Taking scientific notes with (R)Markdown and LaTeX

732A60 - Seminar 5

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Why focus on how to take notes?

- Most popular typesetting software: Word (# WYSIWYG)
- Still used in multiple scientific domain: medicine, sociology,
- But...

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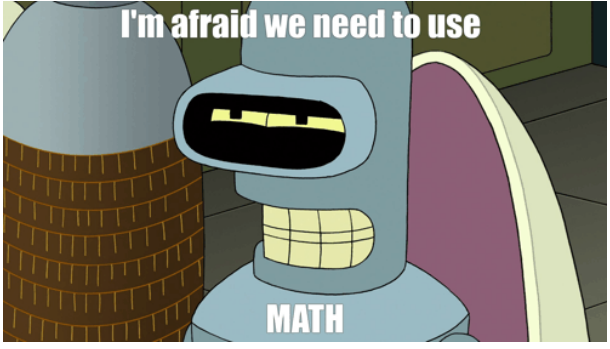

Typing math

Of course, you may type equations with Word:

Once upon a time, a duck met a Taylor expansion

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots, \qquad x \in \mathbb{R}$$

and chose to never use Word again.

But you will achieve greater pace via Tex/LaTeX

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + o(x^3), \forall x \in \mathbb{R}$$

These slides are written using LaTeX!

But I can do much worse...

Typing code

```
# A random comment
from sklearn.base import ClusterMixin, BaseEstimator
class MyModel(ClusterMixin, BaseEstimator):
        """Please use my code"""
        def __init__(self, x):
                self.x = x
```

```
1 # A random comment
2 from sklearn.base import
      BaseEstimator
3 class MyModel(BaseEstimator):
4         """Please use my code"""
5         def __init__(self, x):
6                 self.x = x
```

And last but not least!

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What is LaTeX?

TeX

- Computer program by Donald Knuth for typesetting text and formulas

LaTeX

- Predefined professional layout
- You need to write code to create documents (for ex. scientific papers)
  - A publisher just gives you a style file, and *voilà*, you match the desired formatting. The same may take hours, if not days in MS Word.
  - Formulas can be enumerated and updated automatically
  - Flexible citation and referencing function
- Code is compiled to PDF or PS or other files
- Turing-complete language

This is a different paradigm! You do not know what your document will look like until you compile it.

Let's get started!

Windows OS

- Install MikTeX: https://miktex.org/ (complete installation)

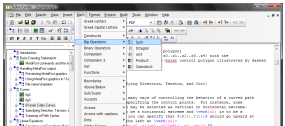
But then... where to code?

Linux

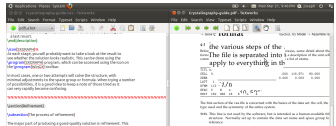
- Install TeXLive (If you do not have it already)

Choose your graphical interface

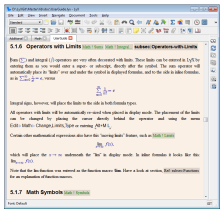
TeXnic Center



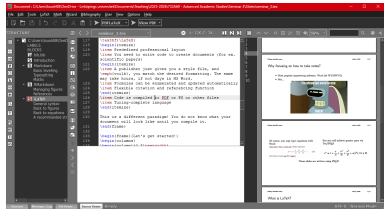
TeXworks



LyX



TeXmaker



Ready?

- Let's dive into the word of LaTeX, step by step!

Ready?

- Let's dive into the word of LaTeX, step by step!
- Our first step consist in not learning LaTeXdirectly.

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What is markdown?

- Created by John Gruber in 2004.
- Lightweight typesetting
- `.md` files
- The easiest to begin with
- No need for a fancy environment, Notepad or Visual Studio Code can do!
- You may also easily find free markdown editors online

Typing - Plain text

- Well, just type text as usual!

```
A plain text sample.
```

Typing - Sections

- Headers are indicated using a #
- Sublevels use ##
- etc
- Up to 6 sublevels

```
# Your best piece of work

## Introduction

###### A tiny paragraph

A plain text sample.
```

Typing - Emphases

- For italic, put text between *stars*
- For bold, use **two stars**

```
# Your best piece of work

By: **Author**

## Introduction

###### A tiny paragraph

A *plain* text sample.
```

Typing - Quotes and citations

- Any line starting by > is a quote.

```
# Your best piece of work

By: **Author**

## Introduction

####### A tiny paragraph

A *plain* text sample.

As someone righteously said:

> Yes
```

Typing - Comments

- Comments are masked parts of texts that will not render in the final output
- They should be written between the tags `<!--` and `-->`

```
# Your best piece of work

By: **Author**

## Introduction

####### A tiny paragraph

<!-- A *plain* text sample.-->

As someone righteously said:

> Yes
```

Typing - Lists

- Unnumbered list items
  - Start the line with `+` or `-`
- Numbered list items
  - Start the line with the number: `1.`
  - `2.`
  - etc

```
+ The first element of the list
  + A sub-element
+ The second element

1. A first numbered element
  - A sub-element
2. Another numbered element
```

