University of BRISTOL

Getting started with R

A beginner’s guide to R and R Studio

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Statistical Computing & Empirical Methods

What will we cover today?

- We will introduce R and RStudio
- We will learn about the basic objects and operations
- We will learn how to write a simple function in R with control flow statements
- We will see how R facilitates a functional paradigm with call-by-value semantics
- We have a brief look at lazy evaluation
- We will give a few signposts for where to learn more.

Why R?

- R is a free, open source programming language designed for Statistical Computing.
- R provides a fantastic ecosystem for:
  a) Graphics and data visualization
  b) Efficient data wrangling
  c) Statistical inference
  d) Machine Learning
- Vast online community of contributors and enthusiasts!
- Remark: Python & Julia provide increasingly competitive alternatives.

Why RStudio?

- RStudio is a free, open source *integrated development environment* for R.
- RStudio provides:

a) A console with a command line interface

b) A source editor for writing, executing and debugging R scripts

c) Syntax highlighting, code completion, smart indentation

d) Reproducible analysis via knitr & R Markdown.

e) Convenient interface for version control via Git

Installing R and RStudio

- You can install both R and RStudio in Windows, Linux or Mac OS X.
- First download and install R from the Comprehensive R Archive Network:

http://www.r-project.org

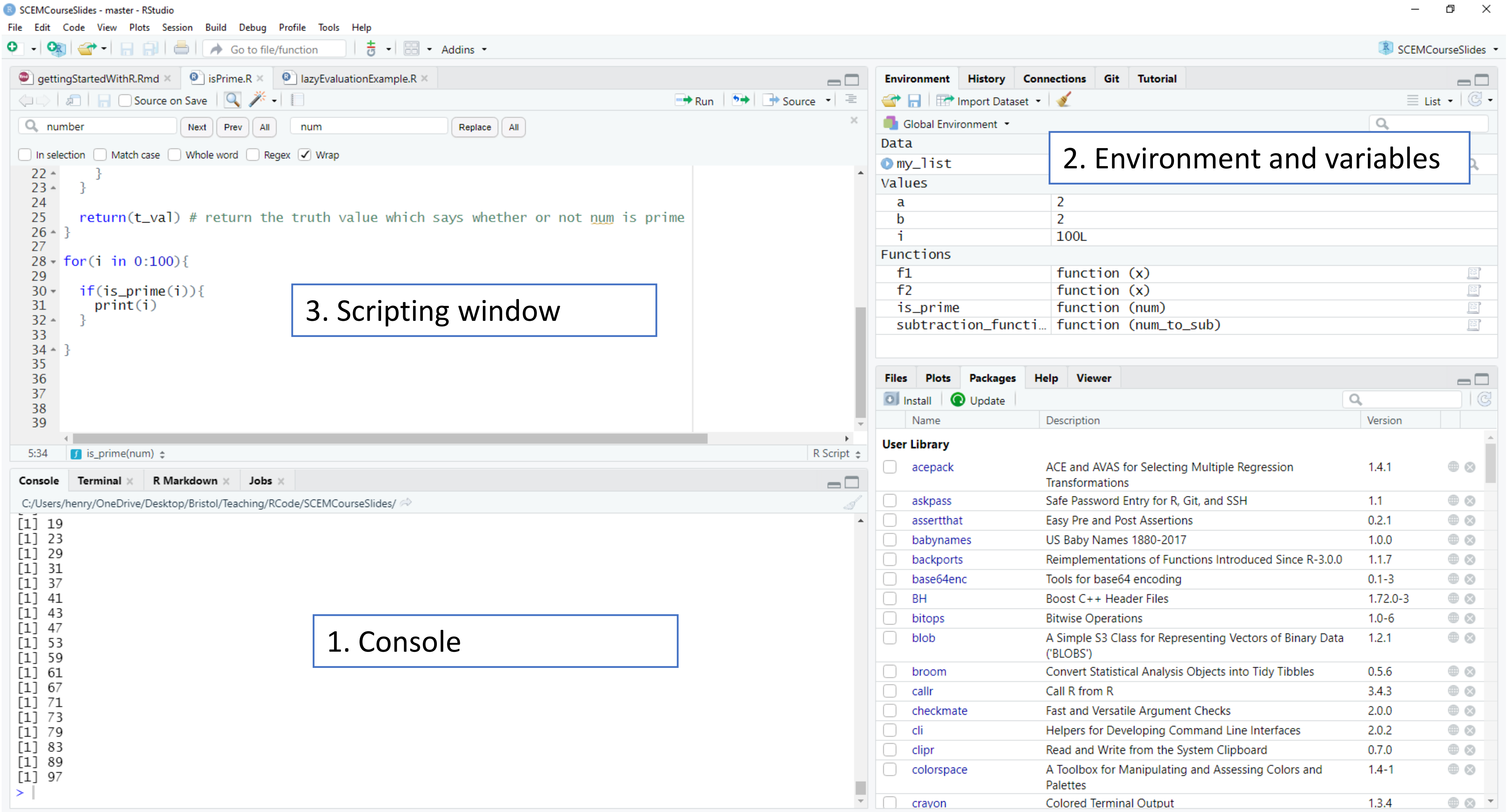
- Then download and install Rstudio:

http://www.rstudio.com/download

- You can also find the links within the assignment!

Now take a break!

Your first R session


SCEMCourseSlides - master - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
SCEMCourseSlides
gettingStartedWithR.Rmd
isPrime.R
lazyEvaluationExample.R
Source on Save
Run
Source
Next
Prev
All
Replace
All
Environment History Connections Git Tutorial
Import Dataset
List
Global Environment
Console Terminal R Markdown Jobs
Files Plots Packages Help Viewer
Install
Update
R Script

Find: number — Replace: num

□ In selection □ Match case □ Whole word □ Regex ☑ Wrap

```
    }
  }

  return(t_val) # return the truth value which says whether or not num is prime
}

for(i in 0:100){

  if(is_prime(i)){
    print(i)
  }

}
```

5:34 is_prime(num)

