Introduction to R

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Program

PART I

Introduction to R and base R programming

PART II

Data manipulation

PART III

Data visualisation

PART IV

Introduction to modelling in R

Bibliography

- R Manual (`https://cran.r-project.org/doc/manuals/R-intro.html`)
- R for Data Science (2e) (`https://r4ds.hadley.nz`)

Part I

Introduction to R and Base R Programming

1. CODING
2. R AND RStudio
3. BASIC CONCEPTS

CODING

What is coding?

R AND RStudio

What is R? And RStudio?

R AND RStudio

- R
  - Created by Ross Ihaka and Robert Gentleman (University of Auckland/R Development Core Team).
  - Open source.

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  - Created by Ross Ihaka and Robert Gentleman (University of Auckland/R Development Core Team).
  - Open source.
- RStudio is an Integrated Development Environment (IDE).
- Download:
  - R: `https://www.r-project.org`.
  - RStudio: `https://www.rstudio.com`.

BASIC CONCEPTS

RStudio interface.

- Interface
  - Source pane
  - Console pane
  - Environment pane (Environment, History, Connections, Build, VCS, and Tutorial)
  - Output pane (Files/ Plots / Packages / Help)

BASIC CONCEPTS

RStudio interface.

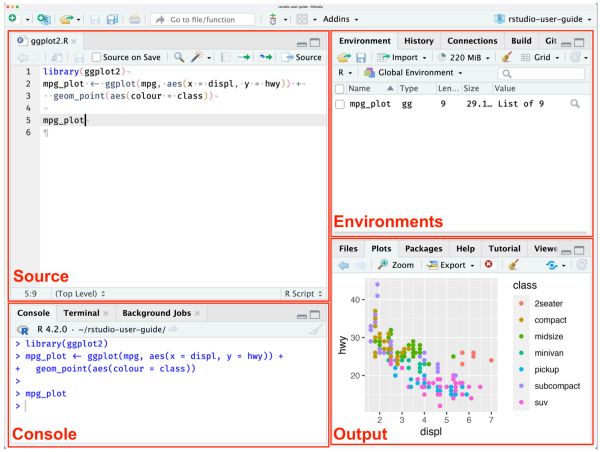


Figure: `https://docs.posit.co/ide/user/ide/guide/ui/ui-panes.html`

BASIC CONCEPTS

RStudio interface.

- Source pane
  - This is where you write and edit your R scripts (.R files).
  - You can write code, comments, and documentation in this area, and run selected lines by pressing Ctrl+Enter (Windows) or Cmd+Enter (macOS).
  - This area allows you to save your code, which is essential for keeping a record of your analysis.
- Console pane
  - The console is where you can execute commands interactively. It shows the output of the code you run and is useful for testing small code snippets or running analyses directly.
  - You can type commands directly into the console and see immediate feedback or results.
- Environment pane
  - Environment Tab: Displays all the objects (e.g., data frames, variables, functions) currently in your R workspace. You can inspect and manage your data and objects here.
  - History Tab: Shows a list of all the commands you have previously executed during the current R session. This is helpful for tracking your steps or re-running commands.

BASIC CONCEPTS

RStudio interface.

- Output pane
  - Files Tab: A file explorer that lets you browse files in your working directory and manage files (open, delete, move, etc.).
  - Plots Tab: Displays any plots or graphs that you generate with R (e.g., ggplot2 visualisations). You can export these plots as images or PDFs.
  - Packages Tab: Manage R packages installed in your system. You can install, load, or remove packages from here.
  - Help Tab: Provides access to R's help documentation. You can search for information about functions, packages, and datasets.
  - Viewer Tab: Used to display web-based content, such as HTML reports generated from R Markdown files.

Note 1: The RStudio layout may look slightly different based on your configuration, but the core functionality remains the same.

BASIC CONCEPTS

Files.

- Files
  - **.R** - To save codes and scripts.
  - **.RData** - To save workspace objects.
  - **.Rhistory** - To save the history of executed commands.

