

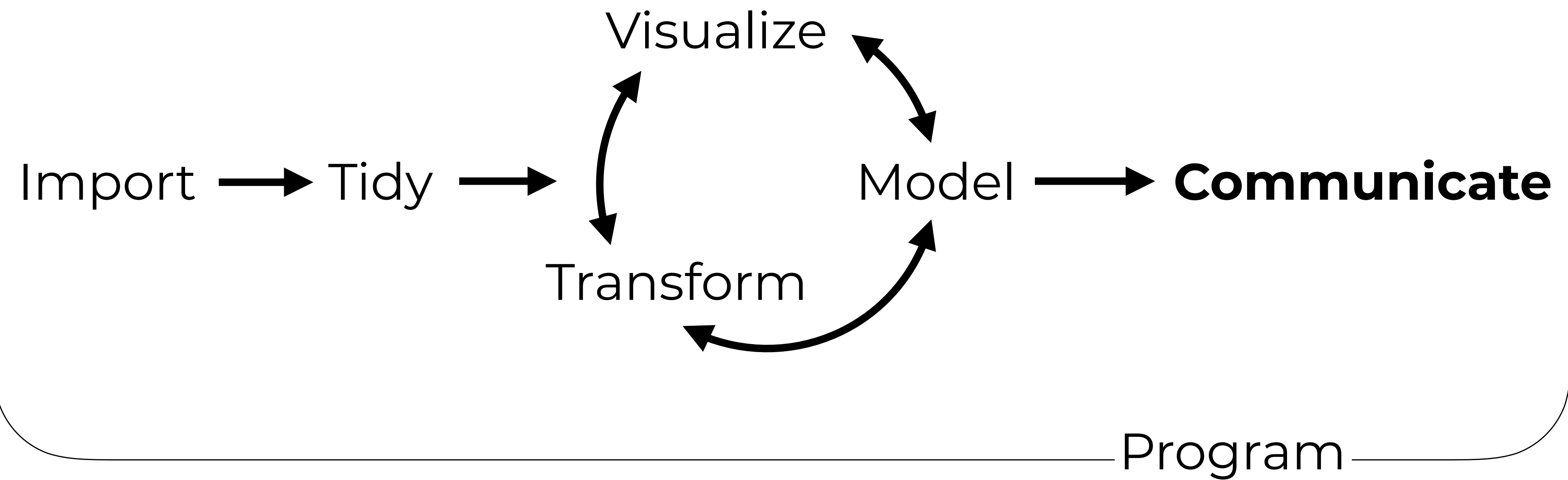
Communicating Results

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Consider

- What is the definition of a reproducible data analysis?
- What tools can you use to make a data analysis reproducible?



Reproducibility

- Are tables and figures reproducible from the code and data?
- Does the code do what you think it does?
- Is it clear **why** things were done?
- Can the code be used for other data?

From *Steps to Reproducible Research*, Karl Broman





In R4DS
R Markdown

Markdown

- Lightweight markup language with plain text formatting syntax
- Designed to be converted to HTML (and other formats, e.g. PDF)

```
1 |This is the repo for "Using R and the tidyverse for Data Science"
2 |given at the 2019 Summer Statistical Institute in May 2019.
3 |
4 |## Description
5 |
6 |This workshop is designed for those who want to learn how to use R to
7 |analyze data. The material is based on Hadley Wickham and Garrett
8 |Grolemund's [*R for Data Science*](https://r4ds.had.co.nz/index.html).
9 |We'll talk about how to conduct a complete data analysis from data
10 |import to final reporting in R using a suite of packages known as the
11 |[**tidyverse**](https://tidyverse.org). The two goals of this workshop
12 |are: 1) learn how to use R to answer questions about our data; and 2)
13 |write code that is human readable and reproducible. We will also talk
14 |about how to share our code and analyses with others.
15 |
16 |## Software Requirements
17 |
18 |In order to install the workshop materials (e.g., slides, exercises),
19 |you'll need **a laptop that can access the internet** (wifi will be
20 |available). Before the workshop, install the following:
21 |
22 |1. A recent version of R (~3.6.0), which is available for free at
23 |[cran.r-project.org](http://www.cran.r-project.org)
24 |2. A recent version of RStudio IDE (~1.2.1335), available for free at
25 |[www.rstudio.com/download](http://www.rstudio.com/download)
26 |3. The set of relevant R packages, which you can install by connecting
27 |to the internet, opening RStudio, and running the code in `setup.R`.
28 |
```



README.md

This is the repo for **"Using R and the tidyverse for Data Science"** given at the 2019 Summer Statistical Institute in May 2019.

