R Software

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What is R ?

* R is an environment for data manipulation, statistical computing, graphics display and data analysis
* **Effective data handling and storage of outputs is possible.**
* **Simple as well as complicated calculations are possible**
* **Graphical display on-screen and hardcopy are possible**

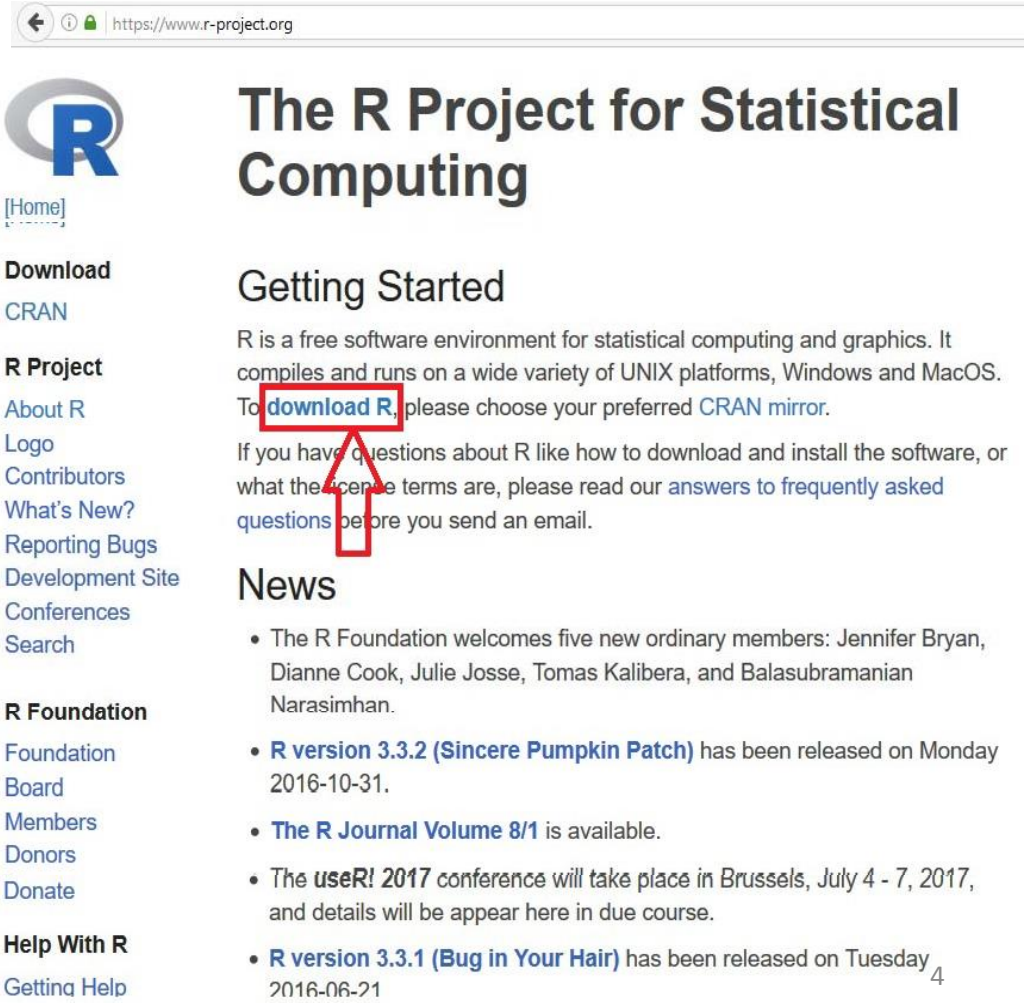
Why R ?

* **R is free.**
* **Many statistical packages are freely available.**
* **It has a computer language which is convenient to use for statistical and graphical applications.**
* **Many people, research and design offices, analytical firms have started using R**

Installing R

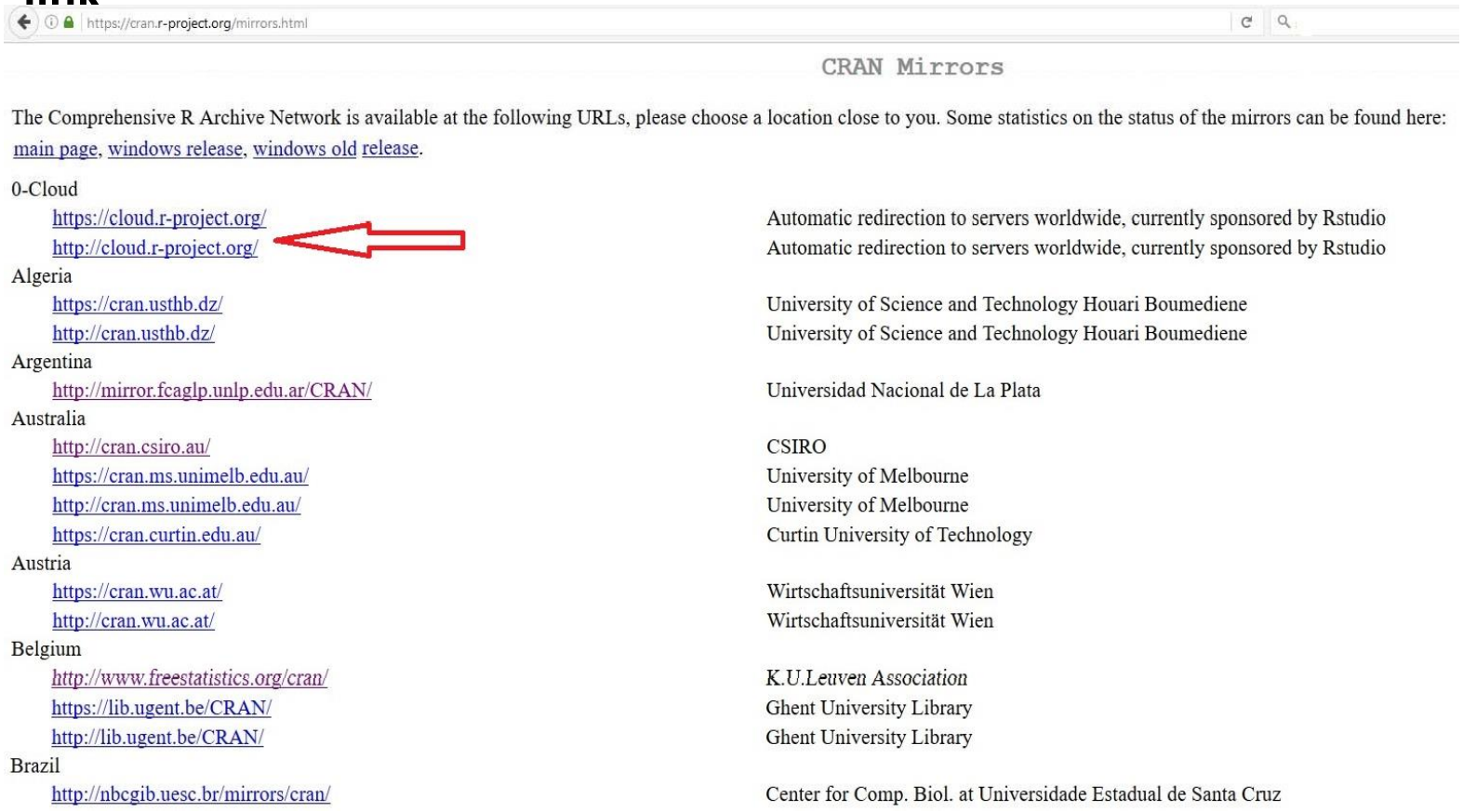
You may install R in a windows or Apple Computer by downloading from https://www.r-project.org

