Week 1: *Getting Started with R*

EMSE 4574: Intro to Programming for Analytics

John Paul Helveston

September 01, 2020

Week 1: *Getting Started with R*

1. Course Introduction
2. Break: Install Course Tools
3. Getting started with R & RStudio
4. Operators & data types
5. Preview of HW 1

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Meet your instructor!

Dr. John Helveston

Assistant Professor, Engineering Management & Systems Engineering

- 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!

Saurav Pantha (aka "The Firefighter")

- Graduate Assistant (GA)
- Masters student in EMSE

Meet your tutors!

Jennifer Kim (aka "The Monitor")

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

Course orientation

🌐 Everything you need will be on the course website:

https://p4a.seas.gwu.edu/2020-Fall/

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

1. Programming
2. Analytics

Homeworks (48% of grade)

📅 ~Every week (12 total)

🕒 Soft due dates (11pm Monday before class)

⚠ **Don't abuse this flexibility**

Two hard deadlines on homework submissions:

1. Oct. 20 (HWs 1-6)

2. Dec. 08 (HWs 7-12)

Quizzes (15% of grade)

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

5 minutes (3-5 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 (32% of grade)

- Midterm (weeks 1 - 6) on Oct. 20
- Final (weeks 1 - 13) on Dec. 15

Grading: Standard

Course Component	Weight	Notes
Homeworks	48%	12 x 4% each
Quizzes	15%	5 x 3% each
Midterm Exam	12%	
Final Exam	20%	
Participation	5%	

Grading: Alternative Minimum Grade (AMG)

- Students who struggle early on, 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.**
- Write your own code (even in "collaborative" assignments)
- Don't cheat

How to succeed in this class

Take care of your brain

- Sleep!
- Exercise!
- Eat good food!

Start HW early!

Take breaks often!

Ask for help!

Getting Help

Use Slack to ask questions.

Meet with your tutors

Schedule a meeting w/Prof. Helveston:

- Tuesdays from 3:30-4:30pm
- Wednesdays from 2:00-4:30pm
- Fridays from 12:00-2:00pm

GW Coders

Course Tools (see course prep lesson)

Slack

- Link to join (also posted on Blackboard announcement).
- Install Slack on your phone and **turn notifications on**!

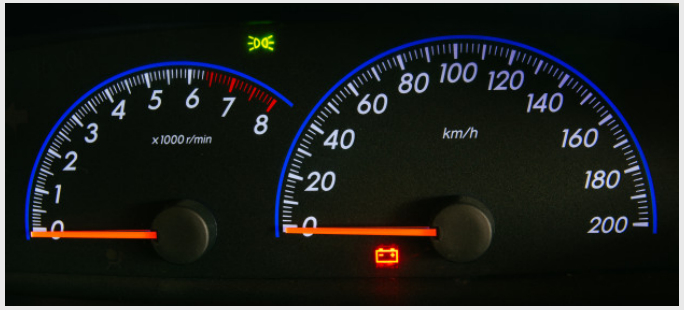
Course Tools (see course prep lesson)

R & RStudio (Install both)

After installed:

Open this:

Not this:

R: Engine	RStudio: Dashboard
	

Course Tools (see course prep lesson)

GWU VPN (Install Cisco AnyConnect VPN Client)

+ = RStudio online!

