Stat-340 – Final Exam

If you are in Stat-341 and/or Stat-342, only write the portion (*SAS* or *R*) that is applicable to your course. Students in Stat-340 must do all questions.

Part 1 - Multiple Choice

Enter your answers to the multiple choice questions on the provided bubble sheets. Each of the multiple choice question is worth 1 mark – there is no correction for guessing. Be sure your student name and number are completed on the bubble sheets.

1. ***R*** Consider the following *R* code fragment;

```
> df
  var abc var.abc
1   1   2   3
2   4   5   6
3   7   8   9
> var <- 'abc'
```

Then the value of `df[,var]` is:

(a) 1, 4, 7

(b) 2, 5, 8

(c) 3, 6, 9

(d) 4, 5, 6

(e) 1, 2, 3

2. ***R*** Consider the following model fit:

```
my.fit <- glm( fatal ~ month, data=accident, family=binomial(link=logit))
```

where the *fatal* and *accident* variables are both declared as factors. The *fatal* variable has two levels 0 and 1 representing *no* and *yes* respectively; the *month* takes the values of $1, \ldots, 12$. Which of the following is correct?

(a) `anova(my.fit)` constructs an Analysis of Deviance Table to test the hypothesis that the mean number of fatalities is the same in all months.

(b) `coef(my.fit)` returns the slope and intercept for a regression of the fatality rate over the months.

(c) `confint(my.fit)` returns confidence intervals for the proportion of fatalites for each month.

(d) `summary(lsmeans(my.fit, month))` returns the log-odds of the proportion of fatalities for each month.

(e) `ggplot(my.fit)` creates a plot of the proportion of fatalities for each month with 95% confidence intervals.

3. ***R*** We wish to consider the average grade of three assignments for student. Here is the data frame:

```
> df
  Student assignment grade
1       a          1    13
2       a          2    20
3       b          1    10
4       b          2    11
5       b          3    12
6       c          1    17
7       c          2    NA
8       c          3    18
```

Notice that student a did not hand in assignment 3, and student c did not hand in assignment 3. Then the value of `ddply(df, "Student", summarize, mean.assign=mean(grade))` is:

(a)
```
  Student mean.assign
1       a        11.0
2       b        11.0
3       c          NA
```

(b)
```
  Student mean.assign
1       a        16.5
2       b        11.0
3       c        11.7
```

(c)
```
  Student mean.assign
1       a          NA
2       b        11.0
3       c          NA
```

(d)
```
  Student mean.assign
1       a          NA
2       b        11.0
3       c        17.5
```

(e)
```
  Student mean.assign
1       a        16.5
2       b        11.0
3       c          NA
```

4. ***R*** Consider the following code fragment that analyzed a survey that asked for a student' sex:

```
survey <- data.frame(sex=c('m','f','yes','f','m','m'), stringsAsFactors=FALSE)
survey$sexF <- factor(survey$sex, levels=c('f','m'))
```

Which of the following is the correct output from `str(survey)`?

(a)
```
  Student mean.assign
'data.frame': 6 obs. of  2 variables:
 $ sex : chr  "m" "f" "yes" "f" ...
 $ sexF: Factor w/ 2 levels "f","m": m f NA f m m
```

(b)
```
'data.frame': 6 obs. of  2 variables:
 $ sex : chr  "m" "f" "yes" "f" ...
 $ sexF: Factor w/ 2 levels "f","m": 1 2 3 2 1 1
```

(c)
```
'data.frame': 6 obs. of  2 variables:
 $ sex : chr  "m" "f" "yes" "f" ...
 $ sexF: Factor w/ 2 levels "f","m": 2 1 3 1 2 2
```

(d)
```
'data.frame': 6 obs. of  2 variables:
 $ sex : chr  "m" "f" "yes" "f" ...
 $ sexF: Factor w/ 2 levels "f","m": 1 2 NA 2 1 1
```

(e)
```
'data.frame': 6 obs. of  2 variables:
 $ sex : chr  "m" "f" "yes" "f" ...
 $ sexF: Factor w/ 2 levels "f","m": 2 1 NA 1 2 2
```

5. **R** Consider a data frame of assignment grades for students:

```
> df
  Student assignment grade
1       a          1    13
2       a          2    20
3       b          1    10
4       b          2    11
5       b          3    12
6       c          1    17
7       c          2    NA
8       c          3    18
```

