R QUICK REFERENCE CARD

Frequently used R commands – Version v1.3 August 2015

A first version of this qrc was created by Tom Short, EPRI PEAC, in 2004-10-21. I modified the document so that it fits my other reference cards; all of its original content has been preserved and, in some cases only, expanded.

Help

Most R functions have online documentation.

`help(topic)` . . documentation on `topic`

`?topic` . . . . . id.

`help.search("topic")`
search the help system

`apropos("topic")`
the names of all objects in the search list matching the regular expression "topic"

`help.start()` start the HTML version of help

Input and output

Most of the I/O functions have a `file` argument. This can often be a character string naming a file or a connection. `file=""` means the standard input or output. Connections can include files, pipes, zipped files, and R variables.

Basic Operations

`<-` . . . . . assign to an object, equivalent to =(?)

`<<-` . . . . . lexical assignment (*NOT* global assignment)

`getwd()` . . . . . get the working directory

`setwd()` . . . . . set the working directory

`system()` . . . . . call the operating system (shell)

`Sys.Date()` . . . Retreive current date, without time

`system.time()`
time an evaluation

`Sys.sleep()` . . pause

`str(a)` . . . . . display the internal [`str`]ucture of an R object a

`summary(a)` . . . gives a "summary" of `a`, usually a statistical summary but it is *generic* meaning it has different operations for different classes of `a`

`ls()` . . . . . show objects in the search path; specify `pat="pat"` to search on a pattern

`ls.str()` . . . . . str() for each variable in the search path

`dir()` . . . . . show files in the current directory

`methods(a)` . . . shows S3 methods of `a`

`methods(class=class(a))`
lists all the methods to handle objects of class a

Fundamentals

`load()` . . . . . load the datasets written with `save`

`data(x)` . . . . . loads specified data set

`library(x)` . . . load add-on packages

`save(file,...)`
saves the specified objects (...) in the XDR platform-independent binary format

`save.image(file)`
saves all objects

`cat(..., file="", sep=" ")`
prints the arguments after coercing to character; `sep` is the character separator between arguments

`print(a, ..)` . prints its arguments; generic, meaning it can have different methods for different objects

`format(x,...)`
format an R object for pretty printing

`sink(file)` . . . output to `file`, until `sink()`

Read from File

`read.table(file)`
reads a file in table format and creates a data frame from it; the default separator `sep=""` is any whitespace

`read.csv("filename",header=T)`
id. but with defaults set for reading comma-delimited files

`read.csv2("filename",header=T)`
id. but with defaults set for reading semicolon-delimited files and `dec=","`

`read.delim("filename",header=T)`
id. but with defaults set for reading tab-delimited files

`read.fwf(file,widths,header=F,sep="\t",as.is=F)`
read a table of [`f`]ixed [`w`]idth [`f`]ormatted data into a 'data.frame'; `widths` is an integer vector, giving the widths of the fixed-width fields

Read Options

`-as.is=TRUE`
to prevent character vectors from being converted to factors

`-blank.lines.skip=TRUE`
blank lines in the input are ignored.

`-fill=TRUE`
in case the rows have unequal length, blank fields are implicitly added

`-header=TRUE`
to read the first line as a header of column names

`-comment.char=""`
to prevent "#" from being interpreted as a comment

`-skip=n` to skip n lines before reading data

Write to file

`write.table(x,file="",row.names=T,col.names=T, sep=" ")`
prints `x` after converting to a data frame; if `quote` is `TRUE`, character or factor columns are surrounded by quotes ("); `sep` is the field separator; `eol` is the end-of-line separator; `na` is the string for missing values; use `col.names=NA` to add a blank column header to get the column headers aligned correctly for spreadsheet input

Clipboard

On windows, the file connection can also be used with description = "clipboard".

⇒ `To read a table copied from Excel, use:`
`x <- read.delim("clipboard")`

⇒ `To write a table to the clipboard for Excel, use:`
`write.table(x,"clipboard",sep="\t",col.names=NA)`

Unix users wishing to write to the primary selection may be able to do so via 'xclip', for example by

⇒ `writes data 'x' to clipboard:`
`pipe('xclip -i', x)`

.

For database interaction, see packages `RODBC`, `DBI`, `RMySQL`, `RPgSQL`, and `ROracle`. See packages `XML`, `hdf5`, `netCDF` for reading other file formats.

