Introduction to R and RStudio

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What is R?

R is a language and environment for statistical computing and graphics. It is widely used for a variety of statistical analysis (i.e., linear and nonlinear modeling, classical statistical tests, clustering, etc.). We can also use R for data visualization and producing figures for presentations. R is freely available and has a large collection of developed packages of different tools. Overall, R is a powerful tool that can be used to handle big data, perform statistics, and visualize results, while enabling end-users to easily develop tools and packages for customized functionality.

What is RStudio?

While R, also called "base R", itself is an interpreted computer language and comes with a terminal, ease of use and more functionality is introduced when using RStudio, an open source Integrated Development Environment (IDE). Rather than using a terminal, RStudio provides a graphical user interface that is platform agnostic and integrates additional packages, project management, version control, and notebooks.

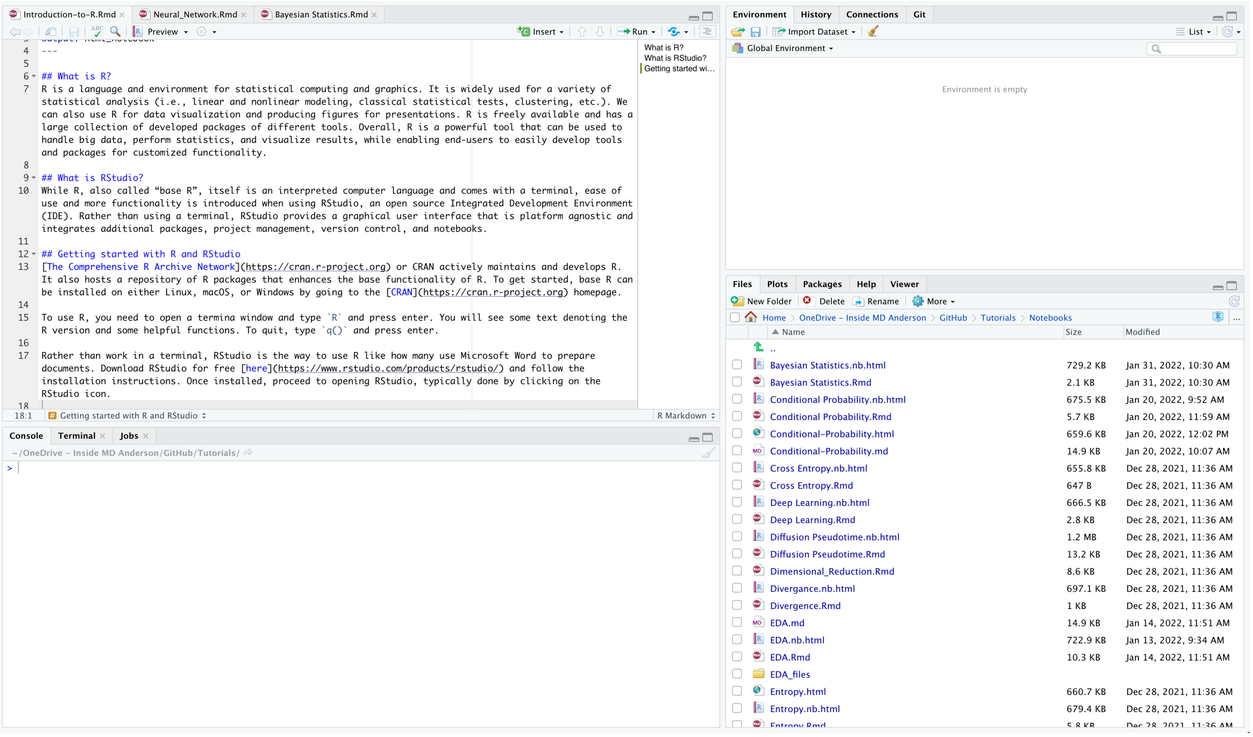
Getting started with R and RStudio

The Comprehensive R Archive Network or CRAN actively maintains and develops R. It also hosts a repository of R packages that enhances the base functionality of R. To get started, base R can be installed on either Linux, macOS, or Windows by going to the CRAN homepage.

To use R, you need to open a termina window and type `R` and press enter. You will see some text denoting the R version and some helpful functions. To quit, type `q()` and press enter.

Rather than work in a terminal, RStudio is the way to use R like how many use Microsoft Word to prepare documents. Download RStudio for free here and follow the installation instructions. Once installed, proceed to opening RStudio, typically done by clicking on the RStudio icon.