BASIC CONCEPTS

First steps

- Creating a script:
  - Click on "File" → "New File" → "R Script" to open a new script file.
- Writing and running code:
  - Type code in the script editor: "Hello World!";
  - Highlight the lines you want to run, and press Ctrl+Enter (Windows) or Cmd+Enter (macOS) to execute the code in the console (or to run all the code, use the Run button at the top of the script editor).
- Saving your work:
  - You can save your R script by clicking "File" → "Save As" and giving your file a .R extension.

BASIC CONCEPTS

Some observations.

- Everything in R is an object.
  - Think of objects like containers that hold data or things you can work with. For example: numbers, words, list of things, group of numbers, functions...
- There are differences between uppercase characters and lowercase characters.
- Parentheses, square brackets and braces:
  - ( ): to group objects inside a function.
  - [ ]: to group functions inside other functions.
  - {}: to index objects inside other objects.
- Comments can be inserted after the # character.
- The dot (.) or underscore (_) symbols can be used, but not spaces.
- A cheatsheet providing a detailed explanation of some available functions can be found at `https://rstudio.github.io/cheatsheets/html/rstudio-ide.html`.

BASIC CONCEPTS

Calculator.

```
> 2+2 # sum
[1] 4
> 2-2 # subtraction
[1] 0
> 2*2 # multiplication
[1] 4
> 2/2 # division
[1] 1
> 2^2 # power
[1] 4
> (2+2^2)/2 # solution priority
[1] 3
```

BASIC CONCEPTS

Assigning.

To assign values to objects, just use the ← operator, which is the combination of the < operator with −. Alternatively, we can use the = operator.

```
> x <- 10 # the value 10 is saved in the object x
> y <- x + 10
```

The ← operator is preferred by many R users because it clearly distinguishes assignment from equality checking (==). The = operator can also be used for assignment, but it is more commonly used for setting function arguments. While it behaves similarly to ← when assigning variables, using ← is generally recommended for clarity and consistency in most R code.

BASIC CONCEPTS

List and remove objects.

- To list the objects in the environment use the function `ls()`;
- To remove the objects from the environment use the function `rm()`

BASIC CONCEPTS

Your turn.

Question 1: *Find the volume of a cylindrical water tank whose base radius is 25 inches and whose height is 120 inches. Use* $\pi = 3.14$.

Remember: $volume = \pi \times radius^2 \times height$.

BASIC CONCEPTS

Types of variables.

R has different classes to accommodate different types of data.

```
> x <- 4.5 # numeric
> x <- 4 # integer
> x <- "summer" # character
> x <- TRUE # logical
```

- We can check the class of any object by using the built-in `class()` function.
- We can check the structure of any object by using the built-in `str()` function.

BASIC CONCEPTS

Logical operators.

Logical operators are binary operators for performing tests between two variables (objects). These operations return the value TRUE or FALSE.

```r
# Logical operators

x <- 10 # assigning the value 10 to the object x
y <- 2 # assigning the value 2 to the object y

x < y # is x smaller than y?
x > y # is x greater than y?
x <= y # is x less than or equal to y?
x == y # is x equal to y?
x != y # is x different than y?
y == 2 | x == 2   # is x or y equal to 2?
x == 2 & y == 2  # are x and y equal to 2?
```

Basic Concepts

Your turn

Question 2: *You have three participants with scores of 85, 50, and 75. Use logical expressions (and, or, not) to answer the following:*

- *Did all participants score above 40?*
- *Did any participant score exactly 50?*
- *Is it true that none of the participants scored less than 30?*

BASIC CONCEPTS

Structures: Vectors

- Vectors are one-dimensional collections of data of the same type (e.g., all numbers or all characters).
- You can create a vector using the c( ) function.
- You can access elements of a vector using the square brackets [ ].

BASIC CONCEPTS

Some functions

Table: Functions and descriptions.

Function	Description
sum()	Returns the sum
mean()	Returns the mean/average
sd()	Returns the standard deviation
median()	Returns the median
var()	Returns the variance
cor()	Returns the correlation between two vectors
min()	Returns the minimum
max()	Returns the maximum
range()	Returns the minimum and maximum
summary()	Returns a data summary
quantile()	Returns the quantiles of the numeric vector

BASIC CONCEPTS

Help function.

