, for autocorrelations of disturbances, for linearity, and functional relations.

Tests from 'lm' package:

```
bgTest            Breusch-Godfrey
bpTest              Breusch-Pagan
dwTest              Durbin-Watson
gqTest            Goldfeld-Quandt
harvTest           Harvey-Collier
hmcTest           Harrison-McCabe
rainbowTest          Rainbow Test
resetTest            Ramsey-Reset
```

EQUATIONS MODELLING: [A3]

```
Based on "systemfit":
S4: fEQNS                   Class
eqnsFit            Fit Parameters
  OLS      Ordinary Least Squares
  WLS      Weighted Least Squares
  SUR     Seemingly Unrelated Reg
  2SLS    Two-Stage Least Squares
  W2SLS     Weighted Two Stage LS
  3SLS             Three-Stage LS
  W3SLS  Weighted Three-Stage LS
```

S3 Methods:

```
print                       print
plot                         plot
summary                   summary
predict                   predict
coef.                coefficients
fitted              fitted values
residuals              residuals
vcov            var-covar matrix
```

S-Plus Like:

```
SUR                     SUR Wrapper
```

MATRIX ADDON: [B1]

Functions for matrix arithmetics and linear algebra. These functions are often useful for the manipulation of multivariate time series data.

Matrix Generation:

```
matrix               create matrix
diag               diagonal matrix
triang           lower tridiagonal
Triang           upper tridiagonal
pascal              pascal matrix
colVec              column vector
rowVec                 row vector
as.matrix       convert to matrix
is.matrix         test for matrix
dimname           dimension names
colnames|rowname            names
colIds|rowId                names
```

Matrix Subsets:

```
dim              matrix dimension
ncol nrow         col/row numbers
length         number of elements
"["|"[["           matrix subsets
(Arith)                Arithmetic
(Lops)              logical Ops
cbind rbind                augment
```

Linear Algebra:

```
det                    determinant
inv chol2inv               inverse
```

```
norm                          norm
rk                            rank
tr                           trace
t                        transposed
%*%                         product
%x% kron       Kronecker product
mexp       matrix exponentiation
```

More Linear Algebra:

```
chol              Cholesky factor
eigen        eigenvalues/vectors
svd                singular values
kappa            condition number
q                QR decomposition
solve                system of LE
backsolve        for upper Triang
forwardsolve         lower triang
```

MISSING VALUES: [B1] MANIPULATING NA's

```
removeNA                Remove NAs
substituteNA       Substitute NAs
interpNA          Interpolate NAs
knnNA              knn Impute Nas
```

TECHNICAL ANALYSIS: [C1] TRADING INDICATORS

Functions for the technical analysis of stock markets. The collection provides a set of the most common technical indicators.

Utility Functions:

```
emaTA          Exp Moving Average
biasTA                    EMA-Bias
medpriceTA           Median Price
typicalpriceTA      Typical Price
wcloseTA           Weighted Close
rocTA              Rate of Change
oscTA              EMA-Oscillator
```

Oscillators:

```
momTA                     Momentum
macdTA              MACD Indicator
cdsTA             MACD Signal Line
cdoTA              MACD Oscillator
vohlTA        High/Low Volatility
```

Stochastic Indicators:

```
fpkTA                      Fast %K
fpdTA                      Fast %D
spdTA                      Slow %D
apdTA                  Averaged %D
wprTA                  Williams %R
rsiTA           Relative Strength
```

BENCHMARK ANALYSIS: [C2]

Utility and benchmark functions for the analysis of financial markets. The collection provides a set of functions for the computation of returns, for the display of price charts, and for benchmark measurements.

```
getReturns                Returns
ohlcPlot         OpenHighLowClose
sharpeRatio           Sharpe Ratio
```

```
sterling Ratio    Sterling Ratio
maxDrawDown     Maximum Drawdown
```

ROLLING ANALYSIS: [C3]

Functions to perform a rolling analysis. A rolling analysis is often required in building trading models.

```
rollFun          Rolling Function
  rollMean           Rolling Mean
  rollVar        Rolling Variance
  rollMin         Rolling Minimum
  rollMax         Rolling Maximum
```

fExtremes

EXPLORATIVE DATA ANALYSIS: [A1]