Which of the following is correct

(a) `df["a",]`
```
  Student assignment grade
1       a          1    13
2       a          2    20
>
```

(b) `> df[,2]`
```
[1] 1 2 1 2 3 1 2 3
```

(c) `> df[3,]`
```
[1] 13 20 10 11 12 17 NA 18
```

(d) `> df['grade' , ]`
```
[1] 13 20 10 11 12 17 NA 18
```

(e) `df[df$assignment==1, ]`
```
[1]  TRUE FALSE  TRUE FALSE FALSE  TRUE FALSE FALSE
```

6. ***SAS*:** Consider the following piece of *SAS* code:

```
data blah;
    infile datalines dlm=',' dsd missover;
    length name $10;
    input name hairs mites;
    datalines;
a, 10, 23
b,  5,  12
c,  3,  .
d,  ., 20
;;;;
proc means data=blah;
    var hairs mites;
run;
```

Which of the following is correct:

(a) The computed mean value for *hairs* is 7.5

(b) The computed mean value for *mites* is 13.75.

(c) The computed mean value for *hairs* is 2.25.

(d) The computed mean value for *mites* is 12.5.

(e) The computed mean value for *hairs* is 6.0.

7. ***SAS*:** Which of the following is correct about the *MISSOVER* option on the *INFILE* statement in the *DATA* step ?

(a) Missing values are automatically skipped in the input dataset.

(b) Short data records are padded with missing values.

(c) It allows *SAS* to read a data record over two (or more) data lines.

(d) It implies that two commas in a row in the data are interpreted as a missing value.

(e) Missing data is replaced by imputed data.

8. ***SAS*:** Given the following SAS error log

```
44   data NEW;
45     set OLD;
46     BMI=(Weight*703)/Height**2;
47     where bmi ge 20;
ERROR: Variable bmi is not on file OLD.
48   run;
```

What change to the program will correct the error?

(a) Replace the *WHERE* statement with an *IF* statement.

(b) Change the ** in the BMI formula to a single *.

(c) Change *bmi* to *BMI* in the *WHERE* statement.

(d) Add a *Keep BMI;* satement.

(e) Add a *bmi=10;* statements after the *set* statement.

9. ***SAS*:** Which of the following is correct?

(a) *Proc Genmod* is typically used for analyses of means.

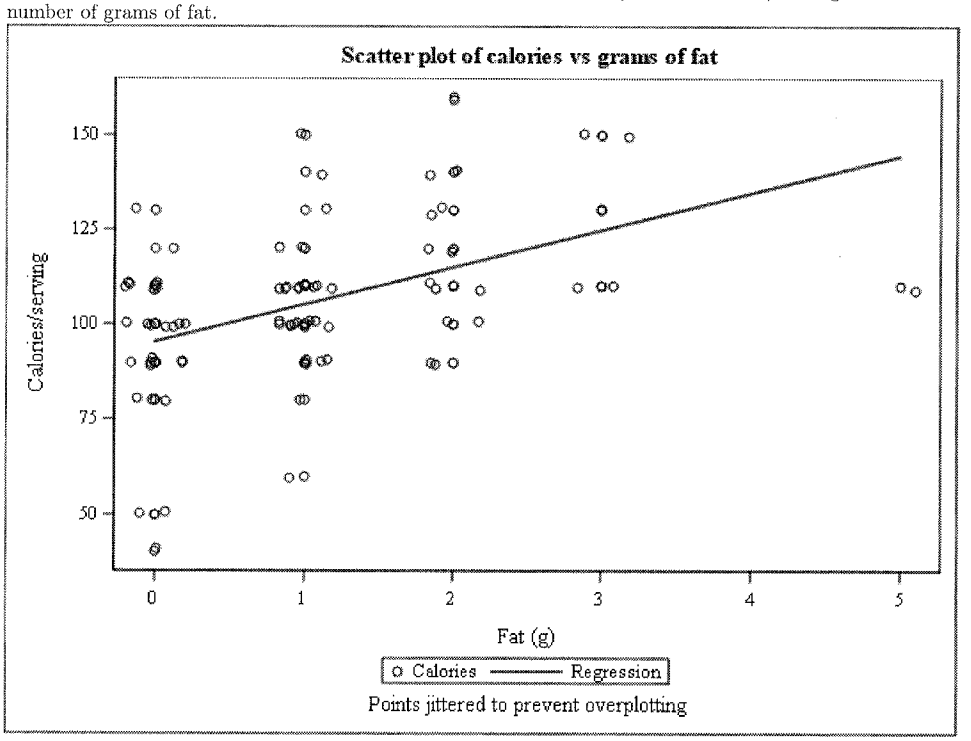
(b) *Proc Glm* is typically used for the analysis or proportions.