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```
[1] 19
[1] 23
[1] 29
[1] 31
[1] 37
[1] 41
[1] 43
[1] 47
[1] 53
[1] 59
[1] 61
[1] 67
[1] 71
[1] 73
[1] 79
[1] 83
[1] 89
[1] 97
>
```

Data	
my_list	
Values	
a	2
b	2
i	100L
Functions	
f1	function (x)
f2	function (x)
is_prime	function (num)
subtraction_functi…	function (num_to_sub)

Name	Description	Version
User Library		
□ acepack	ACE and AVAS for Selecting Multiple Regression Transformations	1.4.1
□ askpass	Safe Password Entry for R, Git, and SSH	1.1
□ assertthat	Easy Pre and Post Assertions	0.2.1
□ babynames	US Baby Names 1880-2017	1.0.0
□ backports	Reimplementations of Functions Introduced Since R-3.0.0	1.1.7
□ base64enc	Tools for base64 encoding	0.1-3
□ BH	Boost C++ Header Files	1.72.0-3
□ bitops	Bitwise Operations	1.0-6
□ blob	A Simple S3 Class for Representing Vectors of Binary Data ('BLOBS')	1.2.1
□ broom	Convert Statistical Analysis Objects into Tidy Tibbles	0.5.6
□ callr	Call R from R	3.4.3
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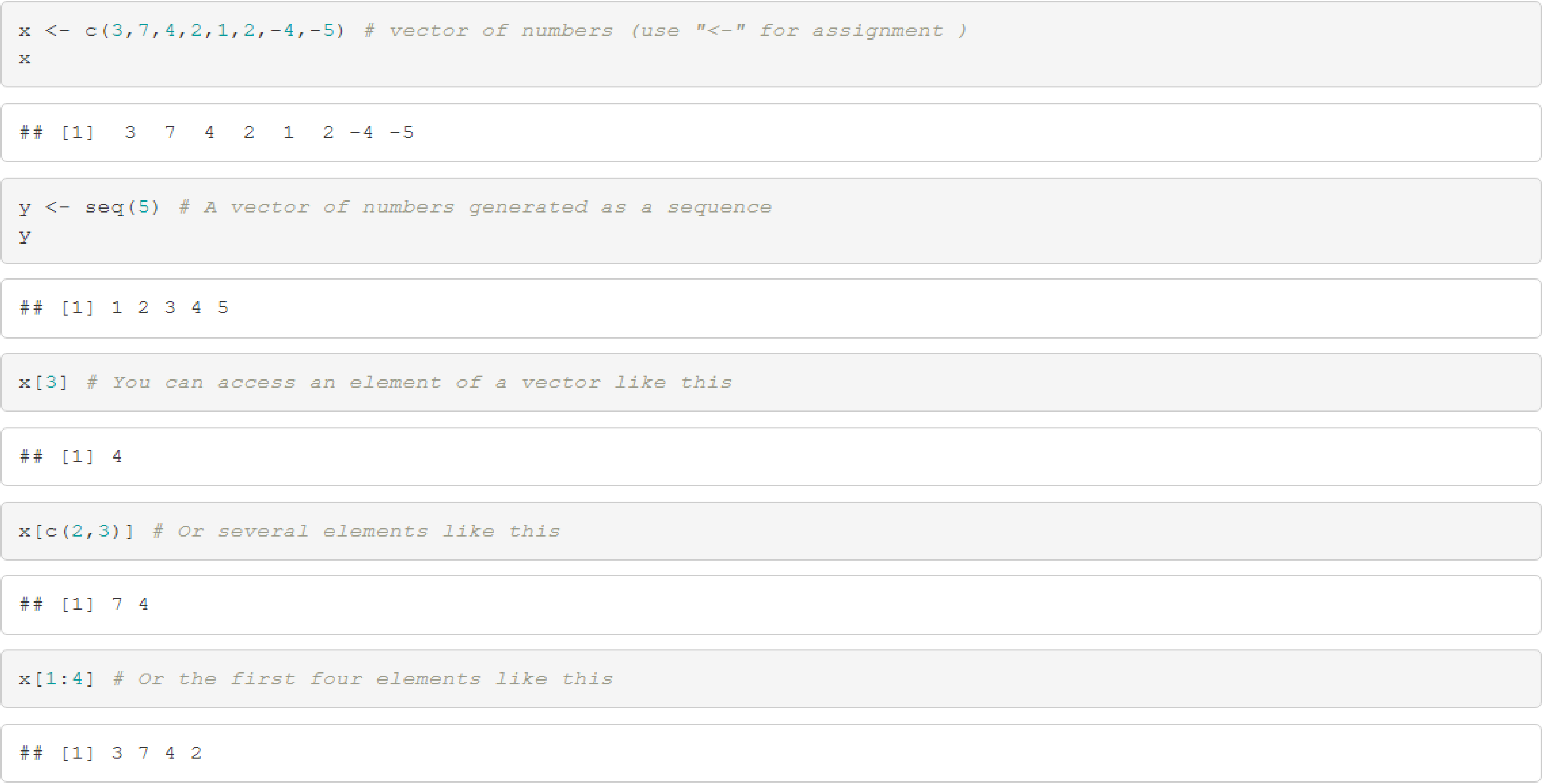
□ clipr	Read and Write from the System Clipboard	0.7.0
□ colorspace	A Toolbox for Manipulating and Assessing Colors and Palettes	1.4-1
□ crayon	Colored Terminal Output	1.3.4

2. Environment and variables

3. Scripting window

1. Console

Vectors



```
x <- c(3,7,4,2,1,2,-4,-5) # vector of numbers (use "<-" for assignment )
x
```

```
## [1]  3  7  4  2  1  2 -4 -5
```

```
y <- seq(5) # A vector of numbers generated as a sequence
y
```

```
## [1] 1 2 3 4 5
```

```
x[3] # You can access an element of a vector like this
```

```
## [1] 4
```

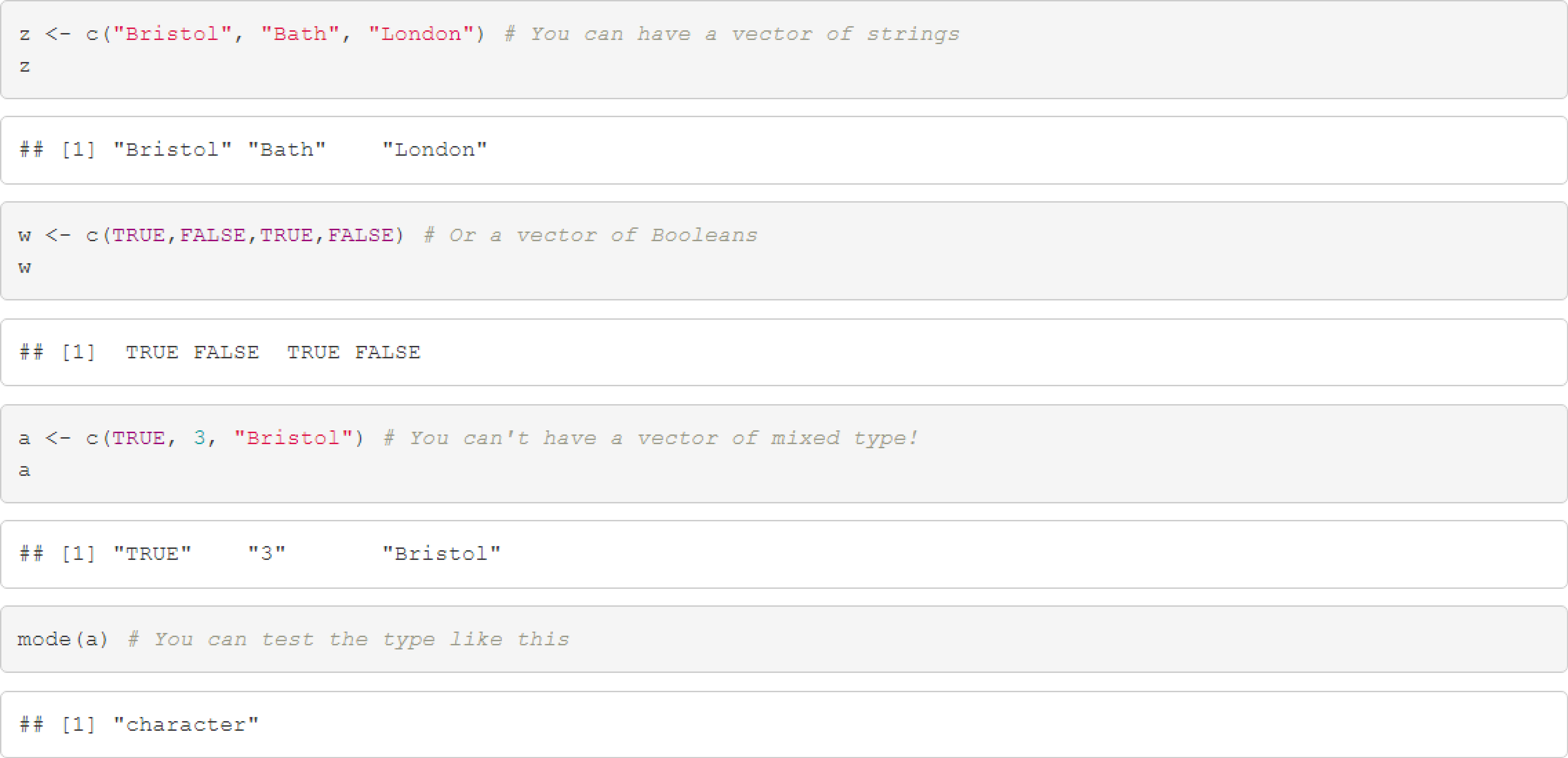
```
x[c(2,3)] # Or several elements like this
```

