

Introduction to R and Reproducible Reporting

Patrick Mathias
Lesson 1
DLMP Core

Lesson Goals

1. Get oriented to the R programming environment
2. Appreciate the importance of reproducible data analysis

Lesson Objectives

1. Define R, RStudio and R Markdown
2. Log in and navigate RStudio Cloud
3. Discuss the risks of unreproducible data analysis
4. Create a R Markdown document



R

Programming
language for
data analysis



RStudio

Interactive
development
environment (IDE)

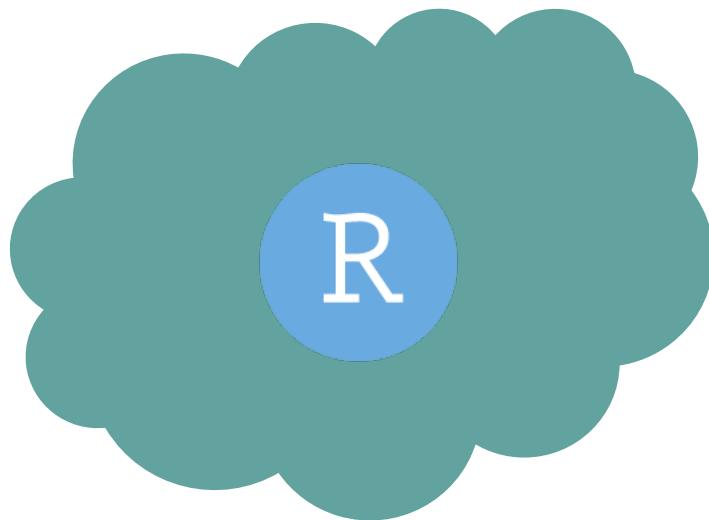


R Markdown

Computational
document format

Getting Started with RStudio

RStudio: On the Web and In Your Home



RStudio Cloud
Hosted on a server
(in the cloud)



RStudio Server
Hosted on a server
(DLMP Server)



RStudio Desktop
Installed locally on
your computer

Note: Use RStudio Cloud only for this course. Do not upload protected health information to the cloud!

Your Turn #1

Navigate to: <https://bit.ly/dImp-core-r>

Enter your log in credentials

Join Space

Make a copy of the Core Exercises for yourself



Log In

Don't have an account?
[Sign Up](#)

[Continue](#)

[Forgot your password?](#)

or

 [Log In with Google](#)

 [Log In with GitHub](#)

Join Space?

Joining a space gives you access to it and to its contents.

Once you join, admins will be able to see your email address.

Would you like to join this space?



Join Space

Cancel



Spaces

 Your Workspace AACC 2019 Introduction to R
Patrick Mathias AACC 2021 Introduction to R
Patrick Mathias DLMP Data Analysis in R
Patrick Mathias LM Core Data Analysis
Patrick Mathias LM Core Data Analysis
Patrick Mathias New Space

Learn

 Guide What's New Primers Cheat Sheets

Help

 Current System Status RStudio Community

All Projects

List All projects 1

Sort By name



dlmp-data-analysis-with-r

 Patrick Mathias RStudio Project

Created Oct 19, 2021 4:26 PM

2



All Projects

New Project ▾

List All projects ▾

Sort By name ▾



dlmp-data-analysis-with-r

 Patrick Mathias

 RStudio Project

Created Oct 19, 2021 4:26 PM

 Copy

3

Copy Project

×

Make your own copy of dlmp-data-analysis-with-r?

OK

4

File Edit Code View Plots Session Build Debug Profile Tools Help

    Go to file/function

R 4.1.0

Console Terminal × Jobs ×

R 4.1.0 · /cloud/project/ ↗

```
R version 4.1.0 (2021-05-18) -- "Camp Pontanezen"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)
```

```
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.
```

```
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
```

```
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
```

>

Environment History Connections Git Tutorial

 Import Dataset  123 MiB 

R  Global Environment

Environment is empty

Files Plots Packages Help Viewer

 New Folder  Upload  Delete  Rename  More

 Cloud > project

	Name	Size	Modified
	..		
	.gitignore	40 B	Oct 19, 2021, 4:26 PM
	.Rhistory	0 B	Oct 19, 2021, 4:26 PM
	coursepack		
	exercises		
	LICENSE	1 KB	Oct 19, 2021, 4:26 PM
	presentations		
	project.Rproj	205 B	Oct 19, 2021, 9:35 PM
	README.md	4.8 KB	Oct 19, 2021, 4:26 PM

Your Turn #1

Navigate to: <https://bit.ly/dImp-core-r>

Enter your log in credentials

Join Space

Make a copy of the Core Exercises for yourself

File Edit Code View Plots Session Build Debug Profile Tools Help

+ | Go to file/function | Addins

R 4.1.3

Untitled1 x
Source Visual

```
1 ---  
2 title: "R Notebook"  
3 output: html_notebook  
4 ---  
5  
6 This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute  
code within the notebook, the results appear beneath the code.  
7  
8 Try executing this chunk by clicking the *Run* button within the chunk or by  
placing your cursor inside it and pressing *Ctrl+Shift+Enter*.
```

10 `r`
11 plot(cars)
4:1 # R Notebook
Console Terminal Jobs
R 4.1.3 · /cloud/project/

>

Restarting R session...