Description

This workshop is designed for those who want to learn how to use R to analyze data. The material is based on Hadley Wickham and Garrett Grolemund's **R for Data Science**. We'll talk about how to conduct a complete data analysis from data import to final reporting in R using a suite of packages known as the **tidyverse**. The two goals of this workshop are: 1) learn how to use R to answer questions about our data; and 2) write code that is human readable and reproducible. We will also talk about how to share our code and analyses with others.

Software Requirements

In order to install the workshop materials (e.g., slides, exercises), you'll need **a laptop that can access the internet** (wifi will be available). Before the workshop, install the following:

1. A recent version of R (~3.6.0), which is available for free at [cran.r-project.org](http://www.cran.r-project.org)
2. A recent version of RStudio IDE (~1.2.1335), available for free at www.rstudio.com/download
3. The set of relevant R packages, which you can install by connecting to the internet, opening RStudio, and running the code in `setup.R`.

More detailed instructions can be found on the [workshop website](#). Don't forget to bring your power cord!

R Markdown

- Markdown + R
- Text + R code (in chunks) gets converted to text + R code + R output
- 3 types of content:
 - YAML header surrounded by ---
 - R code chunks surrounded by `` ` ``
 - Text with markdown formatting



Markdown Formatting

Text and Headers

- Text can be `plain`, `*italic*`, `**bold**`, or ``code``
- Headers use `#`
 - `# Header 1`
 - `## Header 2`
 - `### Header 3`

Links

- Plain web address, or custom phrase
 - `https://tidy-ds.wjakethompson.com`
 - `[Workshop Website](https://tidy-ds.wjakethompson.com)`
- Images from the web or local
 - `![RStudio logo](https://www.rstudio.com/wp-content/uploads/2018/10/RStudio-Logo-Flat.png)`
 - `![RStudio logo](resources/rstudio-logo.png)`

Alt text



Your Turn 1

- Open the **tidyds-2019.Rproj** project
- File > New File > R Markdown...
- Adjust the title, author, ...
- Add an image or equation
- Save your document as **11-Communicate/my-first-rmd.Rmd**
- Compile document to HTML

05 : 00



Customize Output

```
---  
title: "Communicate - Solution"  
author: "Jake Thompson"  
date: "`r Sys.Date()`"  
output: html_document  
---
```


Customize Output

```
---  
title: "Communicate - Solution"  
author: "Jake Thompson"  
date: "`r Sys.Date()`"  
output:  
  html_document:  
    number_sections: true  
    toc: true  
---
```

Pandoc's Markdown

Write with syntax on the left to create effect on right (after render)

```
Plain text
End a line with two spaces
to start a new paragraph.
"Title" and "bold"
verbatim code
subscript2 ~ 2~
escape: \, \_
escaped: \_
equation: SA = 3πr^2/25
equation block:
E = mc^2

> block quote

# Header1 (hanchor)
## Header 2 (hcss_id)
### Header 3 (hcss_class)
#### Header 4
##### Header 5
##### Header 6

<!-- Text comment -->
<!-- HTML ignored in HTML -->
<!-- HTML ignored in pdf -->
<img alt="smallorb.png" />

[Caption](smallorb.png)

* unordered list
+ sub-item 1
+ sub-item 2
+ sub-sub-item 1

* Item 2
Continued (indent 4 spaces)
2. Item 2
1. sub-item 1
A. sub-sub-item 1

@@) A list whose numbering
continues after
@@) an interruption

Term 1
1. Definition 1
[Right | Left | Default | Center]
12 12 12 12
123 123 123 123
1 1 1 1
- slide bullet 1
- slide bullet 2
(- to have bullets appear on click)
horizontal rule/slide break:
***
A footnote [*1]
[*1]: Here is the footnote.
```

