

## R Reference Card 2.0

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V 2 by Matt Baggott, matt@baggott.net

V 1 by Tom Short, t.short@ieee.org

Material from *R for Beginners* by permission of Emmanuel Paradis.

### Getting help and info

**help(topic)** documentation on topic

?**topic** same as above; special chars need quotes: for example `?'&&'`

**help.search("topic")** search the help system; same as `??topic`

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

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

**summary(x)** generic function to give a "summary" of x, often a statistical one

**str(x)** display the internal structure of an R object

**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(x)** shows S3 methods of x

**methods(class=class(x))** lists all the methods to handle objects of class x

**findFn()** searches a database of help packages for functions and returns a data.frame (*sos*)

### Other R References

**CRAN task views** are summaries of R resources for task domains at: [cran.r-project.org/web/views](http://cran.r-project.org/web/views)  
Can be accessed via *ctv* package

**R FAQ:** [cran.r-project.org/doc/FAQ/R-FAQ.html](http://cran.r-project.org/doc/FAQ/R-FAQ.html)

**R Functions for Regression Analysis**, by Vito Ricci: [cran.r-project.org/doc/contrib/Ricci-refcard-regression.pdf](http://cran.r-project.org/doc/contrib/Ricci-refcard-regression.pdf)

**R Functions for Time Series Analysis**, by Vito Ricci: [cran.r-project.org/doc/contrib/Ricci-refcard-ts.pdf](http://cran.r-project.org/doc/contrib/Ricci-refcard-ts.pdf)

**R Reference Card for Data Mining**, by Yanchang Zhao: [www.rdatamining.com/docs/R-refcard-data-mining.pdf](http://www.rdatamining.com/docs/R-refcard-data-mining.pdf)

**R Reference Card**, by Jonathan Baron: [cran.r-project.org/doc/contrib/refcard.pdf](http://cran.r-project.org/doc/contrib/refcard.pdf)

## Operators

<-	Left assignment, binary
->	Right assignment, binary
=	Left assignment, but not recommended
<<-	Left assignment in outer lexical scope; not for beginners
\$	List subset, binary
-	Minus, can be unary or binary
+	Plus, can be unary or binary
~	Tilde, used for model formulae
:	Sequence, binary (in model formulae: interaction)
::	Refer to function in a package, i.e., <code>pkg::function</code> ; usually not needed
*	Multiplication, binary
/	Division, binary
^	Exponentiation, binary
%x%	Special binary operators, x can be replaced by any valid name
%%	Modulus, binary
%/%	Integer divide, binary
%*%	Matrix product, binary
%o%	Outer product, binary
%x%	Kronecker product, binary
%in%	Matching operator, binary (in model formulae: nesting)
! x	logical negation, NOT x
x & y	elementwise logical AND
x && y	vector logical AND
x   y	elementwise logical OR
x    y	vector logical OR
xor(x, y)	elementwise exclusive OR
<	Less than, binary
>	Greater than, binary
==	Equal to, binary
>=	Greater than or equal to, binary
<=	Less than or equal to, binary

## Packages

**install.packages("pkgs", lib)** download and install pkgs from repository (lib) or other external source

**update.packages** checks for new versions and offers to install

**library(pkg)** loads pkg, if pkg is omitted it lists packages

**detach("package:pkg")** removes pkg from memory

## Indexing vectors

x[n]	nth element
x[-n]	all but the nth element
x[1:n]	first n elements
x[-(1:n)]	elements from n+1 to 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
x[x %in% c("a","if")]	elements in the given set

## Indexing lists

x[n]	list with elements n
x[[n]]	nth element of the list
x[["name"]]	element named "name"
x\$name	as above (w. partial matching)

## 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 matrices data frames (same as matrices plus the following)

X[["name"]]	column named "name"
x\$name	as above (w. partial matching)

## Input and output (I/O)

### R data object I/O

**data(x)** loads specified data set; if no arg is given it lists all available data sets

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

**save.image(file)** saves all objects

**load(file)** load datasets written with save

### Database I/O

Useful packages: *DBI* interface between R and relational DBMS; *RJDBC* access to databases through the JDBC interface; *RMySQL* interface to MySQL database; *RODBC* ODBC database access; *ROracle* Oracle database interface driver; *RpgSQL* interface to PostgreSQL database; *RSQLite* SQLite interface for R

## Other file I/O

**read.table(file)**, **read.csv(file)**,  
**read.delim("file")**, **read.fwf("file")** read a file using defaults sensible for a table/csv/delimited/fixed-width file and create a data frame from it.  
**write.table(x,file)**, **write.csv(x,file)** saves x after converting to a data frame  
**txtStart** and **txtStop**: saves a transcript of commands and/or output to a text file (*TeachingDemos*)  
**download.file(url)** from internet  
**url.show(url)** remote input  
**cat(..., file="", sep=" ")** prints the arguments after coercing to character; sep is the character separator between arguments  
**print(x, ...)** 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()

## Clipboard I/O

File connections of functions can also be used to read and write to the clipboard instead of a file.