> |

EDITOR

CONSOLE

Environment History Connections Git Tutorial

Import Dataset 167 MiB

R Global Environment

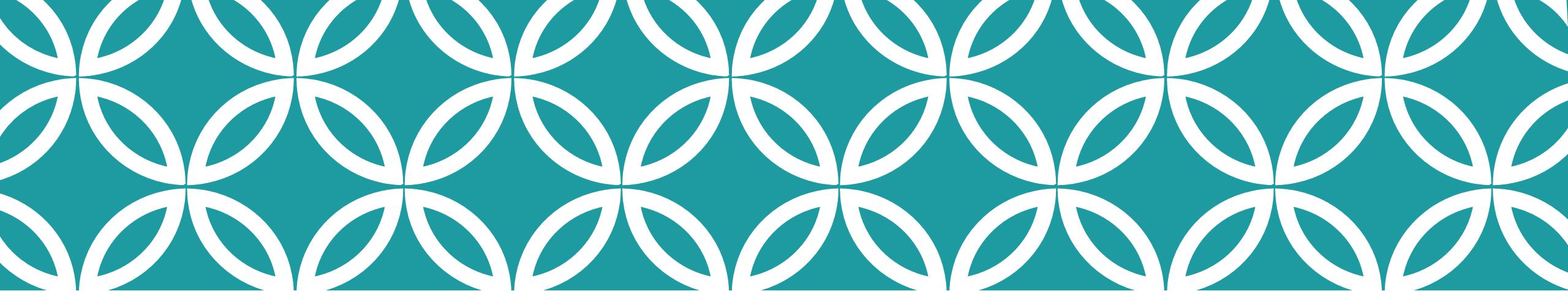
Environment is empty

ENVIRONMENT

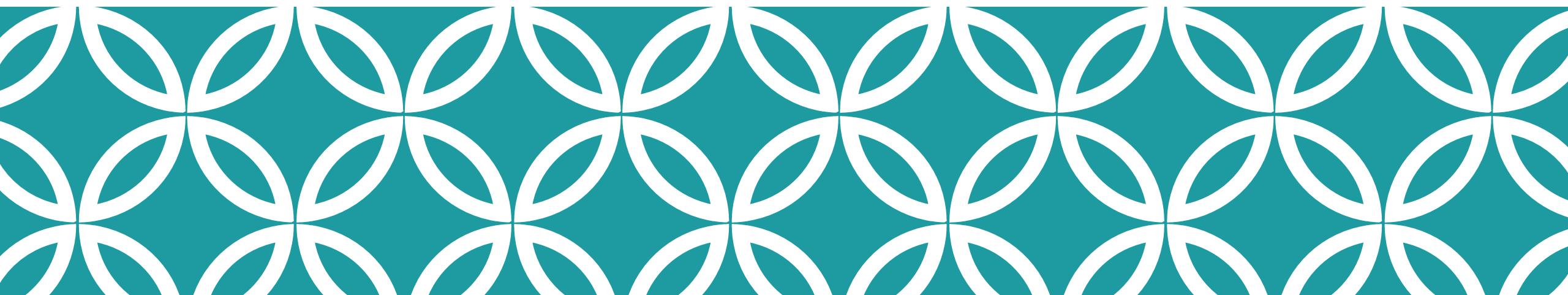
Files Plots Packages Help Viewer Presentation

Folder	Blank File	Upload	Delete	Rename	...
Cloud > project					
	Name	Size	Modified		
	..				
	.gitignore	40 B	Oct 19, 2021, 4:26 PM		
	.Rhistory	0 B	Oct 19, 2021, 4:26 PM		
	coursepack				
	exercises				
	LICENSE	1 KB	Oct 19, 2021, 4:26 PM		
	my_first_notebook.Rmd	1 KB	Oct 28, 2021, 2:18 PM		
	presentations				
	project.Rproj	205 B	Jul 4, 2022, 9:49 AM		
	README.md	4.9 KB	Oct 21, 2021, 1:06 PM		

MISC



Reproducible Data Analysis and R Markdown



The Duke Cancer Scandal

- ❖ Chemo sensitivity from microarrays
- ❖ Errors first, then cover-up
- ❖ Clinical trials based on flawed models
- ❖ Papers retracted, lawsuits settled



Duke

"1881_at"

"31321_at"

"31725_s_at"

"32307_r_at"

...

MD Anderson

"1882_g_at"

"31322_at"

"31726_at"

"32308_r_at"

Off-by-one indexing error

“Common problems are simple...

Off-by-one indexing error

Sensitive / resistant label reversal

Confounding in experimental design

Inclusion of data from non-reported sources

Wrong figure shown

... and simple problems are common.”

Point-and-click is not reproducible



Computer code can precisely document each step of the analysis

Why YOU should analyze your data reproducibly

“Can we redo the analysis with this month’s data?”

“Why do the data in Table 1 not seem to agree with Figure 2?”

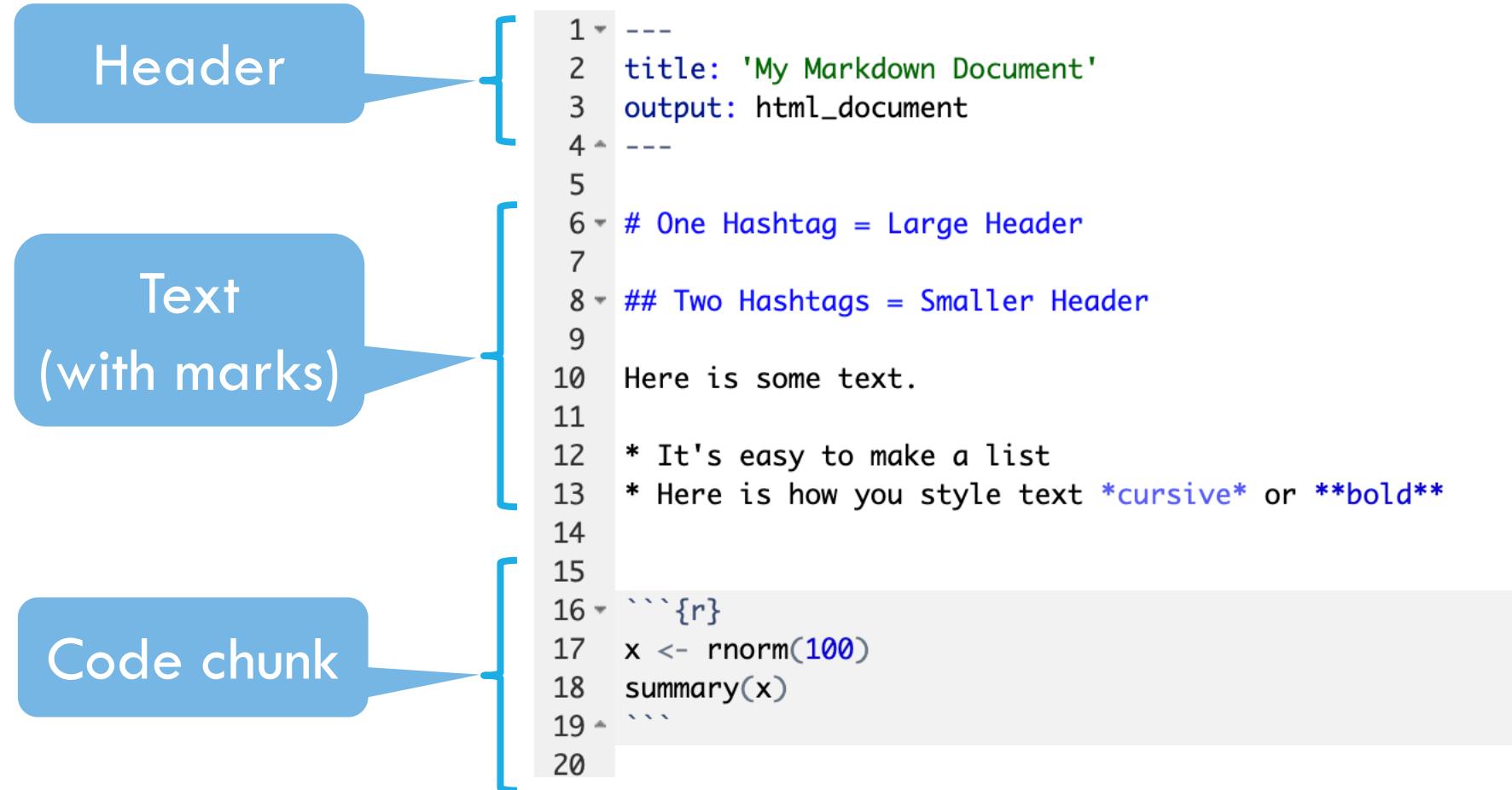
“Why did I decide to omit these six samples from my analysis?”