Set render options with YAML

When you render, R Markdown
1. runs the R code, embeds results and text into .md file with knitr
2. then converts the .md file into the finished format with pandoc

Set a document's
default output format
in the YAML header:

output: html_document
Body

creates

html_document
pdf_document
word_document
odt_document
rtf_document
md_document
github_document
ioslides_presentation
slidy_presentation
beamer_presentation

Customize output with
sub-options (listed to
the right):

html tabsets
Use tabsetcss class to place sub-headers into tabs

Tabset [tabset tabset-fade tabset-pills]
Tab 1
text 1
Tab 2
text 2
End tabset

Create a Reusable Template

1. Create a new package with a inst/rmarkdown/templates
directory
2. In the directory, Place a folder that contains:
template.yaml (see below)
skeleton.html (contents of the template)
any supporting files
3. Install the package
4. Access template in wizard at File ► New File ► R Markdown
template.yaml

name: My Template

sub-option	description	html	pdf	word	odt	rtf	md	github	ioslides	slidy	beamer
citation_package	The LaTeX package to process citations, natbib, biblatex or none		X				X				X
code_folding	Let readers to toggle the display of R code, "none", "hide", or "show"	X									
colortheme	Beamer color theme to use										X
css	CSS file to use to style document	X							X	X	
dev	Graphics device to use for figure output (e.g. "png")	X	X				X	X	X	X	X
duration	Add a countdown timer (in minutes) to footer of slides									X	
fig_caption	Should figures be rendered with captions?	X	X	X	X				X	X	X
fig_height, fig_width	Default figure height and width (in inches) for document	X	X	X	X	X	X	X	X	X	X
highlight	Syntax highlighting: "tango", "pygments", "kate", "zenburn", "textmate"	X	X	X						X	X
includes	File of content to place in document (in_header, before_body, after_body)	X	X		X		X	X	X	X	X
incremental	Should bullets appear one at a time (on presenter mouse clicks)?						X	X	X	X	
keep_md	Save a copy of .md file that contains knitr output	X		X	X	X			X	X	
keep_tex	Save a copy of .tex file that contains knitr output		X								X
latex_engine	Engine to render latex, "pdflatex", "xelatex", or "lualatex"		X								X
lib_dir	Directory of dependency files to use (Bootstrap, MathJax, etc.)	X							X	X	
mathjax	Set to local or a URL to use a local/URL version of MathJax to render equations	X							X	X	
md_extensions	Markdown extensions to add to default definition or R Markdown	X	X	X	X	X	X	X	X	X	X
number_sections	Add section numbering to headers	X	X								
pandoc_args	Additional arguments to pass to Pandoc	X	X	X	X	X	X	X	X	X	X
preserve_yaml	Preserve YAML front matter in final document?						X				
reference_docx	docx file whose styles should be copied when producing docx output			X							
self_contained	Embed dependencies into the doc	X							X	X	
slide_level	The lowest heading level that defines individual slides										X
smaller	Use the smaller font size in the presentation?								X		
smart	Convert straight quotes to curly, dashes to em-dashes, ... to ellipses, etc.	X							X	X	
template	Pandoc template to use when rendering file quarterly_report.html).	X	X		X					X	X
theme	Bootswatch or Beamer theme to use for page	X									X
toc	Add a table of contents at start of document	X	X	X		X	X	X			X
toc_depth	The lowest level of headings to add to table of contents	X	X	X		X	X	X			
toc_float	Float the table of contents to the left of the main content	X									

Table Suggestions

Several functions format R data into tables

data = faithful[1:4,]
knitr::kable(data, caption = "Table with kable")

printable::table(data, caption = "Table with table",
type = "html", htmlTable.attributes = "border=0")
stargazer::stargazer(data, type = "html", title = "Table
with stargazer")

Citations and Bibliographies

Create citations with .bib, .bibtex, .copac, .enl, .json,
.medline, .mods, .ris, .wos, and .xml files

1. Set bibliography file and CSL 1.0
Style file (optional) in the YAML header
2. Use citation keys in text

Smith cited (Smith04).
Smith cited without author (-@Smith04).
Smith04 cited in line.

