CSSC Fall 2022 Workshop on Latex

Jonas Wagner

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Outline

Why LaTeX?

- It makes beautiful documents
  - Especially mathematics
- It was created by scientists, for scientists
  - A large and active community
- It is powerful — you can extend it
  - Packages for papers, presentations, spreadsheets, ...

LaTeX with **Overleaf**

- Overleaf is a website for writing documents in LaTeX.
- It 'compiles' your LaTeX automatically to show you the results.

Click here to open the example document in **Overleaf**

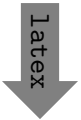
For best results, please use Google Chrome.

- As we go through the following slides, try out the examples by typing them into the example document on Overleaf.
- **No really, you should try them out as we go!**

How does it work?

- You write your document in `plain text` with `commands` that describe its structure and meaning.
- The `latex` program processes your text and commands to produce a beautifully formatted document.

```
The rain in Spain falls \emph{mainly} on the plain.
```



The rain in Spain falls *mainly* on the plain.

More examples of commands and their output...

```
\begin{itemize}
    \item Tea
    \item Milk
    \item Biscuits
\end{itemize}
```

- Tea
- Milk
- Biscuits

```
\begin{figure}
    \centering
    \includegraphics{figs/gerbil.jpg}
\end{figure}
```

```
\begin{equation}
    \alpha + \beta + 1
\end{equation}
```

$$\alpha + \beta + 1 \tag{1}$$

Attitude adjustment

- Use commands to describe ‘what it is’, not ‘how it looks’.
- Focus on your content.
- Let LaTeX do its job.

Caveats

- Quotation marks are a bit tricky:
  use a backtick ` on the left and an apostrophe ' on the right.

Single Quotes:	`‘text’`	‘text’
Double Quotes:	`‘‘text’’`	“text”

- Some common characters have special meanings in LaTeX:

%	percent sign	\%
#	hash (pound / sharp) sign	\#
&	ampersand	\&
$	dollar sign	\$

- If you just type these, you'll get an error. If you want one to appear in the output, you have to *escape* it by preceding it with a backslash.

Handling Errors

- LaTeX can get confused when it is trying to compile your document. If it does, it stops with an error, which you must fix before it will produce any output.
- For example, if you misspell `\emph` as `\meph`, LaTeX will stop with an "undefined control sequence" error, because "meph" is not one of the commands it knows.

Advice on Errors

1. Don't panic! Errors happen.
2. Fix them as soon as they arise — if what you just typed caused an error, you can start your debugging there.
3. If there are multiple errors, start with the first one — the cause may even be above it.

Outline

Typesetting Mathematics: Dollar Signs

- Why are dollar signs ($) special? We use them to mark mathematics in text.

```
% not so good:
Let a and b be distinct positive
integers, and let c = a - b + 1.

% much better:
Let $a$ and $b$ be distinct positive
integers, and let $c = a - b + 1$.
```

Let a and b be distinct positive integers, and let c = a - b + 1.
Let a and b be distinct positive integers, and let $c = a - b + 1$.

- Always use dollar signs in pairs — one to begin the mathematics, and one to end it.
- LaTeX handles spacing automatically; it ignores your spaces.

```
Let $y=mx+b$ be \ldots
Let $y = m x + b$ be \ldots
```

Let $y = mx + b$ be ...
Let $y = mx + b$ be ...

Typesetting Mathematics: Notation

- Use caret ^ for superscripts and underscore _ for subscripts.

```
$y = c_2 x^2 + c_1 x + c_0$
```
$y = c_2 x^2 + c_1 x + c_0$

- Use curly braces { } to group superscripts and subscripts.

```
$F_n = F_n-1 + F_n-2$
$F_{n} = F_{n-1} + F_{n-2}$
```
$F_n = F_n - 1 + F_n - 2$

$F_n = F_{n-1} + F_{n-2}$

- There are commands for Greek letters and common notation.

```
$\mu = A e^{Q/RT}$
$\Omega = \sum_{k=1}^{n} \omega_k$
```
$\mu = A e^{Q/RT}$

$\Omega = \sum_{k=1}^{n} \omega_k$

Typesetting Mathematics: Displayed Equations

- If it's big and scary, *display* it on its own line using `\begin{equation}` and `\end{equation}`.

```
The roots of a quadratic
equation are given by
\begin{equation}
    x = \frac{
        -b \pm \sqrt{b^2 - 4ac}
        }{2a}
\end{equation}
where $a$, $b$ and $c$ are \ldots
```

The roots of a quadratic equation are given by

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{2}$$

where a, b and c are ...

Caution: LaTeX mostly ignores your spaces in mathematics, but it can't handle blank lines in equations — don't put blank lines in your mathematics.