YOUR CLOSEST COLLABORATOR IS YOU FROM 6 MONTHS AGO



Anatomy of an R Markdown Document



```

1 ---  

2 title: 'My Markdown Document'  

3 output: html_document  

4 ---  

5  

6 # One Hashtag = Large Header  

7  

8 ## Two Hashtags = Smaller Header  

9  

10 Here is some text.  

11  

12 * It's easy to make a list  

13 * Here is how you style text *cursive* or **bold**  

14  

15  

16 ```{r}  

17 x <- rnorm(100)  

18 summary(x)  

19 ````  

20  

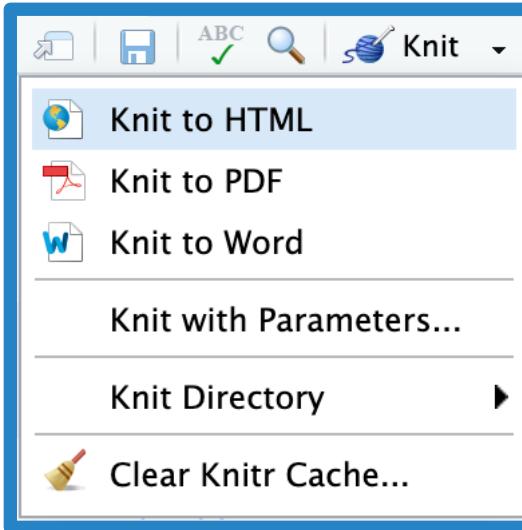
21 ## Including Plots|  

22  

23 ```{r, echo=FALSE}  

24 hist(x)  

25 ````
```



My Markdown Document

One Hashtag = Large Header

Two Hashtags = Smaller Header

Here is some text.

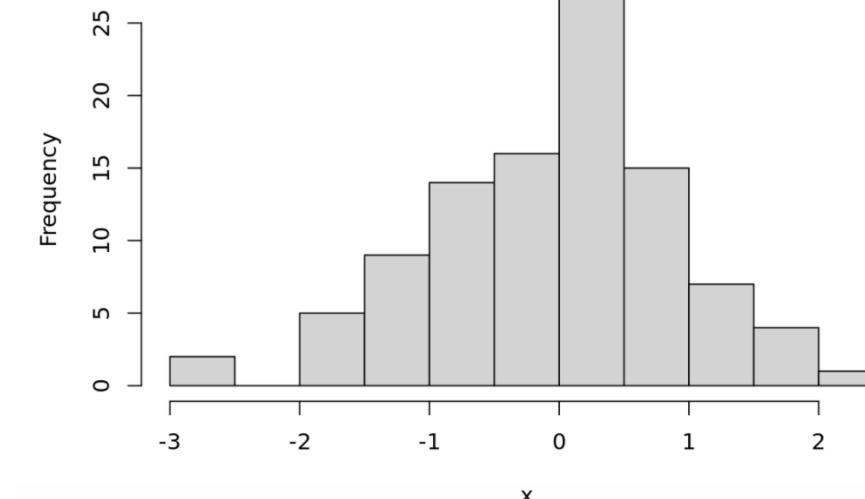
- It's easy to make a list
- Here is how you style text *cursive* or **bold**

```
x <- rnorm(100)
summary(x)
```

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
##	-2.99204	-0.64726	0.14853	-0.02832	0.58218	2.07410



Including Plots



```
1 --
2 title: 'My Markdown Document'
3 output: html_document
4 ---
```

My Markdown Document

```
5
6 # One Hashtag = Large Header
7
8 ## Two Hashtags = Smaller Header
9
10 Here is some text.
11
12 * It's easy to make a list
13 * Here is how you style text *cursive* or **bold**
14
```

One Hashtag = Large Header

Two Hashtags = Smaller Header

Here is some text.

- It's easy to make a list
- Here is how you style text *cursive* or **bold**

```
15
16 ````{r}
17 x <- rnorm(100)
18 summary(x)
19 ````
```



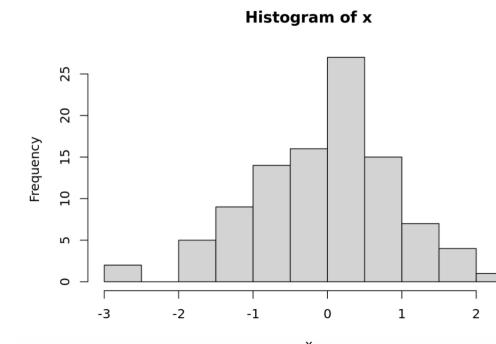
```
x <- rnorm(100)
summary(x)
```

```
##      Min.    1st Qu.     Median      Mean    3rd Qu.      Max.
## -2.99204 -0.64726  0.14853 -0.02832  0.58218  2.07410
```

```
20
21 ## Including Plots|
22
23 ````{r, echo=FALSE}
24 hist(x)
25 ````
```



Including Plots



Your Turn #2

Open a sample R Markdown document (File -> New File -> R Notebook).

Enter a title for the document: “My First Notebook”

Review the format of the document: header, text, code chunks

Execute the individual code chunk by selecting the Run Current Chunk arrow.

Knit the document to HTML (Preview or Knit Button -> Knit to HTML). You will be prompted to save your file first. Name your notebook (my_first_notebook.Rmd) and click save. Review the knitted document.