Functions for explorative data analysis of extreme values. The tools include plot functions for emprical distributions, quantile plots, graphs exploring the properties of exceedences over a threshold, plots for mean/sum ratio and for the development of records.

```
emdPlot   Empirical Distribution
qqPlot          Quantile-Quantile
qqbayesPlot      with Conf Levels
qPlot                 exploratory
mePlot                Mean Excess
  mxfPlot             Mean Excess
  mrlPlot     Mean Residual Life
recordsPlot               Records
  ssrecordsPlot       Subsamples
msratioPlot        Max/Sum Ratio
xacfPlot             Exceedences
```

PREPROCESSING EXTREME DATA: [A2]

Functions for preprocessing data for extreme value analysis. Included are tools to separate data beyond a threshold value, to compute blockwise data like block maxima, and to decluster point process data.

```
findThreshold   Threshold Values
blockMaxima          Block Maxima
deCluster          Declusters PP
```

FLUCTUATIONS OF MAXIMA: [B1]
GENERALIZED EXTREME VALUE DIST

Distribution functions used in extreme value theory. The functions compute density, distribution function, quantile function and generate random deviates for the Generalized Ex-treme Value Distribution, GEV, for the Frechet, Gumbel, and Weibull distributions.

```
dgev             GEV Distribution
pgev                  Probability
qgev                    Quantiles
rgev              Random Variates
```

FLUCTUATIONS OF MAXIMA: [B2]
GEV/GUMBEL | MLE/PWM [EVIR

```
gevSim              Simulates GEV
gevFit                   Fits GEV
```

Included Models/Methods:

```
GEV/MLE              ML Estimator
GUMBEL/MLE           ML Estimator
GEV/PWM               Probability
GUMBEL/PWM      Weighted Moments
```

S3-Methods:

```
print.gev                   Print
plot.gev                     Plot
summary.gev                Summary
```

Plots:

```
gevrlevelPlot      Return Levels
```

ALLOWING FOR GLM [ISMEV] [B3]

```
gevglmFit                adds GLM
```

S3-Methods:

```
print.gevglm                Print
plot.gevglm                  Plot
summary.gevglm             Summary
```

Plots:

```
gevglmprofPlot       Profile LLH
gevglmprofxiPlot      xi Profile
```

HILL ESTIMATOR AND [B4]
SHAPE PARAMETER PLOTS

```
hillPlot        Hill's Estimator
shaparmPlot     Shape Parameters
```

Included Methods:

```
Pickands           MDA Estimator
Hill               MDA Estimator
Decker-Einmahl-deHaan        MDA
```

POINT PROCESSES: [C1]
GENERALIZED PARETO DISTRIBUTION

```
gpdSim              Simulates GPD
gpdFit                   Fits GPD
```

Included Models/Methods:

```
ML Estimator                    .
Probability Weighted Moments    .
```

S3-Methods:

```
print.gpd                   print
plot.gpd                     plot
summary.gpd                summary
```

Plots:

```
gpdPlot             Tail Estimate
gpdtailPlot         Tail Estimate
gpdquantPlot       High Quantiles
```

```
gpdshapePlot     Shape Parameter
gpdqPlot      Quantile Estimates
gpdsfallPlot    Expect Shortfall
gpdriskmeasures         Quantiles
```

ALLOWING FOR GLM [ISMEV]: [C2]
GENERALIZED PARETO DISTRIBUTION

```
gpdglmFit                adds GLM
```

S3-Methods:

```
print.gpdglm                Print
plot.gpdglm                  Plot
summary.gpdglm             Summary
```

Plots:

```
gpdglmprofPlot       Profile LLH
gpdglmprofxiPlot      xi Profile
```

PEAKS OVER THRESHOLD: [C3]
POT MODEL [EVIR]

```
potSim             simulates POT
potFit                   fits POT
```

S3-Methods:

```
print.pot                   print
summary.pot                summary
```

POINT PROCESSES]: [C4]
PP MODEL [ISMEV]

```
ppFit          Fits Point Process
```

S3-Methods:

```
print.pp                    print
summary.pp                 summary
```

Plot

```
ppFitrange         fits for range
```

R-LARGEST PEAKS: [C5]
ORDER STATISTICS MODEL [ISMEV]

```
rlargFit         Fits Order Stats
```

S3-Methods:

```
print.rlarg                 Print
summary.rlarg              Summary
```

EXTREMAL INDEX: [D1]
BLOCKS, RMC, AND RUNS METHOD

```
exindexesPlot       Theta(1,2,3)
exindexPlot           Theta(1,2)
```

fOptions

BASICS OF OPTION PRICING: [A1]
ACCORDING TO E. G. HAUG

Functions to valuate plain vanilla options.