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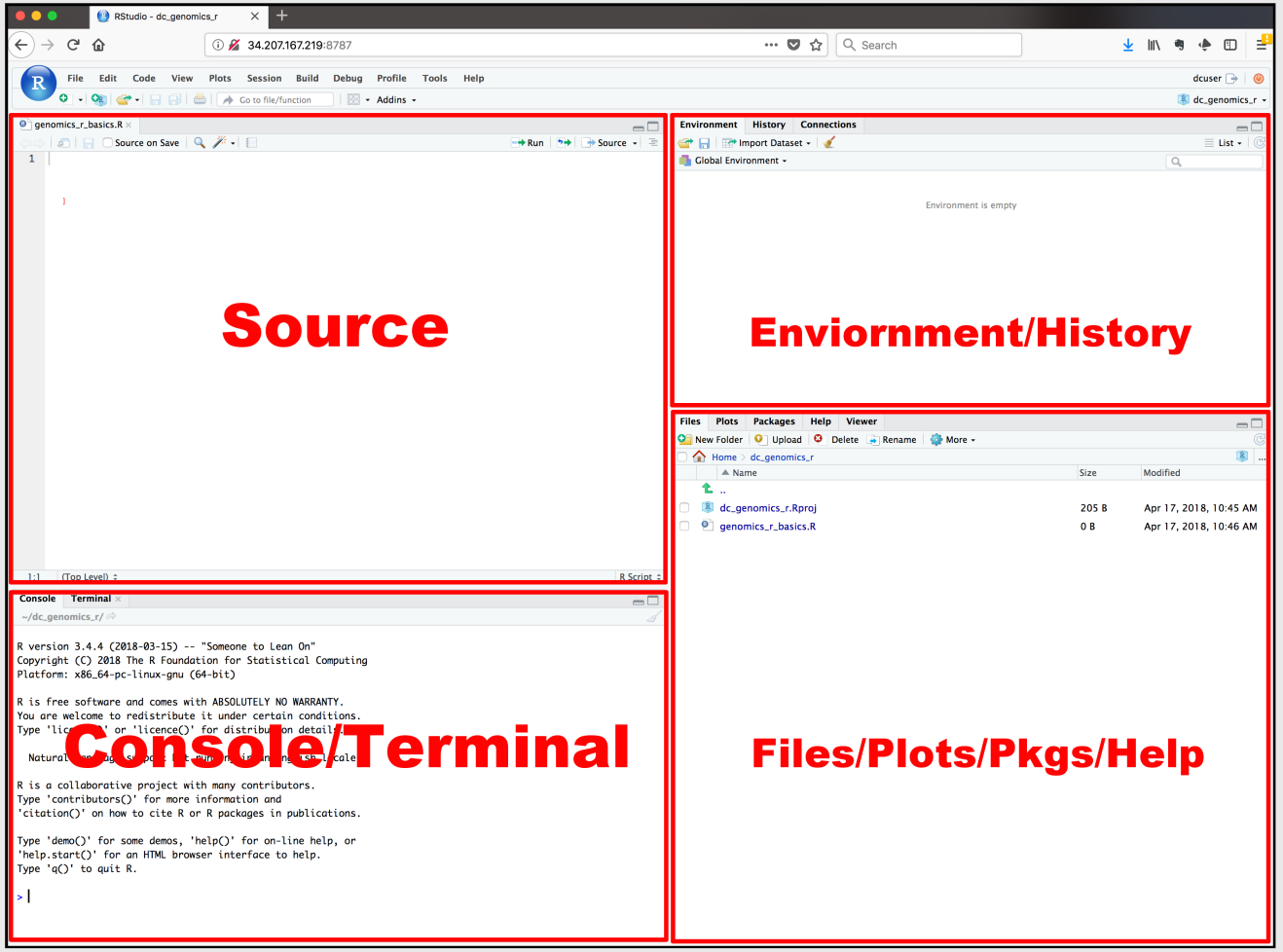
RStudio Orientation



- 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*

Example:

```
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

(but you really should use "<–")

Example:

```
x = 42
x
```

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

```
y <- 42
y
```

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

Storing values

You can store more than just numbers

Example:

```
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 **case**

```
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
```