File Edit Code View Plots Session Build Debug Profile Tools Help



Addins

R 4.1.3

R Script

Quarto Document...

Quarto Presentation...

R Notebook

R Markdown... Create a new R Markdown notebook

Shiny Web App...

Plumber API...

Text File

C++ File

Python Script

SQL Script

Stan File

D3 Script

R Sweave

R HTML

R Documentation...

saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

Environment History Connections Git Tutorial

Import Dataset 134 MiB

R Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

	Name	Size	Modified
	..		
<input type="checkbox"/>	.gitignore	40 B	Oct 19, 2021, 4:26 PM
<input type="checkbox"/>	.Rhistory	0 B	Oct 19, 2021, 4:26 PM
<input type="checkbox"/>	coursepack		
<input type="checkbox"/>	exercises		
<input type="checkbox"/>	LICENSE	1 KB	Oct 19, 2021, 4:26 PM
<input type="checkbox"/>	my_first_notebook.Rmd	1 KB	Oct 28, 2021, 2:18 PM
<input type="checkbox"/>	presentations		
<input type="checkbox"/>	project.Rproj	205 B	Jul 4, 2022, 11:43 PM
<input type="checkbox"/>	README.md	4.9 KB	Oct 21, 2021, 1:06 PM



File Edit Code View Plots Session Build Debug Profile Tools Help

Untitled1 Go to file/function Addins R 4.1.3

Source Visual

Outline

```
1 ---  
2 title: "R Notebook" ← Update title  
3 output: html_notebook  
4 ---  
5  
6 This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute  
code within the notebook, the results appear beneath the code.  
7  
8 Try executing this chunk by clicking the *Run* button within the chunk or by  
placing your cursor inside it and pressing *Ctrl+Shift+Enter*. ↓  
9  
10 ``{r}  
4:1 # R Notebook R Markdown
```

Console Terminal Jobs

R 4.1.3 · /cloud/project/

>

Restarting R session...

Session restored from your saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

>
>
>

Environment History Connections Git Tutorial

Import Dataset 166 MiB List C

R Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

Folder Blank File Upload Delete Rename C

Cloud > project

	Name	Size	Modified
..			
	.gitignore	40 B	Oct 19, 2021, 4:26 PM
	.Rhistory	0 B	Oct 19, 2021, 4:26 PM
	coursepack		
	exercises		
	LICENSE	1 KB	Oct 19, 2021, 4:26 PM
	my_first_notebook.Rmd	1 KB	Oct 28, 2021, 2:18 PM
	presentations		
	project.Rproj	205 B	Jul 4, 2022, 11:43 PM
	README.md	4.9 KB	Oct 21, 2021, 1:06 PM



File Edit Code View Plots Session Build Debug Profile Tools Help

Untitled1 x Go to file/function Addins

R 4.1.3

```
9  
10 ```{r}  
11 plot(cars)  
12 ```  
13  
14 Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by  
pressing *Ctrl+Alt+I*.  
15  
16 When you save the notebook, an HTML file containing the code and output will be  
saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to  
preview the HTML file).  
17
```

4:1 # R Notebook R Markdown

Console Terminal Jobs

R 4.1.3 · /cloud/project/

>

Restarting R session...

Session restored from your saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

>

>

> |

Environment History Connections Git Tutorial

Import Dataset 166 MiB

R Global Environment

Environment is empty

Execute code chunk

Files	Plots	Packages	Help	Viewer	Presentation
Folder	Blank File	Upload	Delete	Rename	...
<input type="checkbox"/> Cloud > project					
Name	Size	Modified			
..					
.gitignore	40 B	Oct 19, 2021, 4:26 PM			
.Rhistory	0 B	Oct 19, 2021, 4:26 PM			
coursepack					
exercises					
LICENSE	1 KB	Oct 19, 2021, 4:26 PM			
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presentations					
project.Rproj	205 B	Jul 4, 2022, 11:43 PM			
README.md	4.9 KB	Oct 21, 2021, 1:06 PM			



File Edit Code View Plots Session Build Debug Profile Tools Help

+ | - | Folders | Print | Go to file/function | Addins

R 4.1.3

Untitled1 x

ABC ✓ Magnifying glass R Preview ▾

Source Visual

```
9
10 ``{r}
11 plot(cars)
12 ``
13
14 Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by
pressing *Ctrl+Alt+I*.
15
16 When you save the notebook, an HTML file containing the code and output will be
saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to
preview the HTML file).
17
```

R Notebook R Markdown

Console Terminal x Jobs x

R 4.1.3 · /cloud/project/ ↵

>

Restarting R session...

Session restored from your saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

>

>

> |

Environment History Connections Git Tutorial

Import Dataset 166 MiB

R Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

Folder Blank File Upload Delete Rename

Cloud project

Name	Size	Modified
..		Oct 19, 2021, 4:26 PM
.gitignore	40 B	Oct 19, 2021, 4:26 PM
.Rhistory	0 B	Oct 19, 2021, 4:26 PM
coursepack		
exercises		
LICENSE	1 KB	Oct 19, 2021, 4:26 PM
my_first_notebook.Rmd	1 KB	Oct 28, 2021, 2:18 PM
presentations		
project.Rproj	205 B	Jul 4, 2022, 11:43 PM
README.md	4.9 KB	Oct 21, 2021, 1:06 PM

Your Turn #2

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Execute the individual code chunk by selecting the Run Current Chunk arrow.

Knit the document to HTML (Preview or Knit Button -> Knit to HTML). You will be prompted to save your file first. Name your notebook (my_first_notebook.Rmd) and click save. Review the knitted document.