Mac OS: **x <- read.delim(pipe("pbpaste"))**

Windows: **x <- read.delim("clipboard")**

See also **read.clipboard** (*psych*)

## Data creation

**c(...)** generic function to combine arguments with the default forming a vector; with recursive=TRUE 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 in for loops  
**rep(x,times)** replicate x times; use each to repeat "each" element of x each times; rep(c(1,2,3),2) is 1 2 3 1 2 3; **rep(c(1,2,3),each=2)** is 1 1 2 2 3 3  
**data.frame(...)** create a data frame of the named or unnamed arguments data.frame(v=1:4, ch=c("a","B","c","d"), n=10); shorter vectors are recycled to the length of the longest  
**list(...)** create a list of the named or unnamed arguments; list(a=c(1,2),b="hi", c=3);

**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

## Data conversion

**as.array(x)**, **as.character(x)**, **as.data.frame(x)**,  
**as.factor(x)**, **as.logical(x)**, **as.numeric(x)**,  
convert type; for a complete list, use **methods(as)**

## Data information

**is.na(x)**, **is.null(x)**, **is.nan(x)**; **is.array(x)**,  
**is.data.frame(x)**, **is.numeric(x)**,  
**is.complex(x)**, **is.character(x)**; for a complete list, use **methods(is)**  
**x** prints x  
**head(x)**, **tail(x)** returns first or last parts of an object  
**summary(x)** generic function to give a summary  
**str(x)** display internal structure of the data  
**length(x)** number of 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)**, **ncol(x)** number of rows/cols; **NROW(x)**, **NCOL(x)** is the same but treats a vector as a one-row/col matrix  
**class(x)** get or set the class of x; **class(x) <- "myclass"**;  
**unclass(x)** removes 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

## Data selection and manipulation

**which.max(x)**, **which.min(x)** returns the index of the greatest/smallest element of x  
**rev(x)** reverses the elements of x  
**sort(x)** sorts the elements of x in increasing order; to sort in decreasing order: **rev(sort(x))**  
**cut(x,breaks)** divides x into intervals (factors); breaks is the number of cut intervals or a vector of cut points  
**match(x, y)** returns a vector of the same length as x with the elements of x that are in y (NA otherwise)  
**which(x == a)** returns a vector of the indices of x if the comparison operation is true (TRUE), 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!]  
**na.omit(x)** suppresses the observations with missing data (NA)  
**na.fail(x)** returns an error message if x contains at least one NA  
**complete.cases(x)** returns only observations (rows) with no NA  
**unique(x)** if x is a vector or a data frame, returns a similar object but with the duplicates suppressed  
**table(x)** returns a table with the numbers of the different values of x (typically for integers or factors)  
**split(x, f)** divides vector x into the groups based on f  
**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 variables to be kept (or dropped, using a minus)  
**sample(x, size)** resample randomly and without replacement size elements in the vector x, for sample with replacement use: replace = TRUE  
**sweep(x, margin, stats)** transforms an array by sweeping out a summary statistic  
**prop.table(x,margin)** table entries as fraction of marginal table  
**xtabs(a b,data=x)** a contingency table from cross-classifying factors  
**replace(x, list, values)** replace elements of x listed in index with values

## Data reshaping

**merge(a,b)** merge two data frames by common col or row names  
**stack(x, ...)** transform data available as separate cols in a data frame or list into a single col  
**unstack(x, ...)** inverse of **stack()**  
**rbind(...)**, **cbind(...)** combines supplied matrices, data frames, etc. by rows or cols  
**melt(data, id.vars, measure.vars)** changes an object into a suitable form for easy casting, (*reshape2* package)  
**cast(data, formula, fun)** applies fun to melted data using formula (*reshape2* package)  
**recast(data, formula)** melts and casts in a single step (*reshape2* package)  
**reshape(x, direction...)** reshapes data frame between 'wide' (repeated measurements in separate cols) and 'long' (repeated measurements in separate rows) format based on direction