Generating, slicing and extracting data

Data creation

`c(...)` ..... generic function to concatenate arguments with the default forming a vector; with `recursive=T` descends through lists combining all elements into one vector

`from:to` ..... generates a sequence; ":" has operator priority; 1:4 + 1 is "2,3,4,5"

`seq(from,to)` generates a sequence `by=` specifies increment; `length=` specifies desired length

`seq(along=x)` generates `1, 2, .., length(along)`; useful for `for` loops

`rep(x,times)` replicate `x` `times`; use `each=` to repeat "each" element of `x` `each` times;

⇒ `rep(c(1,2,3),2): 1 2 3 1 2 3`

⇒ `rep(c(1,2,3),each=2): 1 1 2 2 3 3`

`data.frame(...)`
create a data frame of the named or unnamed arguments

⇒ `shorter vectors are being recycled to the length of the longest:`
`d..ame(v=1:4,ch=c("a","B","c","d"),n=10)`

`list(...)` .... create a list of the named or unnamed arguments

⇒ `use: list(a=c(1,2),b="hi",c=3i)`

`array(x,dim=)`
array with data `x`; specify dimensions like `dim=c(3,4,2)`; elements of `x` recycle if `x` is not long enough

`matrix(x,nrow=,ncol=)`
matrix; elements of `x` recycle

`factor(x,levels=)`
encodes a vector `x` as a factor

`gl(n,k,length=n*k,labels=1:n)`
generate levels (factors) by specifying the pattern of their levels; `k` is the number of levels, and `n` is the number of replications

`expand.grid()`
a data frame from all combinations of the supplied vectors or factors

`rbind(...)` ... combine arguments by rows for matrices, data frames, and others

`cbind(...)` ... id. by columns

⇒ `append column named ''colName'' to matrix x: cbind(x, colName=c(1,2,3))`

Indexing vectors

`x[n]`	n^{th} element
`x[-n]`	all *but* the n^{th} element
`x[-length(x)]`	all *but last* element
`x[1:n]`	first elements
`x[-(1:n)]`	elements from `n+1` to the end
`x[c(1,4,2)]`	specific elements
`x["name"]`	element named `"name"`
`x[x > 3]`	all elements greater than 3
`x[x > 3 & x < 5]`	all elements between 3 and 5

⇒ `elements in the given set:`
`x[x %in% c("a","and","the")]`

Indexing lists

`x[n]`	list with elements `n`
`x[[n]]`	n^{th} element of the list
`x[["name"]]`	element of the list named `"name"`
`x$name`	id.

Indexing matrices

`x[i,j]`	element at row `i`, column `j`
`x[i,]`	row `i`
`x[,j]`	column `j`
`x[,c(1,3)]`	columns 1 and 3
`x["name",]`	row named `"name"`

Indexing data frames

matrix indexing plus the following

`x[["name"]]`	column named `"name"`
`x$name`	id.

Data selection and manipulation

Most common commands

`which.max(x)` returns the index of the greatest element of x

`which.min(x)` returns the index of the smallest element of x

`rev(x)` ..... reverses the elements of `x`

`sort(x)` ..... sorts the elements of `x` in increasing order

`rev(sort(x))` to sort in decreasing order

`cut(x,breaks)`
divides `x` into intervals (factors); `breaks` is the number of cut intervals or a vector of cut points

`x %in% y` ..... logical vector indicating if there is a match or not for its left operand

`match(x, y)` .. returns a vector of the same length than `x` with the elements of `x` which are in `y` (`NA` otherwise)

`which(x == a)`
returns a vector of the indices of `x` if the comparison operation is true (T), in this example the values of `i` for which `x[i] == a` (the argument of this function must be a variable of mode logical)

`choose(n, k)` computes the combinations of k events among n repetitions $= n!/[(n-k)!k!]$

`combn(n, k)`.. generate all combinations of n elements, taken m at a time.

