

USING L^AT_EX AND MARKDOWN FOR REPRODUCIBLE RESEARCH

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2018 US EPA

R USER GROUP WORKSHOP

11 SEPT 2018

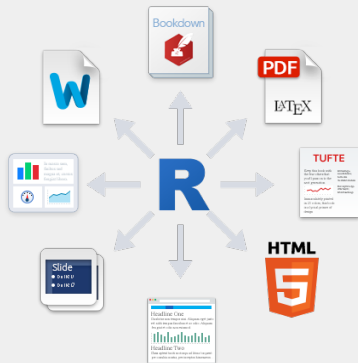


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Using LaTeX and Markdown for Reproducible Research

Day	Time	Room
Tues, Sept 11	8:30-11:30am	C111C

- This 1/2-day workshop will provide attendees with hands-on experience using the basics of LaTeX, Markdown, and the R package knitr.
- After attending this workshop, you will be able to use these tools to facilitate reproducible reports and research with R.

STEPS/AGENDA

We will try to use our three hours as effectively as possible.

Rough Agenda

#	Time	Topic
1	8:30	System checks & agenda
2	8:45	Intro to LaTeX
3	9:00	Intro to Markdown
4	9:15	Markdown & LaTeX
5	9:40	Reproducible Research
	9:50	<i>BREAK</i>
6	10:00	Dynamic documents with Sweave and knitr
7	10:30	Markdown & LaTeX with R
8	11:20	Wrap-up & additional resources

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LaTeX is a tool for high-quality typesetting based on the idea that it is better to leave document design to document designers, and to let authors get on with writing documents.

How do you pronounce “LaTeX”?

TeX is usually pronounced tech, making 'lah-teck, lah-'teck, and 'lay-teck the logical choices; but language is not always logical, so 'lay-'tecks is also possible.

— Leslie B. Lamport, original developer of L^AT_EX

LaTeX is widely used in academia for the publication of scientific documents in many fields, including mathematics, statistics, computer science, engineering, chemistry, physics, economics, and political science.

1. **TeX engines have excellent quality output.** This especially holds for complex documents such as those with mathematics, with many tables, or many cross-references or hyperlinks, or just with many pages.
2. **TeX is fast.**
3. **TeX is stable.** It will never eat your document. *Ever.*

— <https://www.ctan.org/tex/>

LATEX: MINIMAL EXAMPLE

Here is a minimal example of a full document written in LaTeX.

```
\documentclass{article}  
\title{A Minimal LaTeX Example}  
\author{Emily Li}  
  
\begin{document}  
\maketitle  
  
Hello world!  
  
\end{document}
```

LEVELS OF L^AT_EX: A DISAMBIGUATION

Help! There are too many words with “TeX” in them!

If you are wondering, “*Should I use LaTeX or MiKTeX?*”, allow us to clear that up. These two slides will cover four types of TeX-related terms: distributions, editors, engines, and formats.

1. **Distributions:** *MiKTeX, TeX Live, etc.* This is TeX-related software to be downloaded and installed. When someone says, “I need to install TeX on my machine,” they’re usually looking for a distribution.
2. **Editors:** *Emacs, TeXworks, TeXShop, TeXStudio, etc.* These editors are what you use to create a document file. Some (e.g., TeXShop) are devoted specifically to TeX, while others (e.g., Emacs) can be used to edit any sort of file.

— <http://www.tug.org/levels.html>

LEVELS OF L^AT_EX: A DISAMBIGUATION

A quick note on editors

You can also use Notepad to edit plaintext, including LaTeX code.

3. **Engines:** *TeX*, *pdfTeX*, *XeTeX*, *LuaTeX*, etc. These are the executable binaries which implement different TeX variants. When someone says, “TeX can’t find my fonts,” they usually mean an engine.
4. **Formats:** *LaTeX*, *plain TeX*, etc. These are the TeX-based languages in which one actually writes documents. When someone says, “TeX is giving me a mysterious error,” they usually mean a format. (Incidentally, “LaTeX” has meant “LaTeX2e” for many years now.)

— <http://www.tug.org/levels.html>

To compile LaTeX, your computer needs one of these TeX distributions installed:

TeX Distributions

Distribution	Operating System
MiKTeX	Windows OS
TeX Live	Linux and other UNIX-like systems
MacTeX	Mac OS X

You can also use an on-line, ready-to-use option like ShareLaTeX or Overleaf.

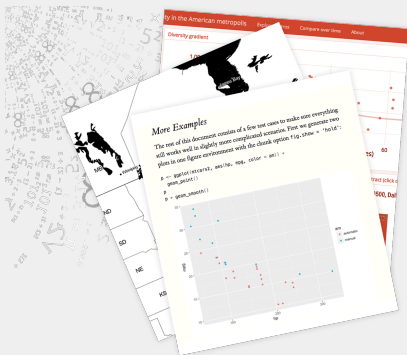
Try compiling this LaTeX

```
\documentclass{article}  
\title{A Minimal LaTeX Example}  
\author{Emily Li}  
  
\begin{document}  
\maketitle  
  
Hello world!  
  
\end{document}
```

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INTRO TO MARKDOWN



<https://rmarkdown.rstudio.com/>

- An **.Rmd file** is an R Markdown file
- Contains the code that a scientist needs to reproduce your work, along with the narration that a reader needs to understand your work.
- Choose to export the finished report in a variety of formats, including HTML, PDF, or MS Word.

INTRO TO MARKDOWN

- Markdown allows us to write using an easy-to-read, easy-to-write plain text format.
- As long as you know how to write emails, you can learn it in a few minutes.
- `https://en.wikipedia.org/wiki/Markdown#Example`

Limitations of Markdown

Markdown was primarily designed to be simple.
For more complicated typesetting, LaTeX may be preferred.