Extended LaTeX: Environments

- `equation` is an *environment* — a context.
- A command can produce different output in different contexts.

```
We can write
$ \Omega = \sum_{k=1}^{n} \omega_k $
in text, or we can write
\begin{equation}
    \Omega = \sum_{k=1}^{n} \omega_k
\end{equation}
to display it.
```

We can write $\Omega = \sum_{k=1}^{n} \omega_k$ in text, or we can write

$$\Omega = \sum_{k=1}^{n} \omega_k \tag{3}$$

to display it.

- Note how the Σ is bigger in the `equation` environment, and how the subscripts and superscripts change position, even though we used the same commands.

  In fact, we could have written `$...$` as `\begin{math}...\end{math}`.

Extended LaTeX: Environments

- The \begin and \end commands are used to create many different environments.
- The itemize and enumerate environments generate lists.

```
\begin{itemize} % for bullet points
\item Biscuits
\item Tea
\end{itemize}
```

- Biscuits
- Tea

```
\begin{enumerate} % for numbers
\item Biscuits
\item Tea
\end{enumerate}
```

1. Biscuits
2. Tea

Extended LaTeX: Packages

- All of the commands and environments we've used so far are built into LaTeX.
- *Packages* are libraries of extra commands and environments. There are thousands of freely available packages.
- We have to load each of the packages we want to use with a `\usepackage` command in the *preamble*.
- Example: `amsmath` from the American Mathematical Society.

```
\documentclass{article}
\usepackage{amsmath} % preamble
\begin{document}
% now we can use commands from amsmath here...
\end{document}
```

amsmath Package: Examples I

- Use `equation*` ("equation-star") for unnumbered equations.

```
\begin{equation*}
    \Omega = \sum_{k=1}^{n} \omega_k
\end{equation*}
```

$$\Omega = \sum_{k=1}^{n} \omega_k$$

- LaTeX treats adjacent letters as variables multiplied together, which is not always what you want. `amsmath` defines commands for many common mathematical operators.

```
\begin{equation*} % bad!
    min_{x,y} (1-x)^2 + 100(y-x^2)^2
\end{equation*}
\begin{equation*} % good!
    \min_{x,y}{(1-x)^2 + 100(y-x^2)^2}
\end{equation*}
```

$$min_{x,y}(1-x)^2 + 100(y-x^2)^2$$

$$\min_{x,y} (1-x)^2 + 100(y-x^2)^2$$

amsmath Package: Examples II

- You can use `\operatorname` for others.

```
\begin{equation*}
\beta_i =
\frac{\operatorname{Cov}(R_i, R_m)}
     {\operatorname{Var}(R_m)}
\end{equation*}
```

$$\beta_i = \frac{\operatorname{Cov}(R_i, R_m)}{\operatorname{Var}(R_m)}$$

- Align a sequence of equations at the equals sign

```
\begin{align*}
(x+1)^3 &= (x+1)(x+1)(x+1) \\
        &= (x+1)(x^2 + 2x + 1) \\
        &= x^3 + 3x^2 + 3x + 1
\end{align*}
```

$$\begin{aligned}(x+1)^3 &= (x+1)(x+1)(x+1) \\ &= (x+1)(x^2+2x+1) \\ &= x^3 + 3x^2 + 3x + 1\end{aligned}$$

  with the `align*` environment.

- An ampersand `&` separates the left column (before the $=$) from the right column (after the $=$).
- A double backslash `\\` starts a new line.

Outline

Title and Abstract

- Tell LaTeX the `\title` and `\author` names in the preamble.
- Then use `\maketitle` in the document to actually create the title.
- Use the `abstract` environment to make an abstract.

Sections

- Just use `\section` and `\subsection`.
- Can you guess what `\section*` and `\subsection*` do?

Graphics

- Requires the `graphicx` package, which provides the `\includegraphics` command.
- Supported graphics formats include JPEG, PNG and PDF (usually).

```
\includegraphics[
    width=0.5\textwidth]{figs/gerbil}

\includegraphics[
    width=0.3\textwidth,
    angle=270]{figs/gerbil}
```

Image license: CC0

Interlude: Optional Arguments

- We use square brackets `[` `]` for optional arguments, instead of braces `{` `}`.
- `\includegraphics` accepts optional arguments that allow you to transform the image when it is included. For example, `width=0.3\textwidth` makes the image take up 30% of the width of the surrounding text (`\textwidth`).
- `\documentclass` accepts optional arguments, too. Example:
  `\documentclass[12pt,twocolumn]{article}`

  makes the text bigger (12pt) and puts it into two columns.
- Where do you find out about these? See the slides at the end of this presentation for links to more information.