Click on download R



Installing R

Choose any mirror and click on the link



https://cran.r-project.org/mirrors.html

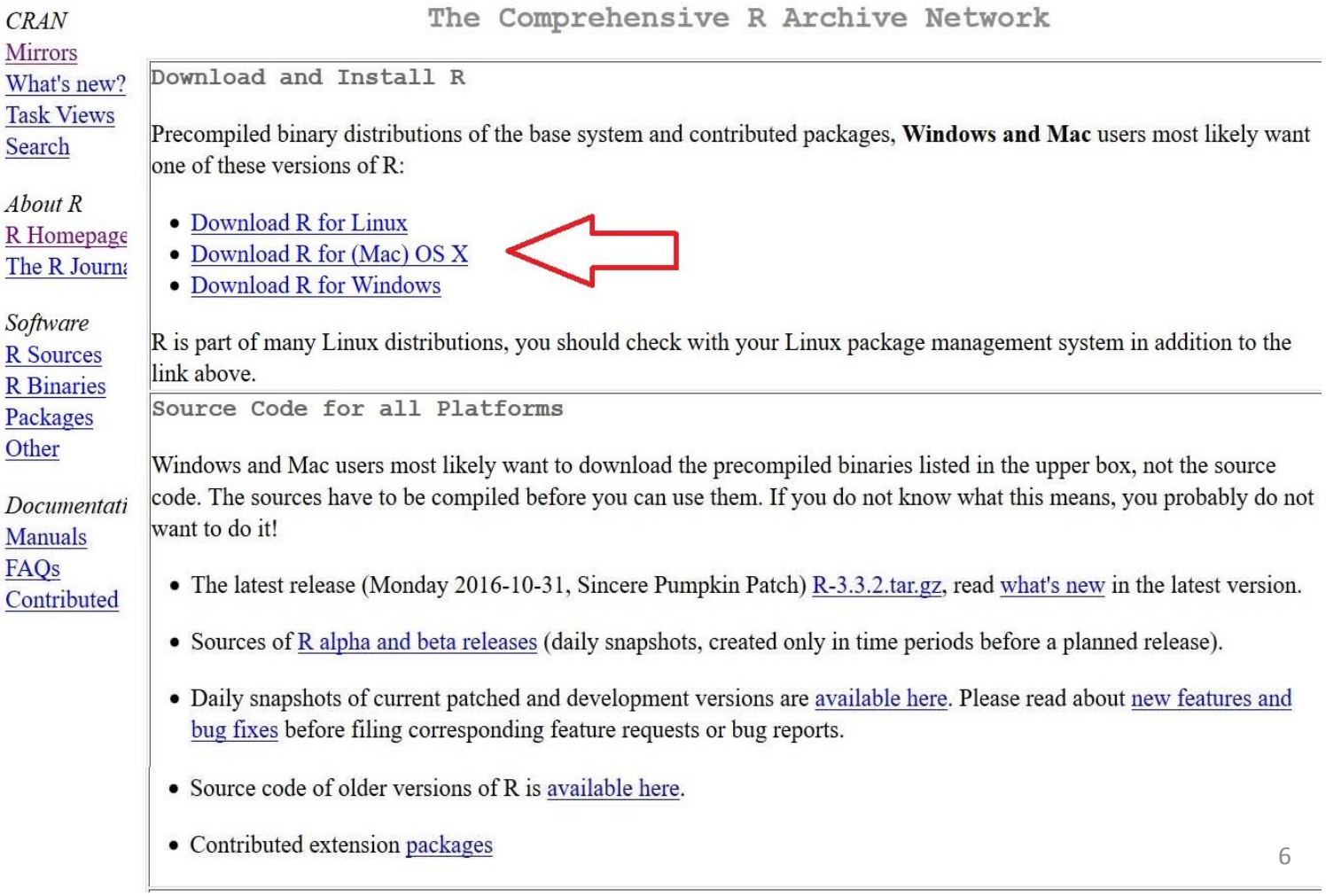
CRAN Mirrors

The Comprehensive R Archive Network is available at the following URLs, please choose a location close to you. Some statistics on the status of the mirrors can be found here: main page, windows release, windows old release.

0-Cloud	
https://cloud.r-project.org/	Automatic redirection to servers worldwide, currently sponsored by Rstudio
http://cloud.r-project.org/	Automatic redirection to servers worldwide, currently sponsored by Rstudio
Algeria	
https://cran.usthb.dz/	University of Science and Technology Houari Boumediene
http://cran.usthb.dz/	University of Science and Technology Houari Boumediene
Argentina	
http://mirror.fcaglp.unlp.edu.ar/CRAN/	Universidad Nacional de La Plata
Australia	
http://cran.csiro.au/	CSIRO
https://cran.ms.unimelb.edu.au/	University of Melbourne
http://cran.ms.unimelb.edu.au/	University of Melbourne
https://cran.curtin.edu.au/	Curtin University of Technology
Austria	
https://cran.wu.ac.at/	Wirtschaftsuniversität Wien
http://cran.wu.ac.at/	Wirtschaftsuniversität Wien
Belgium	
http://www.freestatistics.org/cran/	K.U.Leuven Association
https://lib.ugent.be/CRAN/	Ghent University Library
http://lib.ugent.be/CRAN/	Ghent University Library
Brazil	
http://nbcgib.uesc.br/mirrors/cran/	Center for Comp. Biol. at Universidade Estadual de Santa Cruz

Installing R

Else, download it from the Comprehensive R Archive Network (CRAN) website: http://cran.r-project.org/



Installing R Studio

R studio is a software which helps in running the R software.

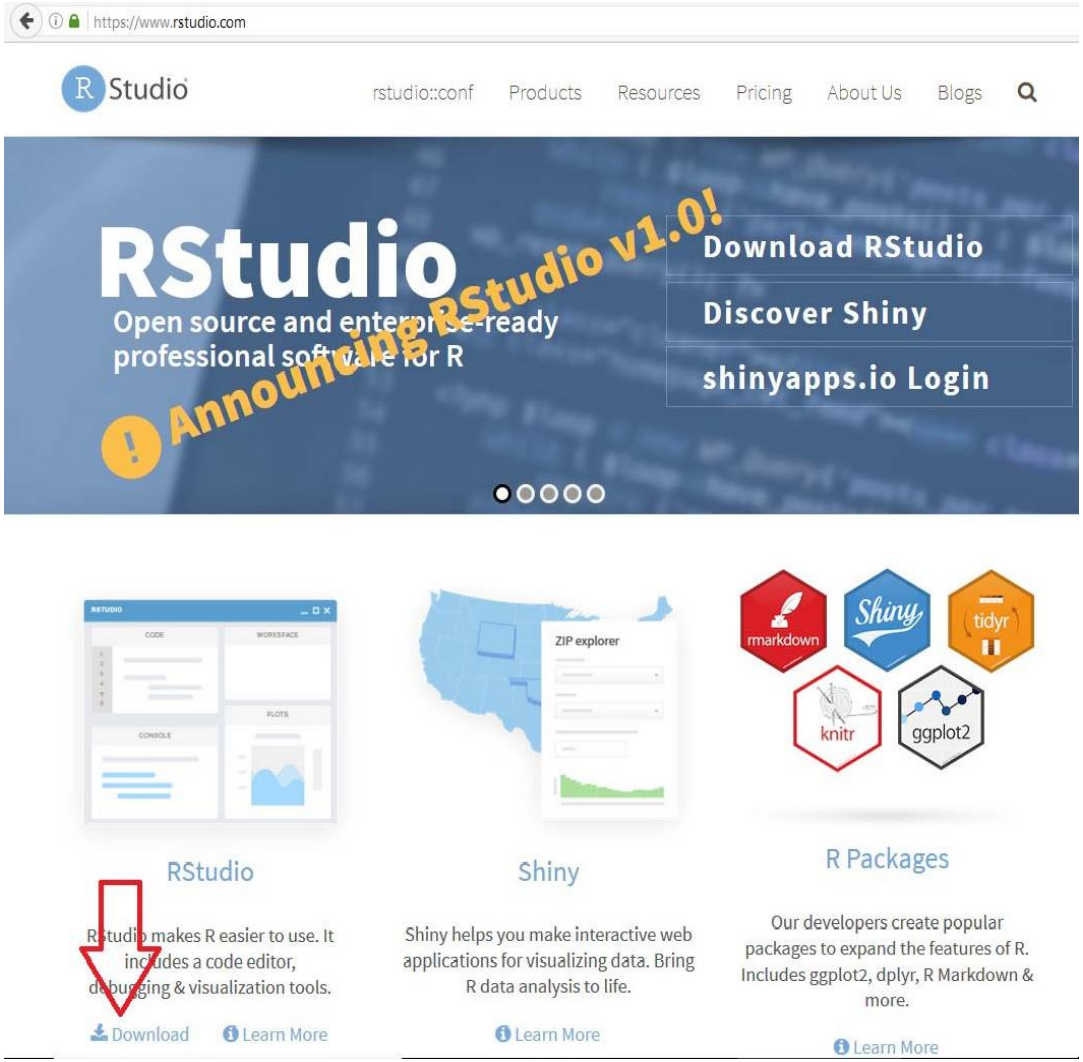
Several such editors are available, e.g. Tinn R (https://sourceforge.net/projects/tinn-r)

R studio is written in C++ programming language.

R studio is a free and open-source integrate development environment (IDE) for R.

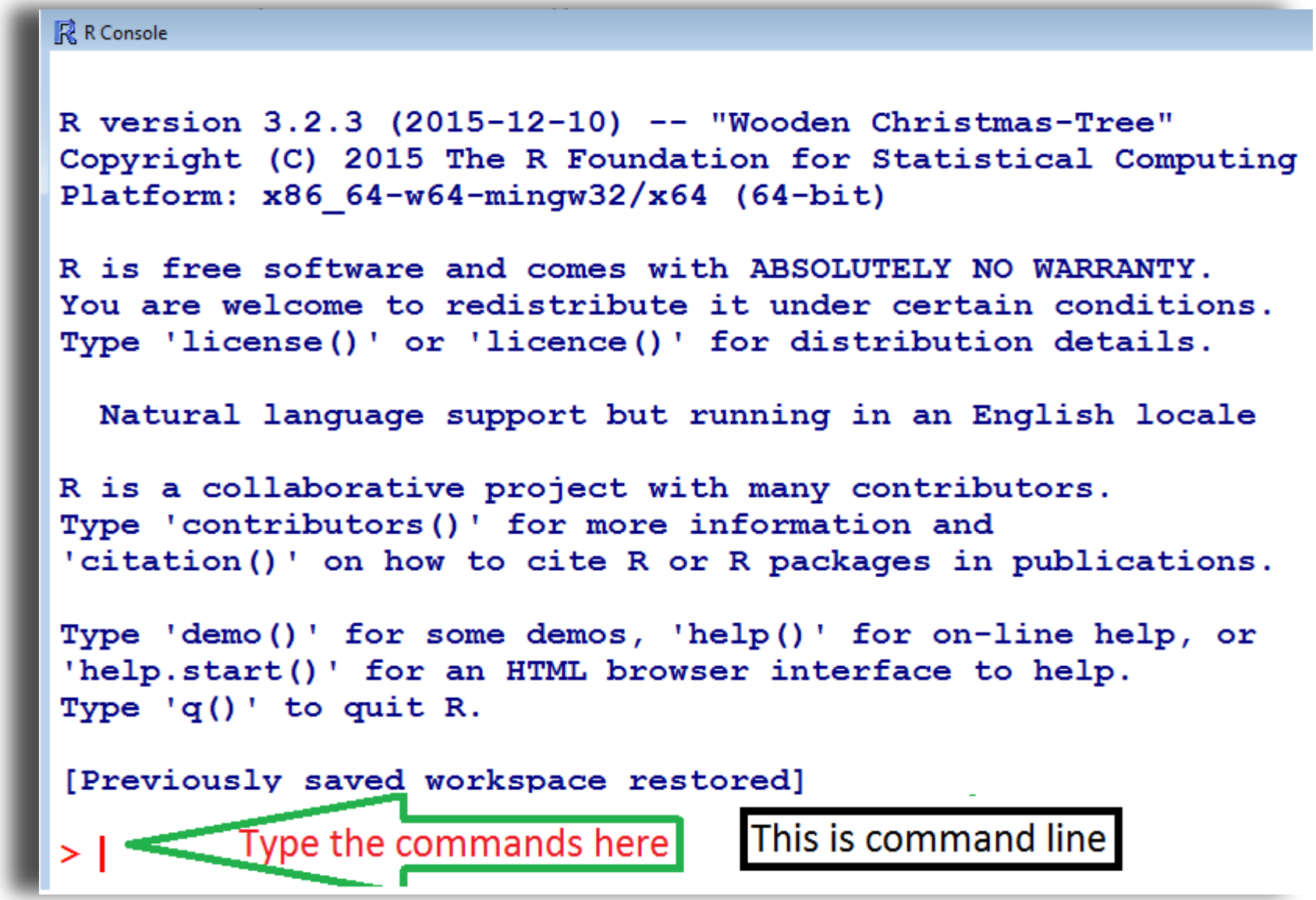
Download R-Studio software from website https://www.rstudio.com/