Code chunks

Open/close with
3 backticks

Language

Chunk
name

Run chunk

Code in body of
chunk

```
17  
18 - ``{r cars}  
19 summary(cars)  
20 ...  
21
```



File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

R 4.1.0

Untitled1*

ABC Knit

```
16 ``{r cars}
17 summary(cars)
18 ``
19
20 ## Including Plots
21
22 You can also embed plots, for example:
23
24 ``{r pressure, echo=FALSE}
25 plot(pressure)
26 ``
27
28 Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R
code that generated the plot.
```

Insert a new R chunk

R Bash D3 Python Rcpp SQL Stan

Environment History Connections Git Tutorial

Import Dataset 228 MiB Global Environment

Environment is empty

Insert code chunk

Place cursor in document

Files Plots Packages Help Viewer

New Folder Upload Delete Rename More

Cloud > project

Name	Size	Modified
..		
.gitignore	40 B	Oct 19, 2021, 4:26 PM
.Rhistory	0 B	Oct 19, 2021, 4:26 PM
coursepack		
exercises		
LICENSE	1 KB	Oct 19, 2021, 4:26 PM
presentations		
project.Rproj	205 B	Oct 19, 2021, 10:00 PM
README.md	4.8 KB	Oct 19, 2021, 4:26 PM

Console Terminal Jobs

R 4.1.0 · /cloud/project/

```
R version 4.1.0 (2021-05-18) -- "Camp Pontanezen"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
```

File Edit Code View Plots Session Build Debug Profile Tools Help

Untitled1* Go to file/function Addins R 4.1.0

```
19
20 ## Including Plots
21
22 You can also embed plots, for example:
23
24 ``{r pressure, echo=FALSE}
25 plot(pressure)
26 ```
27
28 Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R
code that generated the plot.
29
30 ``{r}
31
32 ``
```

New code chunk

Console Terminal Jobs R 4.1.0 · /cloud/project/

```
R version 4.1.0 (2021-05-18) -- "Camp Pontanezen"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

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R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

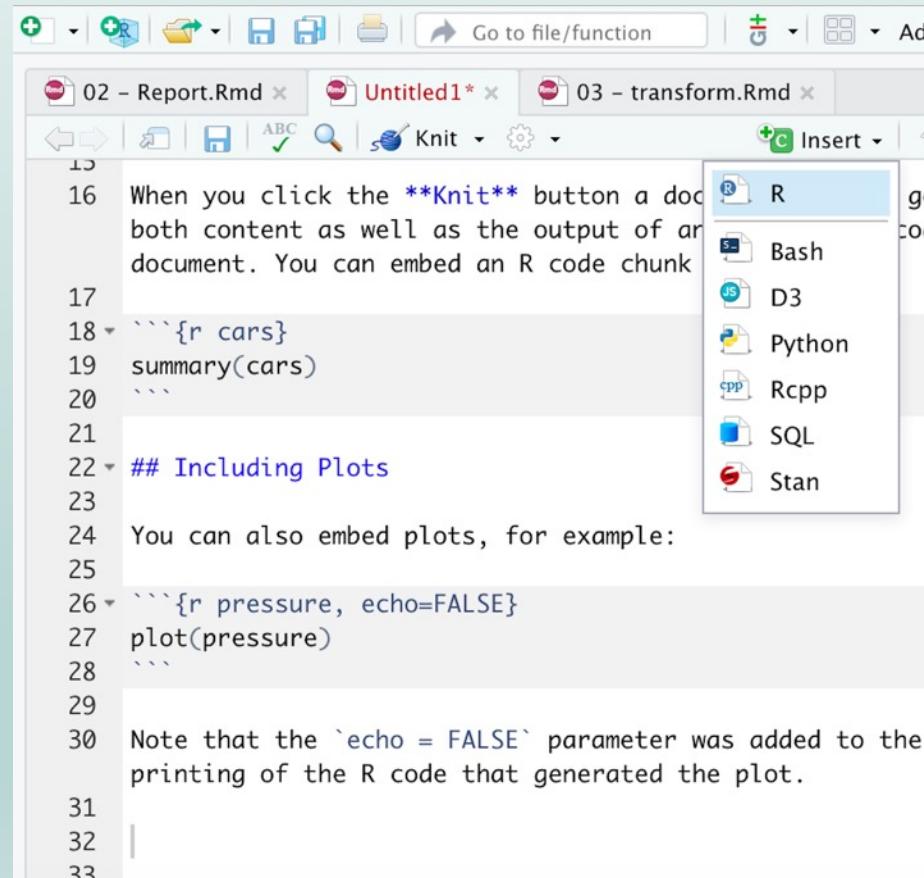
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
```

Environment History Connections Git Tutorial Import Dataset 228 MiB Global Environment Environment is empty

Files Plots Packages Help Viewer New Folder Upload Delete Rename More Cloud > project

Name	Size	Modified
..	40 B	Oct 19, 2021, 4:26 PM
.gitignore	0 B	Oct 19, 2021, 4:26 PM
.Rhistory		
coursepack		
exercises		
LICENSE	1 KB	Oct 19, 2021, 4:26 PM
presentations		
project.Rproj	205 B	Oct 19, 2021, 10:00 PM
README.md	4.8 KB	Oct 19, 2021, 4:26 PM

Your Turn #3



A screenshot of the RStudio interface. The top menu bar includes 'File', 'Edit', 'View', 'Code', 'Tools', 'Help', and 'Go to file/function'. Below the menu is a toolbar with icons for file operations like new, open, save, and knit. The main workspace shows an R Markdown document with the following code:

```
16 When you click the **Knit** button a doc  
both content as well as the output of an  
document. You can embed an R code chunk  
17  
18 ```{r cars}  
summary(cars)  
```  
19
20
21
22 ## Including Plots
23
24 You can also embed plots, for example:
25
26 ```{r pressure, echo=FALSE}
plot(pressure)
```  
27  
28  
29  
30 Note that the `echo = FALSE` parameter was added to the  
printing of the R code that generated the plot.  
31  
32  
33
```

An 'Insert' dropdown menu is open on the right, showing options for R, Bash, D3, Python, Rcpp, SQL, and Stan. The 'R' option is highlighted.

1. At the bottom of your document insert a code chunk into white space using Insert button on top right of code window
2. Type the following into your new code chunk:
`mean(c(10, 20, 30))`
3. Execute code chunk by pressing Run button on top right of code chunk

Recap



Programming
Language



IDE



Document
Format

The **RStudio Panes** include editor (writing code), environment (interact with objects), misc (interact with files), and console (enter individual commands).

Reproducible Data Analysis is a best practice for working with clinical and research data.

R Markdown provides us with an electronic notebook to mix executable data analysis code elements with annotation for effective reproducibility.



What else?

rmarkdown :: CHEAT SHEET

What is rmarkdown?

.Rmd files • Develop your code and ideas side-by-side in a single document. Run code as individual chunks or as an entire document.

Dynamic Documents • Knit together plots, tables, and results with narrative text. Render to a variety of formats like HTML, PDF, MS Word, or MS Powerpoint.

Reproducible Research • Upload, link to, or attach your report to share. Anyone can read or run your code to reproduce your work.