Typing - Links and images

- Web links take the form `[text](path)`
- For images, we just add an exclamation mark: `![caption](path_to_image)`

```
1
2 Link to [LISAM](https://lisam.liu.se)
3
4 This is an image of a cat:
5
6 ![A tabby cat](https://en.wikipedia.org/wiki/Tabby_cat#/
    media/File:Cat_November_2010-1a.jpg)
```

Typing - Tables

- Columns and margins delimited by `|`
- First the header, then the column alignment, then the content
- Alignment:
  - Left: `|:---`
  - Center: `|:---:`
  - Right: `|---:`

```
| Header L | Header C | Header R |
| :--- |:---:| ---: |
| the | table | content |
| even | more | content |
```

Typing - Code blocks

- Simply wrapped up between three quotes: ‘‘‘

````
```
a = 2
print(a*3)
```
````

Maths - Inserting equation

- Inline formula: `$...$`
- Formula on a new line
  - `\[...\]`
  - `$$...$$$`
- OBS: formulas are not numbered

```
1 The area of rectangle is computed:
2
3 \[A = lw,\]
4
5 where $l$ is the length and $w$
    the width.
```

Maths - Inserting equation

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1 The area of rectangle is computed:
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```

$$A = lw$$

Maths - Your first cheat sheet

Typesetting	Code	Output
Superscript	`x^2, x^{a^3}`	x^2, x^{a^3}
Subscript	`x_2, x_{u-2}`	x_2, x^{u-2}
Greek letters	`\alpha \beta \pi \Pi`	$\alpha\beta\pi\Pi$
Comparison	`< > = \geq \leq`	$<>=\geq\leq$
Square root	`\sqrt{a-b}`	$\sqrt{a-b}$
Ratio	`\frac{a}{a+b}`	$\frac{a}{a+b}$
Accents	`\hat{x} \tilde{x} \vec{x}`	$\hat{x}\tilde{x}\vec{x}$
Parentheses	`\left(\Gamma+x\right)`	$(\Gamma + x)$
Brackets	`\left[\Gamma+x\right]`	$[\Gamma + x]$
Series of sums	`\sum_{i=1}^n i = \frac{n(n+1)}{2}`	$\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$
Series of product	`\prod_{i=1}^n i=n!`	$\prod_{i=1}^{n} i = n!$
Integrals	`\int x dx`	$\int x dx$

Even more symbols here.

Can we do more?

- This begins to look good.
- But we may miss a few elements before we call it *professional*.
- What are we missing?

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What is it?

- A convenient way to blend together R code (execution) and markdown typesetting
- Makes it easy to generate lab report: the code is executed when the report is being generated
- Multiple outputs: PDF, HTML, DOCX[a]
- Can even generate slide presentations, interactive documents or websites!
- Some starting resource can be found https://rmarkdown.rstudio.com/index.html

[a] Please do not

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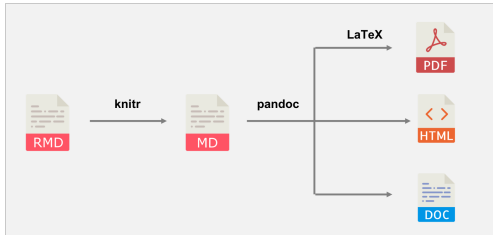

Image taken from https://bookdown.org/yihui/rmarkdown-cookbook/rmarkdown-process.html

[a] Please do not

Set up RMarkdown

- Install MikTeX. Choose the *complete installation*, not the basic one.
- In R, run the following
  - Install Markdown: `install.packages("rmarkdown")`
  - Install knitr: `install.packages("knitr")`
- Then, create a new `.Rmd` file in Rstudio

YAML header

- title
- subtitle
- author
- date
- output_ type
  - `pdf_document`
  - `html_document`
  - `beamer_document`
  - `md_document`
  - `word_document`
  - etc

```
---
title: "Lab 1, 732A98 Visualization"
author: "Louis Ohl"
date: "10 December 2037"
output: pdf_document
---
```

R code chunks

In addition to markdown, R code chunks that should be executed must be flagged with `{r}`.

````
```{r}
# This cell will be executed
head(cars)
```
````

R code chunks - commands

- Multiple options can be passed to the code chunks:
  - `echo=FALSE`: code is not shown in the report
  - `eval=TRUE`: code is executed
  - `include=FALSE`: code is executed but neither the code nor the results are in the report
  - `error=FALSE`: stop rendering when an error occurs
  - `message=FALSE`: do not display the outputs
  - `warning=FALSE`: do not display the warnings

````
```{r, echo=FALSE, message=FALSE, warning=FALSE}
library(TSA)
```
````

Generating figures

- We can also control the code chunk generating a figure to properly highlight it in the report.
  - `fig.cap`
  - `fig.width`
  - `fig.height`
  - `fig.align`: choose between `'center'`, `'left'` or `'right'`
  - `fig.show='hold'`

```
1 ```{r, fig.cap="Figure 1. Classification tree for bank
    decisions.", fig.width=4, fig.height=6, fig.align="
    center"}
2 plot(treefit1, type="uniform")
3 text(treefit1)
4 ```
```