```
## [1] 7 4
```

```
x[1:4] # Or the first four elements like this
```

```
## [1] 3 7 4 2
```

Vectors



```
z <- c("Bristol", "Bath", "London") # You can have a vector of strings
z
```

```
## [1] "Bristol" "Bath"    "London"
```

```
w <- c(TRUE,FALSE,TRUE,FALSE) # Or a vector of Booleans
w
```

```
## [1]  TRUE FALSE  TRUE FALSE
```

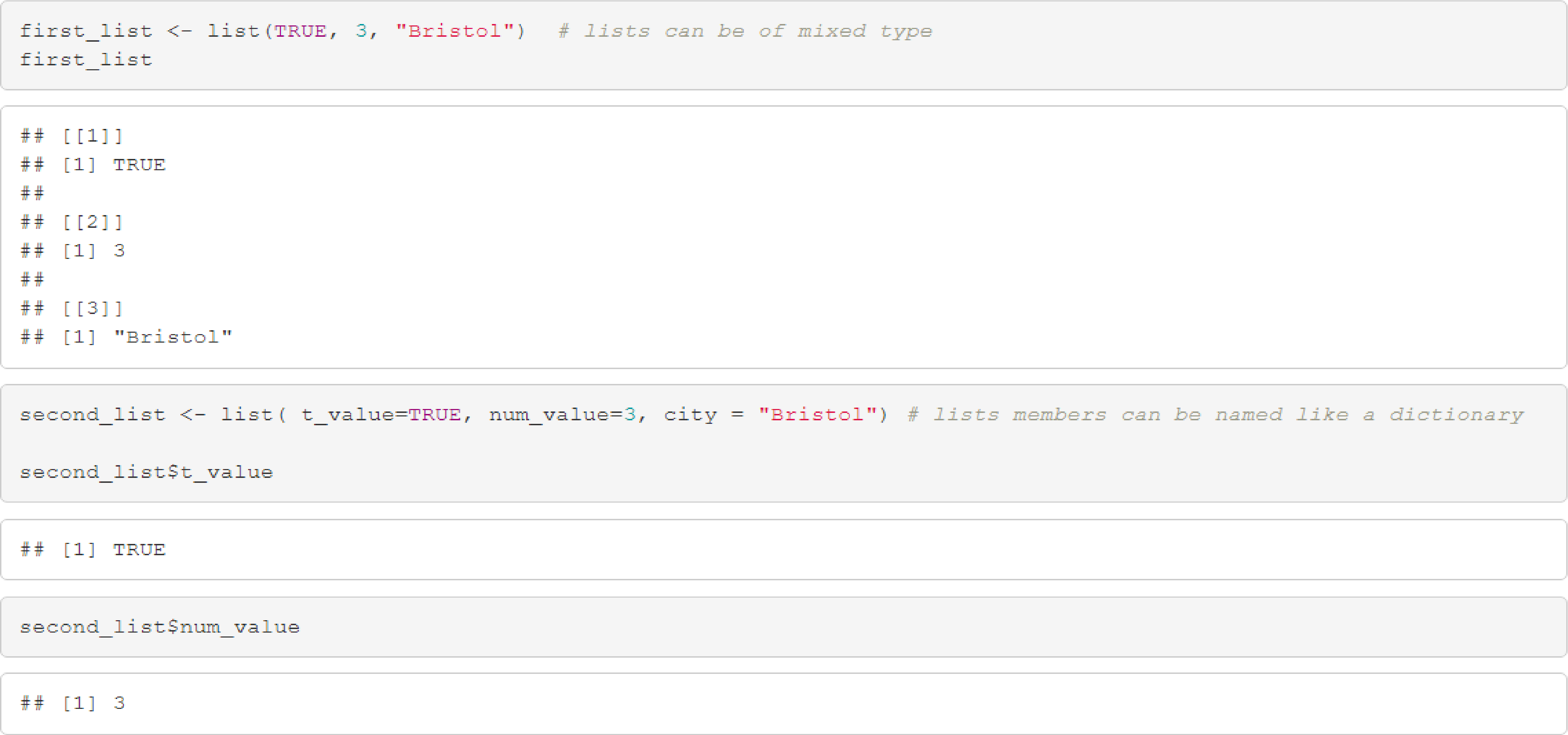
```
a <- c(TRUE, 3, "Bristol") # You can't have a vector of mixed type!
a
```

```
## [1] "TRUE"    "3"       "Bristol"
```

```
mode(a) # You can test the type like this
```

```
## [1] "character"
```

Lists



```
first_list <- list(TRUE, 3, "Bristol")  # lists can be of mixed type
first_list
```