The help function (or ?) allows you to find the help file of the functions.

```
> help(sum) # Open the log function help
> ?sum
> help.search("sum") # Search for the term sum
> ??sum
```

BASIC CONCEPTS

Your turn.

Question 3: *Create a numeric vector named* **scores** *with the following values: [12, 45, 67, 89, 34, 23, 50, 8, 62]. Then:*

- *Select only the values smaller than 50.*
- *Calculate the mean and standard deviation of these values.*

BASIC CONCEPTS

Structures: Matrix

- Matrices are two-dimensional arrays that store elements of the same type (e.g., all numeric).
- You can create a matrix using the matrix( ) function.
- You can access elements of a matrix using the square brackets [ ].

BASIC CONCEPTS

Your turn.

Question 4: *Create a 3x4 numeric matrix named* **sales_data** *with the following values (filled by row):*

[15, 23, 42, 31, 8, 12, 50, 27, 20, 35, 10, 18]

- *Name the rows as "Store_A", "Store_B", and "Store_C".*
- *Name the columns as "Jan", "Feb", "Mar", and "Apr".*

Answer the following:

- *Which store had the highest sales in March ("Mar")?*
- *What is the total sales for "Store_B" across all months?*
- *Extract all sales values greater than 30.*

BASIC CONCEPTS

Structures: Data frames

- Data frames are two-dimensional tables, similar to spreadsheets or SQL tables. Each column in a data frame can hold different data types (numeric, character, etc.).
- You can create a data frame using the data.frame( ) function.

BASIC CONCEPTS

Your turn

Question 5: *Generate a data frame named* **my_data** *with 10 rows and 3 columns:*

- *One numeric column (named "values") with random numbers between 1 and 100;*
- *One logical column (named "flags") with randomly selected TRUE/FALSE values;*
- *One character column (named "categories") with randomly selected categories from: "A", "B", "C".*

Ensure there is exactly one missing value (NA) in the numeric column. Then:

- *Display rows with missing values;*
- *Replace the missing value in the numeric column with the maximum value of that column;*
- *Verify there are no more missing values;*
- *Convert the "categories" column to a factor;*
- *Create a frequency table showing counts for each category.*

BASIC CONCEPTS

Structures: Lists

- Lists can hold elements of different types, including numbers, strings, vectors, and even other lists.
- You can create a list using the list( ) function.

BASIC CONCEPTS

Your turn.

Question 6: *Create a list called* **my_city** *with:*

- *A character element 'name' with your city name;*
- *A numeric element 'population';*
- *A logical element 'capital' (TRUE or FALSE);*
- *A vector 'districts' with 3 district names.*

Access and print the population from your list. Then, add a new element 'area' with the city's area.

BASIC CONCEPTS

Functions

In addition to using R's built-in functions, you can write your own custom functions to perform specific tasks. Writing your own function allows you to create reusable blocks of code for operations you might need frequently.

```
function_name <- function(arguments) {
  # Code to execute
  return(result)
}
```

BASIC CONCEPTS

Your turn.

Question 7: *In agronomy, crop yield is often measured in tons per hectare. However, some researchers need the yield in kilograms per hectare for specific analyses. Create a function in R called* `convert_to_kg` *that:*

- *Takes one argument:* `yield_tons` *(the yield in tons per hectare).*
- *Converts it to kilograms per hectare (1 ton = 1,000 kilograms).*
- *Returns the converted value.*

BASIC CONCEPTS

If else

- if/else: Used for conditional execution on a single value.
  - if: Checks a condition; if it's TRUE, runs the following code block.
  - else: Executes an alternative block if the condition is FALSE.
- ifelse: A vectorised function ideal for performing element-wise checks on a vector.
  ifelse(test_expression, value_if_true, value_if_false)

BASIC CONCEPTS

Your turn.