Smith cited (see Smith 2004).
Smith cited without author (-@Smith 2004).
Joe Smith (2004) cited in line.



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sub-option

description

citation_package

The LaTeX package to process citations, natbib, biblatex or none

code_folding

Let readers to toggle the display of R code, "none", "hide", or "show"

colortheme

Beamer color theme to use

css

CSS file to use to style document

dev

Graphics device to use for figure output (e.g. "png")

duration

Add a countdown timer (in minutes) to footer of slides

fig_caption

Should figures be rendered with captions?

fig_height, fig_width

Default figure height and width (in inches) for document

highlight

Syntax highlighting: "tango", "pygments", "kate", "zenburn", "textmate"

includes

File of content to place in document (in_header, before_body, after_body)

incremental

Should bullets appear one at a time (on presenter mouse clicks)?

keep_md

Save a copy of .md file that contains knitr output

keep_tex

Save a copy of .tex file that contains knitr output

latex_engine

Engine to render latex, "pdflatex", "xelatex", or "lualatex"

lib_dir

Directory of dependency files to use (Bootstrap, MathJax, etc.)

mathjax

Set to local or a URL to use a local/URL version of MathJax to render equations

md_extensions

Markdown extensions to add to default definition or R Markdown

number_sections

Add section numbering to headers

pandoc_args

Additional arguments to pass to Pandoc

preserve_yaml

Preserve YAML front matter in final document?

reference_docx

docx file whose styles should be copied when producing docx output

self_contained

Embed dependencies into the doc

slide_level

The lowest heading level that defines individual slides

smaller

Use the smaller font size in the presentation?

smart

Convert straight quotes to curly, dashes to em-dashes, ... to ellipses, etc.

template

Pandoc template to use when rendering file quarterly_report.html).

theme

Bootswatch or Beamer theme to use for page

toc

Add a table of contents at start of document

toc_depth

The lowest level of headings to add to table of contents

toc_float

Float the table of contents to the left of the main content



Your Turn 2

- Edit the YAML for **11-Communicate/my-first-rmd.Rmd**
- Add a table of contents
- Change the theme to **darkly**

02 : 00

```
---  
...  
output:  
  html_document:  
    toc: true  
    theme: "darkly"  
---
```

Your Turn 3

Analyze. Share. Reproduce.

and do it all

with R Markdown

Your data tells a ~~joke~~ story. Tell it with R Markdown. Turn your analyses into **high quality** documents, reports, presentations and dashboards – and don't forget to drink some H₂O while you do that.¹

R Markdown documents are fully reproducible. Use a productive [notebook interface](#)² to weave together narrative text and code to produce *elegantly formatted* output. Use multiple languages including

- R
- Python

and

- SQL

Do you need still need convincing to use R Markdown? See what a friend once said:

I used to use Sweave, and get terrible headaches. Now I use R Markdown, and life is much more pleasant.

1. Or coffee, whatever floats your boat. ↩

2. This link should point to http://rmarkdown.rstudio.com/r_notebooks.html. ↩

- Open **11-Communicate/analyze-share-repro.Rmd**
- Add styling to the text to create the look on the left.

10 : 00





Putting the R in R Markdown



Run R code inside Markdown

- Code chunks
 - Most powerful
 - Control over computations
 - Handles plots and other non-text output
- Inline code
 - Simple, but only handles text
 - Character strings (including Markdown formatting)
 - Numbers (but not vectors)

Code chunks

- "Fenced" regions of code
- When report is rendered:
 - Each code chunk is run
 - Output placed directly beneath the code chunk
- Insert new chunks with:
 - *Add Chunk* button in toolbar
 - Keyboard shortcut:
 - Mac: **Cmd** + **option** + **I**
 - Windows: **Ctrl** + **Alt** + **I**

Chunk options

Control how the chunk is displayed

- Should the code display? Or just the output?
- Include errors and warnings?
- How should figures be rendered?

R Markdown : : CHEAT SHEET

What is R Markdown?

Rmd files - An R Markdown (.Rmd) file is a record of your research. It contains the code that a scientist needs to reproduce your work along with the narration that a reader needs to understand your work.