Workflow

- 1 Open a new .Rmd file in the RStudio IDE by going to File > New File > R Markdown.
- 2 Embed code in chunks. Run code by line, by chunk, or all at once.
- 3 Write text and add tables, figures, images, and citations. Format with Markdown syntax or the RStudio Visual Markdown Editor.
- 4 Set output format(s) and options in the YAML header. Customize themes or add parameters to execute or add interactivity with Shiny.
- 5 Save and render the whole document. Knit periodically to preview your work as you write.
- 6 Share your work!

Embed Code with knitr

CODE CHUNKS

Surround code chunks with `{{r}}` and `{{` or use the Insert Code Chunk button. Add a chunk label and/or chunk options inside the curly braces after {{r}}.

```
```{r chunk-label, include=FALSE}
summary(mtcars)
```
```

SET GLOBAL OPTIONS

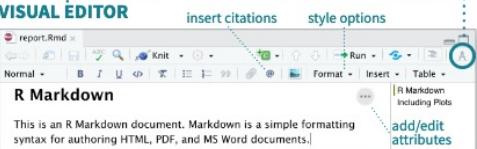
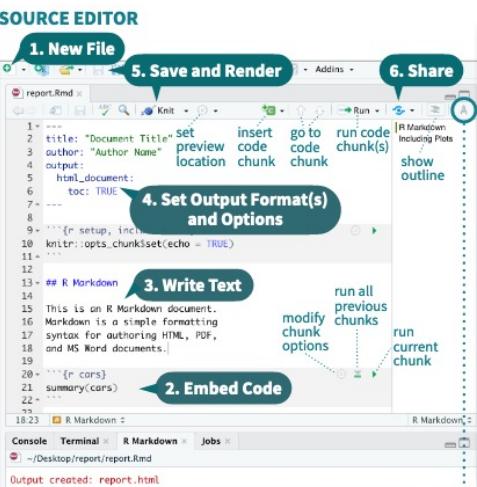
Set options for the entire document in the first chunk.

```
```{r include=FALSE}
knitr::opts_chunk$set(message = FALSE)
```
```

INLINE CODE

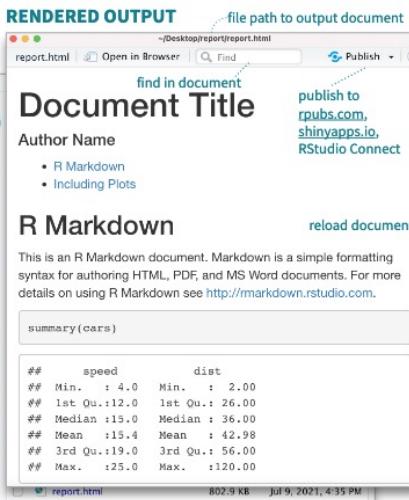
Insert `{{r <code>}}` into text sections. Code is evaluated at render and results appear as text.

"Built with `{{r getRversion()}}`" -> "Built with 4.1.0"



| OPTION | DEFAULT EFFECTS |
|------------------------|---|
| echo | TRUE display code in output document |
| error | FALSE (display error messages in doc) |
| eval | TRUE run code in chunk |
| include | TRUE include chunk in doc after running |
| message | TRUE display code messages in document |
| warning | TRUE display code warnings in document |
| results | "markup" "hide" (don't display results)
"hold" (put all results below all code) |
| fig.align | "default" "left", "right", or "center" |
| fig.alt | NULL alt text for a figure |
| fig.cap | figure caption as a character string |
| fig.path | "figure/" prefix for generating figure file paths |
| fig.width & fig.height | 7 plot dimensions in inches |
| out.width | rescales output width, e.g. "75%", "300px" |
| collapse | FALSE collapse all sources & output into a single block |
| comment | "##" prefix for each line of results |
| child | NULL files(s) to knit and then include |
| purl | TRUE include or exclude a code chunk when extracting source code with knitr::purl() |

See more options and defaults by running `str(knitr::opts_chunk$get())`



Insert Citations

Create citations from a bibliography file, a Zotero library, or from DOI references.

BUILD YOUR BIBLIOGRAPHY

- Add BibTeX or CSL bibliographies to the YAML header.

title: "My Document"
bibliography: references.bib
link-citations: TRUE

- If Zotero is installed locally, your main library will automatically be available.
- Add citations by DOI by searching "from DOI" in the **Insert Citation** dialog.

INSERT CITATIONS

- Access the **Insert Citations** dialog in the Visual Editor by clicking the @ symbol in the toolbar or by clicking **Insert > Citation**.
- Add citations with markdown syntax by typing `[@cite]` or `@cite`.

Insert Tables

Output data frames as tables using `kable(data, caption)`.

```
```{r}
data <- faithful[1:4,]
knitr::kable(data,
 caption = "Table with kable")
```
```

Other table packages include `flextable`, `gt`, and `kableExtra`.

Write with Markdown

The syntax on the left renders as the output on the right.

Plain text.

End a line with two spaces to start a new paragraph. Also end with a backslash\ to make a new line.

italics and **bold**

superscript²/subscript₂

~~strikethrough~~

escaped: ``\``

endash: ---, emdash: ---

Header 1

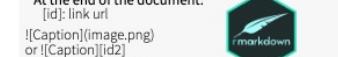
Header 2

Header 6

- unordered list
 - item 2
 - item 2a (indent 1 tab)
 - item 2b
 - ordered list
 - item 2
 - item 2a (indent 1 tab)
 - item 2b
 - item 2
 - item 2a (indent 1 tab)
 - item 2b
 - 1. ordered list
 - 2. item 2
 - 2. item 2a (indent 1 tab)
 - 2. item 2b

<http://www.rstudio.com/>
This is a link.

This is another link.