```
## [[1]]
## [1] TRUE
##
## [[2]]
## [1] 3
##
## [[3]]
## [1] "Bristol"
```

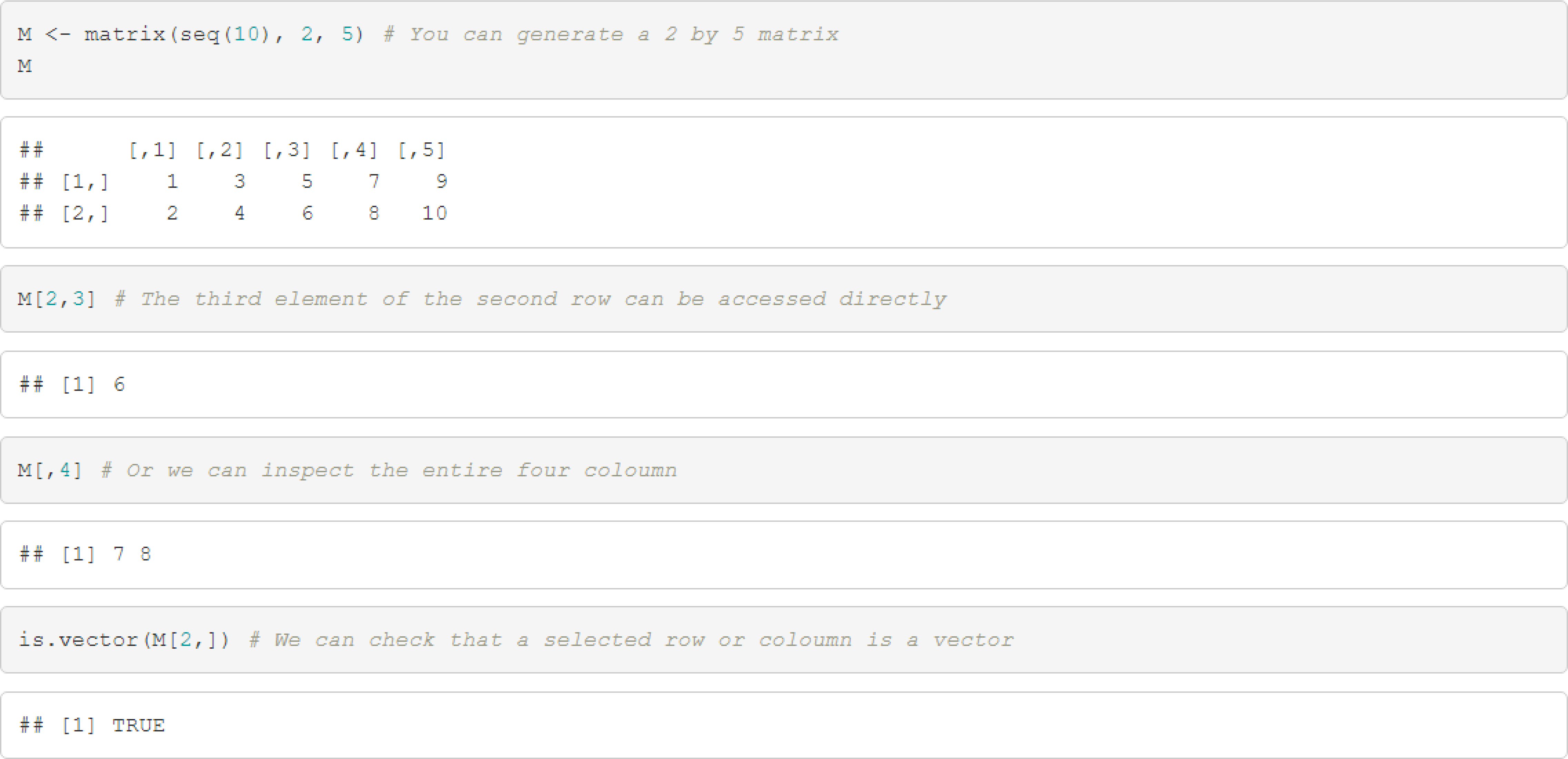
```
second_list <- list( t_value=TRUE, num_value=3, city = "Bristol") # lists members can be named like a dictionary

second_list$t_value
```

```
## [1] TRUE
```

```
second_list$num_value
```

```
## [1] 3
```

Matrices



```
M <- matrix(seq(10), 2, 5) # You can generate a 2 by 5 matrix
M
```

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

```
M[2,3] # The third element of the second row can be accessed directly
```

```
## [1] 6
```

```
M[,4] # Or we can inspect the entire four coloumn
```

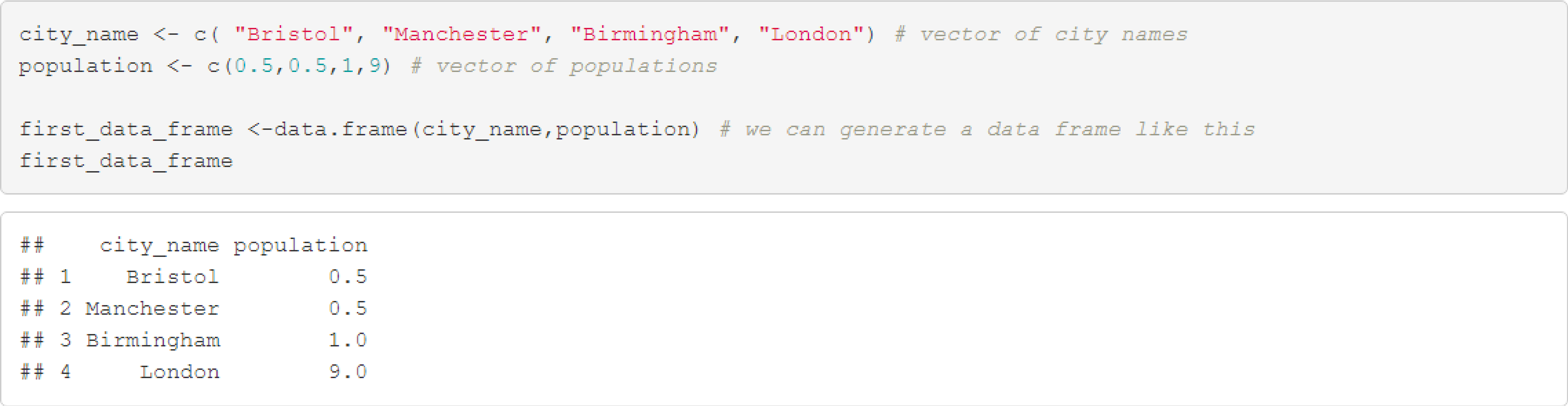
```
## [1] 7 8
```

```
is.vector(M[2,]) # We can check that a selected row or coloumn is a vector
```

```
## [1] TRUE
```

Data frames

- Data frames are powerful objects for representing and manipulating tabular data.

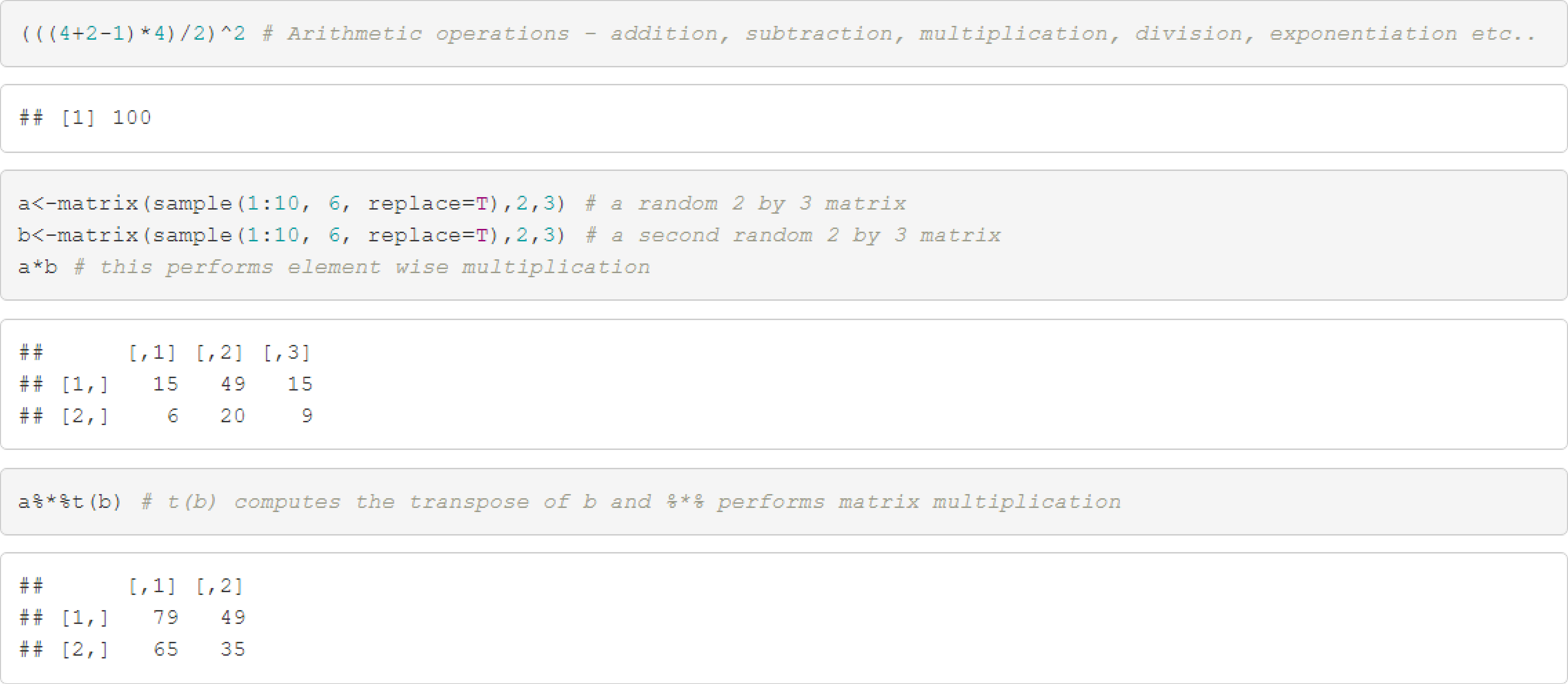