Generating tables

- Along figures, we can also generate tables using the `knitr::kable` function

````
```{r echo=F}
knitr::kable(cars[1:4,], caption="Table 1: A Table of the first 4 rows of the cars data")
```
````

Referencing your figures

- To be able to reference your figures / tables in the text, you must incorporate `\\label{your_label}` in the caption.
- Then, you reference them using `\ref{your_label}` in the text.

````
```{r, fig.cap="\\label{figure1} Classification tree for
    bank decisions."}
plot(treefit1, type="uniform")
text(treefit1)
```
```{r echo=F}
knitr::kable(cars[1:4,], caption="\\label{table1} A Table
    of the first 4 rows of the cars data")
```
From \ref{figure1} and \ref{table1}, we conclude nothing.
````

The most important: references

- A claim is weak without proper support. You might need bibliographic references
- Have a reference manager software, *e.g.* Zotero, EndNote or Mendeley
- Export the references of interest to the BibTeX format

```
@book{bishop_pattern_2007,
  edition = {1},
  title = {Pattern Recognition and
      Machine Learning},
  isbn = {0-387-31073-8},
  publisher = {Springer},
  author = {Bishop, Christopher M.},
  year = {2007},
}
```

Incoporating references

- Change your YAML header to add the bibtex file
  - `"bibliography: your_file.bib"`
- Use `[@reference]` or `@reference` to cite

```
1 Essential elements of machine learning can be learnt by
    reading @bishop_pattern_2007.
```

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Diving into LaTeX

- Best options for documents that are large, *e.g.* a master thesis, a scientific article
- You may need to unlearn a couple things from (R)Markdown
- **Remember** You have little control on the placement of items in LaTeX, let the machine optimise everything.
- More reading on LaTeX: https://www.latex-project.org/

What is different? Commands and environments

- While markdown defined many "shortcuts", LaTeXuses more explicit commands and environments
  - A command is invoked with `\command_name{parameters}`
  - An environment starts with `\begin{environment_name}` and ends with `\end{environment}`.
- Implicitly, you have already seen one command today. Which was it?

What is different? Commands and environments

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Markdown:

```
# A section
## A subsection

Text in *italics* and **bold**.
```

LaTeX:

```
\section{A section}
\subsection{A subsection}

Text in \textit{italics} and \textbf{bold}.
```

What is different? Commands and environments

Markdown:

```
+ A list item
+ Another list item
```

```
1. A list item
2. Another list item
```

LaTeX:

```
\begin{itemize}
\item A list element
\item Another list element
\end{itemize}
```

```
\begin{enumerate}
\item A list element
\item Another list element
\end{enumerate}
```

General structure

```
1  \documentclass{article} % What document are we writing?
2
3  \usepackage{graphicx} % You may load packages to do fancy
       stuff
4
5  \title{My amazing empty document} % Basic document
       properties
6  \author{You, who else}
7
8  \begin{document}
9  % This is where all the content of your document is
       written
10 There is not so much to read here.
11 \end{document}
```

Equations

```
This equation is not numbered:

\[V = \frac{4}{3}\pi r^3 .\]

However, Eq. \ref{eq:volume_sphere} is
    numbered:

\begin{equation}\label{eq:volume_sphere}
V = \frac{4}{3}\pi r^3
\end{equation}
```

This equation is not numbered:

$$V = \frac{4}{3}\pi r^3.$$

However, Eq. 1 is numbered:

$$V = \frac{4}{3}\pi r^3. \tag{1}$$

Figures

```
\begin{figure}
\includegraphics{your_image.png}
\caption{The caption of the figure}
\label{fig:my_figure}
\end{figure}

Take a look at \ref{fig:my_figure}.
```

Tables

```latex
\begin{table}
\caption{Your amazing table}
\label{tab:my_table}
\begin{tabular}{l | c | r}
Left header & Central header & right header \\
A & B & C \\
D & E & F
\end{tabular}
\end{table}

Amazing table \ref{tab:my_table}.
```

Left header	Central header	Right header
A	B	C
D	E	F

Bibliographies

```
\documentclass{article}

[...]

\usepackage{natbib} % Some teachers may prefer biblatex

\bgein{document}
I love reading \cite{bishop_pattern_20007}.
[...]
\bibliographystyle{plainnat} % How the references will be formatted
\bibliography{my_bib_file} % the file name without extension
\end{document}
```

A recommended structure

It is easier to break down your code in multiple legible files than a massive single block.

- `main.tex`
- `bibliography.bib`
- `contents`
  - `introduction.tex`
  - `conclusion.tex`
- `imgs`
  - `cat.png`
  - `dog.png`
- `setup`
  - `packages.tex`

```
1  \documentclass{...}
2
3  \input{setup/packages}
4
5  \begin{document}
6  \section{Introduction}
7  \input{contents/introduction}
8
9  \section{Conclusion}
10 \input{contents/conclusion}
11 \end{document}
```

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Take-home messages

We have seen today:

- How to type in Markdown, RMarkdown, and (light) LaTeX
- You may favour
  - Markdown for lightweight notes
  - RMarkdown for simple lab reports
  - LaTeXfor more text-intensive documents
- Time to start honing your math typing skills!

Thank you for your attention!

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