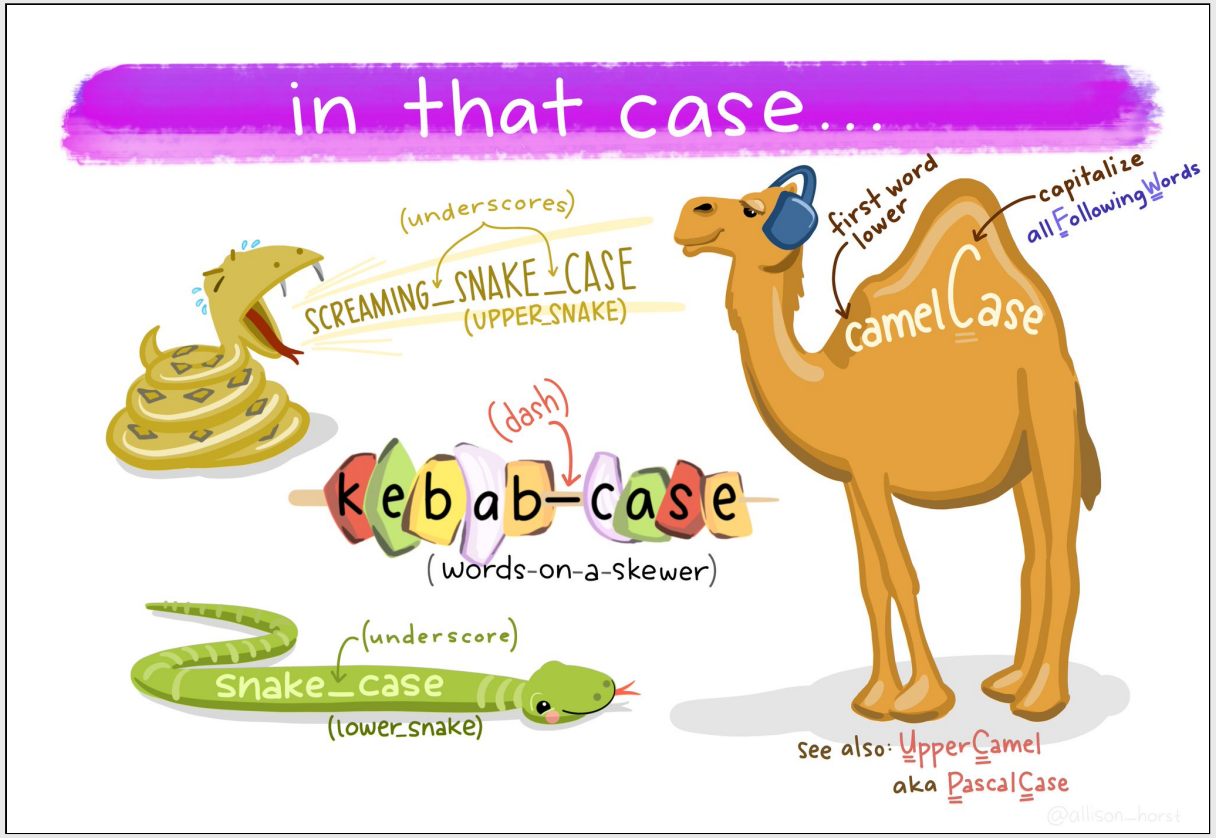
Good variable name:

```
speed <- 42
```

Even better variable name:

```
car_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] "area_chicago"           "area_dc"
##  [3] "area_sf"                "car_speed_mph"
##  [5] "caterpillar_length_mm" "days_in_week"
##  [7] "dens_chicago"           "dens_dc"
##  [9] "dens_sf"                "length_mm"
## [11] "monthsInYear"           "number"
## [13] "numbeR"                 "Number"
## [15] "pop_chicago"            "pop_dc"
## [17] "pop_sf"                 "speed"
## [19] "speed_mph"              "w"
## [21] "x"                      "y"
## [23] "z"
```