```r
city_name <- c( "Bristol", "Manchester", "Birmingham", "London") # vector of city names
population <- c(0.5,0.5,1,9) # vector of populations

first_data_frame <-data.frame(city_name,population) # we can generate a data frame like this
first_data_frame
```

```
##    city_name population
## 1    Bristol        0.5
## 2 Manchester        0.5
## 3 Birmingham        1.0
## 4     London        9.0
```

- Unlike matrices, columns are named & different columns may be of different type
- However, the cells within a column must be of the same type.

Arithmetic operations



```
(((4+2-1)*4)/2)^2 # Arithmetic operations - addition, subtraction, multiplication, division, exponentiation etc..
```

```
## [1] 100
```

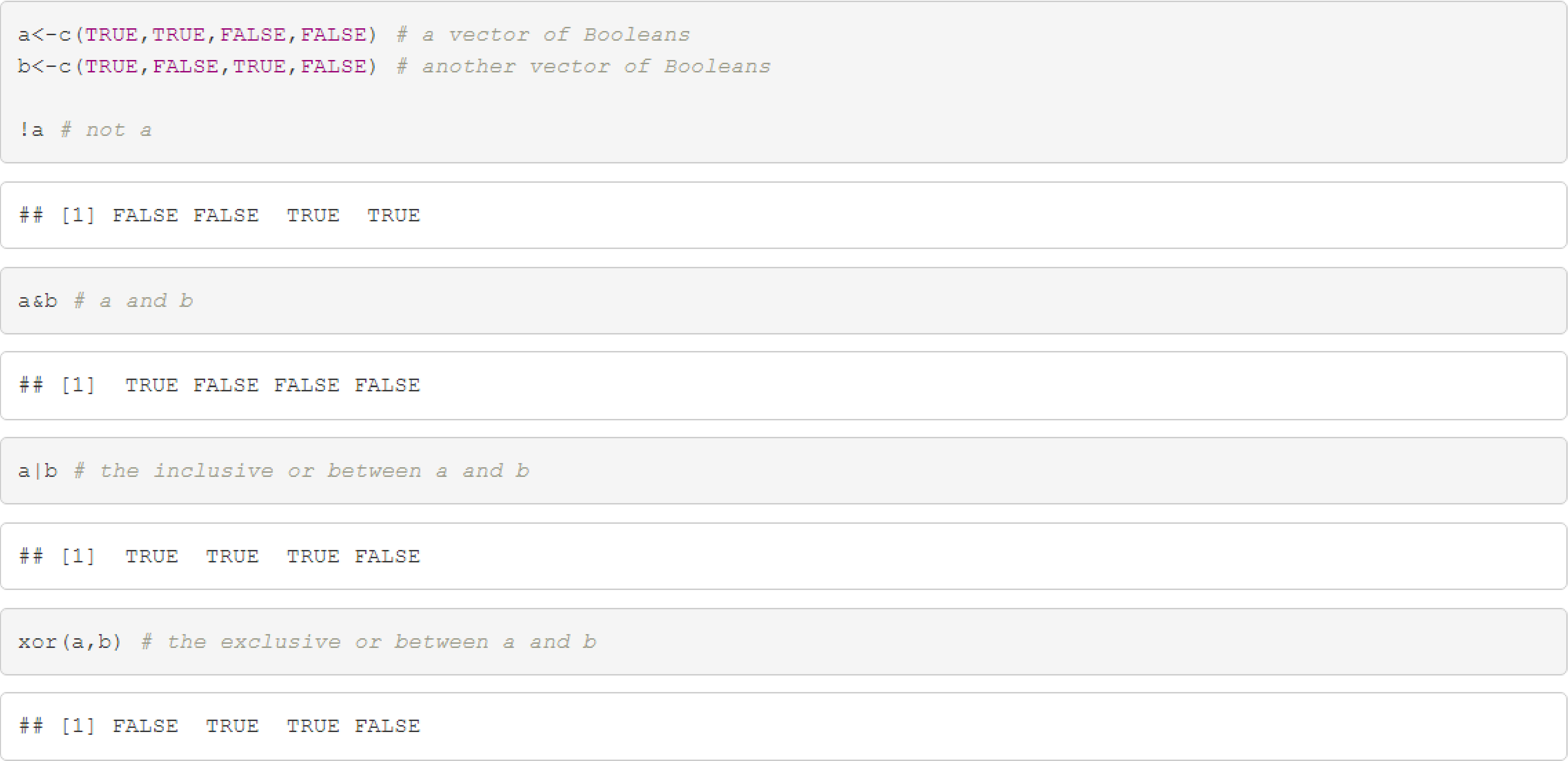
```
a<-matrix(sample(1:10, 6, replace=T),2,3) # a random 2 by 3 matrix
b<-matrix(sample(1:10, 6, replace=T),2,3) # a second random 2 by 3 matrix
a*b # this performs element wise multiplication
```

```
##      [,1] [,2] [,3]
## [1,]   15   49   15
## [2,]    6   20    9
```

```
a%*%t(b) # t(b) computes the transpose of b and %*% performs matrix multiplication
```

```
##      [,1] [,2]
## [1,]   79   49
## [2,]   65   35
```

Boolean operations



```r
a<-c(TRUE,TRUE,FALSE,FALSE) # a vector of Booleans
b<-c(TRUE,FALSE,TRUE,FALSE) # another vector of Booleans

