Week 1: *Getting Started*

EMSE 4571: Intro to Programming for Analytics

John Paul Helveston

January 13, 2022

Week 1: *Getting Started*

1. Course orientation

BREAK

2. Getting started with R & RStudio

3. Operators & data types

4. Preview of HW 1

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Meet your instructor!

John Helveston, Ph.D.

Assistant Professor, Engineering Management & Systems Engineering

- 2016-2018 Postdoc at Institute for Sustainable Energy, Boston University
- 2016 PhD in Engineering & Public Policy at Carnegie Mellon University
- 2015 MS in Engineering & Public Policy at Carnegie Mellon University
- 2010 BS in Engineering Science & Mechanics at Virginia Tech
- Website: www.jhelvy.com

Meet your tutors!

Lujin Zhao

- Graduate Assistant (GA)
- PhD student in EMSE

Meet your tutors!

Michael O'Keefe

- Learning Assistant (LA)
- EMSE Junior & P4A alumni (Fall 2020)

Course orientation

🌐 Everything you need will be on the course website:

https://p4a.seas.gwu.edu/2022-Spring/

🧩 Course is broken into **two chunks**:

1. Programming
2. Analytics

Learning Objectives

After this class, you will know how to...

...write R code to solve medium-sized tasks.

...pro-actively test and debug code.

...reproducibly import, export, manipulate, and visualize data.

Homeworks (55% of grade)

📅 ~Every week (12 total)

🕒 Soft due dates (11:59pm Wed. before class)

⚠ **Don't abuse this flexibility**

Two hard deadlines on homework submissions:

1. Mar. 10 (HWs 1-7)

2. May. 05 (HWs 8-12)

Late submissions

- **5** late days - use them anytime, no questions asked
- No more than **2** late days on any one assignment
- Contact me for special cases (I'm expecting a lot of these)

Quizzes (15% of grade)

In class every other week-ish (7 total, drop lowest 2)

~5 minutes (1-3 questions)

Example quiz

Why quiz at all? There's a phenomenon called the "retrieval effect" - basically, you have to *practice* remembering things, otherwise your brain won't remember them (details in the book "Make It Stick: The Science of Successful Learning").

Exams (30% of grade)

- Midterm (weeks 1 - 7) on March 10
- Final (weeks 1 - 13) on May 05

Grades

Component	Weight	Notes
Homeworks & Readings (12x)	55%	Lowest 1 dropped
Quizzes (7x)	15%	Lowest 2 dropped
Midterm Exam	10%	
Final Exam	20%	

Alternative Minimum Grade (AMG)

- Designed for those who struggle early but work hard to succeed in 2nd half.
- Highest possible grade is "C"

Course Component	Weight
Best 10 Homeworks	40%
Best 4 Quizzes	10%
Midterm Exam	10%
Final Exam	40%

Course policies

- BE NICE
- BE HONEST
- DON'T CHEAT

Copying is good, stealing is bad

> "Plagiarism is trying to pass someone else's work off as your own. Copying is about reverse-engineering."
>
> -- Austin Kleon, from Steal Like An Artist

Don't copy-paste others' code!

How to succeed in this class

- Participate during class!
- Start assignments early and **read carefully**!
- Get sleep and take breaks often!
- Ask for help!

Getting Help

Use Slack to ask questions.

Meet with your tutors

Schedule a meeting w/Prof. Helveston:

- Mondays from 8:00am - 2:00pm
- Wednesdays from 2:00 - 5:00pm
- Fridays from 12:00 - 2:00pm

GW Coders

Course Software

Slack: Install app & **turn notifications on**!

R & RStudio: Install both.

RStudio Cloud: A web-based version of RStudio.