Question 8: *Create a function to check if a number is positive or negative.*

BASIC CONCEPTS

Loops

- For loop:
  - Iterates over each element in a sequence.
  - Use when you know the number of iterations in advance.
- While loop:
  - Repeats a block of code as long as a condition remains true.
  - Use when the number of iterations is not predetermined.

BASIC CONCEPTS

Your turn.

Question 9: *Generates a vector of 10 numbers. Uses loops to calculate the sum of all numbers and to find the largest number*

BASIC CONCEPTS

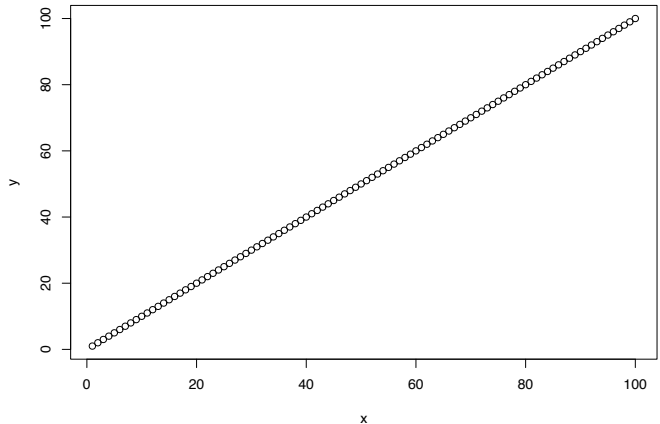
Packages.

- R base and packages.

  A collection of functions that can be written in different programming languages that are called directly from within R. A package contains code, data and documentation.

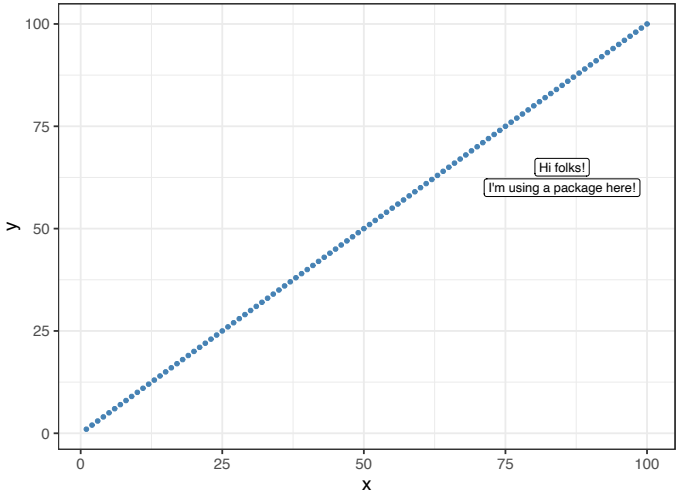
BASIC CONCEPTS

R base and packages.



BASIC CONCEPTS

R base and packages.



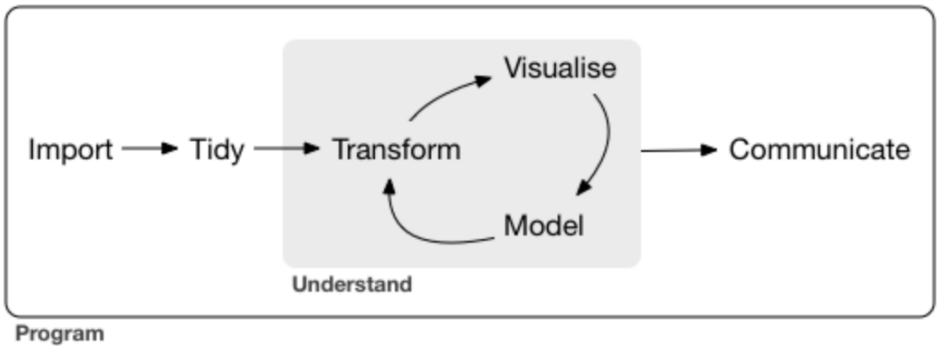
BASIC CONCEPTS

Your turn.