Included are functions for the Generalized Block-Scholes option pricing model, for options on futures, some utility functions, and print and summary methods for options.

Distribution Functions:

```
NDF          Normal Distribution
CND            Cumulative Normal
CBND            Bivariate Normal
```

Generalized Black-Scholes Option:

```
GBSOption          Black-Scholes
GBSGreeks                Greeks
GBSCharacteristics       Report
GBSOption3DPlot            Plot
GBSGreeks3DPlot            Plot
BlackScholesOption      Synonyme
```

S3-Methods:

```
print.option               Print
summary.otion            Summary
```

Options on Futures:

```
Black76Option            Black76
MiltersenSchwartzOption
```

AMERICAN OPTION BASICS: [A2]

Functions to valuate basic American options. Approximative formulas for American calls are given for the Roll, Geske and Whaley Approximation, for the Barone-Adesi and Whaley Approximation, and for the Bjerksund and Stensland Approximation.

```
RollGeskeWhaleyOption
BAWAmericanApproxOption
            Barone-Adesi/Whaley
BSAmericanApproxOption
            Bjerksund-Stensland
```

BINOMIAL TREE OPTION: [A3]

Functions to valuate options in the framework of the Binomial tree option approach.

```
CRRBinomialTreeOption
            Cox-Ross-Rubinstein
JRBinomialTreeOption
         Jarrod-Rudd Modfication
TIANBinomialTreeOption
              Tian Modification
BinomialTreeOption
         with Cost of Carry Term
BinomialTreePlot           Plot
```

EXOTIC OPTIONS: [B1] MULTIPLE EXERCISES OPTIONS

Functions to valuate multiple exercise options. Multiple exercises options, as the name implies, are options whose payoff is based on multiple exercise dates.

```
ExecutiveStockOption          .
ForwardStartOption            .
RatchetOption                 .
TimeSwitchOption              .
SimpleChooserOption           .
ComplexChooserOption          .
OptionOnOption                .
HolderExtendibleOption        .
WriterExtendibleOption        .
```

EXOTIC OPTIONS: [B2] MULTIPLE ASSETS OPTIONS

Functions to valuate multiple asset options. Multiple asset options, as the name implies, are options whose payoff is based on two (or more) assets

```
TwoAssetCorrelationOption     .
ExchangeOneForAnotherOption   .
ExchangeOnExchangeOption      .
EuropeanExchangeOption        .
AmericanExchangeOption        .
TwoRiskyAssetsOption          .
SpreadApproxOption            .
LookbackOptions.R             .
```

EXOTIC OPTIONS: [B3] LOOKBACK OPTIONS

Functions to valuate lookback options. The payoff from a pathdependent lookback call (put) depends on the exercise price being set to the minimum (maximum) asset price achieved during the life of the option.

```
FloatingStrikeLookbackOption  .
FixedStrikeLookbackOption     .
PTFloatingStrikeLookbackOption .
PTFixedStrikeLookbackOption   .
ExtremeSpreadOption           .
```

EXOTIC OPTIONS: [B4] BARRIER OPTIONS

Functions to valuate barrier options. Barrier options are path-dependent options, with payoffs that depend on the price of the underlying asset at expiration and whether or not the asset price crosses a barrier during the life of the option.

```
StandardBarrierOption         .
DoubleBarrierOption           .
PTSingleAssetBarrierOption    .
TwoAssetBarrierOption         .
PTTwoAssetBarrierOption       .
LookBarrierOption             .
DiscreteBarrierOption         .
SoftBarrierOption             .
```

EXOTIC OPTIONS: [B5] BINARY OPTIONS

Functions to valuate binary options. Binary options, also known as digital options, have discontinuous payoffs. They can be used as building blocks to develop options with more complicated payoffs

```
GapOption                     .
CashOrNothingOption           .
TwoAssetCashOrNothingOption   .
AssetOrNothingOption          .
SuperShareOption              .
BinaryBarrierOption           .
```