Break

 Install course software if you haven't

05:00

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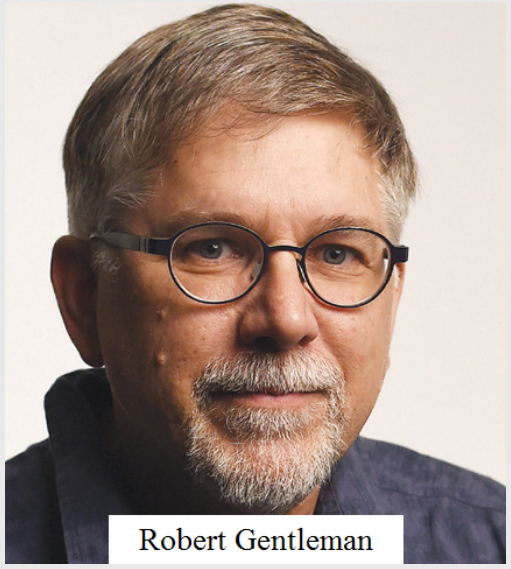
What is R? (Read a brief history here)

Chambers creates "S" (1976, Bell Labs)
Ross & Robert create "R" (1991, U. of Auckland)

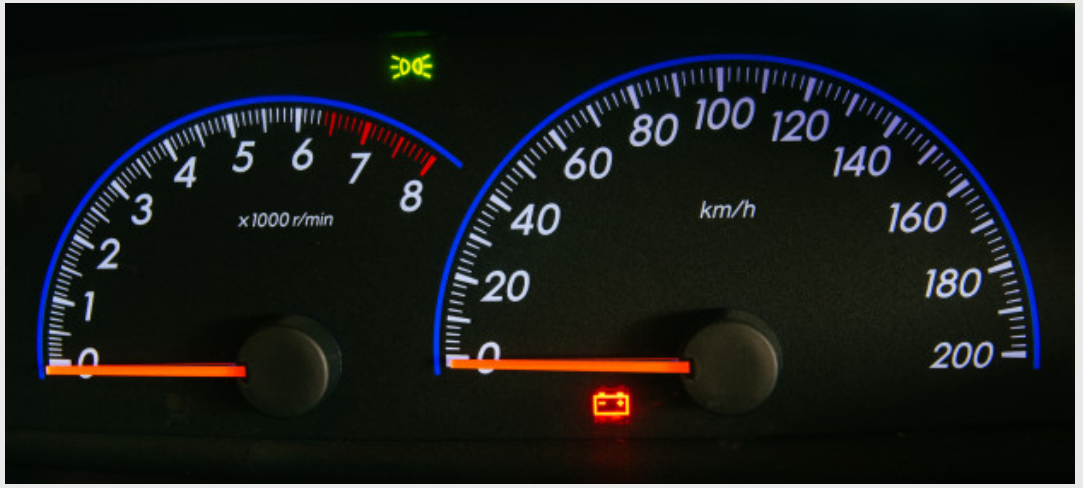
John Chambers

Ross Ihaka

Robert Gentleman




CHEVROLET

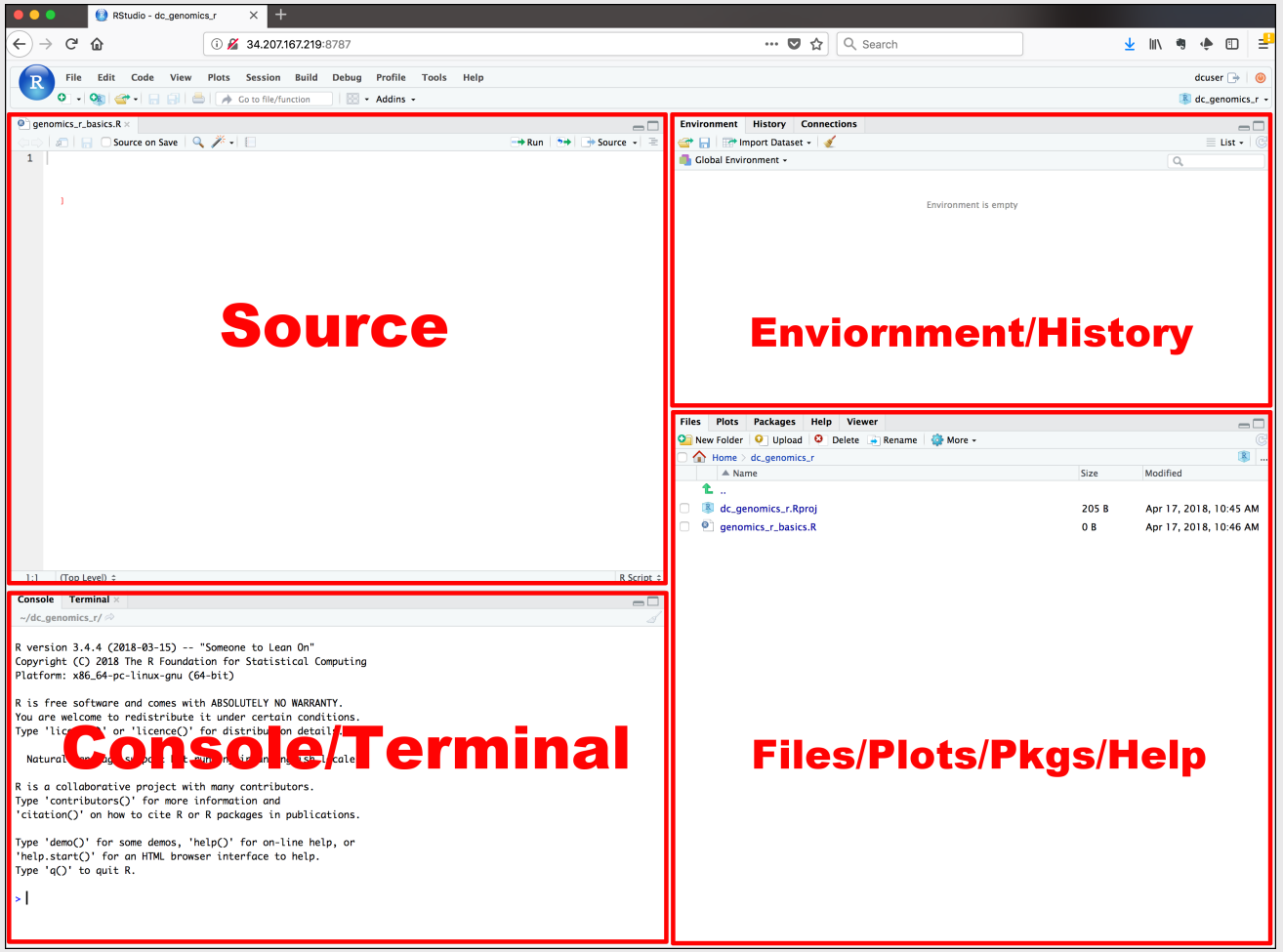

x1000 r/min
km/h

RStudio Orientation

Open this

Not this

RStudio Orientation



- Know the boxes
- Customize the layout
- Customize the look
- Extra themes

Your first conveRsation

Write stuff in the console, then press "enter"

Example: **addition**

```
3 + 4
```

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

Example: **error**

```
3 + "4"
```

```
#> Error in 3 + "4": non-numeric argument to binary operator
```

Storing values

Use the "<–" symbol to assign *values* to *objects*

```
x <- 40
x
```

```
#> [1] 40
```

```
x + 2
```

```
#> [1] 42
```

Storing values

If you overwrite an object, R "forgets" the old value

Example:

```
x <- 42
x
```

```
#> [1] 42
```

```
x <- 50
x
```

```
#> [1] 50
```

Storing values

You can also use the = symbol to assign values

```
x = 50
x
```

```
#> [1] 50
```

(but it's more R-like to use <-)

Storing values

You can store more than just numbers

```
x <- "If you want to view paradise"
y <- "simply look around and view it"
```

```
x
```

```
#> [1] "If you want to view paradise"
```

```
y
```

```
#> [1] "simply look around and view it"
```

Storing values

Pro tip 1:

Shortcut for `<-` symbol

OS	Shortcut
mac	`option` + `-`
windows	`alt` + `-`

(see here for more shortcuts)

Pro tip 2:

Always surround `<-` with spaces

Example:

```
x<-2
```

Does this mean `x <- 2` or `x < -2`?

