Statistics 120
Statistical Computing With R

Resources

- R is available from one of Comprehensive R Archive Network (CRAN) Web sites.

  `http://cran.stat.auckland.ac.nz`

- At this site you can find:
  - The R Software (including source code)
  - Extension Packages
  - Manuals and FAQs
  - Newsletters
  - Mailing List Access

The R System

- This course uses the R computing environment for practical examples.
- R serves both as a statistical package and as a general programming environment.
- R contains a large number of predefined graphical techniques and it is extensible so that new techniques can be easily added to it.
- R was developed at the University of Auckland by Ross Ihaka and Robert Gentleman, but has now matured into an internationally supported system.

Teaching Laboratories

- The Statistics Department teaching laboratories have R (and a variety of other software) installed.
- Because this course is relatively new, and quite small, many demonstrators are not familiar with its contents.
- The lab demonstrators can show you how to get started with R, but they may not be able to help you much with assignments.
- The class has 303.175 reserved on Fridays from Noon to 2pm.

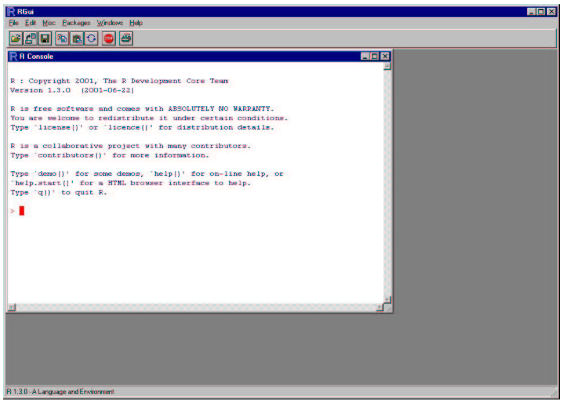
Free Software

- R is an example of *free* software.
- Note the word free has two English meanings:
  - "free beer" (gratis in French)
  - "free speech" (libre in French)
- R is free in both senses. It is available free of charge, and you are free to copy it and give it away to your friends.
- R is a official part of the Free Software Foundation's GNU suite of software.

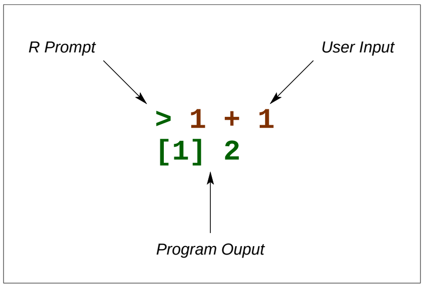
Starting R

- R can be started from the *Start* menu under Windows (look under *Programs*).
- When R is started it opens a *listener* window. This is where you type R commands.
- You should being by typing a few commands in the listener window and seeing what the response is.

An R Development Meeting (Vienna 2001)



R Command Structure



A Simple Dialog

```
> 1 + 1
[1] 2

> 1/2
[1] 0.5

> sqrt(9)
[1] 3

> pi
[1] 3.141593

> cos(pi)
[1] -1
```

R Commands

- R commands look like mathematical expressions.
- You have to type the “Enter” key after each command.
- If a command executes successfully it may or may not print some results.
- If a command fails an error message is printed.
- Error messages can be obscure. e.g.

```
Error: syntax error
```

Assignment

- Values computed by R are stored for later use by assigning them a name.
- Assignment is indicated by an equals sign.

```
x = 42
```

- This means that the value 42 is stored with the name “x”.

Legal Names

- After assignment, the value associated with a name can be recalled by just typing that name.
- Legal names consist of strings of characters from:

A – Z	(upper-case letters)
a – z	(lower-case letters)
0 – 9	(digits)
.	(full stops)

- Names cannot start with any string of letters which looks like a number.

