Introduction to LaTeX

Association for Women in Mathematics - U of T Chapter

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1 Introduction

Have you ever wanted to learn how to make your typeset math look amazing? Well look no further, LaTeX is virtually used to typeset all mathematical textbooks and professional mathematical articles. In this introduction we will walk through some of the basics of getting started with using LaTeX so you can begin to make your own awesomely typeset documents.

2 Getting Started

Whether you want to install LaTeX on your own device or use a web-based version there are many options to suit everyone's needs!

2.1 Downloading and Installing TeX Software

There are a variety of options for installing LaTeX. Some free distributions for different operating systems are

- Miktex (for Windows)
- TeXLive (for Linux)
- MacTex (for MacOSX)

All come with extensive documentation and the installation and set-up is usually straightforward.

2.2 Online Editors

We will focus on using online editors for the rest of this introduction (as they require no installation and all the skills are transferable). One of the most popular and easy to use online LaTeX editors is Overleaf. Some other online editors include ShareLaTex, CoCalc, Authorea, and papeeria. We will focus on Overleaf as it is free, easy to use, and commonly used.

EXERCISE 1

Download a TeX distribution or create an online Overleaf account for yourself.

TIP

Overleaf documents can easily be shared and worked on in collaboration in real time with others making it a valuable resource when collaborating! In addition to this, Overleaf contains hundreds of templates making getting started really easy!

3 Setting Up Documents

3.1 Document Classes

The most basic working LaTeX document looks something like

Input	Output
\documentclass{article} \begin{document} Math is fun! \end{document}	Math is fun!

The two basic ingredients here are the `\documentclass{}` statement and the `\begin{document}...\end{document}` pair.

The `\documentclass{}` statement determines the general format of the document (font sizes, whether to indent paragraphs or not, etc).

The `\begin{document}...\end{document}` is where the body of the document goes, i.e., everything except the title.

EXERCISE 2

Try creating a simple document of your own!

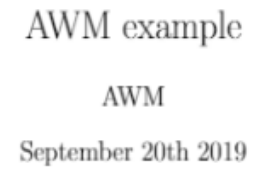
Two of the most often used document classes are the article and beamer document classes. Article is nice for general use (it is actually the document class used for these notes) and beamer is wonderful for making presentation slides (much like powerpoint or google slides).

TIP

To change the font size, paper size or orientation of your document you can pass commands like `\documentclass[a4paper, 12pt, landscape]{article}` into the `\documentclass{}` command which would produce a document that is orientated in landscape using standard a4 size paper and 12 point font.

3.2 Title Matter

It is important to note that all of the "title matter" goes in the "preamble" before the `\begin{document}` instruction but the command that produces the title matter (`\maketitle`) goes after the `\begin{document}` command. The following example shows you how to add elements such as authors, title, the date, etc,

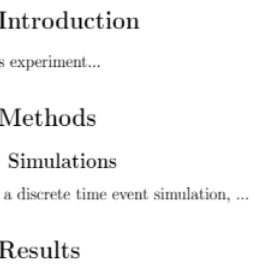
Input	Output
\documentclass{article} \title{AWM example} \author{AWM} \date{September 20th 2019} \begin{document} \maketitle \end{document}	

EXERCISE 3

Try adding a title to your own document!

3.3 Sectioning

Titles of sections, subsections, subsubsections, etc., can be specified using commands like It is important to note that when LaTeXautomatically numbers the sections, subsections,

Input	Output
\section{Introduction} In this experiment... \section{Methods} \subsection{Simulations} Using a discrete time event simulation, ... \section{Results}	

etc.,. The numbering can be avoided by adding an asterisk to the command.
i.e, `\section*{Name of Section}`, `\subsection*{Name of Subsection}`.

EXERCISE 4

Try creating your own sections! Try using the asterisk and see how that changes your document.

3.4 Packages

A very helpful part of are the available packages. Much like packages in computer programming languages (for example, the Numpy package in Python), packages contain many useful functions and features to make typesetting your documents easier. Here we just mention some useful packages.