R ignores **extra space**

```
x      <-         2
y  <-               3
z          <- 4
```

Check:

```
x
```

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

```
y
```

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

```
z
```

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

R cares about **casing**

```
number <- 2
Number <- 3
numbeR <- 4
```

Check:

```
number
```

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

```
Number
```

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

```
numbeR
```

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

Use # for comments

R ignores everything after the # symbol

Example:

```
speed <- 42 # This is mph, not km/h
speed
```

```
#> [1] 42
```

Use meaningful variable names

Example: You are recording the speed of a car in mph

Poor variable name:

```
x <- 42
```

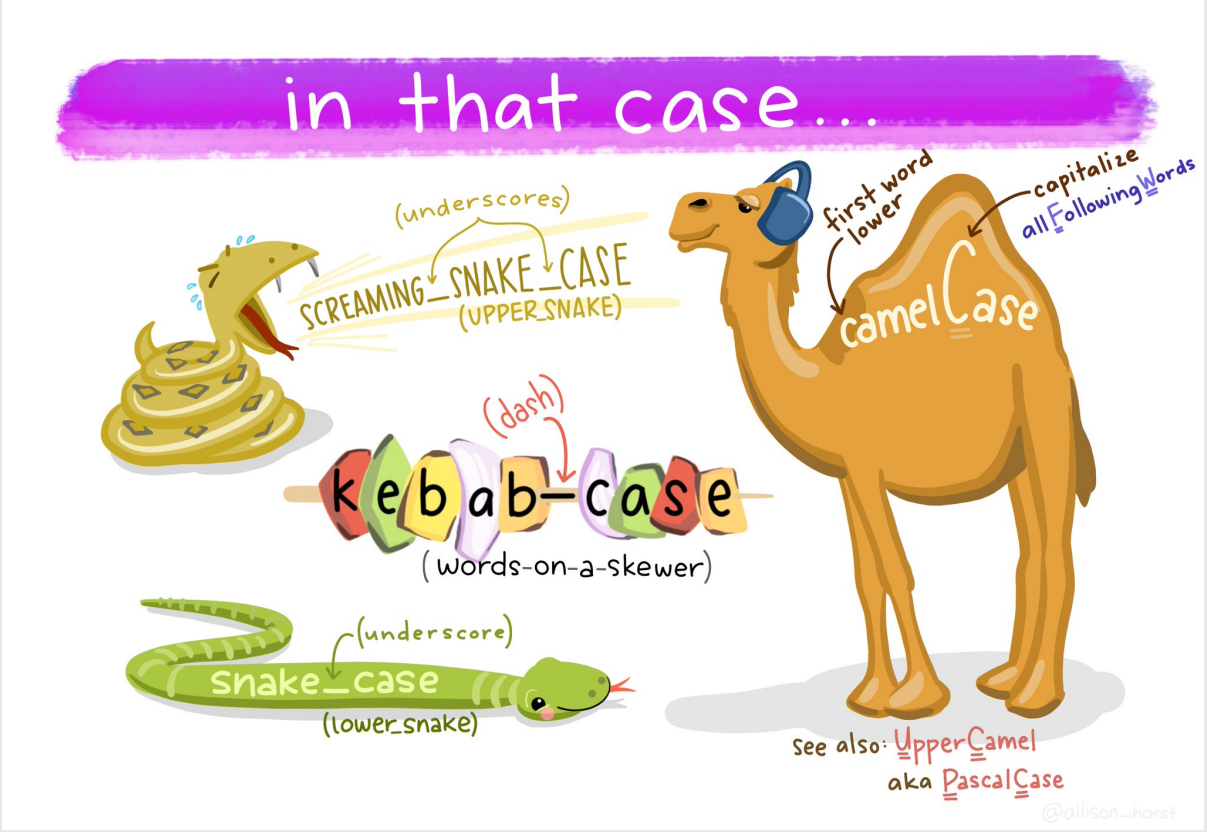
Good variable name:

```
speed <- 42
```