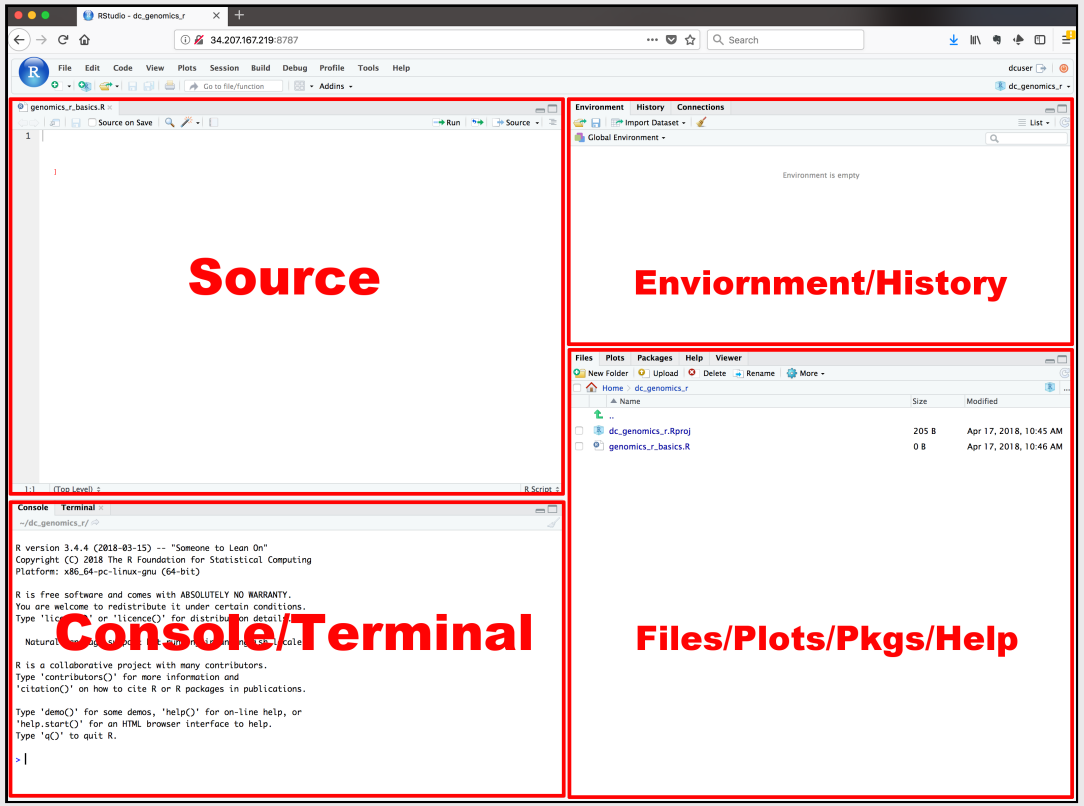
Remove an object by name:

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

```
##  [1] "area_chicago"           "area_dc"
##  [3] "area_sf"                "car_speed_mph"
##  [5] "caterpillar_length_mm" "days_in_week"
##  [7] "dens_chicago"           "dens_dc"
##  [9] "dens_sf"                "length_mm"
## [11] "monthsInYear"           "numbeR"
## [13] "Number"                 "pop_chicago"
## [15] "pop_dc"                 "pop_sf"
## [17] "speed"                  "speed_mph"
## [19] "w"                      "x"
## [21] "y"                      "z"
```

View prior code in history pane

Use "up" arrow see previous code



Staying organized

- Save your code in .R files

> File > New File > R Script

- 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 the question below in it.

10:00

B. Creating & working with objects

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

City	Area (sq. mi.)	Population
San Francisco, CA	46.87	884,363
Chicago, IL	227.63	2,716,450
Washington, DC	61.05	693,972

1. Use the objects you created to 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

Example:

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

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

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

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

Integer division: %/%

Integer division drops the remainder

What will this return?

```
4 %/% 4
```

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

What will this return?

```
4 %/% 5
```

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

Modulus operator: %%

Modulus returns the remainder *after* doing integer division

Example:

```
5 %% 3
```

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

```
3.1415 %% 3
```

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

Modulus operator: %%

Modulus returns the remainder *after* doing integer 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
```

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

```
1 %% 2
```

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

```
13 %% 2
```

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

Also works with negative numbers!

```
-42 %% 2
```

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

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	“Chop” point description
`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: !

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
```

Comparing things: **Logical operators**

Make multiple comparisons with:

- And: &
- Or: |
- Not: !

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**

Make multiple comparisons with:

- And: &
- Or: |
- Not: !

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

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

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

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

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

Comparing things: **Logical operators**

And: &

"Are any of the statements FALSE"?

```
(2 == 2) & (2 == 3) & (4 == 4)
```

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

Or: |

"Are any of the statements TRUE"?

```
(2 == 2) | (2 == 3) | (4 == 7)
```

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

& > |

```
(2 == 2) | (2 == 3) & (4 == 7)
```

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

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 assess the type of any variable:

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

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

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

Example:

```
typeof(3)
```

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

Even though it *looks* like an integer, 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

Infinity: `Inf`

really big numbers

```
1/0
```

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

Not a Number: `NaN`

"not a number"

```
0/0
```

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

Not available: `NA`

value is "missing"

No value: `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`

Final points

HW 1 Preview

❗ Read carefully!

Please take this survey