Question 10: *Install the following packages and look at the vignettes:*

- *dplyr*
- *tidyr*
- *lme4*
- *tidyverse*

DATA MANIPULATION



DATA MANIPULATION

Datasets

Data set 1: Seoul Bike Sharing Demand Dataset.
The dataset provides hourly counts of public bicycle rentals in the Seoul Bike Sharing System. It includes detailed weather data (temperature, humidity, wind speed, visibility, dew point, solar radiation, snowfall, and rainfall), along with rental counts and date information.

Data set 2: Sample data
This data has 6 columns and is in excel format.

WORKING WITH DIRECTORIES IN R

Checking the current directory

- The working directory is the folder where R looks for files to read or write;
- To see your current working directory: `getwd()`;
- This function returns the path to the current directory;
- To change the working directory, use: `setwd("path/to/your/directory")`
- Replace `"path/to/your/directory"` with the full path of the folder you want.

WORKING WITH DIRECTORIES IN R

Checking the current directory

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In RStudio, you can easily set the working directory:

1. Click on Session in the menu bar.
2. Select Set Working Directory > Choose Directory....
3. Navigate to the folder and confirm.

DATA MANIPULATION

Importing data sets

Importing CSV files

- To import CSV files, use the `read.csv()` function. Example:

```
data <- read.csv("path/to/your/file.csv", header = TRUE, sep = ",")
```

- `file`: The path to the CSV file.
- `header`: Logical, TRUE if the first row contains column names.
- `sep`: Specifies the delimiter (default is "," for comma-separated files).

DATA MANIPULATION

Importing data sets

Importing Excel files

- To import Excel files, use the `readxl` package and the `read_excel()` function.
- First, install the package (if not already installed):

```
install.packages("readxl")
library(readxl)
```

- Example:

```
data <- read_excel("path/to/your/file.xlsx", sheet = "Sheet1")
```

- `path`: The path to the Excel file.
- `sheet`: Specifies the sheet name or index (e.g., "Sheet1" or 1).

DATA MANIPULATION

Importing data sets

Importing SAS files

- To import SAS files, use the `haven` package and the `read_sas()` function.
- First, install the package (if not already installed):

```
install.packages("haven")
library(haven)
```

- Example:

```
data <- read_sas("path/to/your/file.sas7bdat") )
```

- `path`: The path to the SAS file.

DATA MANIPULATION

Understanding missing values (NAs)

- NA stands for "Not Available" and represents missing or undefined data in R.
- Use `is.na()` to identify missing values in a dataset.
- Use `sum(is.na())` to count the total number of NAs in a dataset.
- Use `na.omit()` to remove rows with missing values.
- Use `which()` to find the exact positions of NAs in the dataset.
- Many functions allow you to ignore NAs using `na.rm = TRUE`.

BASIC CONCEPTS

Your turn.

Question 11: *Using the 'data1' dataset, check if there are any missing values in any column. Then, calculate the mean and standard deviation of the variable 'Rainfall.mm.'*

Question 12: *Using the 'data2' dataset, replace the missing values related to Frank.*

DATA MANIPULATION

Native pipe operator

- Pipes are powerful tools for simplifying and clarifying sequences of multiple operations.
- The pipe operator makes reading a sequence of code much more logical, easier, and understandable.
- The |> is R's native pipe operator, available from version 4.1 onwards.
- The |> operator takes the result on its left side and uses it as the first argument of the function on its right side.

DATA MANIPULATION

Introduction to `dplyr`

- A package for easy and efficient data manipulation.
- Provides clear and intuitive functions for working with tabular data.
- Simplifies tasks like selecting, filtering, and transforming data.
- Makes code easier to read and write.