Once you open RStudio, you will see four main panes. Each will contain different information. You can see my screen below.



```
output: html_notebook
---

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```

```
>
```

Name	Size	Modified
..		
Bayesian Statistics.nb.html	729.2 KB	Jan 31, 2022, 10:30 AM
Bayesian Statistics.Rmd	2.1 KB	Jan 31, 2022, 10:30 AM
Conditional Probability.nb.html	675.5 KB	Jan 20, 2022, 9:52 AM
Conditional Probability.Rmd	5.7 KB	Jan 20, 2022, 11:59 AM
Conditional–Probability.html	659.6 KB	Jan 20, 2022, 12:02 PM
Conditional–Probability.md	14.9 KB	Jan 20, 2022, 10:07 AM
Cross Entropy.nb.html	655.8 KB	Dec 28, 2021, 11:36 AM
Cross Entropy.Rmd	647 B	Dec 28, 2021, 11:36 AM
Deep Learning.nb.html	666.5 KB	Dec 28, 2021, 11:36 AM
Deep Learning.Rmd	2.8 KB	Dec 28, 2021, 11:36 AM
Diffusion Pseudotime.nb.html	1.2 MB	Dec 28, 2021, 11:36 AM
Diffusion Pseudotime.Rmd	13.2 KB	Dec 28, 2021, 11:36 AM
Dimensional_Reduction.Rmd	8.6 KB	Dec 28, 2021, 11:36 AM
Divergance.nb.html	697.1 KB	Dec 28, 2021, 11:36 AM
Divergence.Rmd	1 KB	Dec 28, 2021, 11:36 AM
EDA.md	14.9 KB	Jan 14, 2022, 11:51 AM
EDA.nb.html	722.9 KB	Jan 13, 2022, 9:34 AM
EDA.Rmd	10.3 KB	Jan 14, 2022, 11:51 AM
EDA_files		
Entropy.html	660.7 KB	Dec 28, 2021, 11:36 AM
Entropy.nb.html	679.4 KB	Dec 28, 2021, 11:36 AM
Entropy.Rmd	5.8 KB	Dec 28, 2021, 11:36 AM

Starting from the top left pane and going from left to right, we have the descriptions of each pane below:

1. **Source Editor**: This pane is where you can write R scripts or notebooks. You can write in other programming languages if you wanted to as well. Each document will have its oown tab. Code written here can be run wiith the `Run` command.
2. **Environment**: This pane displays objects, variables, and functions that are generated in your R session. There is also a history of all code that was run.
3. **Console**: This pane is where you can type commands and interactively run R code. The output will display in the console.
4. **Files, Plots, Packages, Help, Viewer**: This pane has several tabs that are important.
    - *Files*: This tab shows the structure and content of a directory on your computer. This could be your working directory or a directory that you manually navigated to.
    - *Plots*: This tab will display plots or figures as an output from the console.
    - *Packages*: This tab contains a list of all packages that are installed. Packages that are loaded in your R session will have a checked box.
    - *Help*: This tab reveals the help pages for an R package or function.
    - *Viewer*: This tab shows compiledd R Markdown documents.

Starting a new project in RStudio

Basic math calculations in R

Below are some of the most common math calculations that can be done in R.

Operation	Symbol
Addition	`a + b`
Subtraction	`a - b`
Multiplacation	`a * b`

Operation	Symbol
Division	`a / b`
Exponent	`a ^ b`
Remainder	`a %% b`
Integer Division	`a %/% b`

For instance, here is an example of addition.