Floats

- Allow LaTeX to decide where the figure will go (it can "float").
- You can also give the figure a caption, which can be referenced with `\ref`.

```
\documentclass{article}
\usepackage{graphicx}
\begin{document}

Figure \ref{fig:gerbil} shows \ldots

\begin{figure}
\centering
\includegraphics[%
  width=0.5\textwidth]{gerbil}
\caption{\label{fig:gerbil}Aww\ldots.}
\end{figure}

\end{document}
```

Figure 1: Aww....

Figure 1 shows ...

Tables

- Tables in LaTeX take some getting used to.
- The argument specifies column alignment — **l**eft, **r**ight, **r**ight.

```
\begin{tabular}{lrr}
    Item   & Qty & Unit \$ \\
    Widget & 1   & 199.99  \\
    Gadget & 2   & 399.99  \\
    Cable  & 3   & 19.99   \\
\end{tabular}
```

Item	Qty	Unit $
Widget	1	199.99
Gadget	2	399.99
Cable	3	19.99

- It also specifies vertical lines; use `\hline` for horizontal lines.

```
\begin{tabular}{|l|r|r|} \hline
    Item   & Qty & Unit \$ \\\hline
    Widget & 1   & 199.99  \\
    Gadget & 2   & 399.99  \\
    Cable  & 3   & 19.99   \\\hline
\end{tabular}
```

Item	Qty	Unit $
Widget	1	199.99
Gadget	2	399.99
Cable	3	19.99

- Use an ampersand `&` to separate columns and a double backslash `\\` to start a new row.

Outline

bibTEX 1

- Put your references in a `.bib` file in 'bibtex' database format:

```
@Article{Jacobson1999Towards,
author = {Van Jacobson},
title = {Towards the Analysis of Massive Multiplayer Online Role-Playing Games},
journal = {Journal of Ubiquitous Information},
Year = 1999,
Volume = 6,
Pages = {75--83}}

@InProceedings{Brooks1997Methodology,
author = {Fredrick P. Brooks and John Kubiatowicz and Christos Papadimitriou},
title = {A Methodology for the Study of the Location-Identity Split},
booktitle = {Proceedings of OOPSLA},
Year = 1997}
```

- Most reference managers can export to bibtex format.
  (Easy to get from Google Scholar, IEEE Xplore, etc.)

bibTEX 2

- Each entry in the `.bib` file has a *key* that you can use to reference it in the document. For example, `Jacobson1999Towards` is the key for this article:

```
@Article{Jacobson1999Towards,
  author = {Van Jacobson},
  ...
}
```

- It's a good idea to use a key based on the name, year and title.
- LaTeX can automatically format your in-text citations and generate a list of references; it knows most standard styles, and you can design your own.

Outline

More Neat Things

- Add the `\tableofcontents` command to generate a table of contents from the `\section` commands.
- Change the `\documentclass` to `\documentclass{scrartcl}` or `\documentclass[12pt]{IEEEtran}`
  (Use templates!)
- Define your own command for a complicated equation:

```
\newcommand{\rperf}{%
\rho_{\text{perf}}}
$$
\rperf = {\bf c}'{\bf X} + \varepsilon
$$
```

$$\rho_{\text{perf}} = \mathbf{c}'\mathbf{X} + \varepsilon$$

See https://www.overleaf.com/learn/latex/Commands for good documentation.

More Neat Packages

- `beamer`: for presentations (like this one!)
- `todonotes`: comments and TODO management
- `tikz`: make amazing graphics
- `pgfplots`: create graphs in LaTeX
- `listings`: source code printer for LaTeX
- `spreadtab`: create spreadsheets in LaTeX
- `gchords`, `guitar`: guitar chords and tabulature
- `cwpuzzle`: crossword puzzles
- `algorithm2e`: for writing algorithms
- `xcolor`: add colors to text and elements

Installing LaTeX

- To run LaTeX on your own computer, you'll want to use a LaTeX *distribution*. A distribution includes a `latex` program and (typically) several thousand packages: MikTeX (Windows), TeXLive (Windows or Linux), and MacTeX (Mac)
- You'll also want a text editor with LaTeX support. See `http://en.wikipedia.org/wiki/Comparison_of_TeX_editors` for a list of (many) options.
- You'll also have to know more about how `latex` and its related tools work — see the resources on the next slide.

My suggestion: **VS Code with LaTeX Workshop extension**
(Easy install w/ everything included and can can be linked to GitHub & Overleaf)

Online Resources

- The Overleaf Learn Wiki — hosts these slides, more tutorials and reference material
- The LaTeX Wikibook — excellent tutorials and reference material.
- TeX Stack Exchange — ask questions and get excellent answers incredibly quickly
- LaTeX Community — a large online forum
- Comprehensive TeX Archive Network (CTAN) — over four thousand packages plus documentation
- Google (or Brave Search) will usually get you to one of the above.

Thanks, and happy TEXing!