!a # not a
```

```
## [1] FALSE FALSE  TRUE  TRUE
```

```r
a&b # a and b
```

```
## [1]  TRUE FALSE FALSE FALSE
```

```r
a|b # the inclusive or between a and b
```

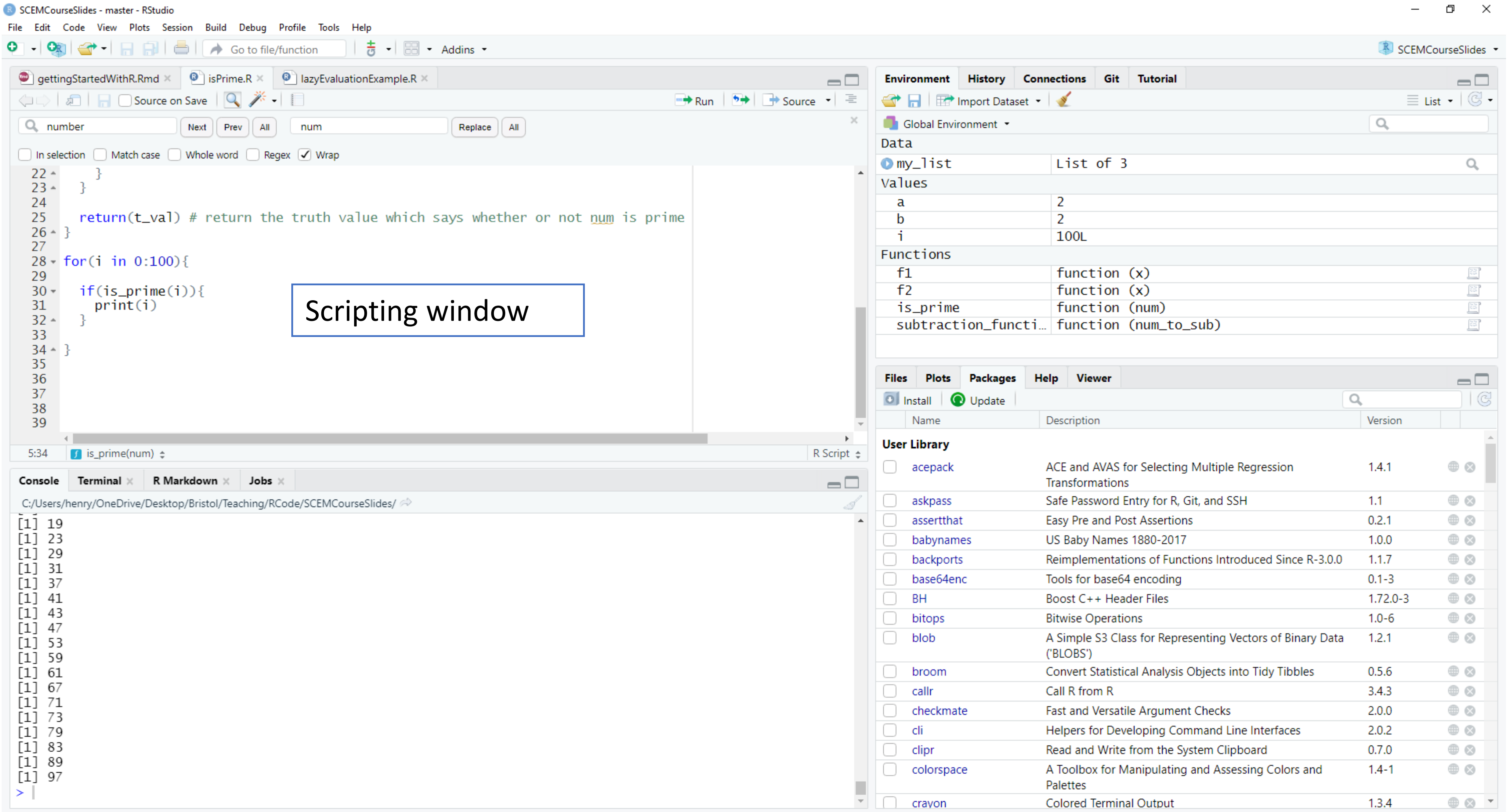
```
## [1]  TRUE  TRUE  TRUE FALSE
```

```r
xor(a,b) # the exclusive or between a and b
```

```
## [1] FALSE  TRUE  TRUE FALSE
```

Now take a break!

Your first R script



number

num

□ In selection □ Match case □ Whole word □ Regex ☑ Wrap

```
    }
  }

  return(t_val) # return the truth value which says whether or not num is prime
}

for(i in 0:100){

  if(is_prime(i)){
    print(i)
  }

}
```

Scripting window

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```
[1] 19
[1] 23
[1] 29
[1] 31
[1] 37
[1] 41
[1] 43
[1] 47
[1] 53
[1] 59
[1] 61
[1] 67
[1] 71
[1] 73
[1] 79
[1] 83
[1] 89
[1] 97
>
```

Data	
my_list	List of 3
Values	
a	2
b	2
i	100L
Functions	
f1	function (x)
f2	function (x)
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colorspace	A Toolbox for Manipulating and Assessing Colors and Palettes	1.4-1
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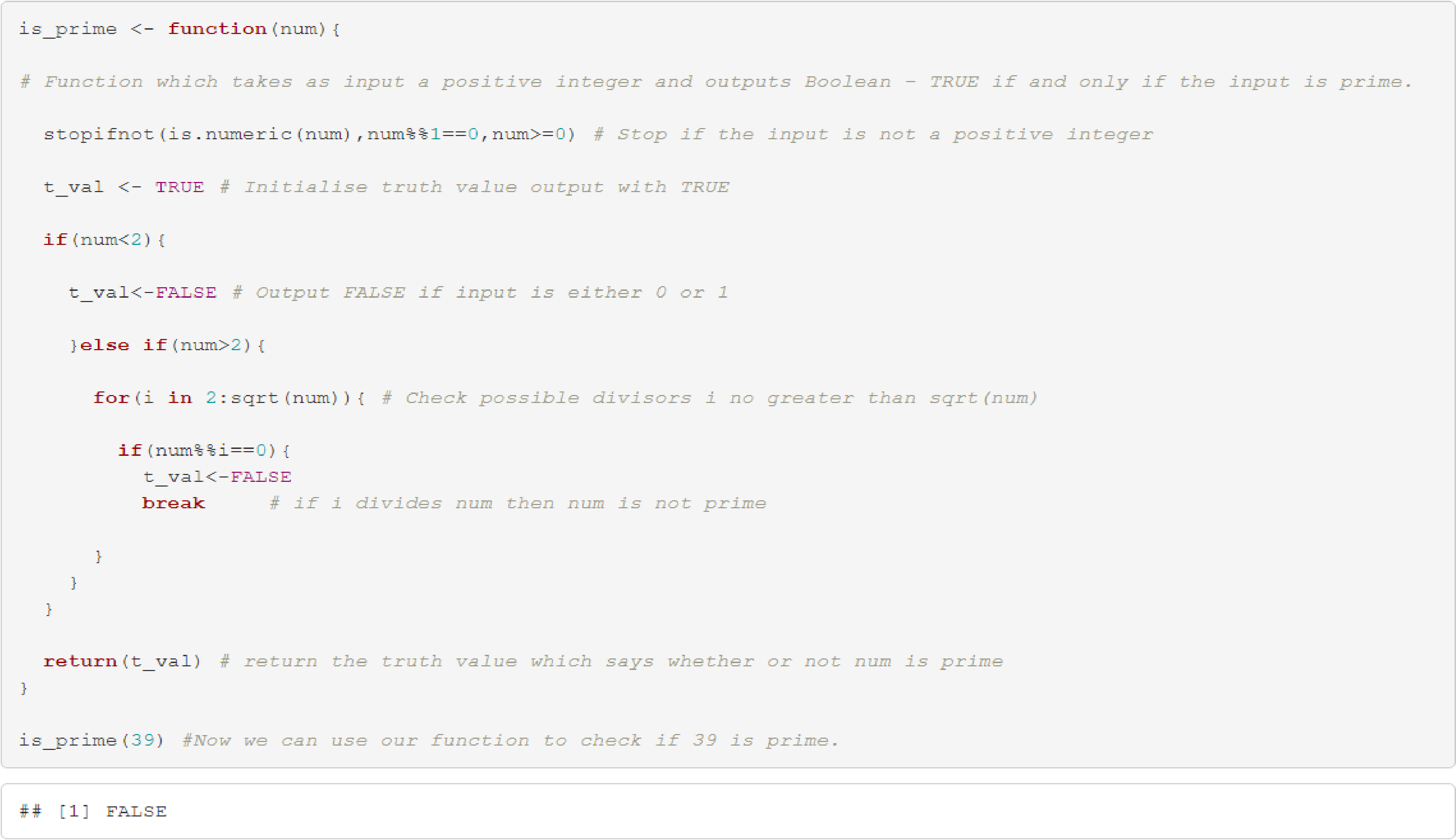
Functions