Caption.
verbatim code

multiple lines of verbatim code

> block quotes

equation: $\sum_{i=1}^n p_i = 1 = 0$

equation block:
$$E = mc^2$$

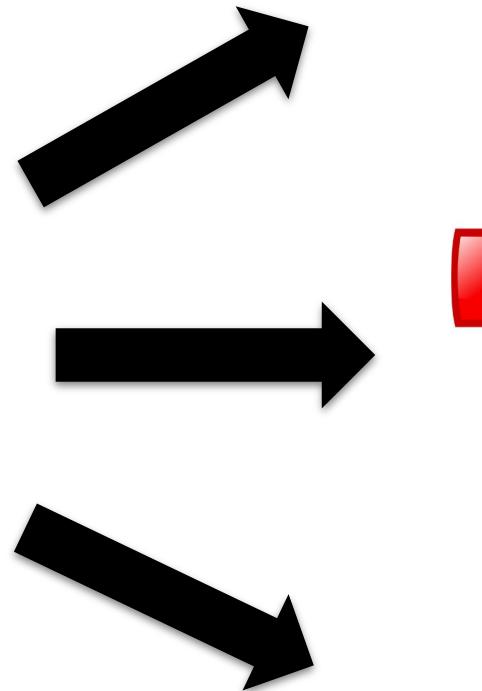
horizontal rule:

| Right | Left | Default | Center |
|-------|------|---------|--------|
| 12 | 12 | 12 | 12 |
| 123 | 123 | 123 | 123 |
| 1 | 1 | 1 | 1 |

HTML Tables
Results {table}
Plots text
text

Tables
more text







File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function

Addins

R 4.1.3

my_first_notebook.Rmd x

ABC Knit Outline

Source Visual

Switch marker to editing mode (F4)

```
1 ---  
2 title: "My First Notebook"  
3 output:  
4   html_document:  
5     df_print: paged  
6 ---  
7  
8 This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute  
code within the notebook, the results appear beneath the code.  
9  
10 Try executing this chunk by clicking the *Run* button within the chunk or by  
placing your cursor inside it and pressing *Ctrl+Shift+Enter*.
```

24:1 C Chunk 2 R Markdown

Console Terminal Render Jobs

R 4.1.3 · /cloud/project/

>

Restarting R session...

Session restored from your saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

```
>  
>  
> plot(cars)  
> mean(c(1,2,3))  
[1] 2  
>
```

Environment History Connections Git Tutorial

Import Dataset 197 MiB

R Global Environment

Environment is empty

| Files | Plots | Packages | Help | Viewer | Presentation | |
|---------------------------|------------|----------|-----------------------|--------|--------------|--|
| Folder | Blank File | Upload | Delete | Rename | | |
| Cloud > project | | | | | | |
| Name | | Size | Modified | | | |
| .. | | | | | | |
| .gitignore | | 40 B | Oct 19, 2021, 4:26 PM | | | |
| .Rhistory | | 0 B | Oct 19, 2021, 4:26 PM | | | |
| coursepack | | | | | | |
| exercises | | | | | | |
| LICENSE | | 1 KB | Oct 19, 2021, 4:26 PM | | | |
| my_first_notebook.Rmd | | 925 B | Jul 4, 2022, 11:57 PM | | | |
| presentations | | | | | | |
| project.Rproj | | 205 B | Jul 4, 2022, 11:43 PM | | | |
| README.md | | 4.9 KB | Oct 21, 2021, 1:06 PM | | | |
| my_first_notebook.nb.html | | 650.3 KB | Jul 4, 2022, 11:54 PM | | | |
| my_first_notebook.html | | 673.2 KB | Jul 4, 2022, 11:54 PM | | | |



File Edit Code View Plots Session Build Debug Profile Tools Help

+ | - | Folders | Print | Go to file/function | G | Addins

R 4.1.3

my_first_notebook.Rmd*

ABC Knit Run

Source Visual B I Normal Format Insert Table

df_print: paged

No outline avail...

This is an [R Markdown](#) Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

```
{r}
plot(cars)
```

(Top Level) R Markdown

Console Terminal Render Jobs

R 4.1.3 · /cloud/project/

Restarting R session...

Session restored from your saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

```
>
>
> plot(cars)
> mean(c(1,2,3))
[1] 2
>
```

Environment History Connections Git Tutorial

Import Dataset 198 MiB

R Global Environment

Environment is empty

| Name | Size | Modified |
|---------------------------|----------|-----------------------|
| .. | 40 B | Oct 19, 2021, 4:26 PM |
| .gitignore | 0 B | Oct 19, 2021, 4:26 PM |
| .Rhistory | | |
| coursepack | | |
| exercises | | |
| LICENSE | 1 KB | Oct 19, 2021, 4:26 PM |
| my_first_notebook.Rmd | 922 B | Jul 5, 2022, 12:01 AM |
| presentations | | |
| project.Rproj | 205 B | Jul 4, 2022, 11:43 PM |
| README.md | 4.9 KB | Oct 21, 2021, 1:06 PM |
| my_first_notebook.nb.html | 650.3 KB | Jul 4, 2022, 11:54 PM |
| my_first_notebook.html | 673.2 KB | Jul 4, 2022, 11:54 PM |

R Markdown: The Next Generation

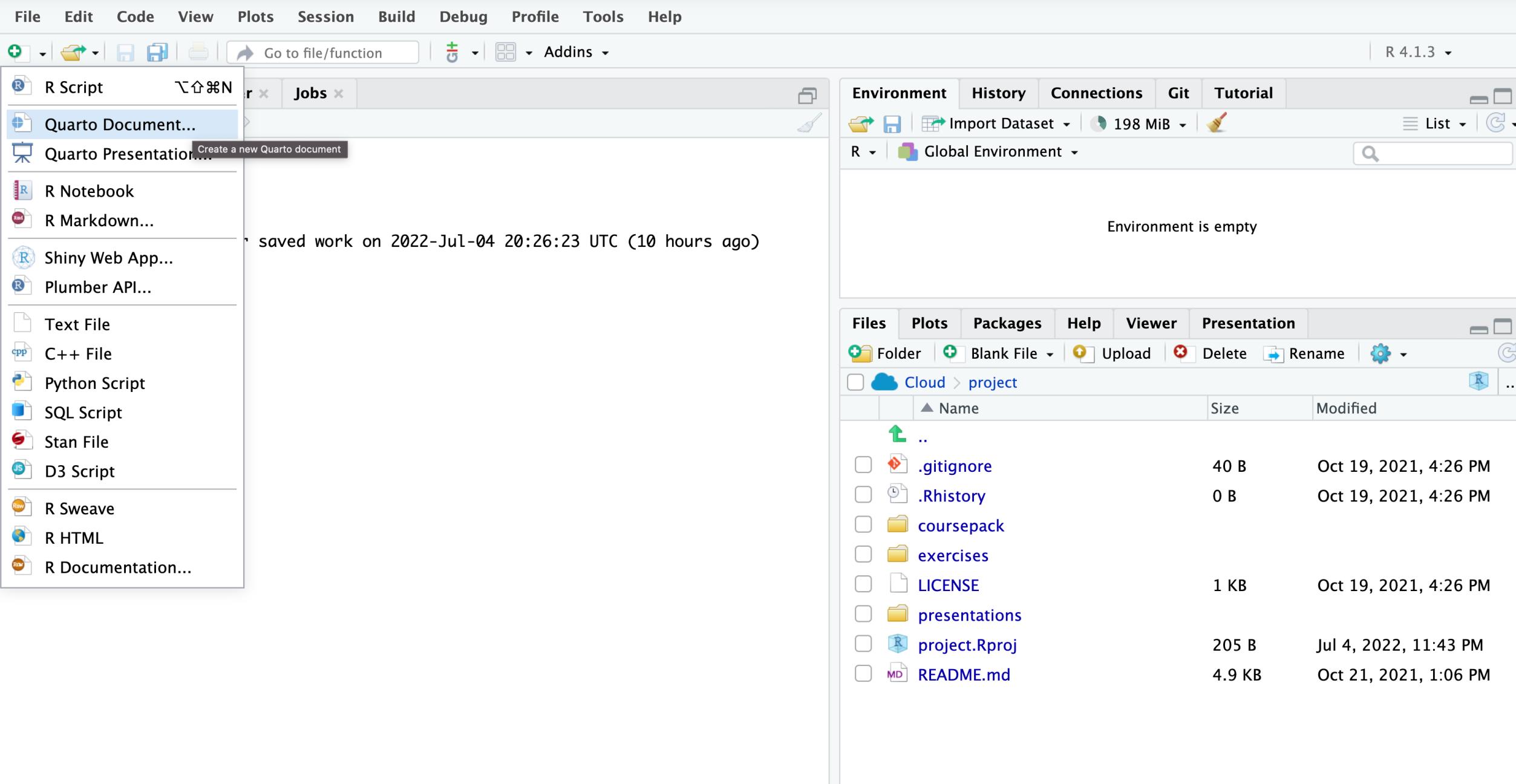
Quarto = open-source scientific and technical publishing format