Reproducible Research - At the click of a button, or the type of a command, you can rerun the code in an R Markdown file to reproduce your work and export the results as a finished report.

Dynamic Documents - You can choose to export the finished report in a variety of formats, including html, pdf, MS Word, or RTF documents; html or pdf based slides, Notebooks, and more.

Workflow

1. Open a new .Rmd file at File > New File > New File
2. R Markdown. Use the wizard that opens to pre-populate the file with a template
3. Write document by editing template
4. Knit document to create report; use knit button or `render()` to knit
5. Preview Output in IDE window
6. Publish (optional) to web server
7. Examine build log in R Markdown console
8. Use output file that is saved alongside .Rmd

Embed code with knitr syntax

INLINE CODE
Insert with `"`r`"`. Results appear as text without code.
Built with `"`r`getVersion()"`. Built with 3.2.2

IMPORTANT CHUNK OPTIONS	CODE CHUNKS	GLOBAL OPTIONS
cache - cache results for future knits (default = FALSE) cache.path - directory to save cached results in (default = "cache/") child - file(s) to knit and then include (default = NULL) collapse - collapse all output into single block (default = FALSE) comment - prefix for each line of results (default = "##")	One of three lines surrounded with <code>"`r`"</code> and <code>"`r`"</code> . Place chunk options within curly braces, after <code>r</code> , insert with <code>"`r`"</code> . <code>"`r`"</code> (echo=TRUE) <code>"`r`"</code> (include=FALSE) <code>"`r`"</code> (knitr.opts_chunk\$set(echo=TRUE))	Set with <code>knitr::opts_chunk\$set()</code> , e.g. <code>"`r`"</code> (include=FALSE) <code>"`r`"</code> (knitr.opts_chunk\$set(echo=TRUE))

Options not listed above: R.options, aniopts, autodep, background, cache.comments, cache.lazy, cache.rebuild, cache.vars, dev, dev.args, dpi, engine.opts, engine.path, fig.asp, fig.env, fig.ext, fig.keep, fig.lp, fig.path, fig.pos, fig.process, fig.retina, fig.scap, fig.show, fig.showtext, fig.subcap, interval, out.extra, out.height, out.width, prompt, purl, ref.label, render, size, split, tidy.opts

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R Markdown
This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents.

For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

render
Use `mardown::render()` to render/knit at cmd line. Important args:
input - file to render
output - output file
output_dir - directory to save output (options as in YAML)
params - list of params to use
envir - environment to evaluate code (chunks in)

Interactive Documents
Turn your report into an interactive Shiny document in 4 steps:
1. Add runtime: shiny to the YAML header.
2. Call Shiny input functions to embed input objects.
3. Call Shiny render functions to embed reactive output.
4. Render with `mardown::run` or click Run Document in RSudio IDE

fig.align - 'left', 'right', or 'center' (default = 'default')
fig.cap - figure caption as character string (default = NULL)
fig.height, **fig.width** - Dimensions of plots in inches
highlight - highlight source code (default = TRUE)
include - include chunk in doc after running (default = TRUE)
message - display code messages in document (default = TRUE)
results (default = 'markup')
'asis' - passthrough results
'hide' - do not display results
'hold' - put all results below all code
tidy - tidy code for display (default = FALSE)
warning - display code warnings in document (default = TRUE)

Embed a complete app into your document with `runtime: shiny`
NOTE: Your report will be rendered as a Shiny app, which means you must choose an HTML output format, like `HTML_document`, and serve it with an active R Session

IMPORTANT CHUNK OPTIONS

cache - cache results for future knits (default = FALSE)
cache.path - directory to save cached results in (default = "cache/")
child - file(s) to knit and then include (default = NULL)
collapse - collapse all output into single block (default = FALSE)
comment - prefix for each line of results (default = "##")

dependson - chunk dependencies for caching (default = NULL)
echo - Display code in output document (default = TRUE)
engine - code language used in chunk (default = 'R')
error - Display error messages in doc (TRUE) or stop render when errors occur (FALSE) (default = FALSE)
eval - Run code in chunk (default = TRUE)

fig.align - 'left', 'right', or 'center' (default = 'default')
fig.cap - figure caption as character string (default = NULL)
fig.height, **fig.width** - Dimensions of plots in inches
highlight - highlight source code (default = TRUE)
include - Include chunk in doc after running (default = TRUE)

message - display code messages in document (default = TRUE)
results (default = 'markup')
'asis' - passthrough results
'hide' - do not display results
'hold' - put all results below all code
tidy - tidy code for display (default = FALSE)
warning - display code warnings in document (default = TRUE)