`na.omit(x)`... suppresses the observations with missing data (`NA`) (suppresses the corresponding line if `x` is a matrix or a data frame)

`complete.cases(x[`n`],x[`n`])`
allows removement of 'na's by using part of the dataframe

⇒ `skip all rows in data frame x, where 'na' appears in column 5 or 6:`
`x[complete.cases(x[,5:6]),]`

`na.fail(x)`... returns an error message if `x` contains at least one `NA`

`unique(x)`.... if `x` is a vector or a data frame, returns a similar object but with the duplicate elements suppressed

`duplicated(x)`
returns a logical vector indicating which elements (rows) of a vector or data frame are duplicates

`table(x)`..... returns a table with the numbers of the differents values of `x` (typically for integers or factors)

`subset(x, ..)`
returns a selection of `x` with respect to criteria (.., typically comparisons: `x$V1 < 10`); if `x` is a data frame, the option `select` gives the variables to be kept or dropped using a minus sign

`sample(x, size)`
resample randomly and without replacement `size` elements in the vector `x`, the option `replace = TRUE` allows to resample with replacement

`prop.table(x,margin=)`
table entries as fraction of marginal table

Variable information

is.na(x), is.null(x), is.array(x), is.data.frame(x), ..

`methods(is)`.. list all available typetests

`methods(as)`.. list of all variable conversions

`any(x)` ..... any TRUE elements of `x`?

`all(x)` ..... all TRUE elements of `x`?

`length(x)`.... number of elements in `x`

`rle(x)` ..... length of consecutive elements in `x`

`dim(x)` ..... Retrieve or set the dimension of an object; `dim(x) <- c(3,2)`

`dimnames(x)`.. Retrieve or set the dimension names of an object

`nrow(x)` ..... number of rows; `NROW(x)` is the same but treats a vector as a one-row matrix

`ncol(x)` ..... and

`NCOL(x)` ..... id. for columns

`class(x)` ..... get or set the class of `x`; `class(x) <- "myclass"`

`unclass(x)`... remove the class attribute of `x`

`attr(x,which)`
get or set the attribute `which` of `x`

`attributes(obj)`
get or set the list of attributes of `obj`

Characters (Strings)

`paste(...)`... concatenate vectors after converting to character; `sep=` is the string to separate terms (a single space is the default); `collapse=` is an optional string to separate "collapsed" results

`substr(x,start,stop)`
substrings in a character vector

⇒ `can also assign, as:`
`substr(x, start, stop) <- value`

`strsplit(x,split)`
split `x` according to the substring `split`

`grep(pattern,x)`
searches for matches to `pattern` within `x`; see `?regex`

`gsub(pattern,replacement,x)`
replacement of matches determined by regular expression matching `sub()` is the same but only replaces the first occurrence.

`tolower(x)`... convert to lowercase

`toupper(x)`... convert to uppercase

`match(x,table)`
a vector of the positions of first matches for the elements of `x` among `table`

`x %in% table`
id. but returns a logical vector

`pmatch(x,table)`
partial matches for the elements of `x` among `table`

`nchar(x)` ..... number of characters

`assign` ..... assign a value to a name

`get` ..... get a value from a name

`eval(parse(text='1+1'))`
compute on the language!!

Dates and Times

The class `Date` has dates without times. `POSIXct` has dates and times, including time zones. Comparisons (e.g. $>$), `seq()`, and `difftime()` are useful. `Date` also allows $+$ and $-$. `?DateTimeClasses` gives more information. See also package `chron`.

`as.Date(s)`... and
`as.POSIXct(s)`
convert to the respective class; `format(dt)` converts to a string representation. The default string format is "2001-02-21". These accept a second argument to specify a format for conversion. Some common formats are:

`%a, %A`	Abbreviated and full weekday name.
`%b, %B`	Abbreviated and full month name.

%d	Day of the month (01–31).
%H	Hours (00–23).
%I	Hours (01–12).
%j	Day of year (001–366).
%m	Month (01–12).
%M	Minute (00–59).
%p	AM/PM indicator.
%S	Second as decimal number (00–61).
%U	Week (00–53); the first Sunday as day 1 of week 1.
%w	Weekday (0–6, Sunday is 0).
%W	Week (00–53); the first Monday as day 1 of week 1.
%X	Same as "%Y-%m-%d"
%y	Year without century (00–99). (Don't use due to ambiguousness!)
%Y	Year with century.
%z	(output only.) Offset from Greenwich; -0800 is 8 hours west of.
%Z	(output only.) Time zone as a character string (empty if not available).