Installing R Studio



Download and double click on the downloaded file.

Command Line versus Scripts



Command Line versus Scripts

Execution of commands in R is not menu driven. (Not like Clicking over buttons to getoutcome)

We need to type thecommands.

Single line and multi line commands are possible to write.

When writing multi-line programs, it is useful to use a text editor rather than execute everything directly at the command line.

Command Line versus Scripts

Option 1:

One may use R's own built-in editor.

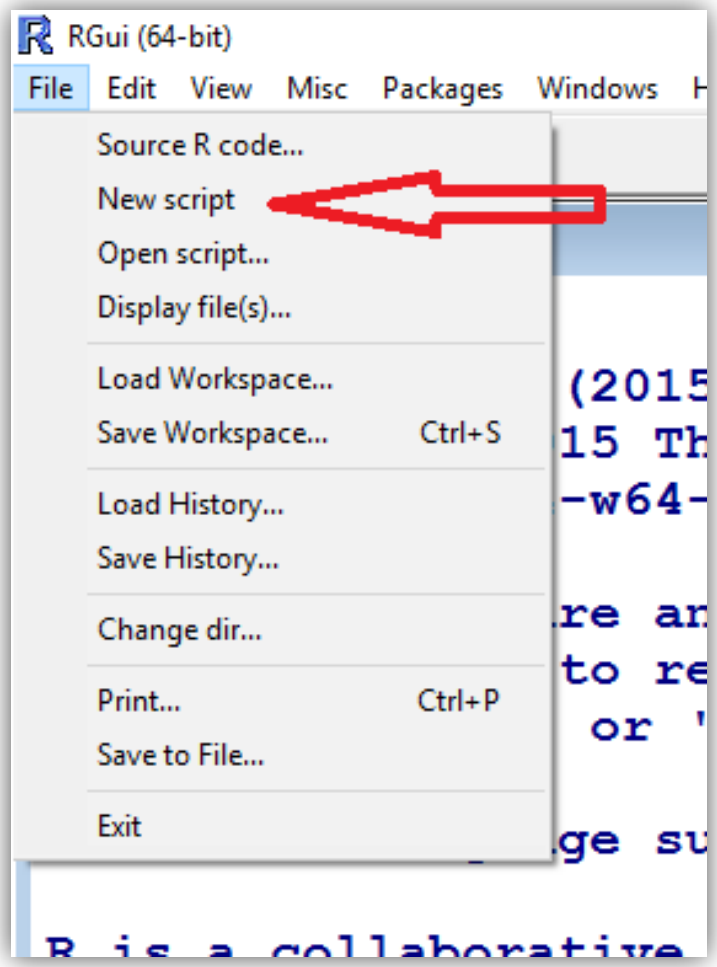
It is accessible from the `RGui` menu bar.

Click `File` and then click on `New script`.

Command Line versus Scripts

At this point R will open a window entitled `Untitled-R Editor.`

We may type and edit in this.



If we want to execute a line or a group of lines, just highlight them and press `Ctrl+R`.

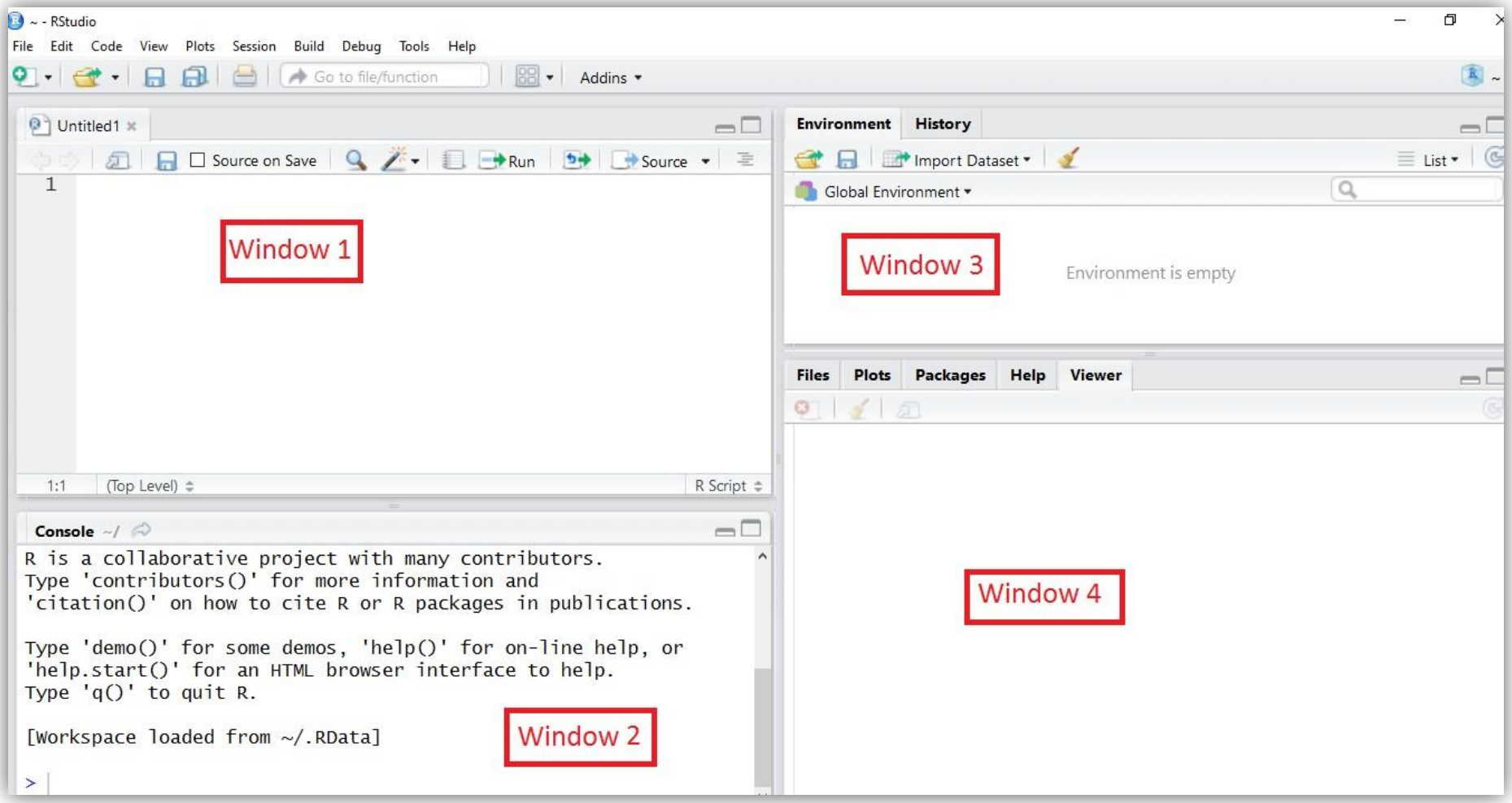
Introduction to R Studio

Option 2:

* It is an interface between R and us.
* More useful for beginners.
* It makes coding easier.
* When we start R studio, we see 4 windows