Even better variable name:

```
speed_mph <- 42
```

Use standard casing styles



Art by Allison Horst

I recommend using one of these:

- `snake_case_uses_underscores`
- `camelCaseUsesCaps`

Example:

```
days_in_week <- 7
monthsInYear <- 12
```

The workspace

View all the current objects:

```
objects()
```

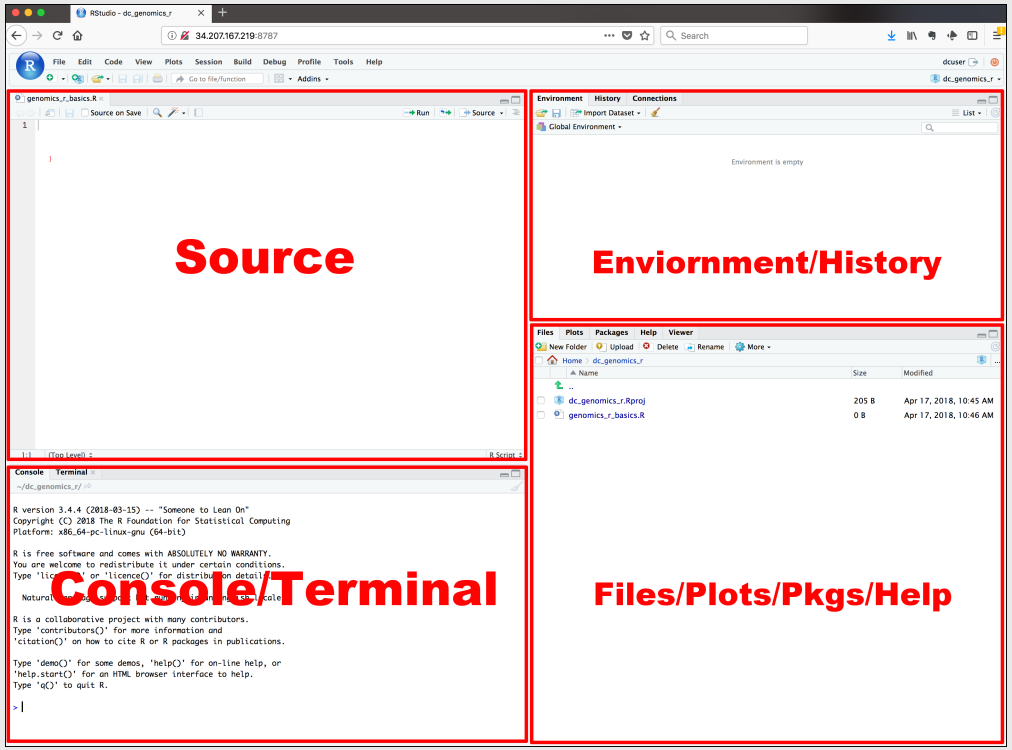
```
#>  [1] "class"          "days_in_week"
"input"          "monthsInYear"   "number"
"numbeR"         "Number"
"output_file"    "path_notes"
"path_pdf"       "path_slides"    "proc"
"rmd_args"       "root"
#> [15] "self_contained" "speed"
"speed_mph"      "x"              "y"
"z"
```

Remove an object by name:

```
rm(number)
objects()
```

```
#>  [1] "class"          "days_in_week"
"input"          "monthsInYear"   "numbeR"
"Number"         "output_file"
"path_notes"     "path_pdf"
"path_slides"    "proc"
"rmd_args"       "root"
"self_contained"
#> [15] "speed"          "speed_mph"
"x"              "y"              "z"
```

View prior code in history pane



Use "up" arrow see previous code

Staying organized

1) Save your code in .R files

File > New File > R Script

2) Keep work in R Project files

File > New Project...