Where leading zeros are shown they will be used on output but are optional on input. See ?strftime.

```
as.POSIXct( strptime( , format= ) )
format()
```

Setting the C locale will overcome NA issues which emerge on some systems due to format incongruencies:

```
lct <- Sys.getlocale("LC_TIME")
Sys.setlocale("LC_TIME", "C")
x <- "1919-01-31"
as.Date(x,...)
...
Sys.setlocale("LC_TIME", lct)
```

Math

```
sin,cos,tan,asin,acos,atan,atan2,log,log10,exp
```

Basic Math Operations

`%%, %/%` ..... modulo/quotient, remainder

`max(x)` ..... maximum of the elements of `x`

`min(x)` ..... minimum of the elements of `x`

`range(x)` ..... id. then `c(min(x), max(x))`

`sum(x)` ..... sum of the elements of `x`

`diff(x)` ..... lagged and iterated differences of vector `x`

`prod(x)` ..... product of the elements of `x`

`mean(x)` ..... mean of the elements of `x`

`median(x)` .... median of the elements of `x`

`quantile(x,probs=)`
sample quantiles corresponding to given probabilities (default: 0,.25,.5,.75,1)

`weighted.mean(x, w)`
mean of `x` with weights `w`

`rank(x)` ..... ranks of the elements of `x`

`var(x)` *or* `cov(x)`
variance of the elements of `x` (calculated on $n-1$); if `x` is a matrix or a data frame, the variance-covariance matrix is calculated

`sd(x)` ..... standard deviation of `x`

`cor(x)` ..... correlation matrix of `x` if it is a matrix or a data frame (1 if `x` is a vector)

`acf(x)` ..... Computes (and by default plots) estimates of the autocovariance or autocorrelation function

`var(x, y)` *or* `cov(x, y)`
covariance between `x` and `y`, or between the columns of `x` and those of `y` if they are matrices or data frames

`cor(x, y)` .... linear correlation between `x` and `y`, or correlation matrix if they are matrices or data frames

`round(x, n)` .. rounds the elements of `x` to `n` decimals

`log(x, base)` computes the logarithm of `x` with base `base`

`scale(x)` ..... if `x` is a matrix, centers and reduces the data; to center only use the option `center=F`, to reduce only `scale=F` (by default `center=T, scale=T`)

`pmin(x,y,..)` . a vector which ith element is the minimum of `x[i]`, `y[i]`, ..

`pmax(x,y,..)` . id. for the maximum

`cumsum(x)` .... a vector which ith element is the sum from `x[1]` to `x[i]`

`cumprod(x)` ... id. for the product

`cummin(x)` .... id. for the minimum

`cummax(x)` .... id. for the maximum

Arithmetic & Boolean Operators

`x + y`	addition
`x - y`	subtraction
`x * y`	multiplication
`x / y`	division
`x ^ y`	exponentiation
`x %% y`	modular arithmetic
`x %/% y`	integer division
`X %*% Y`	matrix multiplication
`x == y`	test for equality
`x <= y`	test for less-than-or-equal
`x >= y`	test for greater-than-or-equal
`x && y`	boolean `and` for scalars
`x || y`	boolean `or` for scalars
`x & y`	boolean `and` for vectors (vector x,y,result)
`x | y`	boolean `or` for vectors (vector x,y,result)
`!x`	boolean negation

Complex Numbers

```
union(x,y), intersect(x,y), setdiff(x,y), setequal(x,y)
```

`is.element(el,set)`
"set" functions

`Re(x)` ..... real part of a complex number

`Im(x)` ..... imaginary part

`Mod(x)` ..... modulus; `abs(x)` is the same

`Arg(x)` ..... angle in radians of the complex number

`Conj(x)` ..... complex conjugate

`convolve(x,y)`
compute the several kinds of convolutions of two sequences

`fft(x)` ..... Fast Fourier Transform of an array

`mvfft(x)` ..... FFT of each column of a matrix

Many math functions have a logical parameter `na.rm=F` to specify missing data (NA) removal.

Matrices

`%o%, outer()` outer products on arrays

`A %*% B` ..... multiplication of A and B

`kronecker` .... kronecker products on arrays

`t(x)` ..... transpose

`diag(x)` ..... diagonal

`solve(a,b)` ... solves `a %*% x = b` for `x`

`solve(a)` ..... matrix inverse of `a`

`rowsum(x)` .... sum of rows for a matrix-like object;

`rowSums(x)` ... is a faster version

`colsum(x)` .... sum of columns for a matrix-like object;

`colSums(x)` ... id. for columns

`rowMeans(x)` .. fast version of row means

`colMeans(x)` .. id. for columns

Advanced data processing and HOFs

Apply functions to elements

The base apply family of function is standardized and parallelized by the `plyr` package.