(c) *Proc Reg* is typically used for analysis of variance.

(d) *Proc Ttest* is typically used for comparing mean of 3 or more groups.

(e) *Proc Means* is typically used for commuting summary statistics.

10. ***SAS*:** Consider the following graph created by *Proc SGplot* looking at the calories/serving vs. the number of grams of fat.



Which of the following is correct?

(a) The `scatter` statement plotted the individual data points with an option for jittering.

(b) The `reg` statement jittered the data points.

(c) The `x-axis` statement added the *Calories/serving* to the Y-axis.

(d) The `geom_smooth` statement added the regression line to the plot.

(e) The `geom_jitter` statement plotted the individual points and added jittering.

Part II - Long Answer

Stat-340 - [ ] - Final Exam

Name

Student Number:

Put your name and student number on the upper right of each of the following pages as well in case the pages get separated.

Answer the following questions in the space provided. Be sure that your answers are legible.

The marks given to these questions are 5, 5, 5, and 5 respectively.

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1. ***R*: Temperature changes over time** - 5 Marks:
Long term temperature records have been used as evidence of global warming. The *temperature.csv* file contains average daily temperatures at several weather stations since 1900. We are particularly interested in the summer temperatures, i.e. between 21 June and 21 September of each year which correspond to julian days (number of days since 1 January of each year) 172 and 264.

The relevant variables in the file are:

- *StationID* identifying the weather station.
- *Year* of the accident (4 digits).
- *Month* of the accident (1 to 12).
- *Day* of the accident (1 to 31).
- *Temp* - the average daily temperature (°C).

There are no missing values for any variable.

Write *R* code to do the following:

- Read the *csv* file. You can assume that the variable names are in the first row of the file.
- Creates a date variable from the year, month, and day variables.
- Extracts the julian date (day of the year) from the date variable.
- Selects only those records where the julian date falls between 172 and 264 inclusive.
- Computes the average summer daily temperature for each year and station combination.
- Plots the yearly average summer daily temperatures vs. year with a separate color and shape for each station.
- Adds a regression line to the plot for each station.

Put your *R* code here and the page overleaf (if needed)

Continue your R code here if needed.

2. *R*: Estimating the average number of mites living on you (a real story) - 5 Marks[1]

Mites are relatives of ticks, spiders, scorpions and other arachnids. Over 48,000 species have been described. Around 65 of them belong to the genus *Demodex*, and two of those species live on your face! (Really, I'm not making this up!). These two species are evolution's special gift to you. They live on humans and humans alone.

The mites aren't inherited at birth, so each generation picks them up anew, probably from direct contact with our parents. They crawl! They move about in darkness and freeze in bright lights. And they have sex! On your face! Their favourite hook-up spots are the rims of your hair follicles on your eye lashes.

Now that I've got your attention, we wish to estimate the average number of these mites on a typical person. A sample of people were selected (we will assume it is a simple random sample); a sample of eye lashes was plucked from each person; and the number of mites on each hair follicle was counted under a microscope. Here is the raw data:

```
> mites
  Person Hairs Mites
1      a    10    23
2      b     5    12
3      c     3    10
4      d     8    20
```

We wish to estimate the average number of mites per hair and then expand this estimate to estimate the number of mites/person. A common estimator is the ratio estimator defined as

$$\widehat{R} = \frac{\text{total mites}}{\text{total hairs}} = \frac{\sum Mites_i}{\sum Hairs_i}$$

The standard error of the ratio estimator under simple random sampling is:

$$se(\widehat{R}) = \frac{sd(diff)}{mean(hairs)\sqrt{n}}$$

where n is the number of people sampled; *diff* is defined as

$$diff_i = Mites_i - \widehat{R} \times Hairs_i$$

i.e. the difference between the actual number of mites and the predicted number of mites given the ratio estimator and the number of hairs measured; *sd()* and *mean()* are the usual standard deviation and mean functions.