Introduction to R Studio

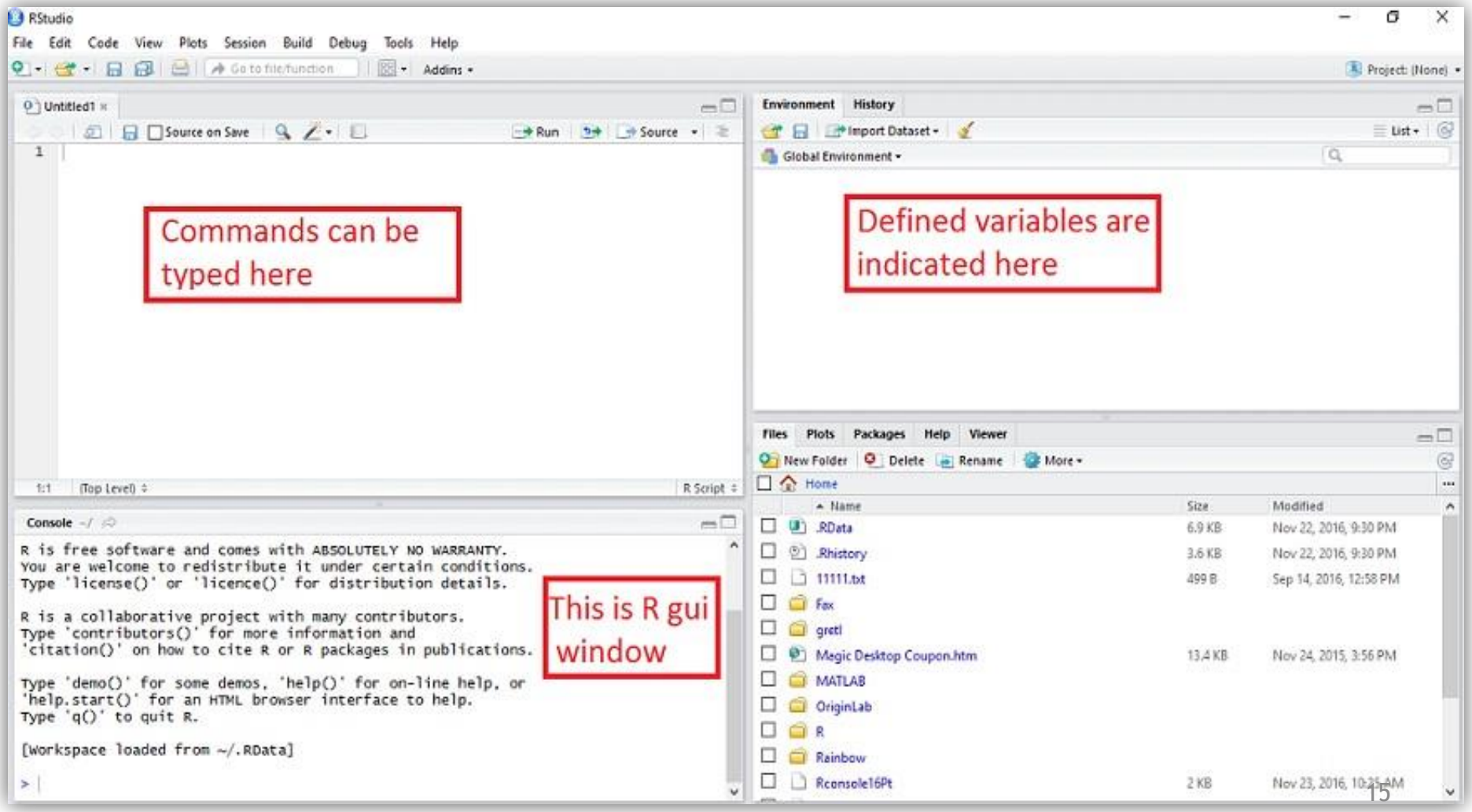
First opening window of Rstudio is as follows having four windows.



Command Line versus Scripts

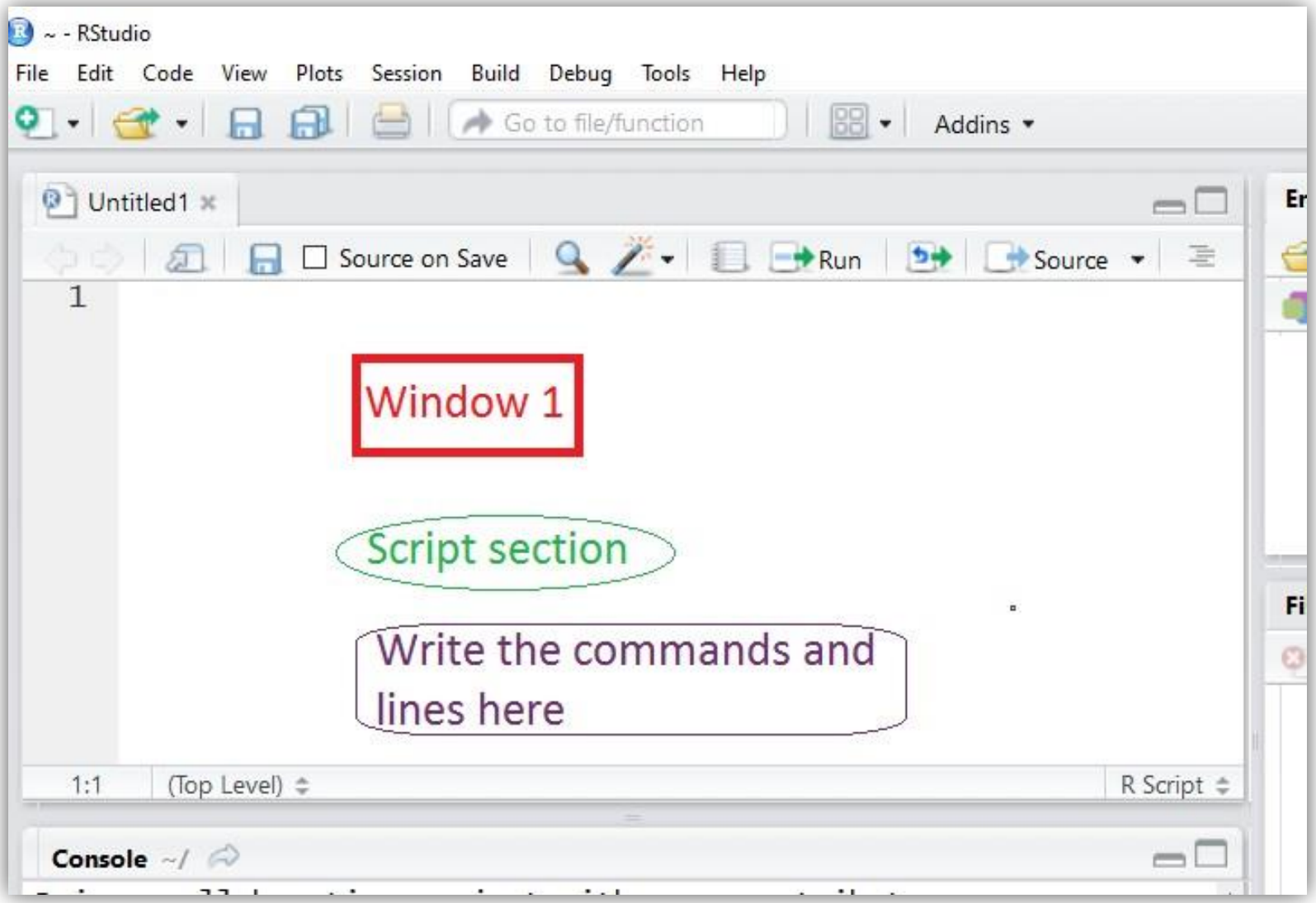
Option 2:

Use R studio software.