`apply(X,INDEX,FUN=)`
a vector or array or list of values obtained by applying a function `FUN` to margins (`INDEX`) of `X`

`lapply(X,FUN)`
apply `FUN` to each element of the list `X`

`tapply(X,INDEX,FUN=)`
apply `FUN` to each cell of a ragged array given by `X` with indexes `INDEX`

`by(data,INDEX,FUN)`
apply `FUN` to data frame `data` subsetted by `INDEX`

Options for INDEX

`1`	apply FUN to array's rows
`2`	apply FUN to array's columns

The 6 common higher-order functions

```
Reduce(f, x, init, right = F, accumulate = F)

Filter(f, x)

Find(f, x, right = F, nomatch = NULL)

Map(f, ..)

Negate(f)

Position(f,x,right = F,nomatch = NA_integer_)
```

Others

`optimise()` ... One Dimensional Optimization

`merge(a,b)` ... merge two data frames by common columns or row names

`xtabs(a b,data=x)`
a contingency table from cross-classifying factors

`aggregate(x,by,FUN)`
splits the data frame `x` into subsets, computes summary statistics for each, and returns the result in a convenient form; `by` is a list of grouping elements, each as long as the variables in `x`

`stack(x, ..)` . transform data available as separate columns in a data frame or list into a single column

`unstack(x, ..)`
inverse of `stack()`

`reshape(x, ..)`
reshapes a data frame between 'wide' format with repeated measurements in separate columns of the same record and 'long' format in separate records

⇒ `use: (direction="wide") or (direction="long")`

Optimization and model fitting

`optim(par, fn, method = c("Nelder-Mead", "BFGS", ..)`: general purpose optimization; `par` is initial values, `fn` is function to optimize (normally minimize)

`nlm(f,p)` ..... minimize function `f` using a Newton-type algorithm with starting values `p`

`lm(formula)` .. fit linear models; `formula` is typically of the form `response termA + termB + ..`; use `I(x*y) + I(x^2)` for terms made of nonlinear components

`glm(formula,family=)`
fit generalized linear models, specified by giving a symbolic description of the linear predictor and a description of the error distribution

⇒ `see ?family: family is a description of the error distribution and link function to be used in the model`

`nls(formula)` nonlinear least-squares estimates of the nonlinear model parameters

`approx(x,y=)` linearly interpolate given data points; `x` can be an xy plotting structure

`spline(x,y=)` cubic spline interpolation

`loess(formula)`
fit a polynomial surface using local fitting

Many of the formula-based modeling functions have several common arguments: `data=` the data frame for the formula variables, `subset=` a subset of variables used in the fit, `na.action=` action for missing values: `"na.fail"`, `"na.omit"`, or a function.

Statistics

help.search("test") gives you a range of validity tests such as `t.test()`, `binom.test()`, `prop.test()`, `power.t.test()`, `pairwise.t.test()`, ..

Model Analysis

The following generics often apply to model fitting functions

`predict(fit,...)`
: predictions from `fit` based on input data

`df.residual(fit)`
: returns the number of residual degrees of freedom

`coef(fit)` ....
: returns the estimated coefficients (sometimes with their standard-errors)

`residuals(fit)`
: returns the residuals

`deviance(fit)`
: returns the deviance

`fitted(fit)` ..
: returns the fitted values

`logLik(fit)` ..
: computes the logarithm of the likelihood and the number of parameters

`AIC(fit)` .....
: computes the Akaike information criterion or AIC

`aov(formula)`
: analysis of variance model

`anova(fit,...)`
: analysis of variance (or deviance) tables for one or more fitted model objects

`density(x)` ...
: kernel density estimates of `x`

Distributions

`rnorm(n, mean=0, sd=1)`
: Gaussian (normal)

`rexp(n, rate=1)`
: exponential

`rgamma(n, shape, scale=1)`
: gamma

`rpois(n, lambda)`
: Poisson

`rweibull(n, shape, scale=1)`
: Weibull

`rcauchy(n, location=0, scale=1)`
: Cauchy

`rbeta(n, shape1, shape2)`
: beta

`rt(n, df)` .... 'Student' (t)

`rf(n, df1, df2)`
: Fisher–Snedecor (F) (χ^2)

`rchisq(n, df)`
: Pearson

`rbinom(n, size, prob)`
: binomial

`rgeom(n, prob)`
: geometric

`rhyper(nn, m, n, k)`
: hypergeometric

`rlogis(n, location=0, scale=1)`
: logistic

`rlnorm(n, meanlog=0, sdlog=1)`
: lognormal

`rnbinom(n, size, prob)`
: negative binomial

`runif(n, min=0, max=1)`
: uniform

`rwilcox(nn, m, n)`
: `rsignrank(nn, n)` Wilcoxon's statistics

All these functions can be used by replacing the letter `r` with `d`, `p` or `q` to get, respectively, the probability density (`d`*func*`(x, ..)`), the cumulative probability density (`p`*func*`(x, ..)`), and the value of quantile (`q`*func*`(p, ..)`, with $0 < p < 1$).