Write an *R* function that takes a data frame, the numerator (the top variable in a fraction) variable, the denominator (the bottom variable in a fraction) variable, computes the ratio estimator and its standard error, and returns the values in a data frame.

I'll start you off:

```
ratio.est <- function( df, num, denom){}
```

Here is some output:

```
> ratio.est(mites, "Mites", "Hairs")
   R        se
1 2.5 0.1439099
```

By the way, the average person is estimated to have about 400 eyelashes in total. So, on average, how many 'close friends' do you have living in your eyelashes?

Put your *R* code overleaf:

[1] Adopted from http://blogs.discovermagazine.com/notrocketscience/2012/08/31/everything-you-never-wanted-to-know-about-the-mi
#.VSdRR1yp3C4

Put your R code here for the mites problem.

3. ***SAS*: Temperature changes over time** - 5 Marks:

Long term temperature records have been used as evidence of global warming. The *temperature.csv* file contains average daily temperatures at several weather stations since 1900. We are particularly interested in the summer temperatures, i.e. between 21 June and 21 September of each year which correspond to julian days (number of days since 1 January of each year) 172 and 264.

The relevant variables in the file are:

- *StationID* identifying the weather station - up to 20 characters long.
- *Date* - date in the format yyyy-mm-dd.
- *Temp* - the average daily temperature (°C).

There are no missing values for any variable.

Write *SAS* code to do the following:

- Read the *csv* file. The variable names are NOT in the first row of the dataset.
- Extract the year from the date. The `year(date)` returns the year from a date variable.
- Extracts the julian date (day of the year) from the date variable. The `JULDATE7(date)` function converts the *SAS* date to a numeric value of the form *yyyyddd*. For example `juldate7('31Dec2013'd)` returns the numeric value 2013365 where the first four digits are the year (2013) and the last three digits are the julian date (001 to 366). The `mod(value, 1000)` will extract the last 3 digits, i.e. `mod(2013365,1000)` returns the value of 365.
- Selects only those records where the julian date falls between 172 and 264 inclusive.
- Computes the average summer daily temperature for each year and station combination.
- Plots the yearly average summer daily temperatures vs. year with a separate color for each station.
- Adds a regression line to the plot for each station.

Put your *SAS* code here and the page overleaf (if needed)

Continue your *SAS* code here if needed.

4. *SAS*: Relationship of GPA and grade in Stat-340 - 5 marks

I'm interested in the relationship between a student's grade in Stat-340 and their incoming GPA.

I have two csv files. The first file, named *stat340.csv*, contains the student number (character with up to 8 characters) and the student mark (out of 100) in Stat-340. The second file, named *sfu.csv*, contains the student number (character with up to 8 characters), the student incoming GPA, and the students sex for ALL students at SFU. Obviously, not every student at SFU takes Stat-340 (but they should!)

Write *SAS* code to do the following:

- Reads the two files.
- Merges the two dataset to get a final data set that has the student number, Stat-340 grade, the incoming GPA, and the sex. The merged data frame should contain only the students in Stat-340.
- Plots the Stat-340 grade vs. the GPA. The GPA will be the predictor variable. Points on the plot should be distinguished by the sex of the student. Add a regression line to the plot for each sex. The plot must have suitable labels for both axes and a proper title.
- Fits a simple regression line between the two variables for each sex and saves the coefficients to a data table. The ODS table name is *ParameterEstimates*. The output data set has the variables as shown below:

Obs	sex	Model	Dependent	Variable	DF	Estimate	StdErr	tValue	Probt

- Makes a nice table showing the sex, the estimates, the standard error, and the p-value with suitable labels for each column. The estimates and standard errors should be displayed with at most 2 decimal places.

Continue your *SAS* code here if needed.

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 Can be accessed via *ctv* package
R FAQ: 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
R Functions for Time Series Analysis, by Vito Ricci: 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
R Reference Card, by Jonathan Baron: 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, pkg::function; 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 %*% 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*) (!!!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

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 depdendent 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
contrasts(fit, contrasts = TRUE) view contrasts 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 lengths 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 plotr 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 abcissa 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 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")

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 "]" (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

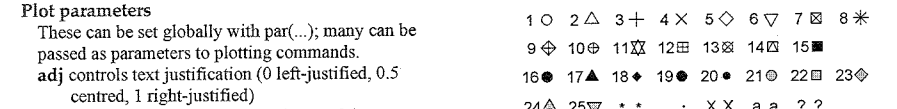
lwd numeric that controls the width of lines, default 1