EXOTIC OPTIONS: [B6] ASIAN OPTIONS

Functions to valuate Asian options. Asian options are path-dependent options, with payoffs that depend on the average price of the underlying asset or the average exercise price.

```
GeometricAverageAsianOption   .
TurnbullWakemanAsianApproxOption
LevyAsianApproxOption         .
```

EXOTIC OPTIONS: [B7] FX TRANSLATED OPTIONS

Functions to valuate currency translated options. Currency translated options are options on foreign assets where the payoff is exchanged into domestic currency at expiration.

```
FEInDomesticCurrencyOption    .
QuantoOption                  .
EquityLinkedFXOption          .
TakeoverFXOption              .
```

HESTON-NANDI OPTION PRICING: [C1] GARCH TIME SERIES ANALYSIS

Functions to model the GARCH(1,1) price paths which underly Heston and Nandi's option pricing model.

```
hngarchSim              Simulates
hngarchFit          Fit Process
hngarchStats       True Moments
```

S3-Methods:

```
print.hngarch              Print
summary.hngarch          Summary
```

HESTON-NANDI OPTION PRICING: [C2] VALUATION OF OPTIONS

Functions to valuate Heston-Nandi options. Included are functions to compute the option price and the delta and gamma sensitivities for call and put options.

```
HNGOption           Option price
HNGGreeks                Greeks
HNGCharacteristics       Summary
```

MONTE CARLO OPTION VALUATION: [D1] LOW DISCREPANCY SEQUENCES

Functions to compute Halton's and Sobol's low discrepancy sequences, distributed in form of a uniform or normal distribution.

```
runif.pseudo      Uniform Pseudo
rnorm.pseudo       Normal Pseudo
runif.halton      Uniform Halton
rnorm.halton       Normal Halton
runif.sobol       Uniform Sobol
rnorm.sobol        Normal Sobol
```

MONTE CARLO OPTION VALUATION: [D2]

Functions to valuate options by Monte Carlo methods. The functions include beside the main Monte Carlo Simulator, example functions to generate Monte Carlo price paths and to compute Monte Carlo price payoffs.

```
MonteCarloOption                .
  sobolInnovations              .
  wienerPath                    .
  plainVanillaPayoff            .
  arithmeticAsianPayoff         .
```

Included Methods:

```
  antithetic valuation          .
```

EXPONENTIAL BROWNIAN MOTION: [E1]

Distributions and related functions which are useful in the theory of exponential Brownian motion and Asian option valuation. The functions compute densities and probabilities for several distributions. In addition a function is availalble to compute numerically first and second derivatives of a given function.

Distributions:

```
dlognorm      log-Normal Density
plognorm             Probability
dgam               Gamma Density
pgam                 Probability
drgam          Reciprocal-Gamma
prgam                Probability
djohnson         Johnson Type I
pjohnson             Probability
```

Moments:

```
mnorm              Normal Density
mlognorm               log-Normal
mrgam          Reciprocal-Gamma
masian      Asian Option Density
```

Numerical Derivatives:

```
derivativ      1st/2nd Derivative
```

ERROR, GAMMA AND RELATED\FUNCTIONS: [E2]

Special mathematical functions including the error function, the Psi function, the incomplete Gamma function, the Gamma function for complex argument, and the Pochhammer symbol. Furthermore, the Gamma function the logarithm of the Gamma function, their first four derivatives, and the Beta function and the logarithm of

the Beta. These functions are required to valuate Asian Options based on the theory of exponential Brownian motion.

```
erf                Error Function
gamma*             Gamma Function
lgamma*       Log-Gamma Function
digamma*   1st Deriv of LogGamma
trigamma*          2nd Derivative
tetragamma*        3rd Derivative
pentagamma*        4th Derivative
beta*               Beta Function
lbeta*         Log-Beta Function
Psi             Digamma Function
igamma      Incomplete Gamma Fct
cgamma         Complex Gamma Fct
Pochhammer     Pochhammer Symbol
```

CONFLUENT HYPERGEOMETRIC AND RELATED\FUNCTIONS: [E3]