```
5 + 3
```

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

Functions in R

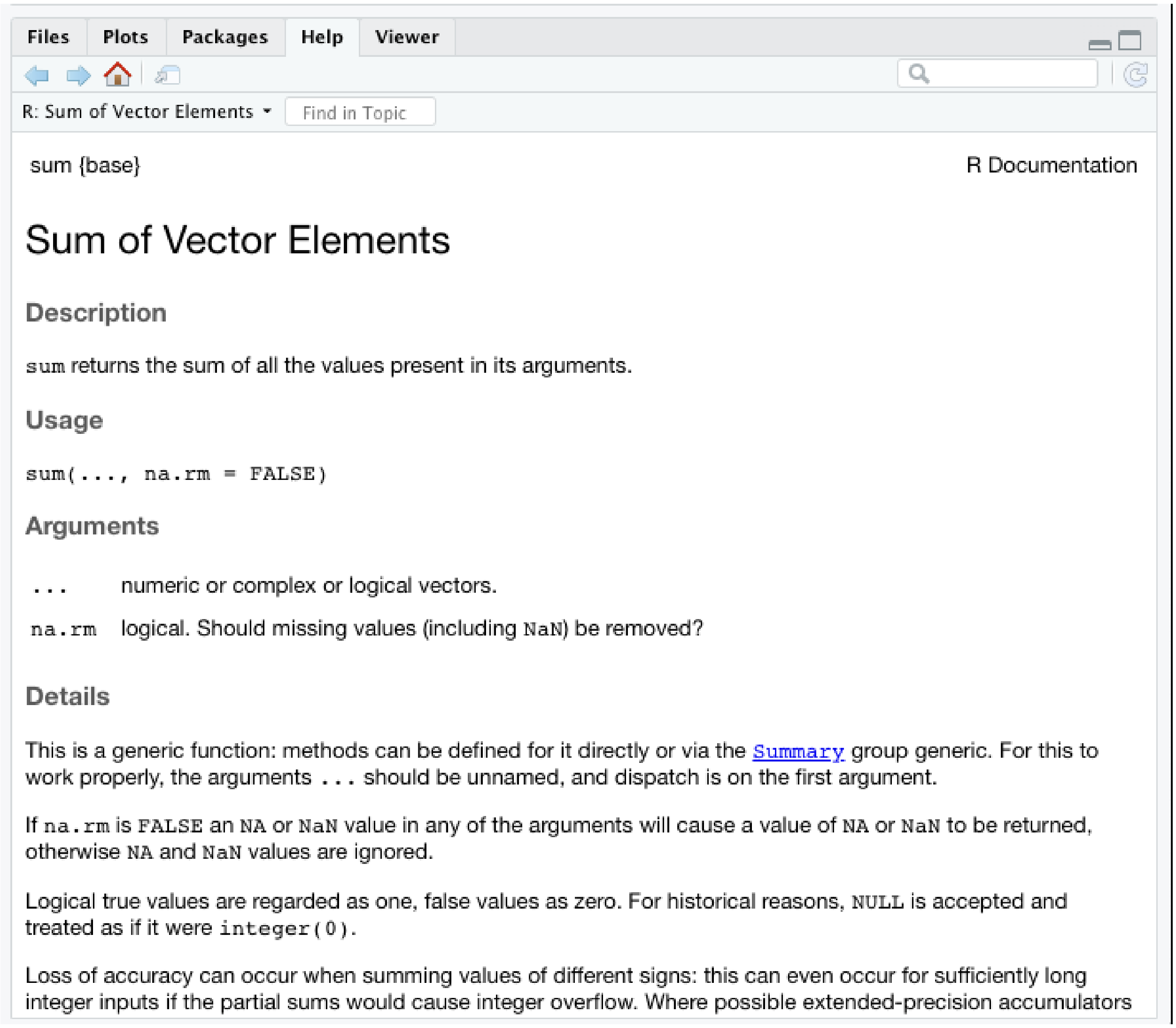
R has several pre-built functions. For instance, we can use `sum()` instead of the `+` symbol for addition.

```
sum(1,3) #This gives the sum of 1 and 3
```

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

We can also call the *R documentation* for a function by using `?` before the function name. The documentation will show up under the Help tab. It contains information regarding description, usage, and arguments for a function.

```
?sum #Find the R Documentation for sum()
```



sum {base}   R Documentation

Sum of Vector Elements

Description

`sum` returns the sum of all the values present in its arguments.

Usage

```
sum(..., na.rm = FALSE)
```

Arguments

`...`	numeric or complex or logical vectors.
`na.rm`	logical. Should missing values (including `NaN`) be removed?

Details

This is a generic function: methods can be defined for it directly or via the `Summary` group generic. For this to work properly, the arguments `...` should be unnamed, and dispatch is on the first argument.

If `na.rm` is `FALSE` an `NA` or `NaN` value in any of the arguments will cause a value of `NA` or `NaN` to be returned, otherwise `NA` and `NaN` values are ignored.

Logical true values are regarded as one, false values as zero. For historical reasons, `NULL` is accepted and treated as if it were `integer(0)`.

Loss of accuracy can occur when summing values of different signs: this can even occur for sufficiently long integer inputs if the partial sums would cause integer overflow. Where possible extended-precision accumulators

We can see that `sum()` can return the sum of more than two values.