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)

mfcol 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 ""



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 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 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 x|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

Geoms

geom_abline(aes(intercept, slope), alpha, colour, linetype, size)
The abline geom adds a line with specified slope and intercept to the plot.

geom_area(aes(x, ymin=0, ymax), alpha, colour, fill, linetype, size)
An area plot is the continuous analog of a stacked bar chart (see geom_bar), and can be used to show how composition of the whole varies over the range of x. Choosing the order in which different components is stacked is very important, as it becomes increasing hard to see the individual pattern as you move up the stack.

geom_bar(aes(x), alpha, colour, fill, linetype, size, weight)
The bar geom is used to produce 1d area plots: bar charts for categorical x, and histograms for continuous y. stat_bin explains the details of these summaries in more detail. In particular, you can use the weight aesthetic to create weighted histograms and barcharts where the height of the bar no longer represent a count of observations, but a sum over some other variable.

geom_bin2d(aes(xmax, xmin, ymax, ymin), alpha, colour, fill, linetype, size, weight)
Add heatmap of 2d bin counts.

geom_blank(aes(),)
The blank geom draws nothing, but can be a useful way of ensuring common scales between different plots.

geom_boxplot(aes(lower, middle, upper, x, ymax, ymin), alpha, colour, fill, linetype, shape, size, weight, notch=FALSE,)
The upper and lower "hinges" correspond to the first and third quartiles (the 25th and 75th percentiles). This differs slightly from the method used by the boxplot function, and may be apparent with small samples. See boxplot.stats for for more information on how hinge positions are calculated for boxplot.

geom_contour(aes(x, y), alpha, colour, linetype, size, weight)
Display contours of a 3d surface in 2d. See stat_contour.

geom_crossbar(aes(x, y, ymax, ymin), alpha, colour, fill, linetype, size)
Hollow bar with middle indicated by horizontal line. See geom_linerange.

geom_density(aes(x, y), alpha, colour, fill, linetype, size, weight)
A smooth density estimate calculated by stat_density.

geom_density2d(aes(x, y), alpha, colour, fill, linetype, size)
Perform a 2D kernel density estimatation using kde2d and display the results with contours.

geom_dotplot(aes(x, y), alpha, colour, fill)
In a dot plot, the width of a dot corresponds to the bin width (or maximum width, depending on the binning algorithm), and dots are stacked, with each dot representing one observation.

geom_errorbar(aes(x, ymax, ymin), alpha, colour, linetype, size, width)
Error bars.

geom_freqpoly(aes(x), alpha, colour, linetype, size)
Frequency polygon.

geom_hex(aes(x, y), alpha, colour, fill, size)
Hexagon binning.

geom_histogram(aes(x), alpha, colour, fill, linetype, size, weight)
geom_histogram is an alias for geom_bar plus stat_bin (look there to see parameters).

geom_hline(aes(yintercept), alpha, colour, linetype, size)
This geom allows you to annotate the plot with horizontal lines.

geom_jitter(aes(x, y), alpha, colour, fill, shape, size)
The jitter geom is a convenient default for geom_point with position = 'jitter'. See position_jitter to see how to adjust amount of jittering.

geom_line(aes(x, y), alpha, colour, linetype, size)
Connect observations, ordered by x value.

geom_linerange(aes(x, ymin, ymax),)
An interval represented by a vertical line

geom_map(aes(map_id), alpha, colour, fill, linetype, size)
Need data frame with map coordinates, with columns x or long, y or lat, and region or id. With geom_polygon will need two data frames - coordinates of the polygon (positions) and values for each polygon (values) linked by an id variable. expand_limits() may also be helpful.

geom_path(aes(x, y), alpha, colour, linetype, size)
Connect observations in original order.

geom_point(aes(x, y), alpha, colour, fill, shape, size)
Used to create scatterplots.

geom_pointrange(aes(x, y, ymax, ymin), alpha, colour, fill, linetype, shape, size)
An interval represented by a vertical line with a point in the middle. See geom_linerange.

geom_polygon(aes(x, y), alpha, colour, fill, linetype, size)
Polygon, a filled path.

geom_quantile(aes(x, y), alpha, colour, linetype, size, weight)
A continuous analogue of geom_boxplot.