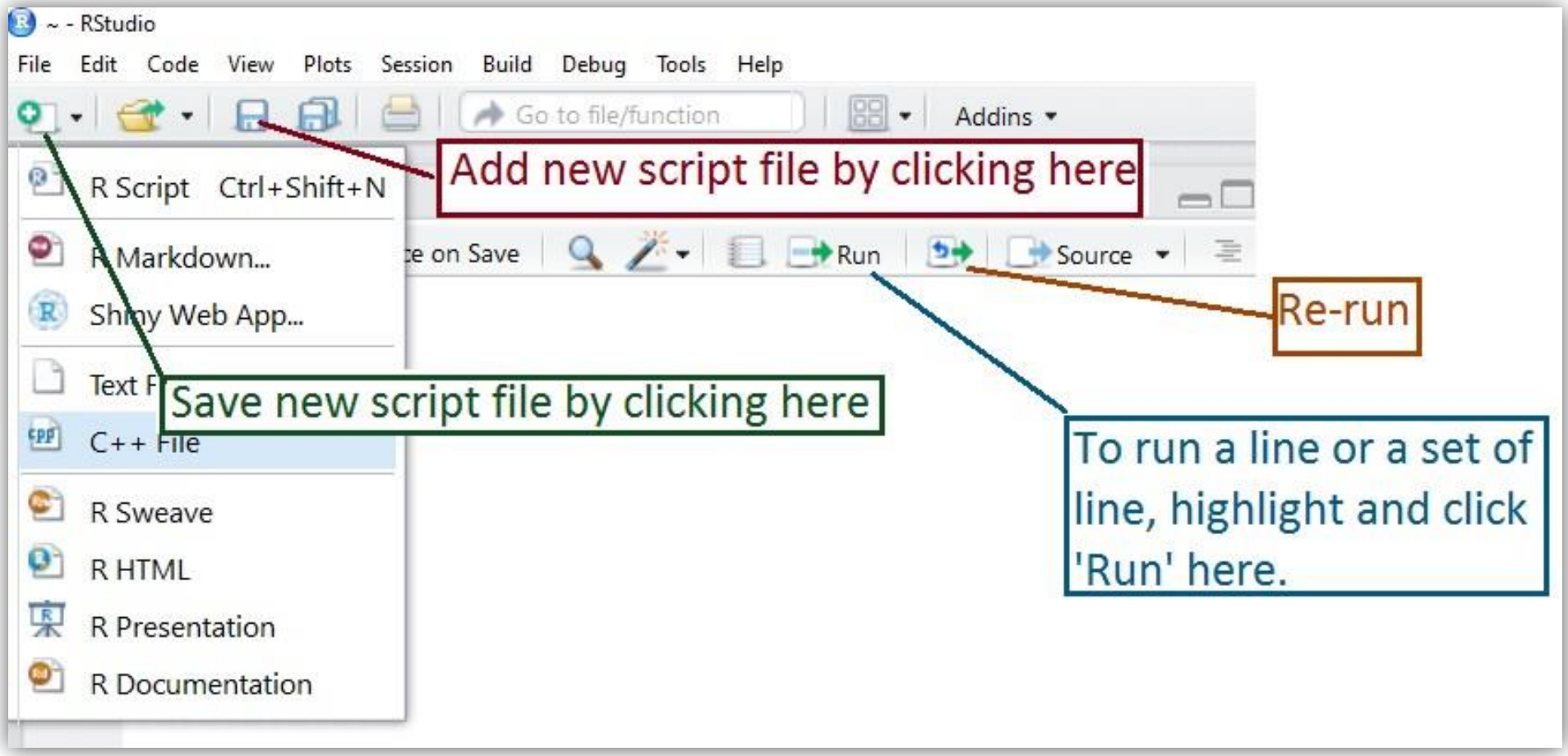
Introduction to R Studio

Description of Window 1



Introduction to R Studio

Description of Window 1



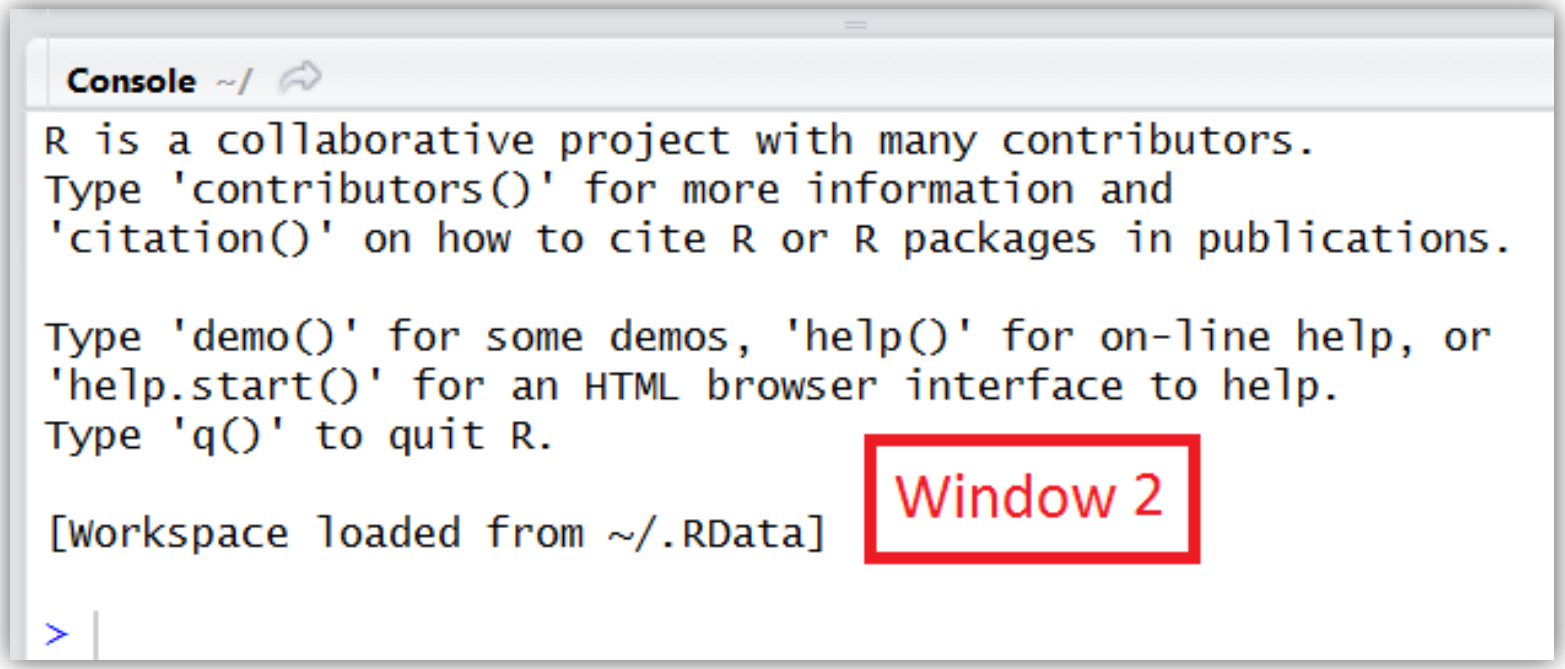
Introduction to R Studio

Description of Window 2 : Console

R program window appears here.

Calculations take place inconsole window.

One can write programmes in console also but it is hard to make corrections and experiments with the coding.

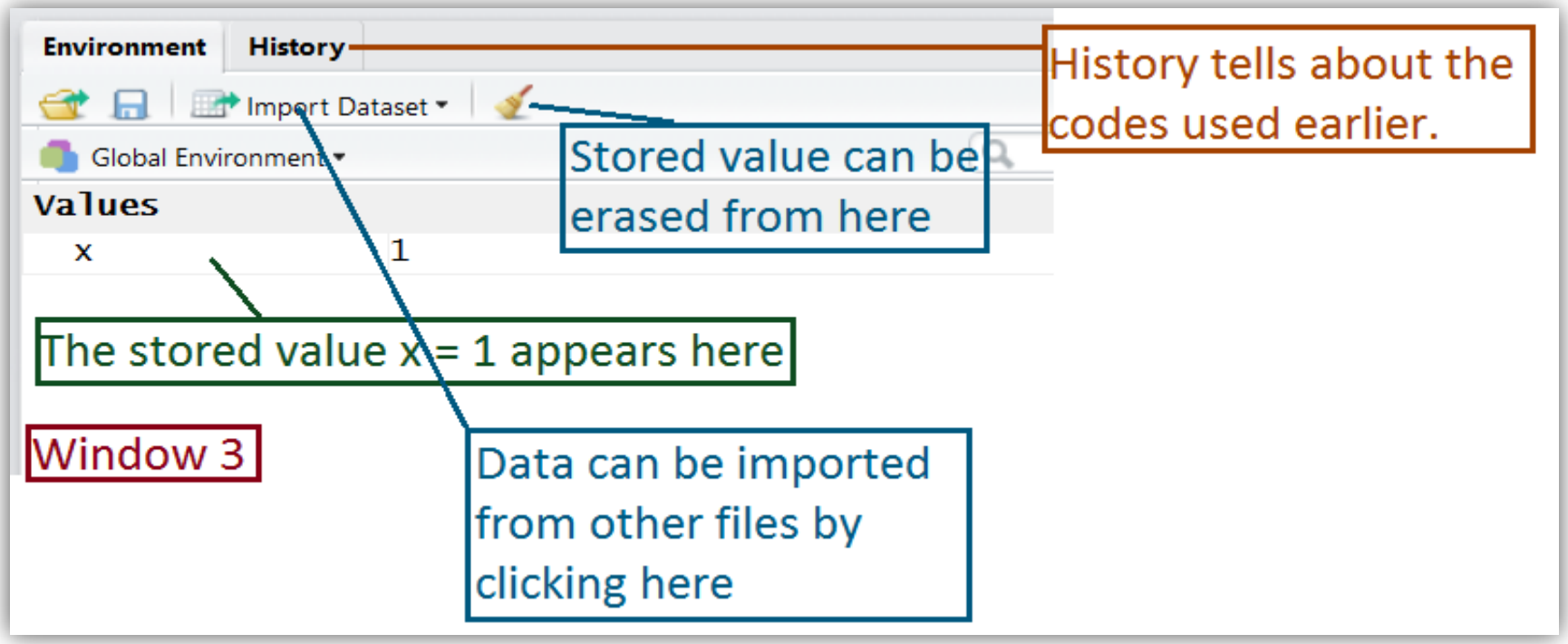


Introduction to R Studio

Description of Window 3 : Environment window

All the variables and objects used in the programme appear here.

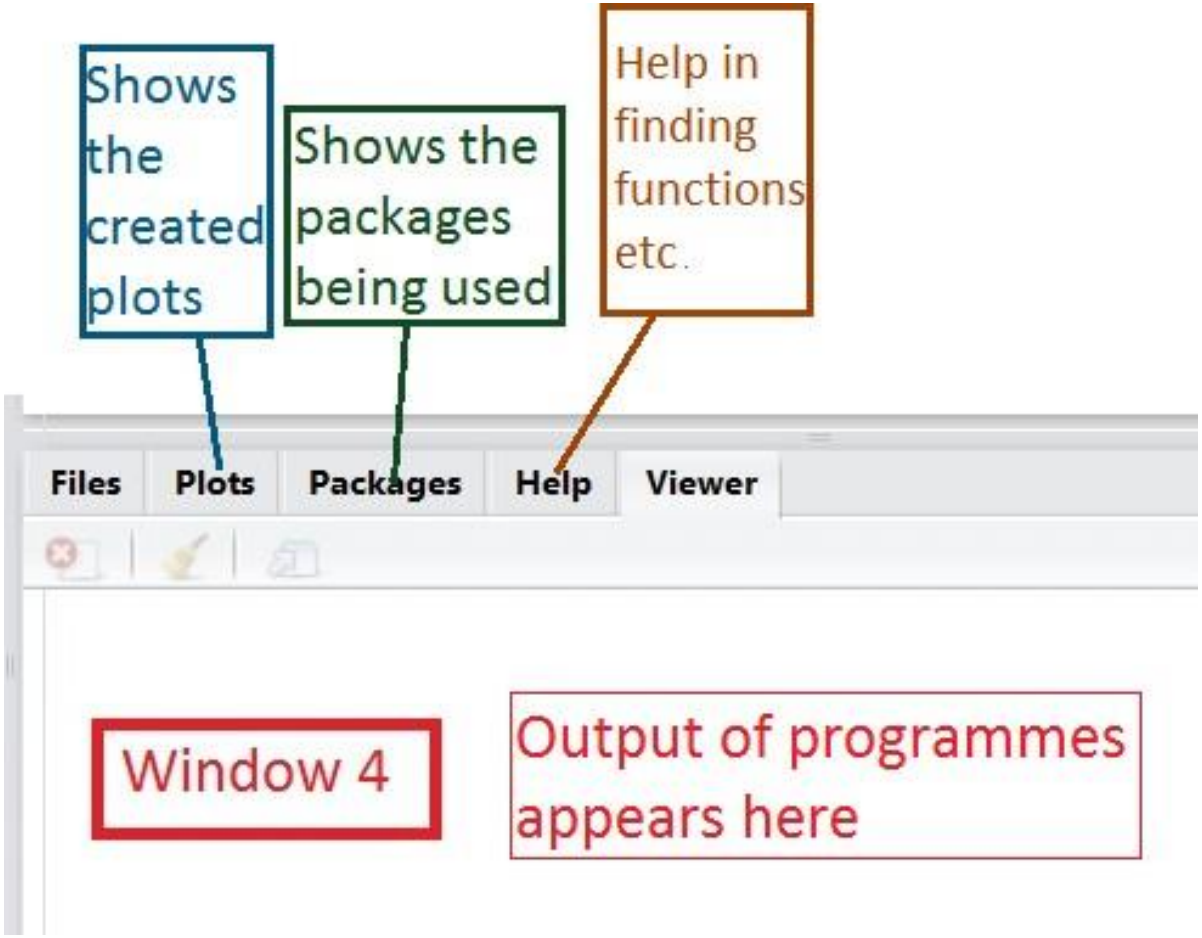
The nature and values of variables and objects also appear here.