```
sum(1,2,3,4,5)
```

```
## [1] 15
```

Math functions in R

In addition to the basic calculations, there are many common pre-built math functions in R.

Operation	Function
Square root	`sqrt()`
Logarithm	`log()`
Logarithm, base 10	`log10()`
Exponential	`exp()`
Summation	`sum()`
Round	`round()`

Operation	Function
Mean	mean()
Median	median()
Minimum	min()
Maximum	max()

```
#What is the square root of 4?
sqrt(4)
```

```
## [1] 2
```

```
#Can we round 3.14?
round(3.14)
```

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

Defining variables

A key aspect of programming is defining variables. We store data or values as variables so that we can use in other functions or recall it at a later time. It allows us to save time by storing the data and not having to re-calculate it again. R has two *assignment operators* for defining variables: `<-` and `=`. The operator `<-` can be used anywhere, whereas the operator `=` is only allowed at the top level.

```
x <- 1

#What is in ‘x‘?
x
```

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

```
y = 15.3

#What is in ‘y‘?
y
```

```
## [1] 15.3
```

```
#What is in x + y?
x + y
```

```
## [1] 16.3
```

We can also define variables within functions.

```
sqrt(y <- 5)
```

```
## [1] 2.236068
```

```
#What is in 'y'?
y
```

```
## [1] 5
```

However, we cannot use the = to do so. This is because functions already have pre-defined arguments that the function is looking for. In this case, sqrt() is looking for the argument x, not y.

```
sqrt(y = 5)
```

We see the following error: `Error in sqrt(y = 5) : supplied argument name 'y' does not match 'x'`

```
sqrt(x = y <- 5) #Here we define y as 5 and pass y into x
```

```
## [1] 2.236068
```

```
sqrt(x = 5) #Here we pass 5 into x
```

```
## [1] 2.236068
```

Importantly, when defining variable names, ensure that you use an *informative* name. This enables yourself and others when reviewing code to know how the variable was used. For instance, we used x and y in the examples, but their meaning is unknown. Something like country_population or room_capacity provides better definition for a variable.

R Data Types

There are different types of data in R, which can be stored as a variable. Below is a table of some of the most commonly used data types.

Data Type	Definition	Example
numeric	Any number value	3.14
integer	Any whole number value	42
character	Any number of ASCII characters defined within quotation marks	"Hello world!"
logical	A value of TRUE or FALSE	TRUE
factor	A categorical type of data	#> [1] Male Male Male Female Female #> Levels: Male Female

The function class() can be used to find out the type of data that you are dealing with.

```
x <- 3
class(x)
```

```
## [1] "numeric"
```

```
x <- TRUE
class(x)
```

```
## [1] "logical"
```

Vectors

Vectors are a data structure in R containing one or more values. In fact, you may have noticed a `[1]` in the output of `x`. This indicates that it is a vector of length `1`.

```
length(x) #This function gives you the length of a vector
```

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

We use the function `c()` to define a vector with multiple elements. The `c` stands for combine.

```
my_first_vector <- c(1,2,3,4,5) #We can also do this with the following, 1:5 instead of c()
my_first_vector
```

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

We can add more elements to the same vector.

```
my_first_vector <- c(my_first_vector, 6,7)
my_first_vector
```

```
## [1] 1 2 3 4 5 6 7
```

We can call specific elements in a vector by using a procecss called *indexing*. Basically, we can subset specific elements of a vector for further analysis. We do this by defining which position we want in brackets `[]` after the vector.

```
#Let's take out the 3rd element
my_first_vector[3]
```

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

What if we wanted to select multiple elements? We can use another vector with the positions we want.

```
#Let's take out the 2nd and 4th elements
my_first_vector[c(2,4)]
```

```
## [1] 2 4
```

We can also do the oposite and select all elements but a single or multiple element by using `-`.

```r
#Let's keep all but the 5th element
my_first_vector[-5]
```

```
## [1] 1 2 3 4 6 7
```

```r
#Let's keep all but the 1st and 3rd elements
my_first_vector[-c(1,3)]
```

```
## [1] 2 4 5 6 7
```

Importantly, R functions are typically *vectorized*. This means that the function will perform its operation on all elements of the vector without having to loop through for each element.

```r
my_first_vector
```

```
## [1] 1 2 3 4 5 6 7
```

```r
my_first_vector * 2
```

```
## [1]  2  4  6  8 10 12 14
```

We can also test some of math functions we listed above.

```r
mean(my_first_vector) #This gives the mean of a numeric vector
```

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

```r
min(my_first_vector) #This gives the minimum numeric value in a vector
```

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

```r
max(my_first_vector) #This gives the maximmum numeric value in a vector
```

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

User-Written Functions

We can build custom functions to peform operations that are not pre-built in base R.