geom_raster(aes(x, y), alpha, fill)
This is a special case of geom_tile where all tiles are the same size. It is implemented highly efficiently using the internal rasterGrob function.

geom_rect(aes(xmax, xmin, ymax, ymin), alpha, colour, fill, linetype, size)
2d rectangles.

geom_ribbon(aes(x, ymax, ymin), alpha, colour, fill, linetype, size)
Ribbons, y range with continuous x values.

geom_rug(aes(), alpha, colour, linetype, size)
Marginal rug plots.

geom_segment(aes(x, xend, y, yend), alpha, colour, linetype, size)
Single line segments.

geom_smooth(aes(x, y), alpha, colour, fill, linetype, size, weight)
Add a smoothed conditional mean. See stat_smooth()

geom_step(aes(x, y), alpha, colour, linetype, size)
Connect observations by stairs.

geom_text(aes(label, x, y), alpha, angle, colour, family, fontface, hjust, lineheight, size, vjust)
Textual annotations.

geom_tile(aes(x, y), alpha, colour, fill, linetype, size)
Similar to levelplot and image.

geom_violin(aes(x, y), alpha, colour, fill, linetype, size, weight)
Violin plot

geom_vline(aes(xintercept), alpha, colour, linetype, size)
This geom allows you to annotate the plot with vertical lines (see geom_hline and geom_abline for other types of lines.

Positions

position_dodge(width = NULL, height = NULL)
Adjust position by dodging overlaps to the side.

position_fill(width = NULL, height = NULL)
Stack overlapping objects on top of one another, and standardise to have equal height.

position_identity(width = NULL, height = NULL)
Don't adjust position

position_stack(width = NULL, height = NULL)
Stack overlapping objects on top of one another

position_jitter(width=NULL, height=NULL)
Jitter points to avoid overplotting.

Statistics

`stat_bin`(binwidth, breaks, origin, width, right=TRUE, drop=FALSE, ...)

`stat_bin2d`(bins, drop=FALSE, ...)

`stat_bindot`(binaxis="x", method="dotdensity", binwidth, binpositions, origin, right=TRUE, drop=FALSE, na.rm=FALSE, aes(), geom, position)

`stat_binhex`(bins=c(30, 30), na.rm=FALSE, ...)
Bin 2d plane into hexagons

`stat_boxplot`(coef=1.5, na.rm=FALSE, ...)
Calculates components of box and whisker plot.

`stat_contour`(na.rm=FALSE, ..., bins, binwidth)
Calculates contours of 3d data; bins gives number of contours, binwidth specifies the same thing by contour width. Also possible to map size or color to contour level by =..level..

`stat_density`(adjust, kernel, trim=TRUE, na.rm=FALSE, ...)
1d kernel density estimate.

`stat_density2d`(contour=TRUE, n, kde2d(...), na.rm=TRUE, ...)
2d density estimation. `kde2d(...)` is for other arguments to be passed to `kde2d`.

`stat_ecdf`(n, ...)
Empirical CDF of x. If n is NULL, do not interpolate, otherwise, interpolate over n points.

`stat_function`(fun, n, args, ...)
Superimpose a function, `fun`, n points to interpolate along, with `args()` to pass to `fun`.

`stat_identity`(width, height)
Identity statistic - width and height describe the width and height of the tiles.

`stat_qq`(distribution, dparams, ..., na.rm=FALSE, ...)
Calculation for quantile-quantile plot. distribution function `dist` with parameters `dparams` and other arguments ...

`stat_quantiles`(quantiles, formula, method="rq", na.rm=FALSE, ...)
quantiles of y to calculate, using `formula` and currently only supports method `rq`

`stat_smooth`(method, formula, se=TRUE, fullrange, level=0.95, n, na.rm=FALSE, ...)
Uses a smoother fit by one of `lm`, `glm`, `gam`, `loess`, or `rlm`.

`stat_spoke`(...)
convert angle and radius to xend and yend. Requires aes(angle, radius, x, y).

`stat_summary_hex`(bins, drop=TRUE, fun, ..., ...)
Apply function for 2d hexagonal bins. Bins from `stat_binhex` with `fun` for summary applied to each bin. ... includes function arguments as well as standard stat arguments

`stat_summary2d`(bins, drop, fun, ..., ...)
Apply function for 2d rectangular bins. Bins from `stat_bin2d` with `fun` for summary applied to each bin. ... includes function arguments as well as standard stat arguments

`stat_unique`(...)
Removes duplicates

`stat_ydensity`(trim=TRUE, scale="area", na.rm=FALSE, ..., adjust, kernel, ...)
1d kernel density estimate along y axis for violin plot. If scale="count" areas are scaled proportionate to the number of observations. If scale="width", all violins have the same maximum width.