Time Series Calculations

`ts(x)` .....
: Create a time-series vector

`window(x)` ....
: Extracts the subset of the object x observed between the times start and end. If a frequency is specified, the series is then re-sampled at the new frequency

⇒ `Resampling a timeseries for every 11th entry eg. monthly data: window(x, start=c(1901, 11), frequency=T)`

`time(x)` .....
: creates the vector of times at which a time series was sampled

`cycle(x)` .....
: gives the positions in the cycle of each observation

`frequency(x)`
: returns the number of samples per unit time and deltat the time interval between observations

`filter(x,filter)`
: applies linear filtering to a univariate time series or to each series separately of a multivariate time series

Plotting

`plot(x)` .....
: plot of the values of `x` (on the y-axis) ordered on the x-axis

`plot(x, y)` ...
: bivariate plot of `x` (on the x-axis) and `y` (on the y-axis)

`hist(x)` .....
: histogram of the frequencies of `x`

`barplot(x)` ...
: histogram of the values of `x`; use `horiz=F` for horizontal bars

`dotchart(x)` ..
: if `x` is a data frame, plots a Cleveland dot plot (stacked plots line-by-line and column-by-column)

`pie(x)` .....
: circular pie-chart

`boxplot(x)` ...
: "box-and-whiskers" plot

`sunflowerplot(x, y)`
: id. than `plot()` but the points with similar coordinates are drawn as flowers which petal number represents the number of points

`stripplot(x)`
: plot of the values of `x` on a line (an alternative to `boxplot()` for small sample sizes)

`coplot(x~| z)`
: bivariate plot of `x` and `y` for each value or interval of values of `z`

`interaction.plot (f1, f2, y)`
: if `f1` and `f2` are factors, plots the means of `y` (on the y-axis) with respect to the values of `f1` (on the x-axis) and of `f2` (different curves); the option `fun` allows to choose the summary statistic of `y` (by default `fun=mean`)

`matplot(x,y)` bivariate plot of the first column of `x` *vs.* the first one of `y`, the second one of `x` *vs.* the second one of `y`, etc.

`fourfoldplot(x)`
visualizes, with quarters of circles, the association between two dichotomous variables for different populations (`x` must be an array with `dim=c(2, 2, k)`, or a matrix with `dim=c(2, 2)` if $k = 1$)

`assocplot(x)` Cohen–Friendly graph showing the deviations from independence of rows and columns in a two dimensional contingency table

`mosaicplot(x)`
'mosaic' graph of the residuals from a log-linear regression of a contingency table

`pairs(x)` ..... if `x` is a matrix or a data frame, draws all possible bivariate plots between the columns of `x`

`plot.ts(x)` ... if `x` is an object of class `"ts"`, plot of `x` with respect to time, `x` may be multivariate but the series must have the same frequency and dates

`ts.plot(x)` ... id. but if `x` is multivariate the series may have different dates and must have the same frequency

`qqnorm(x)` .... quantiles of `x` with respect to the values expected under a normal law

`qqplot(x, y)` quantiles of `y` with respect to the quantiles of `x`

`contour(x, y, z)`
contour plot (data are interpolated to draw the curves), `x` and `y` must be vectors and `z` must be a matrix so that `dim(z)=c(length(x), length(y))` (`x` and `y` may be omitted)

`filled.contour(x, y, z)`
id. but the areas between the contours are coloured, and a legend of the colours is drawn as well

`image(x, y, z)`
id. but with colours (actual data are plotted)

`persp(x, y, z)`
id. but in perspective (actual data are plotted)

`stars(x)` ..... if `x` is a matrix or a data frame, draws a graph with segments or a star where each row of `x` is represented by a star and the columns are the lengths of the segments

`symbols(x, y, ..)`
draws, at the coordinates given by `x` and `y`, symbols (circles, squares, rectangles, stars, thermometres or "boxplots") which sizes, colours .. are specified by supplementary arguments