DATA MANIPULATION

Function: `select()`

- Selects specific columns from a dataset.

```
select(data, column1, column2, ...)
```

DATA MANIPULATION

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```

Question 14: *Using 'dataset1', create a new object and select only the columns 'Date', 'Rented.Bike.Count', 'Hour', and 'Seasons'.*

DATA MANIPULATION

Function: `rename()`

- Renames columns in a dataset while keeping everything else unchanged.

```
rename(data, new_name = old_name)
```

DATA MANIPULATION

Function: `rename()`

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```

Question 16: *Using 'data1', rename the columns as follows:*

Rented.Bike.Count = RBC
Temperature.C. = Temp
Humidity... = Humidity
Solar.Radiation..MJ.m2. = SR
Rainfall.mm. = Rainfall
Snowfall..cm. = Snowfall

DATA MANIPULATION

Function: `mutate()`

- Adds or modifies columns in the dataset.

```
mutate(data, new_column = operation)
```

DATA MANIPULATION

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```
mutate(data, new_column = operation)
```

Question 18: *Using the 'data1' create a new column called* ***`Humidity_new`****, where*

$$Humidity\_new = Humidity/100$$

DATA MANIPULATION

Changing variable types

- Some analyses require specific types of variables (e.g., factors for categorical data, numeric for calculations).
- Use `as.factor()` to convert a numeric variable to a factor.
- Use `as.numeric()` carefully to convert a factor to numeric.
- Use `as.character()` to convert numeric variables to text.

DATA MANIPULATION

Changing variable types

- Some analyses require specific types of variables (e.g., factors for categorical data, numeric for calculations).
- Use `as.factor()` to convert a numeric variable to a factor.
- Use `as.numeric()` carefully to convert a factor to numeric.
- Use `as.character()` to convert numeric variables to text.

Question 20: *Using 'data1', convert the columns 'Seasons' and 'Holiday' to factor.*

DATA MANIPULATION

Function: `filter()`

- Filters rows based on a condition.

```
filter(data, condition)
```

DATA MANIPULATION

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```
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```

Question 22: *Using the 'data1' filter the rows with Rainfall above 25mm and Season 'Spring'*

DATA MANIPULATION

Function: `summarise()`

- Creates a summary of the data.

```
summarise(data, summary_name = operation(column))
```

DATA MANIPULATION

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- Creates a summary of the data.

```
summarise(data, summary_name = operation(column))
```

Question 24: *Using the 'data1' calculate the mean and the sd of the variable Rainfall.*

DATA MANIPULATION

Function: `group_by()`

- Groups data by one or more columns.

```
group_by(data, column)
```

DATA MANIPULATION

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```
group_by(data, column)
```

Question 26: *Using the 'data1', group by 'Holiday' and calculate the average Rainfall.*

DATA MANIPULATION

Function: `arrange()`

- Sorts rows in ascending or descending order.

```
arrange(data, column)

arrange(data, desc(column))
```

DATA MANIPULATION

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- Sorts rows in ascending or descending order.

```
arrange(data, column)

arrange(data, desc(column))
```

Question 28: *Using data1, display the data in ascending order of Temperature.*

DATA MANIPULATION

Seoul Bike Sharing Demand Dataset

1. **Import the dataset**: Read the `sbd.csv` file into R using the appropriate function and examine the structure.
2. **Summarise the dataset**: Use the `dplyr` package to summarise the dataset, showing the mean, median, and standard deviation for `Temperature(C)` and `Rented Bike Count`.
3. **Count seasonal data**: Use `count` to determine how many records there are for each `Seasons`.
4. **Filter by time**: Filter the data to show only records where `Hour` is between 6 and 9 (inclusive).
5. **Create a new column**: Use `mutate` to create a column `Temperature_F` that converts `Temperature(C)` to Fahrenheit using the formula:

$$\text{Temperature\_F} = \text{Temperature\_C} \times \frac{9}{5} + 32$$

Seoul Bike Sharing Demand Dataset

6. **Rename a column**: Rename the column `Rented.Bike.Count` to `Bike_Rentals` using `rename`.
7. **Select specific columns**: Use `select` to create a new dataset with only the columns `Date`, `Hour`, `Seasons`, and `Bike_Rentals`.
8. **Group by and summarise**: Group the data by `Seasons` and calculate the average `Rented Bike Count` and `Temperature(C)` for each season.
9. **Arrange by temperature**: Arrange the dataset by `Temperature(C)` in ascending order and display the first 10 rows.
10. **Subset by weather conditions**: Filter and display rows where `Humidity(%)` is greater than 80 and `Solar Radiation (MJ/m2)` is equal to 0.

Thank you!