Introduction to R Studio

Description of Window 4 : Output window

The output of programmes appears in this window.



Introduction to R Studio

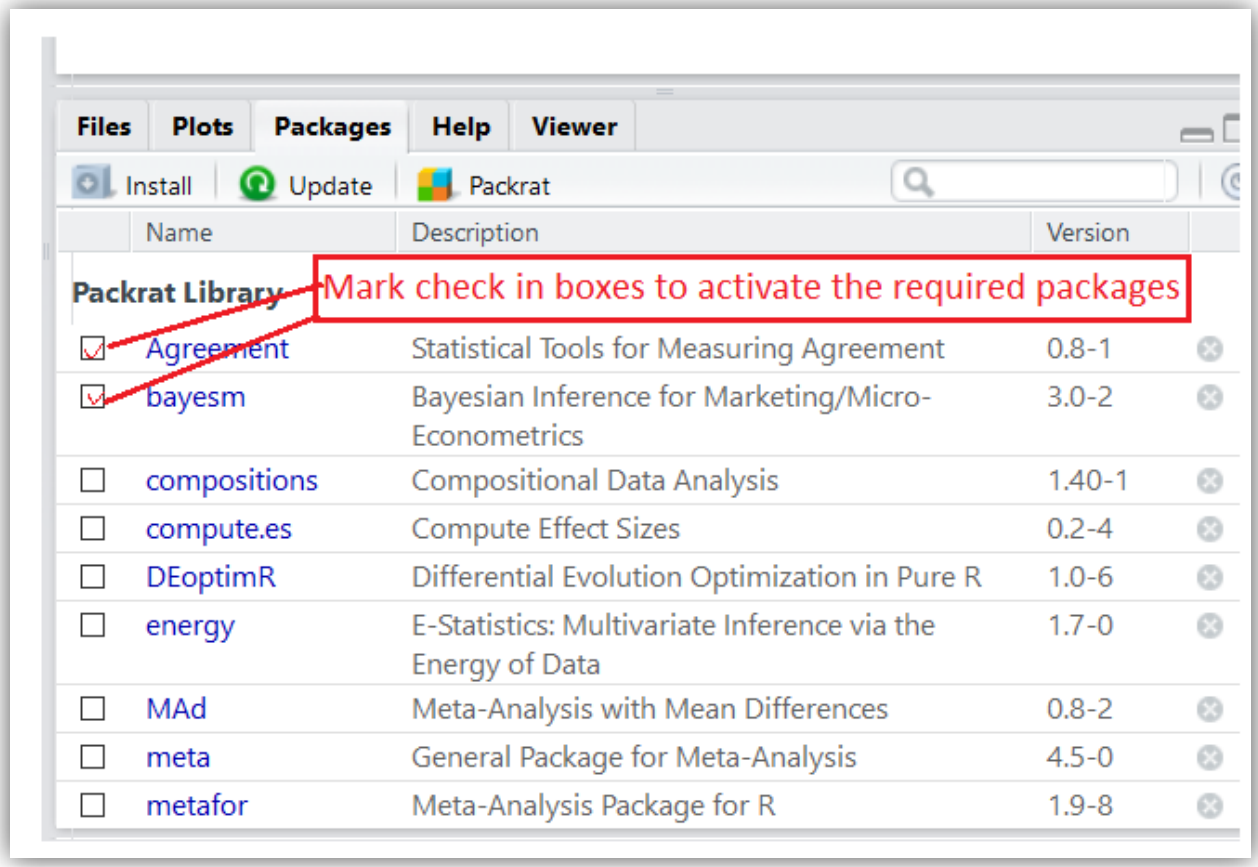
Description of Window 4 : Output window

Packages:

All the packages being installed appear here.

Packages are not active.

Check mark in the boxes to activate them.



Introduction to R Studio

Window 4 : Output window

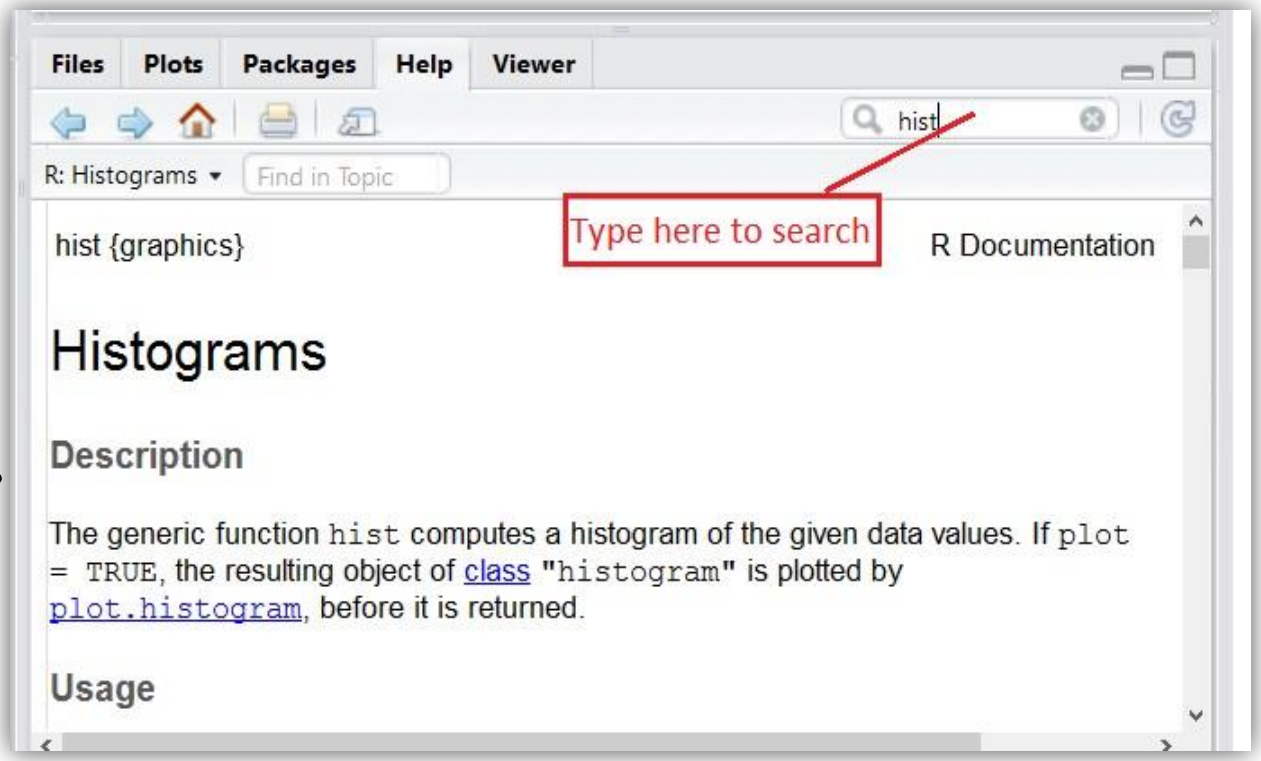
Help:

Various types of help can be asked.

E.g., to know about histogram,

type hist.

Information appears.