`stat_sum`(...)
Sum unique values - useful for overplotting on scatterplots.

`stat_summary`(...)
Allows flexibility in specification of summary functions - either operating on the data frame with argument name `fun.data` or on a vector `fun.y`, `fun.ymax`, `fun.ymin`.

Coordinate systems

`coord_cartesian`(xlim, ylim)
Setting limits on the coordinate system will zoom the plot (like you're looking at it with a magnifying glass), and will not change the underlying data like setting limits on a scale will.

`coord_fixed`(ratio = 1, xlim = NULL, ylim = NULL)
Forces a specified ratio between the physical representation of data units on the axes. The ratio represents the number of units on the y-axis equivalent to one unit on the x-axis.

`coord_flip`(...)
Flipped cartesian coordinates so horizontal becomes vertical.

`coord_map`(projection = "mercator", ..., orientation = c(90, 0, mean(range(x))), xlim = NULL, ylim = NULL)
This coordinate system provides the full range of map projections available in the mapproj package. Alternate projections can be found in that package.

`coord_polar`(theta = "x", start = 0, direction = 1)
The polar coordinate system is most commonly used for pie charts, which are a stacked bar chart in polar coordinates.

`coord_trans`(xtrans = "identity", ytrans = "identity", limx = NULL, limy = NULL)
Different from scale transformations in that it occurs after statistical transformation and will affect the visual appearance of geoms - there is no guarantee that straight lines will continue to be straight. Currently works only with cts values.

Faceting

`facet_grid`(facets, margins = FALSE, scales = "fixed", space = "fixed", shrink = TRUE, labeller = "label_value", as.table = TRUE, drop = TRUE)
Lay out panels in a grid.

`facet_null`(shrink=TRUE)
Specifies a single panel. If shrink=TRUE, will shrink scales to fit output of statistics, not raw data. If FALSE, will be range of raw data before statistical summary.

`facet_wrap`(facets, nrow = NULL, ncol = NULL, scales = "fixed", shrink = TRUE, as.table = TRUE, drop = TRUE)
Wrap a 1d ribbon of panels into 2d.

`label_both`
Passed in `facet_grid` to the labeller argument. Labels with variable name and value.

`label_bquote`(...)
Passed in `facet_grid` to the labeller argument. See bquote for details on the syntax of the argument. The label value is x. Useful for facet labels that are expressions

`label_parsed`(...)
Passed in `facet_grid` to the labeller argument. Label facets with parsed label. Useful for facet labels that are expressions.

`label_value`(...)
Passed in `facet_grid` to the labeller argument. Default labels.

Scales

`expand_limits`(...)
named list of aesthetics specifying the value that should be included in each scale

guides(...)
List of scale guide pairs

`guide_legend`(title = waiver(), title.position = NULL, title.theme = NULL, title.hjust = NULL, title.vjust = NULL, label = TRUE, label.position = NULL, label.theme = NULL, label.hjust = NULL, label.vjust = NULL, keywidth = NULL, keyheight = NULL, direction = NULL, default.unit = "line", override.aes = list(), nrow = NULL, ncol = NULL, byrow = FALSE, reverse = FALSE, order = 0, ...)
Legend type guide shows key (i.e., geoms) mapped onto values. Legend guides for various scales are integrated if possible.

`guide_colorbar`(title = waiver(), title.position = NULL, title.theme = NULL, title.hjust = NULL, title.vjust = NULL, label = TRUE, label.position = NULL, label.theme = NULL, label.hjust = NULL, label.vjust = NULL, barwidth = NULL, barheight = NULL, nbin = 20, raster = TRUE, ticks = TRUE, draw.ulim = TRUE, draw.llim = TRUE, direction = NULL, default.unit = "line", reverse = FALSE, order = 0, ...)
Colour bar guide shows continuous color scales mapped onto values. Colour bar is available with `scale_fill` and `scale_colour`.

