Applied LaTeX for Researchers

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What is LaTeX ? Why even care?

- A typesetting system, widely used in academia.
- Allows for additional control over the structure and layout of documents other software does not easily provide.
- Free, open-source, and cross-platform.
- *What you see is what you mean* (WYSIWYM) vs. *What you see is what you get* (WYSIWYG).
- Allows for the creation and automation of complex, structured and consistent documents.

Outline

1. Getting started

2. Beginning a document

3. Math mode

Important keys

- **Command keys:** \
- **Curly braces:** { }
- **Square brackets:** [ ]
- **Percent sign:** % (comments)
- **Dollar sign:** $ (math mode)
- **Underscore:** _
- **Circumflex:** ^
- **Tilde:** ∼
- **Backslash:** \

Using LaTeX locally

- You will need a TeX distribution.
- For Windows, MikTeX is a popular choice, or TeX Live.
- A LaTeX editor will also be needed.
  - TeXWorks
  - TeXMaker
  - TeXStudio
  - Sublime Text
  - VS Code

Using LaTeX online

- Overleaf is a popular online LaTeX editor.
- Share projects with collaborators.
- Real-time collaboration.
- Access to a wide range of templates.
- Free and paid versions.
- IMO great for starters and probably the best option for collaborative work and best-looking UI.

Basic structure

- A LaTeX document is divided into two main parts: the preamble and the body.
- The preamble contains document-wide settings and commands.
- The body contains the content of the document (text, figures, tables, etc.).
- The document is enclosed in the `document` environment.

Document preamble

- The preamble is the first part of the document, containing configuration settings for the complete document.
- Technically, it is a TEX environment (more on that later)
- We can set the document class, font size, margins, packages, etc.
- The preamble is enclosed between `documentclass` and `begin{document}` commands.

Writing commands/code

- Commands start with a backslash (\).
- Commands can have arguments enclosed in curly braces ({ }).
- Some commands have optional arguments enclosed in square brackets ([ ]).
- Comments are preceded by a percent sign (%).
- Commands are case-sensitive.

Declaring the document class

- The document class defines the overall layout of the document.
- The most common document classes are `article`, `report`, `book`, and `beamer`.
- Declared with the `documentclass` command.
- We will typically work with the `article` class.

  ```
  \documentclass{article}
  ```

Some basic options for the document class

- `10pt, 11pt, 12pt`: Sets the font size. Default is 10pt.
- `a4paper, letterpaper`: Sets the paper size.
- Other options are available depending on the document class.
- Packages can be used to extend the functionality of the document class.
- Use comments to keep track of the options used!

The document environment

- The `document` environment is where the content of the document is placed.
- It is enclosed within the `begin{document}` and `end{document}` commands.
- All LaTeX environments require a `begin` and `end` command.
- Nothing should be written after the `end{document}` command.
- Before the `begin{document}` command, we have the preamble.

Writing some text

- Text is written directly in the document environment.
- LaTeX ignores multiple spaces.
- Use the `\\` command to start a new line.
- Use the `\par` command to start a new paragraph.
- Use the `\newline` command to start a new line.

Basic text management

- To italicize text, use the `\textit{}` command.
- To bold text, use the `\textbf{}` command.
- To underline text, use the `\underline{}` command.
- To change the font size, use the `\tiny`, `\small`, `\large`, etc. commands.

Special characters

- Some characters have special meanings in LaTeX, hence, they need to be escaped to be printed in the document.
- The following characters are reserved: `# $ % ^ & _ { } ~`.
- To print these characters, use the `\#`, `\$`, `\%`, etc. commands.
- The \ itself is printed with `\textbackslash`.

Structure

- LaTeX provides commands to structure the document with sections, subsections, and subsubsections.
- It is generally a good idea to use these commands to organize the content of the document.
- LaTeX-produced PDFs generally bookmark the sections, making navigation easier (if the viewer supports it and a package is used, more on that later).

Structure commands

- `\section{Section title}`
- `\subsection{Subsection title}`
- `\subsubsection{Subsubsection title}`
- `\paragraph{Paragraph title}`
- `\subparagraph{Subparagraph title}`

Titles

- In the preamble of the document, one can define “document metadata” such as the title, author, and date.
- This information can be printed in the document using the `\maketitle` command.
- Use the `\title{}`, `\author{}`, and `\date{}` commands to define the metadata.
- The title commands are largely determined by the document class, but can be customized with packages

Packages

- Packages are used to extend the functionality of the document class.
- They can be loaded in the preamble with the `\usepackage{}` command.
- Some packages are included by default in the document class.
- Some common packages are `graphicx`, `amsmath`, `hyperref`, `babel`, `inputenc`, `fontenc`, `geometry`, `fancyhdr`, among others.