## Applying functions repeatedly

(m=matrix, a=array, l=list; v=vector, d=dataframe)  
**apply(x,index,fun)** input: m; output: a or l; applies function fun to rows/cols/cells (index) of x  
**lapply(x,fun)** input l; output l; apply fun to each element of list x  
**sapply(x,fun)** input l; output v; user friendly wrapper for **lapply()**; see also **replicate()**  
**tapply(x,index,fun)** input l output l; applies fun to subsets of x, as grouped based on index  
**by(data,index,fun)** input df; output is class "by", wrapper for **tapply**  
**aggregate(x,by,fun)** input df; output df; applies fun to subsets of x, as grouped based on index. Can use formula notation.  
**ave(data, by, fun = mean)** gets mean (or other fun) of subsets of x based on list(s) by

**plyr** package functions have a consistent names: The first character is input data type, second is output. These may be d(ataframe), l(ist), a(rray), or \_(discard). Functions have two or three main arguments, depending on input:

**a\*ply(.data, .margins, .fun, ...)**  
**d\*ply(.data, .variables, .fun, ...)**  
**l\*ply(.data, .fun, ...)**

Three commonly used functions with ply functions are **summarise()**, **mutate()**, and **transform()**

## Math

Many math functions have a logical parameter **na.rm=FALSE** to specify missing data removal.  
**sin,cos,tan,asin,acos,atan,atan2,log,log10,exp**  
**min(x), max(x)** min/max of elements of x  
**range(x)** min and max elements of x  
**sum(x)** sum of elements of x  
**diff(x)** lagged and iterated differences of vector x  
**prod(x)** product of the elements of x  
**round(x, n)** rounds the elements of x to n decimals  
**log(x, base)** computes the logarithm of x  
**scale(x)** centers and reduces the data; can center only (scale=FALSE) or reduce only (center=FALSE)  
**pmin(x,y,...), pmax(x,y,...)** parallel minimum/maximum, returns a vector in which ith element is the min/max of x[i], y[i], ...  
**cumsum(x), cummin(x), cummax(x),**  
**cumprod(x)** a vector which ith element is the sum/min/max from x[1] to x[i]  
**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 convolutions of sequences  
**fft(x)** Fast Fourier Transform of an array  
**mvfft(x)** FFT of each column of a matrix  
**filter(x,filter)** applies linear filtering to a univariate time series or to each series separately of a multivariate time series

## Correlation and variance

**cor(x)** correlation matrix of x if it is a matrix or a data frame (1 if x is a vector)  
**cor(x, y)** linear correlation (or correlation matrix) between x and y  
**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  
**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

## Matrices

**t(x)** transpose  
**diag(x)** diagonal  
**%\*%** matrix multiplication  
**solve(a,b)** solves a  $a \%*\% x = b$  for x solve(a) matrix inverse of a  
**rowsum(x), colsum(x)** sum of rows/cols for a matrix-like object (consider **rowMeans(x)**, **colMeans(x)**)

## Distributions

Family of distribution functions, depending on first letter either provide: r(andom sample) ; p(robability density), c(umulative probability density), or q(uantile):

**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) (!!!?)  
**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  
**rbinom(n, size, prob)** negative binomial  
**runif(n, min=0, max=1)** uniform  
**rwilcox(nn, m, n), rsignrank(nn, n)** Wilcoxon

## Descriptive statistics

**mean(x)** mean of the elements of x  
**median(x)** median of the elements of x  
**quantile(x,probs=)** sample quantiles corresponding to the given probabilities (defaults to 0,.25,.5,.75,1)  
**weighted.mean(x, w)** mean of x with weights w  
**rank(x)** ranks of the elements of x  
**describe(x)** statistical description of data (in *Hmisc* package)  
**describe(x)** statistical description of data useful for psychometrics (in *psych* package)  
**sd(x)** standard deviation of x  
**density(x)** kernel density estimates of x

## Some statistical tests

**cor.test(a,b)** test correlation; **t.test()** t test;  
**prop.test()**, **binom.test()** sign test; **chisq.test()** chi-square test; **fisher.test()** Fisher exact test;  
**friedman.test()** Friedman test; **ks.test()** Kolmogorov-Smirnov test... use **help.search("test")**

## Models

### Model formulas

Formulas use the form: response ~ termA + termB ...