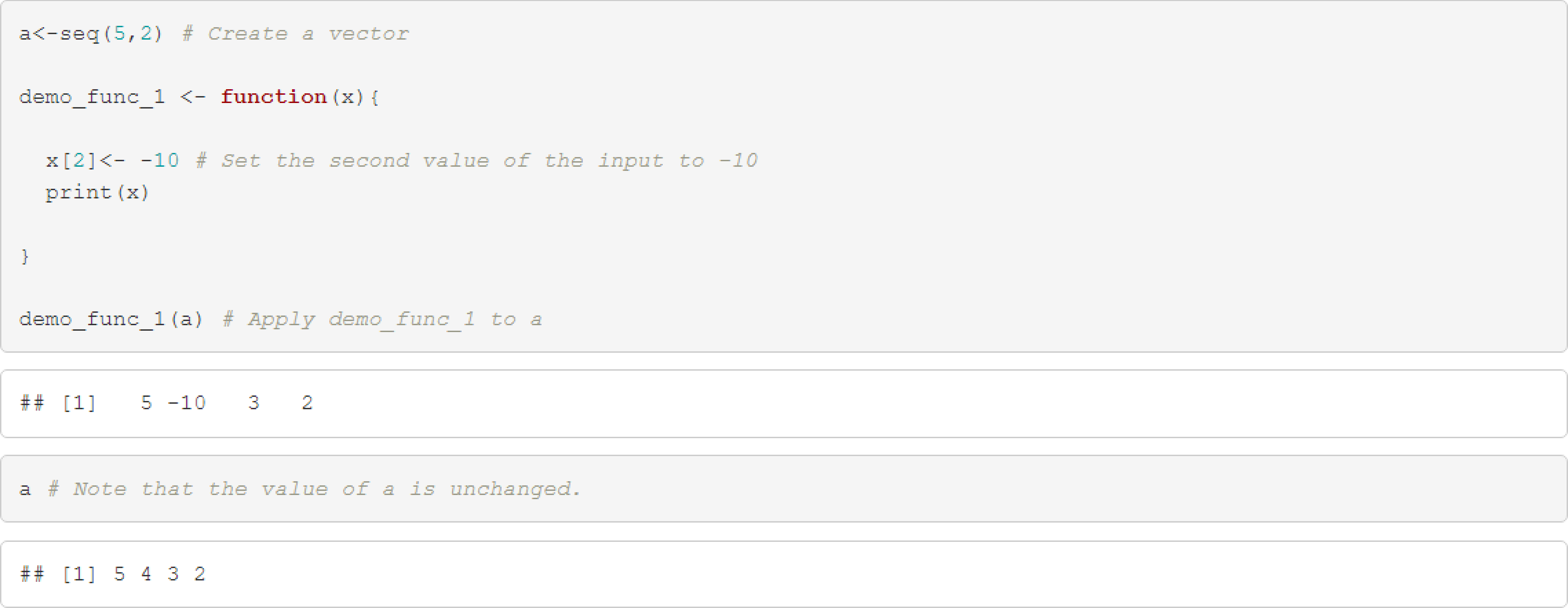


```r
is_prime <- function(num){

# Function which takes as input a positive integer and outputs Boolean - TRUE if and only if the input is prime.

  stopifnot(is.numeric(num),num%%1==0,num>=0)  # Stop if the input is not a positive integer

  t_val <- TRUE # Initialise truth value output with TRUE

  if(num<2){

    t_val<-FALSE # Output FALSE if input is either 0 or 1

    }else if(num>2){

      for(i in 2:sqrt(num)){ # Check possible divisors i no greater than sqrt(num)

        if(num%%i==0){
          t_val<-FALSE
          break     # if i divides num then num is not prime

        }
      }
    }

  return(t_val) # return the truth value which says whether or not num is prime
}

is_prime(39) #Now we can use our function to check if 39 is prime.
```

```
## [1] FALSE
```

Call by value semantics

- In R arguments in functions are passed with call-by-value semantics.



```
a<-seq(5,2) # Create a vector

demo_func_1 <- function(x){

  x[2]<- -10 # Set the second value of the input to -10
  print(x)

}

demo_func_1(a) # Apply demo_func_1 to a
```

```
## [1]   5 -10   3   2
```

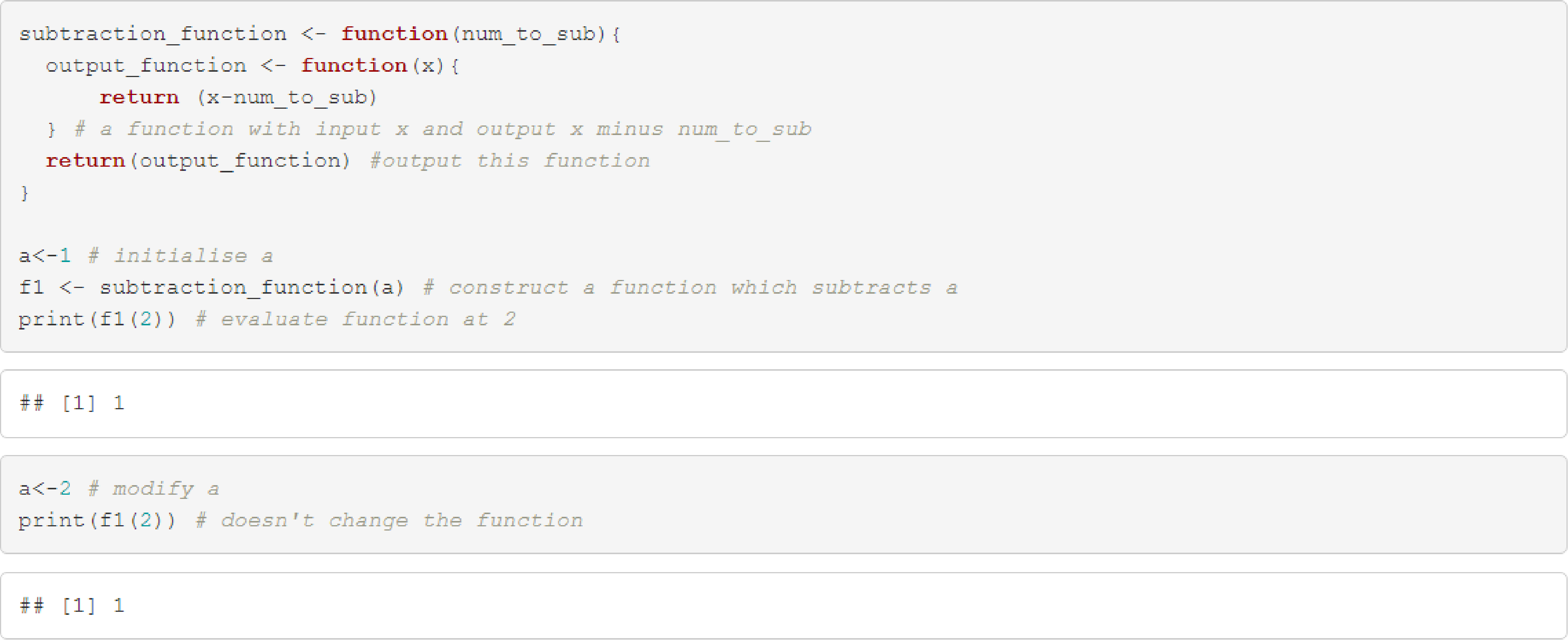
```
a # Note that the value of a is unchanged.
```

```
## [1] 5 4 3 2
```

- This facilitates a functional programming style with limited side effects.