Special mathematical functions which compute the confluent hypergeometric and related functions. For example, these functions are required to valuate Asian Options based on the theory of exponential Brownian motion

```
kummerM      CHF of the 1st Kind
kummerU                  2nd Kind
whittakerM     Whittaker's M Fct
whittakerW     Whittaker's W Fct
hermiteH      Hermite Polynomial
```

MODIFIED BESSEL FUNCTIONS : [E4]

Special mathematical functions which compute the modified Bessel functions of integer order of the first and second kind as well as their derivatives.

```
BesselI          of the 1st kind
BesselDI          its derivative
BesselK          of the 3nd Kind
BesselDK          its derivative
```

ADDITIONAL FUNCTIONS PART OF THE DEMO SECTION:

Trinomial Tree Model:

```
TrinomialTreeOption
```

fPortfolio

MULTIVARIATE DISTRINUTION: [A1]

Functions to compute multivariate densities and probabilities from skew normal and skew Student-t distribution functions. Furthermore, multivariate random daviates can be generated, and for multivariate data, the parameters of the underlying distribution can be estimated by the maximum log-likelihood estimation.

Multivariate Skew Normal Distribution:

```
dmvsnorm           Normal Density
pmvsnorm              Probability
rmvsnorm          Random Variates
```

Multivariate Skew Studemt-tl Distribution:

```
dmvst              Normal Density
pmvst                 Probability
rmvst             Random Variates
```

Parameter Fit:

```
fMV                        S4 Class
mvFit                Parameter Fit
print.fMV          S3 Print Method
plot.fMV            S3 Plot Method
summary.fMV     S3 Summary Method
```

ASSETS MODELLING: [A2]

Functions which generate multivariate artificial data sets of assets, which fit the parameters to a multivariate normal, skew normal, or (skew) Student-t distribution and which compute some benchmark statistics. In addition a function is provided which al lows for the selection and clustering of individual assets from portfolios using hierarchical and k-means clustering approaches.

```
assetsSim              Simulation
assetsSelect         Selection by
..hclust    hierarchical Clusters
..kmeans           k-means Cluster
fASSETS                  S4 Class
assetsFits                Fitting
  norm              Normal Assets
..snorm        Skew Normal Assets
..st       Skew Student-t Assets
assetsStats            Statistics
print.fASSETS        Print Method
plot.fASSETS          Plot Method
summary.fASSETS    Summary Method
```

DRAWDOWN STATISTICS: [A3]

Functions which compute drawdown statistics. Included are density, distribution function, and random generation for the maximum-drawdown distribution. In addition the expectation of drawdowns for Brownian motion can be computed.

Maximum Drawdown Statistics:

```
maxddStats             Statistics
```

Maximum Drawdown Distribution:

```
dmaxdd                    Density
pmaxdd                Probability
rmaxdd             Random Variates
```

VALUE-AT-RISK MODELLING: [B1]

Functions to compute Value-at-Risk and related risk measures for a portfolio of assets. In addition utility functions are available to compute the maximum loss, to calculate the total return, and to plot a histogram of the total return.

Value-at-Risk Functions:

```
VaR               Portfolio VaR
CVaRplus    Conditional VaR Plus
CVaR             Conditional VaR
lambdaCVaR    Atomic Split Value
```

Portfolio Functions:

```
pfolioMaxLoss       Maximum Loss
pfolioReturn       Return Series
pfolioTargetReturn    Target Ret
pfolioTargetRisk     Target Risk
pfolioHist             Histogram
```

MARKOWITZ PORTFOLIO: [B2]

Functions to investigate the efficient frontier for a Markowitz portfolio from a given return series in the mean-variance sense when short selling is forbidden. Tangency, equal weigths, and Monte Carlo portfolios can also be evaluated.

```
fPFOLIO                 S4 Class
portfolioMarkowitz     Markowitz
frontierPortfolio   Eff.Frontier
montecarloMarkowitz       MC Sim

print.fPFOLIO       Print Method
plot.fPFOLIO         Plot Method
summary.fPFOLIO   Summary Method
```

TWO ASSETS PORTFOLIO: [B3] MARKOWITZ AND CVAR PORTFOLIOS:

Functions to investigate the efficient frontier for a two assets portfolio from a given return series in the mean-variance and CVaR sense when short selling is forbidden.

```
FrontierTwoAssetsMarkowitz
FrontierTwoAssetsCVaR
```

*functions are part of R's base installation.

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