Options not listed above: R.options, aniopts, autodep, background, cache.comments, cache.lazy, cache.rebuild, cache.vars, dev, dev.args, dpi, engine.opts, engine.path, fig.asp, fig.env, fig.ext, fig.keep, fig.lp, fig.path, fig.pos, fig.process, fig.retina, fig.scap, fig.show, fig.showtext, fig.subcap, interval, out.extra, out.height, out.width, prompt, purl, ref.label, render, size, split, tidy.opts



Some normal text.

```
```{r make-plot, echo = FALSE, fig.align = "c"}  
ggplot(mtcars, aes(mpg, disp)) +
 geom_point()
```
```

Some more plain text.

Some normal text.

```
```{r make-plot, echo = FALSE, fig.align = "c"}  
ggplot(mtcars, aes(mpg, disp)) +
 geom_point()
```
```

Language
engine

Some plain text.

Some normal text.

```
```{r make-plot, echo = FALSE, fig.align = "c"}  
ggplot(mtcars, aes(mpg, disp)) +
 geom_point()
```
```

Language
engine

Chunk
label

text.

Some normal text.

```
```{r make-plot, echo = FALSE, fig.align = "c"}  
ggplot(mtcars, aes(mpg, disp)) +
 geom_point()
```
```

Language
engine

Chunk
label

text.

Chunk
options

Inline code

- Can be anywhere in your document... except a chunk
- Fenced with a single back tick ``r contents``
- Uses current workspace

Your Turn 4

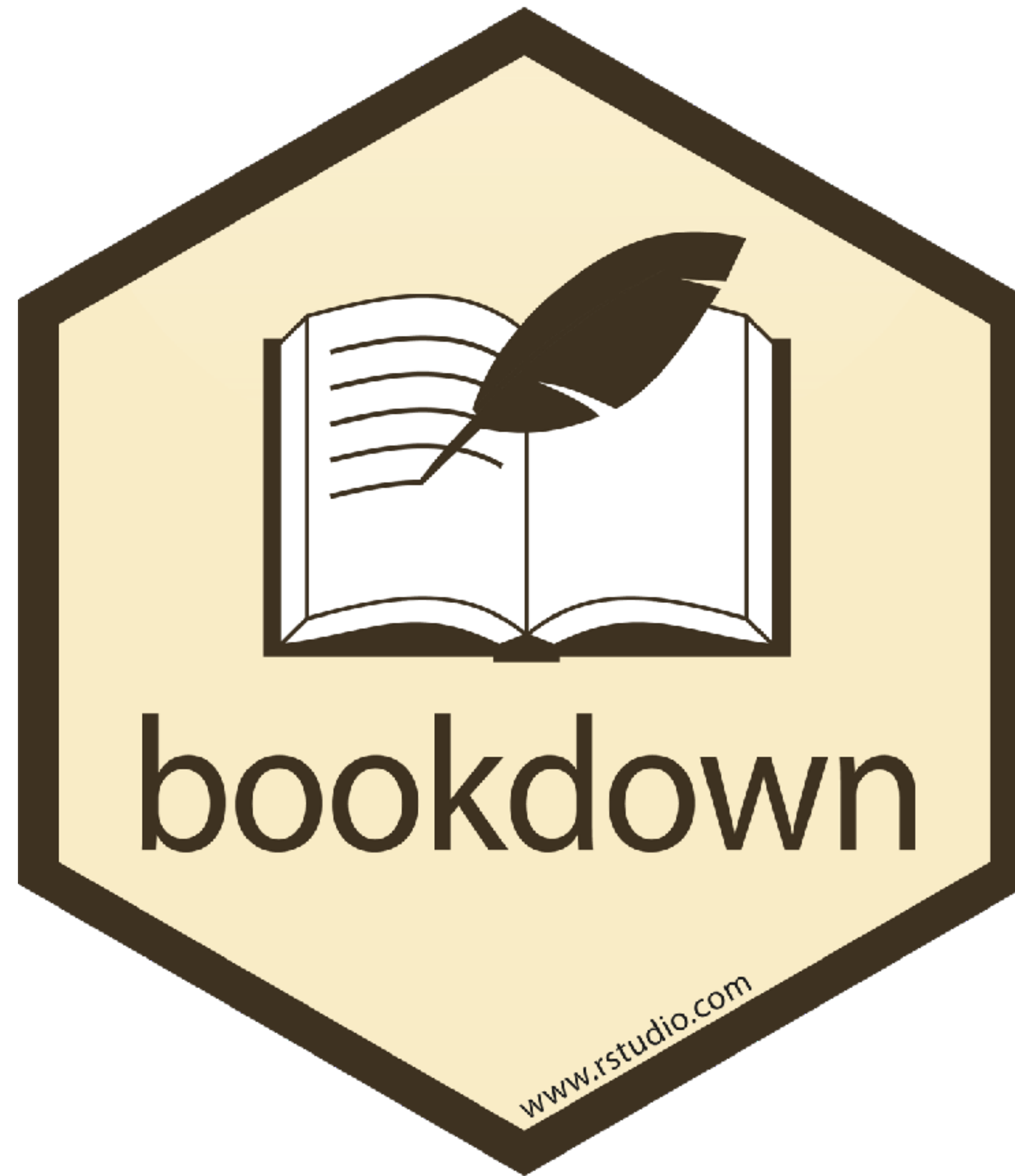
- Open **11-Communicate/chunk-basics.Rmd**
- Follow the numbered directions to add and modify code chunks and inline code.