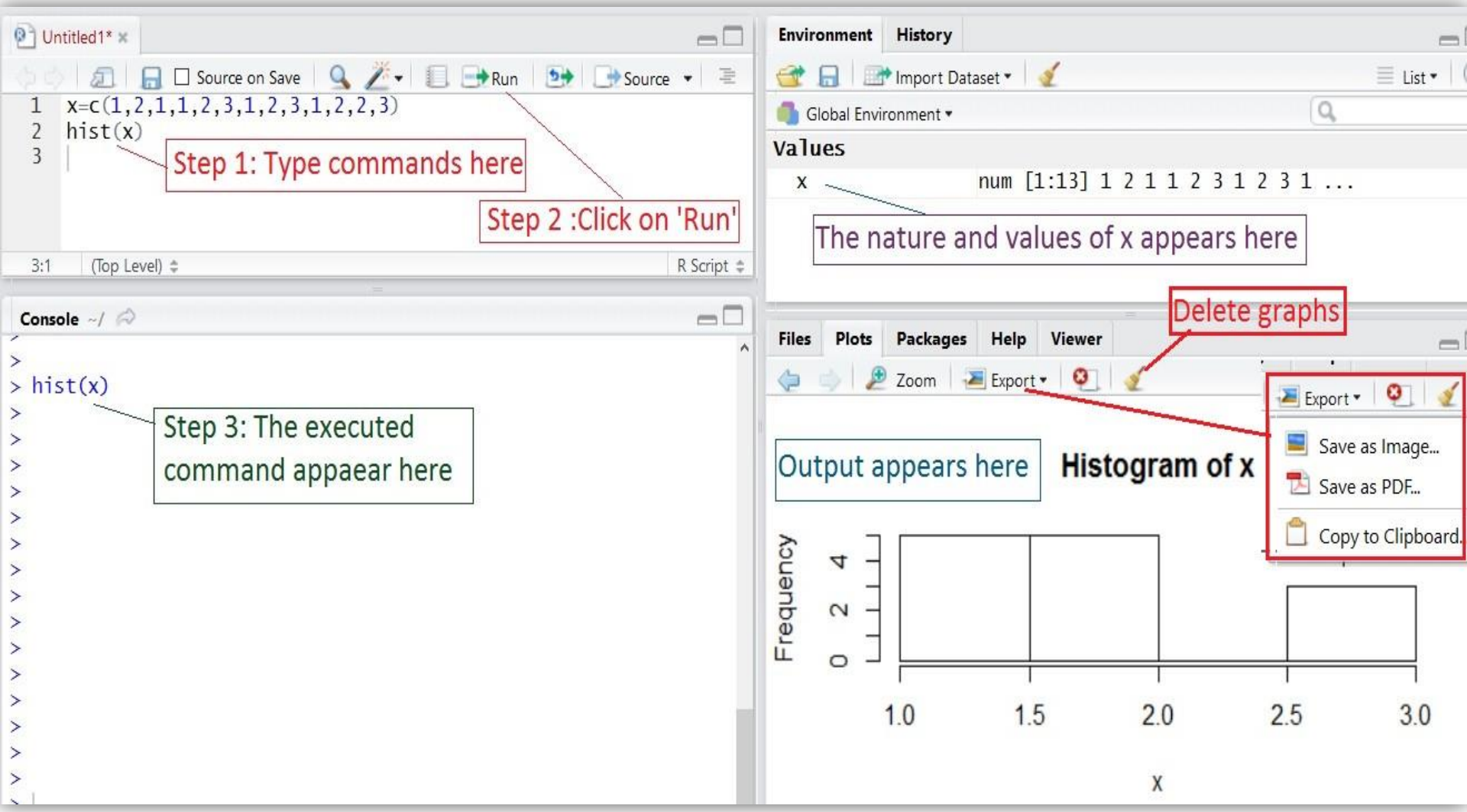


Introduction to R Studio

Example:

Histogram of values 1,2,1,1,2,3,1,2,3,1,2,2,3

R studio has following operation and output:


Untitled1*
Source on Save
Run
Source
1 x=c(1,2,1,1,2,3,1,2,3,1,2,2,3)
2 hist(x)
3
Step 1: Type commands here
Step 2 :Click on 'Run'
3:1
(Top Level)
R Script
Console ~/
> hist(x)
Step 3: The executed command appaear here
Environment
History
Import Dataset
List
Global Environment
Values
x num [1:13] 1 2 1 1 2 3 1 2 3 1 ...
The nature and values of x appears here
Delete graphs
Files
Plots
Packages
Help
Viewer
Zoom
Export
Save as Image...
Save as PDF...
Copy to Clipboard...
Output appears here
Histogram of x
Frequency
0
2
4
1.0
1.5
2.0
2.5
3.0
x

Getting Help in R

* Search for help in Google www.google.com
* If you need help with a function, then type question mark followed by the of the function.
* For example,?read.table to get help for function read.table.
* Sometimes, you want to search by the subject on which we want help (e.g. data input). In such a case, type
* help.search("data input")
* 'help()' for on-line help, or 'help.start()' for an HTML browser interface to help.

Getting Help in R

* Other useful functions are find and apropos.
* The find function tells us what package something is in.
* The apropos returns a character vector giving the names of all objects in the search list that match your enquiry.

Basics and R as a Calculator

* The assignment operators are the left arrow with dash <- and equal sign =

  > x = 20 assigns the value 20 to x.

  > y = x * 2 assigns the value 2*x to y.

  > z = x + y assigns the value x + y to z.

* The character # marks the beginning of a comment. All characters until the end of the line are ignored.
* Capital and small letters are different.
* R as a calculator eg. 2+3 command gives the output 5, > 2**3 or 2^3 Command gives the output 8

Basics and R as a Calculator

* The command c(1,2,3,4,5) combines the numbers 1,2,3,4 and 5 to a vector.
* Multiplication and Division x * y, x/y
* Addition and Subtraction x + y, x – y
* Integer Division %/% (fractional part (remainder) is discarded)
* Modulo Division (x mod y) %% (remainder is the output)

Exercise

* Assign values 2 to variable x, -5 to variable y and find
  1. z1= x^2+y^2
  2. z2=2x-5y
  3. z3=y**2
  4. z4=y%/%x
  5. z5=y%%x

Application to a Vector

Command	**output**
c(2,3,5,7)^2	[1] 4 9 25 49
> c(2,3,5,7)^c(2,3)	[1] 4 27 25 343
> c(2,3,5,7)^c(2,3,4)	[1] 4 27 625 49

Warning message : longer object length is not a multiple of shorter object length in: c(2,3,5,7)^c(2,3,4)

Application to a Vector

Command	**output**
> c(2,3,5,7) + 10	[1] 12 13 15 17
> c(2,3,5,7) + c(-2,-3, -5, 8)	[1] 0 0 0 15
> c(2,3,5,7) + c(8,9,10)	[1] 10 12 1515 (warning)
> c(2,3,5,7) %/% 2	[1] 1 1 2 3
> c(2,3,5,7) %% 2	[1] 0 1 1 1
> max(1.2, 3.4, -7.8)	[1] 3.4
> min(1.2, 3.4, -7.8)	[1] -7.8
>sqrt(c(4,1,9))	[1] 2 1 3

Functions

* Functions are a bunch of commands grouped together in a sensible unit

* Functions take input arguments, do calculations (or make some graphics, call other functions) and produce some output and return a result in a variable. The returned variable can be a complex construct, like a list.

Functions

Syntax

```
Name <- function(Argument1, Argument2, ...)
{
expression
}
```

where expression is a single command or a group of commands

Functions

Syntax
Name <- function(Argument1, Argument2, ...)
{
expression
}
where expression is a single command or a group of commands

Examples

* Functions (Single variable)

  > abc <- function(x){ x^2 }

  > abc(3) [1] 9

* Functions (Two variables)

  > abc <- function(x,y){ x^2+y^2 }

  > abc(2,3) [1] 13

  > abc <- function(x){ sin(x)^2+cos(x)^2 + x }

  > abc(8) [1] 9

Matrices

* Matrices are important objects in any calculation. A matrix is a rectangular array with p rows and n columns. An element in the i-th row and j-th column X[i, j], i = 1,2,...,n, j = 1,2,...,p.

* We are mostly interested in numerical matrices, whose elements are generally real numbers in R,

Matrices

* A 4 × 2-matrix X can be created with a following command:
* > x <- matrix(nrow=4, ncol=2, data=c(1,2,3,4,5,6,7,8))

```
> x
     [,1] [,2]
[1,]    1    5
[2,]    2    6
[3,]    3    7
[4,]    4    8
```

Matrices

* The parameter nrow defines the row number of a matrix.
* The parameter ncol defines the column number of a matrix.
* The parameter data assigns specified values to the matrix elements. The values from the parameters are written column-wise in matrix.
* One can access a single element of a matrix with x[i,j]:
* > x[3,2] [1] 7

Matrices

* In case, the data has to be entered row wise, then a 4 × 2-matrix X can be created with > x <- matrix(nrow=4, ncol=2, data=c(1,2,3,4,5,6,7,8), byrow = TRUE)

```
> x
     [,1] [,2]
[1,]    1    2
[2,]    3    4
[3,]    5    6
[4,]    7    8
```

Matrices

- x1<-matrix(1:9,3,3,byrow=F)

```
> x1
     [,1] [,2] [,3]
[1,]    1    4    7
[2,]    2    5    8
[3,]    3    6    9
```

- > x2 <- diag(3, nrow=2, ncol=2)

```
> x2
     [,1] [,2]
[1,]    3    0
[2,]    0    3
```

Matrices

- x3<-matrix(1,3,3)

```
> x3
     [,1] [,2] [,3]
[1,]    1    1    1
[2,]    1    1    1
[3,]    1    1    1
```

- x4<-matrix(1,3,2)

```
> x4
     [,1] [,2]
[1,]    1    1
[2,]    1    1
[3,]    1    1
```

Matrices

- diag(nrow = 3)

```
     [,1] [,2] [,3]
[1,]    1    0    0
[2,]    0    1    0
[3,]    0    0    1
```

Matrices

x1<-matrix(1:9,3,3,byrow=F)

```
 > x1
     [,1] [,2] [,3]
[1,]    1    4    7
[2,]    2    5    8
[3,]    3    6    9
```

Command	Output
> dim(x1)	[1] 3 3
> x1[2,3]	[1] 8
> x1[,2]	[1] 4 5 6
> x1[1,]	[1] 1 4 7

Matrices Multiplication

- x1<-matrix(1:9,3,3,byrow=F)

```
> x1
     [,1] [,2] [,3]
[1,]    1    4    7
[2,]    2    5    8
[3,]    3    6    9
```

```
> x4<-matrix(1,3,2)
 > x1
     [,1] [,2]
[1,]    1    1
[2,]    1    1
[3,]    1    1
```

x%*%y is the correct command to obtain the multiplication of two matrices x and y if exists.

```
 > x1%*%x4
     [,1] [,2]
[1,]    3    3
[2,]    3    3
```