Other formula operators are:

- 1** intercept, meaning dependent variable has its mean value when independent variables are zeros or have no influence
- :** interaction term
- \*** factor crossing, **a\*b** is same as **a+b+a:b**
- ^** crossing to the specified degree, so **(a+b+c)^2** is same as **(a+b+c)\*(a+b+c)**
- removes specified term, can be used to remove intercept as in **resp ~ a - 1**
- %in%** left term nested within the right: **a + b %in% a** is same as **a + a:b**
- I()** operators inside parens are used literally: **I(a\*b)** means a multiplied by b
- |** conditional on, should be parenthetical

Formula-based modeling functions commonly take the arguments: data, subset, and na.action.

### Model functions

**aov(formula, data)** analysis of variance model  
**lm(formula, data)** fit linear models;  
**glm(formula, family, data)** fit generalized linear models; family is description of error distribution and link function to be used; see ?family  
**nls(formula, data)** nonlinear least-squares estimates of the nonlinear model parameters  
**lmer(formula, data)** fit mixed effects model (*lme4*); see also **lme()** (*nlme*)  
**anova(fit, data...)** provides sequential sums of squares and corresponding F-test for objects associated with a factor; to set use:  
**contrasts(fit, how.many) <- value**  
**glht(fit, linfct)** makes multiple comparisons using a linear function linfct (*mutcomp*)  
**summary(fit)** summary of model, often w/ t-values  
**confint(parameter)** confidence intervals for one or more parameters in a fitted model.  
**predict(fit,...)** predictions from fit

**df.residual(fit)** returns residual degrees of freedom  
**coef(fit)** returns the estimated coefficients (sometimes with 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)**, **BIC(fit)** compute Akaike or Bayesian information criterion  
**influence.measures(fit)** diagnostics for lm & glm  
**approx(x,y)** linearly interpolate given data points; x can be an xy plotting structure  
**spline(x,y)** cubic spline interpolation  
**loess(formula)** fit polynomial surface using local fitting  
**optim(par, fn, method = c("Nelder-Mead", "BFGS", "CG", "L-BFGS-B", "SANN"))** 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

### Flow control

**if(cond) expr**  
**if(cond) cons.expr else alt.expr**  
**for(var in seq) expr**  
**while(cond) expr repeat expr**  
**break**  
**next**  
**switch**  
Use braces {} around statements  
**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

### Writing functions

**function( arglist )** expr function definition,  
**missing** test whether a value was specified as an argument to a function  
**require** load a package within a function  
**<<-** attempts assignment within parent environment before search up thru environments  
**on.exit(expr)** executes an expression at function end  
**return(value)** or **invisible**

## Strings

**paste(vectors, sep, collapse)** concatenate vectors after converting to character; sep is a string to separate terms; collapse is optional string to separate “collapsed” results; see also **str\_c** below  
**substr(x,start,stop)** get or assign substrings in a character vector. See also **str\_sub** below  
**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)** replace pattern in x using regular expression matching; **sub()** is similar but only replaces the first occurrence.  
**tolower(x)**, **toupper(x)** convert to lower/uppercase  
**match(x,table)** a vector of the positions of first matches for the elements of x among table  
**x %in% table** as above but returns a logical vector  
**pmatch(x,table)** partial matches for the elements of x among table  
**nchar(x)** # of characters. See also **str\_length** below

**stringr** package provides a nice interface for string functions:

**str\_detect** detects the presence of a pattern; returns a logical vector  
**str\_locate** locates the first position of a pattern; returns a numeric matrix with col start and end. (**str\_locate\_all** locates all matches)  
**str\_extract** extracts text corresponding to the first match; returns a character vector (**str\_extract\_all** extracts all matches)  
**str\_match** extracts “capture groups” formed by () from the first match; returns a character matrix with one column for the complete match and one column for each group  
**str\_match\_all** extracts “capture groups” from all matches ; returns a list of character matrices  
**str\_replace** replaces the first matched pattern; returns a character vector  
**str\_replace\_all** replaces all matches.  
**str\_split\_fixed** splits string into a fixed number of pieces based on a pattern; returns character matrix  
**str\_split** splits a string into a variable number of pieces; returns a list of character vectors  
**str\_c** joins multiple strings, similar to paste  
**str\_length** gets length of a string, similar to nchar  
**str\_sub** extracts substrings from character vector, similar to substr



## Dates and Times

Class **Date** is dates without times. Class **POSIXct** is dates and times, including time zones. Class **timeDate** in *timeDate* includes financial centers.