`termplot(mod.obj)`
plot of the (partial) effects of a regression model (`mod.obj`)

Plot Modifiers

The following parameters are common to many plotting functions

`add=F`	if `TRUE` superposes the plot on the previous one (if it exists)
`axes=T`	if `FALSE` does not draw the axes and the box
`type="p"`	specifies the type of plot, `"p"`: points, `"l"`: lines, `"b"`: points connected by lines, `"o"`: id. but the lines are over the points, `"h"`: vertical lines, `"s"`: steps, the data are represented by the top of the vertical lines, `"S"`: id. but the data are represented by the bottom of the vertical lines
`xlim=, ylim=`	specifies the lower and upper limits of the axes, for example with `xlim=c(1, 10)` or `xlim=range(x)`
`xlab=, ylab=`	annotates the axes, must be variables of mode character
`main=`	main title, must be a variable of mode character
`sub=`	sub-title (written in a smaller font)

Low-level plotting commands

`dev.new()` .... open a new graphics device (typically a window). see similar in help.

`graphics.off()` closes before opened plot. it is implemented by calling $dev.off()$ as many times as necessary.

⇒ equvialent commands for *rgl*, *iplots* packages: `rgl.close()`, `iplot.off()`

`points(x, y)` adds points (the option `type=` can be used)

`lines(x, y)` .. id. but with lines

`text(x, y, labels...)`
adds text given by `labels` at coordinates (`x`,`y`); a typical use is: `plot(x, y, type="n"); text(x, y, names)`

`mtext(text, side=3, line=0, ..)`
adds text given by `text` in the margin specified by `side` (see `axis()` below); `line` specifies the line from the plotting area

`segments(x0, y0, x1, y1)`
draws lines from points (`x0`,`y0`) to points (`x1`,`y1`)

`arrows(x0, y0, x1, y1, angle= 30, code=2)`
id. with arrows at points (`x0`,`y0`) if `code=2`, at points (`x1`,`y1`) if `code=1`, or both if `code=3`; `angle` controls the angle from the shaft of the arrow to the edge of the arrow head

`abline(a,b)` .. draws a line of slope `b` and intercept `a`

`abline(h=y)` .. draws a horizontal line at ordinate `y`

`abline(v=x)` .. draws a vertical line at abcissa `x`

`abline(lm.obj)`
draws regression line given by `lm.obj`

`rect(x1, y1, x2, y2)`
draws a rectangle which left, right, bottom, and top limits are `x1`, `x2`, `y1`, and `y2`, respectively

`polygon(x, y)`
draws a polygon linking the points with coordinates given by `x` and `y`

`legend(x, y, legend)`
adds the legend at the point (`x,y`) with the symbols given by `legend`. You may as well add `"bottom", "topleft"` etc. in place of coordinates `x,y` manually

`title()` ..... adds a title and optionally a sub-title

`axis(side, vect)`
adds an axis at the bottom (`side=1`), on the left (`2`), at the top (`3`), or on the right (`4`); `vect` (optional) gives the abcissa (or ordinates) where tick-marks are drawn

`rug(x)` ..... draws the data `x` on the x-axis as small vertical lines

`locator(n, type="n", ..)`
returns the coordinates (x, y) after the user has clicked `n` times on the plot with the mouse; also draws symbols (`type="p"`) or lines (`type="l"`) with respect to optional graphic parameters (..)

⇒ `by default nothing is drawn: type="n"`

Graphical parameters

These can be set globally with `par(...)`; many can be passed as parameters to plotting commands.

`adj` ..... controls text justification (`0` left-justified, `0.5` centred, `1` right-justified)

`bg` ..... specifies the colour of the background (ex. : `bg="red"`, `bg="blue"`, .. the list of the 657 available colours is displayed with `colors()`)

`bty` ..... controls the type of box drawn around the plot, allowed values are: `"o"`, `"l"`, `"7"`, `"c"`, `"u"` or `"]"` (the box looks like the corresponding character)

⇒ `if bty="n": the box is not drawn`

`cex` ..... a value controlling the size of texts and symbols with respect to the default; the following parameters have the same control for numbers on the axes, `cex.axis`, the axis labels, `cex.lab`, the title, `cex.main`, and the sub-title, `cex.sub`

`col` ..... controls the color of symbols and lines; use color names e.g. "red", "blue" or as "#RRGGBB"