Assignment & Variables

```
> x = 100

> x
[1] 100

> x + 17
[1] 117

> y = x + 1

> a.big.name = 123
```

Case Sensitivity

```
> x = 100

> X = 200

> x
[1] 100

> X
[1] 200
```

Checking Name Use

- At any time, you can check which names are in use by using the “objects” command. This lists any names currently in use.
- You can restrict to just printing those names which contain a particular pattern, e.g.

```
> objects()
> objects(pat = "xxx")
```

Using the “objects” Function

```
> objects()
[1] "a.big.name" "x"          "X"
[4] "y"
```

```
> objects(pat = "big")
[1] "a.big.name"
```

```
> objects(pat = "x|y")
[1] "x" "y"
```

Removing Objects

```
> rm(x)

> rm(x, y)

> rm(list = objects(pat = "x|y"))

> rm(list = objects())
```

Vectors

- R is designed to work on collection of values called vectors.
- A simple way to create a vector is by using the `c()` function.
- The command:

  ```
  > x = c(1, 2, 3, 4)
  ```

  creates a vector containing the four values, 1, 2, 3, 4, and stores it with the name “x”.

Vector Examples

```
> x = c(1, 2, 3, 4)

> x
[1] 1 2 3 4

> length(x)
[1] 4

> y = c(x, x)

> length(y)
[1] 8

> y
[1] 1 2 3 4 1 2 3 4
```

Vector Examples

```
> x + 10
[1] 11 12 13 14

> x/10
[1] 0.1 0.2 0.3 0.4

> sqrt(x)
[1] 1.000000 1.414214 1.732051 2.000000

> min(x)
[1] 1

> max(x)
[1] 4

> range(x)
[1] 1 4
```

Vector Examples

```
> mean(x)
[1] 2.5

> median(x)
[1] 2.5

> sd(x)
[1] 1.290994
```

Regular Patterns

- R has facilities for generating patterned vectors.
- The main functions for doing this are “`seq()`” (and its shorthand operator “`:`”) and “`rep()`”.
- Using these functions together makes it possible to generate some quite general sequences.

Generating Sequences

```
> seq(0, 10)
 [1]  0  1  2  3  4  5  6  7  8  9 10

> seq(0, 10, length = 6)
[1]  0  2  4  6  8 10

> seq(0, 10, by = 2.5)
[1]  0.0  2.5  5.0  7.5 10.0

> 0:10
 [1]  0  1  2  3  4  5  6  7  8  9 10

> 10:0
 [1] 10  9  8  7  6  5  4  3  2  1  0
```

Repetition

```
> x = 1:4
> rep(x, 3)
 [1] 1 2 3 4 1 2 3 4 1 2 3 4
> rep(x, c(2, 3, 3, 2))
 [1] 1 1 2 2 2 3 3 3 4 4
> rep(x, 3)
 [1] 1 2 3 4 1 2 3 4 1 2 3 4
> rep(x, rep(3, length(x)))
 [1] 1 1 1 2 2 2 3 3 3 4 4 4
```

Comments

- The character # provides a "comment facility" for R.
- Any input on a line which follows # is ignored.
- This can be used to document your code.
- There is no multiple line comment symbol.

Combining Vectors

- It is possible to combine vectors using arithmetic operations like $+$ or $-$.
- When the vectors have the same length, corresponding elements are combined.
- When the vectors have different lengths, the shorter vector is first "recycled" to the length of the longer one.

Miscellaneous

```
> prod(1:10)
[1] 3628800
> prod(1:10)/prod(1:3, 1:7)
[1] 120
> choose(10, 3)
[1] 120
> pnorm(1.96) - pnorm(-1.96)
[1] 0.9500042
> sum(1:100)
[1] 5050
```

Combining Vectors

```
> x = c(1, 2, 3, 4)
> y = c(10, 20)
> x
[1] 1 2 3 4
> y
[1] 10 20
> rep(y, 2)
[1] 10 20 10 20
> x + y
[1] 11 22 13 24
```

Combining Vectors

```
> 2 * (1:10)
 [1]  2  4  6  8 10 12 14 16 18 20
> round(1/3, 1:6)
[1] 0.300000 0.330000 0.333000 0.333300 0.333330
[6] 0.333333
> 1:10 + 10:1
 [1] 11 11 11 11 11 11 11 11 11 11
```