Your turn

A. Practice getting organized

1. Open RStudio and create a new R project called `week1`.
2. Create a new R script and save it as `practice.R`.
3. Open the `practice.R` file and write your answers to these questions in it.

10:00

B. Creating & working with objects

1). Create objects to store the values in this table:

City	Area (sq mi)	Population (thousands)
San Francisco, CA	47	884
Chicago, IL	228	2,716
Washington, DC	61	694

2) Using the objects you created, answer the following questions:

- Which city has the highest density?
- How many *more* people would need to live in DC for it to have the same population density as San Francisco?

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R as a calculator

Basic operators:

- Addition: `+`
- Subtraction: `-`
- Multiplication: `*`
- Division: `/`

Other important operators:

- Power: `^`
- Integer Division: `%/%`
- Modulus: `%%`

Integer division: %/%

Integer division drops the remainder from regular division

```
4 / 3 # Regular division
```

```
#> [1] 1.333333
```

```
4 %/% 3 # Integer division
```

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

Integer division: %/%

Integer division drops the remainder from regular division

What will this return?

```
4 %/% 4
```

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

What will this return?

```
4 %/% 5
```

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

Modulus operator: %%

Modulus returns the *remainder* after doing division

```
5 %% 3
```

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

```
3.1415 %% 3
```

```
#> [1] 0.1415
```

Modulus operator: %%

Modulus returns the *remainder* after doing division

What will this return?

```
4 %% 4
```

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

What will this return?

```
4 %% 5
```

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

Odds and evens with `n %% 2`

If `n %% 2` is `0`, `n` is **EVEN**

```
10 %% 2
```

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

```
12 %% 2
```

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

Also works with negative numbers!

```
-42 %% 2
```

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

If `n %% 2` is `1`, `n` is **ODD**

```
1 %% 2
```

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

```
13 %% 2
```

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

Also works with negative numbers!

```
-47 %% 2
```

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

Number "chopping" with 10s

The mod operator (%%) "chops" a number and returns everything to the *right*

```
123456 %% 1
```

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

```
123456 %% 10
```

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

```
123456 %% 100
```

```
#> [1] 56
```

Integer division (%/%) "chops" a number and returns everything to the *left*

```
123456 %/% 1
```

```
#> [1] 123456
```

```
123456 %/% 10
```

```
#> [1] 12345
```

```
123456 %/% 100
```

```
#> [1] 1234
```

Number "chopping" with 10s

- `%%` returns everything to the *right* (`"chop" ->`)
- `%/%` returns everything to the *left* (`<- "chop"`)
- The "chop" point is always just to the *right* of the chopping digit

Example	“Chop” point	
`1234 %% 1`	`1234 | `	Right of the `1`’s digit
`1234 %% 10`	`123 | 4`	Right of the `10`’s digit
`1234 %% 100`	`12 | 34`	Right of the `100`’s digit
`1234 %% 1000`	`1 | 234`	Right of the `1,000`’s digit
`1234 %% 10000`	`| 1234`	Right of the `10,000`’s digit

Comparing things: **Relational operators**

Compare if condition is TRUE or FALSE using:

- Less than: <
- Less than or equal to : <=
- Greater than or equal to: >=
- Greater than: >
- Equal: ==
- Not equal: !=

```
2 < 2
```

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

```
2 <= 2
```

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

```
(2 + 2) == 4
```

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

```
(2 + 2) != 4
```

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

```
"penguin" == "penguin"
```

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

Comparing things: **Logical operators**

Make multiple comparisons with:

- And: &

- Or: |

- Not: !