**lubridate** package is great for manipulating time/dates and has 3 new object classes:

**interval class:** time between two specific instants.

Create with **new\_interval()** or subtract two times. Access with **int\_start()** and **int\_end()**

**duration class:** time spans with exact lengths  
**new\_duration()** creates generic time span that can be added to a date; other functions that create duration objects start with d:  
dyears(), dweeks()...

**period class:** time spans that may not have a consistent length in seconds; functions include: years(), months(), weeks(), days(), hours(), minutes(), and seconds()

**ymd(date, tz), mdy(date, tz), dmy(date, tz)**  
transform character or numeric dates to POSIXct object using timezone tz (*lubridate*)

**Other time packages:** *zoo*, *xts*, *its* do irregular time series; *TimeWarp* has a holiday database from 1980+; *timeDate* also does holidays; *tseries* for analysis and computational finance; *forecast* for modeling univariate time series forecasts; *fts* for faster operations; *tis* for time indexes and time indexed series, compatible with FAME frequencies.

**Date and time formats** are specified with:

%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); first Sun is day 1 of wk 1

%w Weekday (0-6, Sunday is 0)

%W Week (00-53); 1st Mon is day 1 of wk 1

%y Year without century (00-99) Don't use

%Y Year with century

%z (output only) signed offset from Greenwich;  
-0800 is 8 hours west of

%Z (output only) Time zone as a character string

## Graphs

There are three main classes of plots in R: base plots, grid & lattice plots, and *ggplot2* package. They have limited interoperability. Base, grid, and lattice are covered here. *ggplot2* needs its own reference sheet.

### Base graphics

**Common arguments for base plots:**

**add=FALSE** if TRUE superposes the plot on the previous one (if it exists)

**axes=TRUE** 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": same as previous but lines are over the points, "h": vertical lines, "s": steps, data are represented by the top of the vertical lines, "S": same as previous but 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)

### Base plot functions

**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=TRUE 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)

**boxplot(x)** "box-and-whiskers" plot

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

**coplot(x~y | 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)** same as above 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 distribution

**qqplot(x, y)** diagnostic plot of quantiles of y vs. quantiles of x; see also qqPlot in *cars* package and distplot in *vcd* package

**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). See also filled.contour, image, and persp

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

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

**colorRampPalette** creates a color palette (use: colfunc <- colorRampPalette(c("black", "white")); colfunc(10)

### Low-level base plot arguments

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

**lines(x, y)** same as above 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)** same as above 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 abscissa x

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

**rect(x1, y1, x2, y2)** draws a rectangle with left, right, bottom, and top limits of 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

**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 abscissa (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")

## Plot 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" ou "j"

(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: "red", "blue" see `colors()` or as "#RRGGBB"; see `rgb()`, `hsv()`, `gray()`, and `rainbow()`; as for `cex` there are: `col.axis`, `col.lab`, `col.main`, `col.sub`

**font** an integer that 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 that 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") that 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** numeric that controls the width of lines, default 1

**mar** a vector of 4 numeric values that 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)`

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

**mfrow** same as above but the plots are drawn by row

**pch** controls the type of symbol, either an integer between 1 and 25, or any single char within ""

1 ○ 2 △ 3 + 4 × 5 ◇ 6 ▽ 7 ☒ 8 ✱  
 9 ⬡ 10 ⊕ 11 ⊗ 12 ⊞ 13 ⊠ 14 ⊞ 15 ■  
 16 ● 17 ▲ 18 ◆ 19 ● 20 ● 21 ○ 22 □ 23 ◇  
 24 △ 25 ▽ \* \* . . X X a a ? ?

**ps** an integer that controls the size in points of texts and symbols

**pty** a character that specifies the type of the plotting region, "s": square, "m": maximal

**tck** a value that 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 that 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 conjunction with `axis(side=1, ...)`)

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

## Lattice graphics

Lattice functions return objects of class `trellis` and must be printed. Use `print(xyplot(...))` inside functions where automatic printing doesn't work. Use `lattice.theme` and `lset` to change Lattice defaults. In the normal Lattice formula, `y | g1*g2` has combinations of optional conditioning variables `g1` and `g2` plotted on separate panels. Lattice functions take many of the same args as base graphics plus also `data=` the data frame for the formula variables and `subset=` for subsetting. Use `panel=` to define a custom panel function (see `apropos("panel")` and `?llines`).

**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