05 : 00





Writing Reports with R Markdown



```
---  
...  
output:  
  html_document:  
    toc: true  
    theme: "darkly"  
---
```

```
---  
...  
output:  
  bookdown::html_document2:  
    toc: true  
    theme: "darkly"  
---
```




Case Study 2 Report

Your Turn 5

- Create a new R Markdown document.
- Title it "*Examining the Effect of Gender on Graduate Program Admission*" and add yourself as the author
- Make the date update automatically to today's date
- Change the output to **bookdown::html_document2**
- Save the file as **11-Communicate/case-study-2-report/case-study-2-report.Rmd**

03 : 00

Your Turn 6

Setup global options in the **setup** chunk

- Load the packages that we used in Case Study 2 + **knitr**, **hrbrthemes**, and **colorblindr**
- Set global chunk options inside **knitr::opts_chunk\$set()**
 - Don't show code
 - Don't show **messages**, **warnings**, or **errors**
 - Save figure to **figures/**
 - Make all figures **8** inches wide with an aspect ratio of **0.618**
 - Align all pictures in the **center** and use **90%** of the output width

05 : 00

```
` `{r setup, include = FALSE}  
library(tidyverse)  
library(broom)  
library(rsample)  
library(tidydscompanion)  
library(knitr)  
library(hrbrthemes)  
library(colorblindr)  
  
knitr::opts_chunk$set(  
  echo = FALSE,  
  message = FALSE,  
  warning = FALSE,  
  error = FALSE,  
  fig.path = "figures/",  
  fig.retina = 3,  
  fig.width = 8,  
  fig.asp = 0.618,  
  fig.align = "center",  
  out.width = "90%"  
)  
...
```

Your Turn 7

- Remove the boilerplate text from the document
- Add an introduction that describes the purpose of the report.