Comparing things: **Logical operators**

With "and" (&), every part must be TRUE, otherwise the whole statement is FALSE:

```
(2 == 2) & (3 == 3)
```

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

```
(2 == 2) & (2 == 3)
```

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

With "or" (|), if *any* part is TRUE, the whole statement is TRUE:

```
(2 == 2) | (3 == 3)
```

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

```
(2 == 2) | (2 == 3)
```

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

Comparing things: **Logical operators**

The "not" (`!`) symbol produces the *opposite* statement:

```
! (2 == 2)
```

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

```
! (2 == 2) | (3 == 3)
```

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

```
! ((2 == 2) | (3 == 3))
```

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

Comparing things: **Logical operators**

Order precedence for logical operators: `!` > `&` > `|`

```
TRUE | FALSE & FALSE
```

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

```
(TRUE | FALSE) & FALSE
```

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

```
! TRUE | TRUE
```

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

```
! (TRUE | TRUE)
```

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

Comparing things: **Logical operators**

Pro tip: Use parentheses

```
! 3 == 5   # Confusing
```

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

```
! (3 == 5) # Less confusing
```

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

Other important points

R follows BEDMAS:

1. **B**rackets
2. **E**xponents
3. **D**ivision
4. **M**ultiplication
5. **A**ddition
6. **S**ubtraction

Pro tip: Use parentheses

```
1 + 2 * 4   # Confusing
```

```
#> [1] 9
```

```
1 + (2 * 4) # Less confusing
```

```
#> [1] 9
```

Your turn

10:00

Consider the following objects:

```
w <- TRUE
x <- FALSE
y <- TRUE
```

Write code to answer the following questions:

1. Fill in *relational* operators to make the following statement return TRUE:

   ```
   ! (w __ x) & ! (y __ x)
   ```

2. Fill in *logical* operators to make this statement return FALSE:

   ```
   ! (w __ x) | (y __ x)
   ```

Data Types

Type	Description	Example
`double`	Numbers w/decimals (aka "float")	`3.14`
`integer`	Numbers w/out decimals	`42`
`character`	Text (aka "string")	`"this is some text"`
`logical`	Used for comparing objects	`TRUE`, `FALSE`

Use `typeof()` to find the type

```
typeof(2)
```

```
#> [1] "double"
```

```
typeof("hello")
```

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

```
typeof(TRUE)
```

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

Numeric types (there are 2)

Integers

No decimals (e.g. `7`)

Doubles (aka "float")

Decimals (e.g. `7.0`)

In R, numbers are "doubles" by default

```
typeof(3)
```

```
#> [1] "double"
```

R assumes that `3` is really `3.0`

Make it an integer by adding `L`:

```
typeof(3L)
```

```
#> [1] "integer"
```

Character types

Use single or double quotes around anything:

```
typeof('hello')
```

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

```
typeof("3")
```

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

Use single / double quotes if the string *contains* a quote symbol:

```
typeof("don't")
```

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

Logical types

Logical data only have two values: TRUE or FALSE

```
typeof(TRUE)
```

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

```
typeof(FALSE)
```

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

Note that these have to be in all caps, and **not** in quotes:

```
typeof('TRUE')
```

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

```
typeof(True)
```

```
#> Error in typeof(True): object 'True'
not found
```

Logical types

Use to answer questions about logical statements.

Example: Is 1 greater than 2?

```
1 > 2
```

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

Example: Is 2 greater than 1?

```
1 < 2
```

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

Special values

`Inf`: Infinity (*or really big numbers*)

```
1/0
```

```
#> [1] Inf
```

`NaN`: Not a Number

```
0/0
```

```
#> [1] NaN
```

`NA`: Not available (*value is missing*)

`NULL`: no value whatsoever

Your turn

05:00

Will these return TRUE or FALSE?

(try to answer first, then run the code to check)

- `! typeof('3') == typeof(3)`
- `(typeof(7) != typeof("FALSE")) | FALSE`
- `! (typeof(TRUE) == typeof(FALSE)) & FALSE`

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HW 1 - read carefully!