`scale_alpha`(..., range = c(0.1, 1))

`scale_area`(..., range=c(1,6))

`scale_colour_brewer`(..., type="seq", palette=1)
Substitute color or fill for colour. If palette is a string, will use that name, otherwise, will index the list of palettes.

`scale_colour_gradient`(..., low = "#132B43", high = "#56B1F7", space = "Lab", na.value = "grey50", guide = "colourbar")
Substitute color or fill for colour. Also aliases `scale_colour_continuous`.

`scale_colour_gradient2`(..., low = muted("red"), mid = "white", high = muted("blue"), midpoint = 0, space = "rgb", na.value = "grey50", guide = "colourbar")
Diverging color scheme. Substitute color or fill for colour.

`scale_colour_gradientn`(..., colours, values = NULL, space = "Lab", na.value = "grey50", guide = "colourbar")
Smooth color gradient between n colors. Substitute color or fill for colour.

`scale_colour_grey`(..., start = 0.2, end = 0.8, na.value = "red")

`scale_colour_hue`(..., h = c(0, 360) + 15, c = 100, l = 65, h.start = 0, direction = 1, na.value = "grey50")
Qualitative colour scale with evenly spaced hues. Substitute color or fill for colour. Also aliases `scale_colour_discrete`.

`scale_colour_identity`(..., guide="none")
Use values without scaling. Substitute fill, shape, linetype, alpha, size, color for colour.

`scale_colour_manual`(..., values)
Create your own discrete scale

`scale_linetype_discrete`(..., na.value = "blank")
Must be a discrete scale.

`scale_shape_discrete`(..., solid = TRUE)
Must be a discrete scale.

`scale_size`(..., range = c(1, 6))
Can be discrete (`scale_size_discrete`) or continuous. Range specifies minimum and maximum size of plotting symbols after transformation.

`scale_x_continuous`(..., expand=waiver())
Also works for y. Common parameters: name, breaks, labels, na.value, limits, trans. Aliases for transformations: `scale_x_log10`, `scale_x_reverse`, `scale_x_sqrt`.

`scale_x_date`(..., expand = waiver(), breaks = pretty_breaks(), minor_breaks = waiver())
Also works for y. Args: `breaks` = vector of breaks, `minor_breaks` = locations of minor breaks between labeled breaks.

`scale_x_datetime`(..., expand = waiver(), breaks = pretty_breaks(), minor_breaks = waiver())
Also works for y. Args: `breaks` = vector of breaks, `minor_breaks` = locations of minor breaks between labeled breaks.

`scale_x_discrete`(..., expand = waiver())
Also works for y. You can use continuous positions even with a discrete position scale - this allows you (e.g.) to place labels between bars in a bar chart. Continuous positions are numeric values starting at one for the first level, and increasing by one for each level (i.e. the labels are placed at integer positions). This is what allows jittering to work.

`labs`(title, x, y)

`xlab`(label)

ggtitle(title)

`update_labels`(p, labels)
p is the plot to modify, labels are a named list of new labels. Works for axis, legend labels.

`xlim`(...)
If numeric, will create a continuous scale, if factor or character, will create a discrete scale. Observations not in this range will be dropped completely and not passed to any other layers.

Themes

`add_theme`(t1, t2, t2name)
Modify properties of an element in a theme object. Add t1 to t2 and name it t2name.

`element_blank`()()
This theme element draws nothing, and assigns no space

`element_line`(colour = NULL, size = NULL, linetype = NULL, lineend = NULL, color = NULL)

`element_rect`(fill = NULL, colour = NULL, size = NULL, linetype = NULL, color = NULL)

`element_text`(family = NULL, face = NULL, colour = NULL, size = NULL, hjust = NULL, vjust = NULL, angle = NULL, lineheight = NULL, color = NULL)

`theme`(..., complete = FALSE)
Use this function to modify theme settings. Elements include line, rect, text, title, axis.title, axis.text, axis.ticks, axis.ticks.length, axis.ticks.margin, axis.line, legend.background, legend.box, panel.background, panel.border, panel.margin, panel.grid, plot.background, plot.title, plot.margin, strip.background, strip.text

`theme_bw`(base_size=12, base_family="")
A theme with white background and black gridlines.

`theme_grey`(base_size=12, base_family="")
A theme with grey background and white gridlines. (default theme)

`theme_classic`()
A classic-looking theme, with x and y axis lines and no gridlines.

`theme_minimal`()
A minimalistic theme with no background annotations.