Common packages

- The `geometry` package can be used to set the margins of the document.
- The `setspace` package can be used to set the line spacing (single, 1.5, double).
- The `lipsum` package can be used to generate dummy text.

Lists

- Two main lists are commonly used in LaTeX: `itemize` and `enumerate`.
- The `itemize` environment is used for unordered lists.
- The `enumerate` environment is used for ordered lists.
- Items are declared with the `\item` command.
- Nested lists are possible, and the `description` environment can be used for descriptions for all items.

Why math mode?

- LaTeX's math mode is where it truly shines.
- This synthax has become a standard for typesetting math, even beyond LaTeX.
- While Microsoft Word's equation editor has come a long way, when things get complex, LaTeX is the way to go
    - Aligning equations
    - Repetitive notation
    - Lemmas, theorems, proofs
    - Complex symbols

Enter Math Mode

- Math mode is entered with the $ symbol.
- Inline math mode is entered with a single $ symbol.
- Display math mode is entered with double $ symbols. This will center the equation and do an automatic line break.

$$\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$$

Some simple algebra

- Math mode changes the font of the text to the “math font”.
- To create exponents, use theˆ symbol (“caret” or “hat”).
- To create subscripts, use the _ symbol (“underscore”).
- To create fractions, use the `\frac{}{}` command.
- To create square roots, use the `\sqrt{}` command

$$x_1^2 + y_2^2 = z_1^2$$

Greek letters

- Greek letters can be written in math mode using their name preceded by a backslash.
- You will need the `amsmath` package for some of these (the package includes the `amssymb` package).
- They are case sensitive. To write the uppercase version, capitalize the first letter of the command. For example, `\delta` for δ and `\Delta` for Δ.
- Some Greek letters have variants, such as `\varphi` and `\phi`.

Summations and integrals

- To write a summation, use the `\sum` command.
- To write an integral, use the `\int` command.
- Since these have limits, use the _ andˆ symbols to denote the lower and upper limits. They are like subscripts and superscripts!

$$\int x^2 dx = \frac{x^3}{3} + C$$

Using text within math mode

- If you try to write text within math mode, it will be printed in the math font.
  - For example, where will be printed as *where*.
  - Spacing and formatting will be weird
- To write text within math mode, use the `\text{}` command.
- This will change the font back to the regular text font.
- This is useful for writing text within equations, such as units.

$$\text{ln(income)} = \beta_0 + \beta_1\text{education} + \text{other stuff} + \epsilon$$

Math environments

- Many math environments are available in LaTeX, which can be used to align math expressions.
- The `align` environment is one of the most useful.
- Additionally, the `equation` environment can be used to number equations.

Alignment of equations

- The `align` environment is used to align equations.
- The `&` symbol is used to specify the alignment point
- A double backslash (\\\\) is used to start a new line.
- The `align*` environment can be used to suppress equation numbering.
- Double & symbols can be used to align multiple points.
- The `quad` command can be used to add space between equations.

Creating tables

- Tables are created using the `tabular` environment.
- Columns are defined using the `l`, `c`, and `r` specifiers for left, center, and right alignment, respectively.
- Columns are separated by the `&` symbol.
- Rows are separated by the double backslash (\\) command.
- Horizontal lines can be added using the `\hline` command.

Example of a simple table

Column 1	Column 2	Column 3
Data 1	Data 2	Data 3
Data 4	Data 5	Data 6
Data 7	Data 8	Data 9

Advanced tables

- The `booktabs` package provides additional commands for creating professional-looking tables.
- The `\toprule`, `\midrule`, and `\bottomrule` commands can be used to add horizontal lines.
- The `multirow` package allows for cells to span multiple rows.
- The `tabu` package provides additional functionality for creating complex tables.

Example of an advanced table

Column 1	Column 2	Column 3
Data 1	Data 2	Data 3
	Data 5	Data 6
Data 7	Data 8 and 9	

Tools for creating tables

- Manually creating the `tabular` environment can be tedious.
- Check out online tools such as the Overleaf tables editor or tablesgenerator.com.
- The Excel addin, Excel2LaTeX, can be used to convert Excel tables to LaTeX, download here.

Figures

- Figures can be included in a LaTeX document using the `figure` environment.
- The `graphicx` package is used to include images.
- The `\includegraphics` command is used to include images.
- The `caption` command is used to add a caption to the figure.
- The `label` command is used to add a label to the figure for cross-referencing.
- Tips: take care of file paths!