Lazy evaluation

- Lazy evaluation enables efficiency but has some surprising consequences.



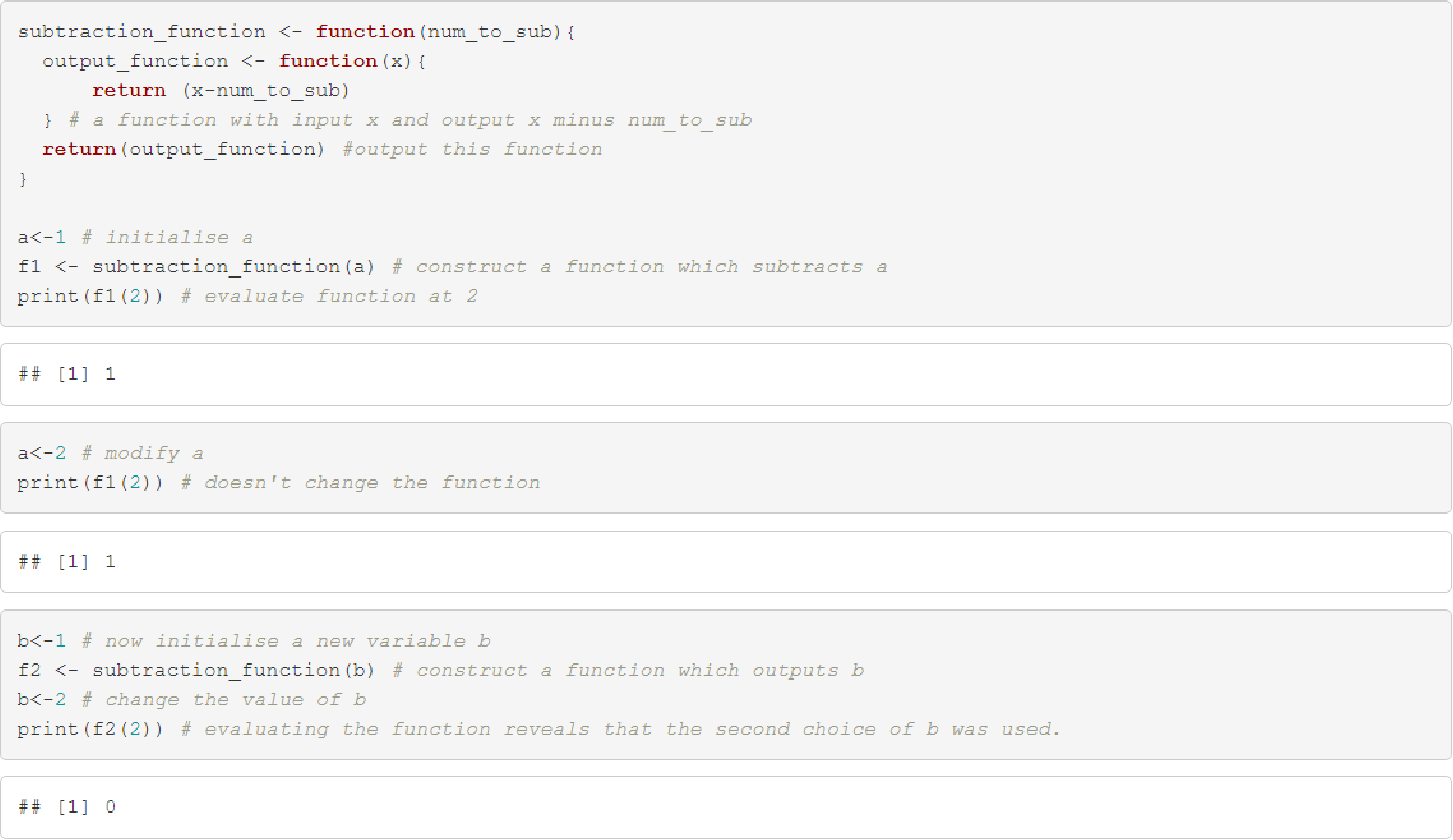
```
subtraction_function <- function(num_to_sub){
  output_function <- function(x){
      return (x-num_to_sub)
  } # a function with input x and output x minus num_to_sub
  return(output_function) #output this function
}

a<-1 # initialise a
f1 <- subtraction_function(a) # construct a function which subtracts a
print(f1(2)) # evaluate function at 2
```

```
## [1] 1
```

```
a<-2 # modify a
print(f1(2)) # doesn't change the function
```

```
## [1] 1
```

Lazy evaluation



```r
subtraction_function <- function(num_to_sub){
  output_function <- function(x){
      return (x-num_to_sub)
  } # a function with input x and output x minus num_to_sub
  return(output_function) #output this function
}

a<-1 # initialise a
f1 <- subtraction_function(a) # construct a function which subtracts a
print(f1(2)) # evaluate function at 2
```

```
## [1] 1
```

```r
a<-2 # modify a
print(f1(2)) # doesn't change the function
```

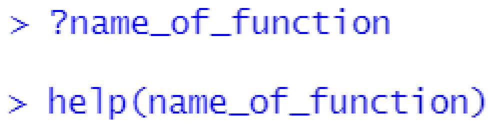
```
## [1] 1
```

```r
b<-1 # now initialise a new variable b
f2 <- subtraction_function(b) # construct a function which outputs b
b<-2 # change the value of b
print(f2(2)) # evaluating the function reveals that the second choice of b was used.
```

```
## [1] 0
```

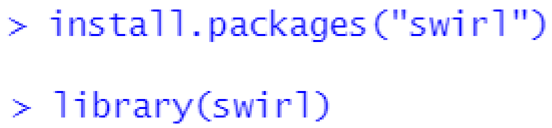
How can we learn more?

- Almost every R function has an associated help function which can be accessed via



```
> ?name_of_function
> help(name_of_function)
```

- A fantastic resource to learn more about R is the Swirl package:



```
> install.packages("swirl")
> library(swirl)
```

- Another great resource is StackOverflow for R:

https://stackoverflow.com/questions/tagged/r

What have we covered?

- We installed R and RStudio and started our first session.
- We learned about the basic objects – vectors, lists, matrices & data frames.
- We considered basic operations – arithmetic and Boolean
- We learnt how to write a simple function with control flow statements
- We saw that R facilitates a functional paradigm with call-by-value semantics
- We briefly looked at lazy evaluation and its surprising consequences
- We discussed a few resources for learning more – the help function, Swirl, stack etc.

That's plenty for today! – now onto the exercises.

University of BRISTOL

Thanks for listening,

… now onto the assignment!

Henry W J Reeve

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