⇒ `see: colors(), rgb(), hsv(), gray() and rainbow()`

⇒ `as for cex there are: col.axis, col.lab, col.main, col.sub`

`font` ..... an integer which controls the style of text (`1`: normal, `2`: italics, `3`: bold, `4`: bold italics)

⇒ `as for cex there are: font.axis, font.lab, font.main, font.sub`

`las` ..... an integer which controls the orientation of the axis labels (`0`: parallel to the axes, `1`: horizontal, `2`: perpendicular to the axes, `3`: vertical)

`lty` ..... controls the type of lines, can be an integer or string (`1`: `"solid"`, `2`: `"dashed"`, `3`: `"dotted"`, `4`: `"dotdash"`, `5`: `"longdash"`, `6`: `"twodash"`, or a string of up to eight characters (between `"0"` and `"9"`) which specifies alternatively the length, in points or pixels, of the drawn elements and the blanks, for example `lty="44"` will have the same effect than `lty=2`

`lwd` ..... a numeric which controls the width of lines, default `1`

`mar` ..... a vector of 4 numeric values which control the space between the axes and the border of the graph of the form `c(bottom, left, top, right)`, the default values are `c(5.1, 4.1, 4.1, 2.1)`

`mfcol` ..... a vector of the form `c(nr,nc)` which partitions the graphic window as a matrix of `nr` lines and `nc` columns, the plots are then drawn in columns

`mfrow` ..... id. but the plots are drawn by row

`pch` ..... controls the type of symbol, either an integer between 1 and 25, or any single character within `""`

`ps` ..... an integer which controls the size in points of texts and symbols

`pty` ..... a character which specifies the type of the plotting region, `"s"`: square, `"m"`: maximal

`tck` ..... a value which specifies the length of tick-marks on the axes as a fraction of the smallest of the width or height of the plot; if `tck=1` a grid is drawn

`tcl` ..... a value which specifies the length of tick-marks on the axes as a fraction of the height of a line of text (by default `tcl=-0.5`)

`xaxt` ..... if `xaxt="n"` the x-axis is set but not drawn (useful in conjonction with `axis(side=1, ..)`)

`yaxt` ..... if `yaxt="n"` the y-axis is set but not drawn (useful in conjonction with `axis(side=2, ..)`)

Lattice (Trellis) graphics

Use `panel=` to define a custom panel function (see `apropos("panel")` and `?llines`). Lattice functions return an object of class trellis and have to be `print`ed to produce the graph. Use `print(xyplot(..))` inside functions where automatic printing doesn't work. Use `lattice.theme` and `lset` to change Lattice defaults.

`xyplot(y~x)` .. bivariate plots (with many functionalities)

`barchart(y~x)`
histogram of the values of `y` with respect to those of `x`

`dotplot(y~x)` Cleveland dot plot (stacked plots line-by-line and column-by-column)

`densityplot(~x)`
density functions plot

`histogram(~x)`
histogram of the frequencies of `x`

`bwplot(y~x)` .. "box-and-whiskers" plot

`qqmath(~x)` ... quantiles of `x` with respect to the values expected under a theoretical distribution

`stripplot(y~x)`
single dimension plot, `x` must be numeric, `y` may be a factor

`qq(y~x)` ..... quantiles to compare two distributions, `x` must be numeric, `y` may be numeric, character, or factor but must have two 'levels'

`splom(~x)` .... matrix of bivariate plots

`parallel(~x)` parallel coordinates plot

`levelplot(z~x*y|g1*g2)`
coloured plot of the values of `z` at the coordinates given by `x` and `y` (`x`, `y` and `z` are all of the same length)

`wireframe(z~x*y|g1*g2)`
3d surface plot

`cloud(z~x*y|g1*g2)`
3d scatter plot

In the normal Lattice formula, `y ~ x|g1*g2` has combinations of optional conditioning variables `g1` and `g2` plotted on separate panels. Lattice functions take many of the same arguments as base graphics plus also `data=` the data frame for the formula variables and `subset=` for subsetting.

Programming

Use curly braces {} around statements

```
function( arglist ) expr # function definition
return(value) if(cond) expr
if(cond) cons.expr else alt.expr
for(var in seq) expr
while(cond) expr
repeat expr
break
next
```

`ifelse(test, yes, no)`
a value with the same shape as `test` filled with elements from either `yes` or `no`

`do.call(funname, args)`
executes a function call from the name of the function and a list of arguments to be passed to it

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