Compatible with multiple language (Python, Julia, Observable in addition to R)

Integrated with newest version of RStudio

Expected to be the standard markdown format in RStudio in the future

More info available at: <https://quarto.org/>



File Edit Code View Plots Session Build Debug Profile Tools Help

 Go to file/function

R 4.1.3



The screenshot shows the Quarto Editor interface. The title bar says "Untitled1*". The toolbar includes icons for file operations (New, Open, Save), ABC (spell check), a magnifying glass (search), a blue square with a white arrow (Render), settings, and a plus sign with a 'c' (Code). Below the toolbar are tabs: Source (selected), Visual, B (bold), I (italic), $\langle \rangle$ (code block), Normal (dropdown), and various format and insert options. The main content area contains the following code:

```
---
```

```
title: "My First Quarto Document"
format: html
editor: visual
```

```
---
```

The right side has a sidebar with the text "Quarto Running Code".

Quarto

Quarto enables you to weave together content and executable code into a finished document. To learn more about Quarto see <https://quarto.org>.

(Top Level) ▲

Console Terminal × Render × Jobs ×

R 4.1.3 : /cloud/project/ 

Restarting R session

Session restored from your saved work on 2022-11-04 20:26:23 UTC (10 hours ago)

3

7

```
> plot(cars)
```

```
> mean(c(1,2,3))
```

[1] 2

>

Environment **History** **Connections** **Git** **Tutorial**

Import Dataset

R ▾ Global Environment ▾

Environment is empty

Files Plots Packages Help Viewer Presentation

| | Name | Size | Modified |
|--------------------------|---------------|--------|-----------------------|
| | .. | | |
| <input type="checkbox"/> | .gitignore | 40 B | Oct 19, 2021, 4:26 PM |
| <input type="checkbox"/> | .Rhistory | 0 B | Oct 19, 2021, 4:26 PM |
| <input type="checkbox"/> | coursepack | | |
| <input type="checkbox"/> | exercises | | |
| <input type="checkbox"/> | LICENSE | 1 KB | Oct 19, 2021, 4:26 PM |
| <input type="checkbox"/> | presentations | | |
| <input type="checkbox"/> | project.Rproj | 205 B | Jul 4, 2022, 11:43 PM |
| <input type="checkbox"/> | README.md | 4.9 KB | Oct 21, 2021, 1:06 PM |

File Edit Code View Plots Session Build Debug Profile Tools Help

A horizontal bar containing five icons: a green plus sign inside a circle, a folder with a right-pointing arrow, a blue folder, a blue folder with a copy icon, and a blue folder with a paste icon. To the right of these icons is the text "Go to file/function".

- Addins -

R 4.1.3 ▾

The toolbar includes icons for file operations (New, Open, Save, Save All), search (Search, Find and Replace), render (Render, Render All), and format tools (Format, Insert, Table). The status bar at the bottom right shows "Quarto Running Code".

You can add options to executable code like this

```
{r}  
#| echo: false  
2 * 2
```

The `echo: false` option disables the printing of code (only output is displayed).

Top Level) ▲

Writing Code

Environment is empty

Console Terminal × Render × Jobs ×

B 4.1.3 : /cloud/project/ 

Restarting R session...

Session restored from your saved work on 2022-Jul-04 20:26:23 UTC (10 hours ago)

```
>  
>  
> plot(cars)  
> mean(c(1,2,3))  
[1] 2  
>
```

[Environment](#) [History](#) [Connections](#) [Glossary](#) [Tutorial](#)

 Import Dataset

R ▾ Global Environment ▾

Files Plots Packages Help Viewer Presentation

 Folder Blank File Upload Delete R

| | Name | Size | Modified |
|--------------------------|---|--------|-----------------------|
| | .. | | |
| <input type="checkbox"/> |  .gitignore | 40 B | Oct 19, 2021, 4:26 PM |
| <input type="checkbox"/> |  .Rhistory | 0 B | Oct 19, 2021, 4:26 PM |
| <input type="checkbox"/> |  coursepack | | |
| <input type="checkbox"/> |  exercises | | |
| <input type="checkbox"/> |  LICENSE | 1 KB | Oct 19, 2021, 4:26 PM |
| <input type="checkbox"/> |  presentations | | |
| <input type="checkbox"/> |  project.Rproj | 205 B | Jul 4, 2022, 11:43 PM |
| <input type="checkbox"/> |  README.md | 4.9 KB | Oct 21, 2021, 1:06 PM |

Lesson Goals

1. Get oriented to the R programming environment
2. Appreciate the importance of reproducible data analysis

Lesson Objectives

1. Define R, RStudio and R Markdown
2. Log in and navigate RStudio Cloud
3. Discuss the risks of unreproducible data analysis
4. Create a R Markdown document