A short example of Markdown

```
# First level header
```

```
Hello world!
```

```
## Second level header
```

```
This is bold, and italic.
```

- ```
- list item
```
- ```
- list item
```

```
You can write an ordered list:
```

- ```
1. item 1
```
- ```
1. item 2 # this line will render as "2."
```

WORKFLOW IN MARKDOWN

Using RStudio:

Open a new .Rmd file, which pre-populates with a template

Write a document by editing the template

Knit the document to create a report; use the knitr button or `render()` to knit

Preview output in IDE window

Publish to web server (optional)

Use output file that is saved alongside .Rmd

Helpful link:

<https://rmarkdown.rstudio.com/lesson-2.html>

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REPRODUCIBLE RESEARCH

IS THERE A REPRODUCIBILITY CRISIS?

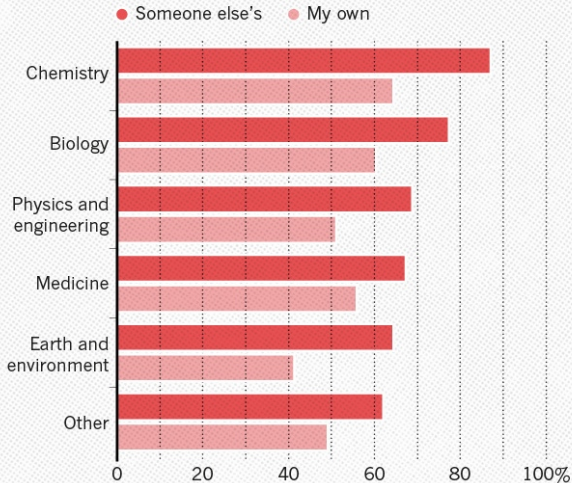


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REPRODUCIBLE RESEARCH

HAVE YOU FAILED TO REPRODUCE AN EXPERIMENT?

Most scientists have experienced failure to reproduce results.



Results must be reproducible to be trustworthy.

*An article about computational science in a scientific publication is not the scholarship itself, it is merely the advertising of the scholarship. The actual scholarship is the complete software development environment **and the complete set of instructions which generated the figures.***

— 1995, David L. Donoho, professor of statistics at Stanford University

This chunk of R code produces a figure that illustrates a simulation of Brownian motion for 100 steps.

Try running this in RStudio

```
set.seed(1213) # for reproducibility
x <- cumsum(rnorm(100))
plot(x, type = 'l',
      ylab = '$x_{i+1}=x_i+\\epsilon_{i+1}$',
      xlab = 'step')
```



```
set.seed(1213)
x <- cumsum(rnorm(100))
plot(x, type = 'l',
      ylab = '$x_{i+1}=x_i+\\epsilon_{i+1}$',
      xlab = 'step')
```

To put this into a document by hand, we would have to open RStudio, compile the code to draw the plot, save it as an image, then insert it into a document with `\includegraphics{}` in LaTeX or 'Insert Image' in Word.

Then what if we want to change the random seed in `set.seed()`, or the y-axis label?

Dynamic report generation by integrating code with narratives is not only easier but closely related to reproducible research. Dynamic report generation is an important step toward RR. (It does not guarantee RR.)

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Apples & Oranges?

The next few slides will show a side-by-side comparison of Markdown and LaTeX using the exact same analysis.

EXAMPLE L^AT_EX WITH ANALYSIS

```
\documentclass{article}  
\begin{document}  
\title{Speed and Stopping Distance}  
\author{Yihui Xie, creator of knitr}  
  
\maketitle
```

We examine the relationship between speed and stopping distance. The model is

$$Y = \beta_0 + \beta_1 x + \epsilon$$

```
<<model, fig.width=4, fig.height=3, fig.align='center',  
par(mar = c(4, 4, 1, 1), mgp = c(2, 1, 0), cex = 0.8),  
plot(cars, pch = 20, col = 'darkgray')  
fit <- lm(dist ~ speed, data = cars)  
abline(fit, lwd = 2)  
@
```

The slope of a simple linear regression is $\hat{\beta}_1 = \frac{\text{S}_{xy}}{\text{S}_{xx}}$

When embedding R code in LaTeX, start a code chunk with `«»=` and terminate it with `@`.

EXAMPLE MARKDOWN WITH ANALYSIS

title: Speed and Stopping Distance

We examine the relationship between speed and stopping distance. The model is:

$$Y = \beta_0 + \beta_1 x + \epsilon$$

```
'''{r fig.width=4, fig.height=3, fig.align='center'}
par(mar = c(4, 4, 1, 1), mgp = c(2, 1, 0), cex = 0.8)
plot(cars, pch = 20, col = 'darkgray')
fit <- lm(dist ~ speed, data = cars)
abline(fit, lwd = 2)
```

The slope of a simple linear regression is `r coef(fit)`.

- Quickly insert chunks with the keyboard shortcut Ctrl + Alt + I (OS X: Cmd + Option + I).
- By comparison, Markdown has simpler commands.

- Write code chunks between ````{r}` and `````
- Inline R code is written in ```
- Chunk options are written before closing brace in the chunk header.

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RESOURCES

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- <https://www.rstudio.com/resources/cheatsheets/>
- <https://support.rstudio.com/hc/en-us/articles/200552056-Using-Sweave-and-knitr>
- knitr document source + output examples:
<https://yihui.name/knitr/demos/>
- To Markdown or LaTeX, that is the question:
<https://yihui.name/en/2013/10/markdown-or-latex/>

THANKS FOR COMING!