An Interactive Introduction to LaTeX

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February 1, 2023

Overleaf

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Disclaimer

- These slides were originally written by John D. Lees-Miller at Bristol / Overleaf.
- I have amended them for my own purposes.

Why LaTeX?

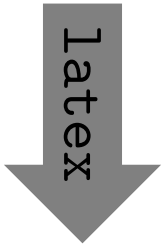
- It makes beautiful documents
  - Especially mathematics
- It was created by scientists, for scientists
  - A large and active community
- It is powerful — you can extend it
  - Packages for papers, presentations, spreadsheets, ...

For example, this presentation is written using LaTeX.

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}
\includegraphics{gerbil}
\end{figure}
```

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

$$\alpha + \beta + 1 \quad (1)$$

Attitude adjustment

- LaTeX is not a "what you see is what you get" editor.
- You write your content and guide LaTeX on how best to present it.
- But ultimately LaTeX determines the best way to order things.
- Let LaTeX do its job.

Getting started

A minimal LaTeX document:

- Commands start with a *backslash* \ .
- Every document starts with a `\documentclass` command.
- The *argument* in curly braces { } tells LaTeX what kind of document we are creating: an `article`.
- A percent sign % starts a *comment* — LaTeX will ignore the rest of the line.

Getting started 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 or a recent FireFox.

- As we go through the following slides, try out the examples by typing them into the example document on Overleaf.

Typesetting Text

- Type your text between `\begin{document}` and `\end{document}`.
- For the most part, you can just type your text normally.

```
Words are separated by one or more
spaces.

Paragraphs are separated by one
or more blank lines.
```

Words are separated by one or more spaces.

Paragraphs are separated by one or more blank lines.

- Space in the source file is collapsed in the output.

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

The rain in Spain falls mainly on the plain.

Typesetting Text: Caveats

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

`Single quotes: `text'.`	Single quotes: ‘text’.
`Double quotes: ``text''.`	Double quotes: “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.
4. Deleting blocks of text and attempting to recompile can be really useful.

Typesetting Exercise 1

Typeset this in LaTeX: [1]

In March 2006, Congress raised that ceiling an additional $0.79 trillion to $8.97 trillion, which is approximately 68% of GDP. As of October 4, 2008, the "Emergency Economic Stabilization Act of 2008" raised the current debt ceiling to $11.3 trillion.

Click to open this exercise in **Overleaf**

- Hint: watch out for characters with special meanings!
- Once you've tried, click here to see my solution.

[1] `http://en.wikipedia.org/wiki/Economy_of_the_United_States`

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.

```
$F_n = F_n-1 + F_n-2$      % oops!

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

$F_n = F_n - 1 + F_n - 2$

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

- 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

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

where a, b and c are ...

Interlude: Environments

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

$$\Omega = \sum_{k=1}^{n} \omega_k \qquad (3)$$

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.

Interlude: 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}

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

- Biscuits
- Tea

1. Biscuits
2. Tea

Interlude: 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}
```

Typesetting Mathematics: Examples with amsmath

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

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

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

Typesetting Mathematics: Examples with amsmath

- Align a sequence of equations at the equals sign

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

with the `align*` environment.

```
\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*}
```

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

Typesetting Exercise 2

Typeset this in LaTeX:

Let $X_1, X_2, \ldots, X_n$ be a sequence of independent and identically distributed random variables with $\mathrm{E}[X_i] = \mu$ and $\mathrm{Var}[X_i] = \sigma^2 < \infty$, and let

$$S_n = \frac{1}{n} \sum_{i=1}^{n} X_i$$

denote their mean. Then as n approaches infinity, the random variables $\sqrt{n}(S_n - \mu)$ converge in distribution to a normal $N(0, \sigma^2)$.

Click to open this exercise in **Overleaf**

- Hint: the command for ∞ is `\infty`.
- Once you've tried, click here to see my solution.

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.

```
\documentclass{article}

\title{The Title}

\author{A. Author}

\date{\today}

\begin{document}
\maketitle

\begin{abstract}
Abstract goes here...
\end{abstract}

\end{document}
```

Sections

- Just use \section and \subsection.

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

\section{Introduction}

The problem of \ldots

\section{Method}

We investigate \ldots

\subsection{Sample Preparation}

\subsection{Data Collection}

\section{Results}

\section{Conclusion}

\end{document}
```

Labels and Cross-References

- Use `\label` and `\ref` for automatic numbering.
- The amsmath package provides `\eqref` for referencing equations.

```
\documentclass{article}
\usepackage{amsmath} % for \eqref
\begin{document}

\section{Introduction}
\label{sec:intro}

In Section \ref{sec:method}, we \ldots

\section{Method}
\label{sec:method}

\begin{equation}
\label{eq:euler}
e^{i\pi} + 1 = 0
\end{equation}

By \eqref{eq:euler}, we have \ldots

\end{document}
```

Structured Documents Exercise

Typeset this short paper in LaTeX: [2]

Click to open the paper

Make your paper look like this one. Use `\ref` and `\eqref` to avoid explicitly writing section and equation numbers into the text.

Click to open this exercise in **Overleaf**

- Once you've tried, click here to see my solution.

[2] From `http://pdos.csail.mit.edu/scigen/`, a random paper generator.

Graphics

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

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

\includegraphics[
  width=0.3\textwidth,
  angle=270]{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.

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}
```

Tables

- Tables in LaTeX take some getting used to.
- Use the `tabular` environment from the `tabularx` package.
- 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 (like in the `align*` environment that we saw in part 1).

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},
  Month = jun,
  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},
  Month = jun,
  Year = 1997}
```

- Most reference managers can export to bibtex format.

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.

bibTeX 3

- Use the natbib package with \citet and \citep.
- Reference \bibliography at the end, and specify a \bibliographystyle.

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

\citet{Brooks1997Methodology}
show that \ldots. Clearly,
all odd numbers are prime
\citep{Jacobson1999Towards}.

\bibliography{bib-example}
% if `bib-example' is the name of
% your bib file

\bibliographystyle{plainnat}
% try changing to abbrvnat

\end{document}
```

Exercise: Putting it All Together

Add an image and a bibliography to the paper from the previous exercise.

1. Download these example files to your computer.

   Click to download example image

   Click to download example bib file

2. Upload them to Overleaf (use the project menu).

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.
  - On Windows: MikTeX or TeXLive
  - On Linux: TeXLive
  - On Mac: MacTeX
- 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.

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 will usually get you to one of the above.

Thanks, and happy TEXing!