05 : 00

Citations and References

Citations are added to a **.bib** file

bib/references.bib

```
@book{gre,  
  author = {{Educational Testing Service}},  
  year = {2012},  
  title = {The official guide to the {GRE} revised general test},  
  edition = {2nd},  
  address = {New York, NY},  
  publisher = {McGraw-Hill},  
  isbn = {9780071791236}  
}
```



```
@book{gre,
  author = {{Educational Testing Service}},
  year = {2012},
  title = {The official guide to the {GRE} revised general test},
  edition = {2nd},
  address = {New York, NY},
  publisher = {McGraw-Hill},
  isbn = {9780071791236}
}
```

Citation key

| syntax | renders as |
|-----------------------|--|
| Blah blah [@gre]. | Blah blah (Educational Testing Service, 2012). |
| ETS say blah [-@gre]. | ETS says blah (2012). |
| @gre says blah. | Educational Testing Service (2012) says blah. |

More on citations here:

https://rmarkdown.rstudio.com/authoring_bibliographies_and_citations.html#citations

Example bib entries:

<https://www.verbosus.com/bibtex-style-examples.html>

```
---  
...  
bibliography: ["bib/references.bib"]  
biblio-style: apalike2  
csl: csl/apa.csl  
link-citations: true  
...  
---
```

List of .bib files
containing references

Bibliography style

Citation style guide

Citations include
hyperlinks

Your Turn 8

- Update the YAML to include **bib/references.bib** as a bibliography
- Set **biblio-style** to "apalike2" and **csf** to "csf/apa.csf"
- Make citations have a hyper link

Where do the references appear?

Add a "References" heading.

02 : 00

Tables

```
kable(x, digits, col.names = NA, align, caption, format.args, ...)
```

Data
frame or
matrix

For numbers,
how many
digits to
round to

Column
names for
the table

Column
alignment

Table
caption

Formatting
options

Additional
arguments

```
kable(head(admission), digits = 1, align = "c",
  col.names = c("Decision", "Verbal", "Quant", "Writing", "GPA", "Gender"),
  caption = "A table of data", format.args = list(big.mark = ","),
  booktabs = TRUE)
```

| Table 1: A table of data | | | | | |
|--------------------------|--------|-------|---------|-----|--------|
| Decision | Verbal | Quant | Writing | GPA | Gender |
| 0 | 142 | 151 | 2.5 | 3.1 | Female |
| 0 | 148 | 140 | 2.5 | 3.4 | Male |
| 1 | 156 | 147 | 2.5 | 3.5 | Male |
| 0 | 154 | 152 | 4.0 | 3.3 | Male |
| 1 | 160 | 164 | 4.0 | 2.9 | Male |
| 1 | 154 | 164 | 3.5 | 3.1 | Male |

Look at those results in Table \@ref(tab:some-table)!

```
```{r some-table}  
kable(head(admission), caption = "Here is a table")
```
```

It really is incredible!

Your Turn 9

- Add a "Data" section that describes the data and provides summary statistics
- Include a table of the median score on academic measures by gender

05 : 00

Equations

Let define the Log Loss in equation below.

$$\text{LogLoss} = -\frac{1}{n} \sum_{i=1}^n [\dots]$$

Equations

Let define the Log Loss in equation \@ref(eq:logloss).

```
\begin{equation}
  \text{LogLoss} = -\frac{1}{n} \sum_{i=1}^n [\dots]
  (\#eq:logloss)
\end{equation}
```

Cite your software!

```
` `` {r write-packages, include = FALSE}  
if (!file.exists("bib/packages.bib")) file.create("bib/packages.bib")  
if (!file.exists("bib/knit.bib")) file.create("bib/knit.bib")  
suppressWarnings(  
  knitr::write_bib(c("rmarkdown", "bookdown"), "bib/knit.bib")  
)  
suppressWarnings(  
  knitr::write_bib(c(.packages()), "bib/packages.bib")  
)  
` ``
```

Then cite the package with @R-pkg.

Your Turn 10

- Add a methods section that describes what we did
- Include the equation for the Log Loss

$$\text{LogLoss} = -\frac{1}{n} \sum_{i=1}^n [y_i \log(\hat{y}_i) + (1 - y_i) \log(1 - \hat{y}_i)]$$

- Cite the relevant R packages we used

05 : 00

Figures

Include code for figures in their own chunk.

```
`{r figure, fig.cap = "Here is a figure!"}  
ggplot() +  
  ...  
`
```

Add a **fig.cap** so the figure can be referenced with **\@ref(fig:figure)**

Your Turn 11

- Add a results section that include the analysis we did in Case Study 2
- Include each figure in its own chunk
- Reference the figures in the text

10 : 00

Communicating Results