Eigen Values and Vectors of Matrices

* > x1<-matrix(1:9,3,3,byrow=F)
  > x1
  [,1] [,2] [,3]
  [1,] 1 4 7
  [2,] 2 5 8
  [3,] 3 6 9
  > eigen(x1)

eigen() decomposition $values
[1] 1.611684e+01 -1.116844e+00 -4.054214e-16
$vectors
[,1] [,2] [,3]
[1,] -0.4645473 -0.8829060 0.4082483
[2,] -0.5707955 -0.2395204 -0.8164966
[3,] -0.6770438 0.4038651 0.4082483

system of linear equations

* x + y + z =5,
* 2x + 3y + z = 10,
* 3x -2 y +2z = 3

```
> a <- rbind(c(1, 1, 1), c(2, 3, 1), c(3, -2, 2))
> b <- c(5, 10, 3)
>solve(a, b)

[1] 1 2 2
```

Conditional Executions and Loops

* Conditional execution -- ifelse(test, yes, no)
* Syntax

if (condition) {executed commands if condition is TRUE} else { executed commands if condition is FALSE }

```
> x <- 1:10
>x
[1] 1 2 3 4 5 6 7 8 9 10
>ifelse( x<6, x^2, x+1 )
[1] 1 4 9 16 25 7 8 9 10 11
```

Control structures in R :Loops

* Repetitive commands are executed by loops for loop, while loop, repeat loop
* The for loop: If the number of repetitions is known in advance,a for() loop can be used.
* for (name in vector) {commands to be executed}
* > for (i in 1:5) { print(i^2) }

[1] 1
[1] 4
[1] 9
[1] 16
[1] 25

Control structures in R :Loops

```
> for ( i in c(2,4,6,7) ) { print( i^2 ) }
[1] 4
[1] 16
[1] 36
[1] 49
```

Control structures in R :Loops

```
> for ( i in c(2,4,6,7) ) { print( i^2 ) }
[1] 4
[1] 16
[1] 36
[1] 49
```

The while() loop

* If the number of loops is not known in before, e.g. when an iterative algorithm to maximize a likelihood function is used, one can use a while() loop.

* Syntax

while(condition){ commands to be executed as long as condition is TRUE }

The while() loop

```
> i <- 1
>while (i<5) {
+ print(i^2)
+ i <- i+2
+}
[1] 1
[1] 9
```

Note: The programmer itself has to be careful that the counting variable i within the loop is incremented. Otherwise an infinite loop occurs.

Sequences

* The default increment is +1 or –1

> seq(from=-4, to=4) [1] -4 -3 -2 -1 0 1 2 3 4

* Sequence with constant increment:

Command	Output
seq(from=10, to=20, by=2)	[1] 10 12 14 16 18 20
seq(from=3, to=-1, by=-0.5)	[1] 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
seq(to=10, length=10)	[1] 1 2 3 4 5 6 7 8 9 10
seq(from=10, length=10, by=0.1)	[1] 10.0 10.1 10.2 10.3 10.4 10.5 10.6 10.7 10.8 10.9

> x<-2

> seq(1, x, x/10) [1] 1.0 1.2 1.4 1.6 1.8 2.0

Sequences

Command

Output

The regular sequences can be generated in R.

* **Code**

```
>seq(10)

>seq(1:10)

>abs(seq(-2,2))

>sqrt(abs(seq(-6,6, by = 3)))
```

* **Output**

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

* [1] 1 2 3 4 5 6 7 8 9 10

* [1] 2 1 0 1 2

* [1] 2.449490 1.732051 0.000000 1.732051 2.449490

The regular sequences can be generated in R.

* **Code**

```
>seq(10)

>seq(1:10)

>abs(seq(-2,2))

>sqrt(abs(seq(-6,6, by = 3)))
```

* **Output**

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

* [1] 1 2 3 4 5 6 7 8 9 10

* [1] 2 1 0 1 2

* [1] 2.449490 1.732051 0.000000 1.732051 2.449490

The regular sequences can be generated in R.

* **Code**

```
>seq(to = 100, length = 8)

>seq(to = 22, length = 5, by
  = 6)

>seq(from = -10, length = 5,
  by = -0.3)
```

* **Output**
* [1]93 94 95 96 97 98 99 100
* [1] -2 4 10 16 22
* [1] -10.0 -10.3 -10.6 -10.9 -11.2

Sorting

* sort function sorts the values of a vector in ascending order (by default) or descending order.
* Example
* > y <- c(8,5,7,6)

  > Y [1] 8 5 7 6
* > sort(y) [1] 5 6 7 8
* > sort(y, decreasing = TRUE) [1] 8 7 6 5

Repeats

* Command rep is used to replicates the values
* rep(x, times=n) # Repeat x as a whole n times a vector.
* Rep(x, each=n) # Repeat each cell n times

```
> rep(3.5, times=4)                    [1] 3.5 3.5 3.5 3.5
> rep(1:4, 2)                          [1] 1 2 3 4 1 2 3 4
>rep(1:4, each = 2, times = 3)
[1] 1 1 2 2 3 3 4 4 1 1 2 2 3 3 4 4 1 1 2 2 3 3 4 4
```

Repeats

* Every object is repeated a different number of times:

```
>rep(1:4, 2:5)
 [1] 1 1 2 2 2 3 3 3 3 4 4 4 4
>rep(c("a", "b", "c"), 2)
  [1] "a" "b" "c" "a" "b" "c“
>rep(c("apple", "banana", "cake"), 2)
 [1] "apple" "banana" "cake" "apple" "banana"
   "cake"
```

Generating current time and date

* Sys.time() command provides the current time and date from the computer system.

```
Sys.time()
[1] "2019-01-02 14:24:29 IST"
```

* Sys.Date() command provides the current date from the computer system.

```
> Sys.Date()
[1] "2019-01-02"
```

Generating current time and date

* Generating sequences of dates
* Sequence of years, months or days

```
> seq(as.Date("2017-01-01"), by = "years", length =5)
[1] "2017-01-01" "2018-01-01" "2019-01-01" "2020-01-01" "2021-01-
    01"
> seq(as.Date("2017-01-01"), by = "months", length = 4)
[1] "2017-01-01" "2017-02-01" "2017-03-01" "2017-04-01“
> seq(as.Date("2017-01-01"), by = "days", length = 5)
[1] "2017-01-01" "2017-01-02" "2017-01-03" "2017-01-04" "2017-01-
    05"
```

Generating sequences of letters

* A vector of positive integers (letters and LETTERS return the 26 lowercase and uppercase letters, respectively).
* > letters

  [1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j" "k" "l" "m" "n"

  [15] "o" "p" "q" "r" "s" "t" "u" "v" "w" "x" "y" "z“
* > letters[21:23]

  [1] "u" "v" "w“
* > LETTERS[1:3]

  [1] "A" "B" "C"

Vector indexing A logical vector

* > x <- 1:10
* >x
* [1] 1 2 3 4 5 6 7 8 9 10

* > x[(x > 5)]
* [1] 6 7 8 9 10

* > x[(x%%2==0)] #%% indicates x mod y
* [1] 2 4 6 8 10 #values for which x mod 2 is 0

* > x[(x%%2==1)]
* [1] 1 3 5 7 9 # values for which x mod 2 is 1

logical vector

* > x <- 1:10
* >x
* [1] 1 2 3 4 5 6 7 8 9 10
* > x[5] <- NA
* > x
* [1] 1 2 3 4 NA 6 7 8 9 10
  > y <- x[!is.na(x)] #! Means negation
* > y
* [1] 1 2 3 4 6 7 8 9 10 # 5 is missing
  > mean(x)
* [1] NA
* > mean(y)
* [1] 5.555556

Partition values

* Quartile: Divides the data into 4 equal parts.
* Decile: Divides the data into 10 equal parts.
* Percentile: Divides the data into 100 equal parts.

Partition values

* `quantile` function computes quantiles corresponding to the given probabilities.
* The smallest observation corresponds to a probability of 0 and the largest to a probability of 1.

* `quantile(x, ...)`

* `quantile(x, probs = seq(0,1,0.25),...)`

* Arguments
* `x` numeric vector whose sample quantiles are wanted,
* `probs` numeric vector of probabilities with values in [0, 1].

Partition values

Example: Marks of 15 students are

marks <- c(68, 82, 63, 86, 34, 96, 41, 89, 29, 51, 75, 77, 56, 59, 42)

Command

quantile(marks)

Output

0% 25% 50% 75% 100%

29.0 46.5 63.0 79.5 96.0

Partition values

Example: Marks of 15 students are

marks <- c(68, 82, 63, 86, 34, 96, 41, 89, 29, 51, 75, 77, 56, 59, 42)

Defining probabilities

Command

quantile(marks, probs=c(0,0.20,0.4,0.6,0.8,1))

Output

0%	20%	40%	60%	80%	100%
29.0	41.8	57.8	70.8	82.8	96.0

Central tendency of data

Example

marks<- c(68, 82, 63, 86, 34, 96, 41, 89, 29, 51, 75, 77, 56, 59, 42)

	Command	Output
Mean	mean(marks)	63.2
Geometric mean	prod(marks)^(1/length(marks))	59.61099
Harmonic mean	1/mean(1/marks)	55.78628
Median	median(marks)	63
Variance	var(Marks)	439.3143
standard deviation	sqrt(var(marks))	20.95983

References

* Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.
* Hands-On Programming with R. Garrett Grolemund Publisher: O'Reilly Media