- "amsmath" is a common package used that contains all sorts of mathematical commands. From the amsmath documentation "... provides various features for displayed equations and other mathematical constructs". To use this package, the command

  ```
  \usepackage{amsmath}
  ```

  can be used

- "amssymb" is a common package that can be used to typeset a variety of mathematical symbols.

- "graphicx" is a common package that can be used to include images/plots/graphics in your document.

- "geometry" is a package that allows you to customize the geometry of your package. For example, the margins in the article document class are set to 1.5 inches. To change this, the command

  ```
  \usepackage{geometry}[margins = 1.0in]
  ```

  could be used.

NOTE

It is generally considered to be poor programming practice to "hard code" things such as margin size. Instead, use a document class or create a document class that has the properties you want!

TIP

To save time and keep your work consistent you can create your own LaTeX templates! Overleaf has hundreds of templates that are free to use and edit if you don't feel like making your own!

4 Environments

Now we are going to talk about the important concept of LaTeX environments. In short, a environment is a pair of commands of the form `\begin{command} ... \end{command}` that cause TeX to behave a certain way when processing the material between the commands. We have already seen an example of an environment with the `\begin{document}...\end{document}` pair. We mention some useful environments below.

Align Environment

The align environment is a math environment used for typesetting multi-line numbered equations. To remove the numbers, we add an asterisk after the word align.
i.e., `\begin{align*}... \end{align*}`
In this environment we use the "&" symbol to set where to align things and `\\` to end a line.

Enumerate and Itemize Environment

To create an ordered list the pair `\begin{enumerate}...\end{enumerate}` can be used.
To create an unordered list, the pair `\begin{itemize}...\end{itemize}` can be used.
In both cases, to create a new entry in the list you must use the command `\item`.

Input	Output
\begin{align} \zeta (s) & = \sum_{n=1}^{\infty} \frac{1}{n^{s}}\\\\ & = \prod_{p \text{ prime}} \frac{1}{1-p^{-s}} \end{align}	$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s}$ (1) $= \prod_{p \text{ prime}} \frac{1}{1-p^{-s}}$ (2)

A set of square brackets with different commands can be added so that one can obtain custom numbering options (roman numerals, letters, start at a number other than one, etc...).

TIP

When nesting environments (i.e., using environments inside of environments) it is often a good practice to create a new "indentation level". This allows you to more readily see which environment you are currently working in! This can be a real time saver!

Figure Environment

To include figures in your LaTeX document you will need to use a package such as graphicx. Using the graphicx package the pair `\begin{figure}...\end{figure}` can be used to create a figure environment. To include figures in Overleaf, the figure needs to be uploaded (can be done using the third button from the left under the menu). There are many ways to adjust and fine tune your images (scaling, centering, captions, etc...) so we recommend reading more about this in the Overleaf documentation since there are really good examples there!

EXERCISE 5:

Use the Resources Section of this document to learn how to create a basic table!

5 Typesetting Math

5.1 Text and Math Modes

TEX has three basic modes when it comes to typesetting a document. At any point, TEX is in one of the following three modes:

- text mode - used for typing ordinary text. This is the default mode of TEX and it stays in this mode unless told otherwise!
- inline math mode - used to typeset mathematical material "inline". To use this mode mathematical material needs to be surrounded by a pair of single $ signs, such as `$e^{2 \pi i}=1$` which would render inline as $e^{2\pi i} = 1$. It's important to notice that the spaces in math mode are ignored.
- Display math mode - used for displaying math on a separate line. If we want to empathize or have a single equation separate from the main text, we enclose it in by the pair `\[ ... \]` such as
  `\[ \zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^{s}} \]` which renders:

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s}$$

TIP

To improve readability of your TEX file it is a good practice to include the "display math symbols" (the pair `\[ ... \]`) on separate lines. For example

```
\[
\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^{s}}
\]
```

this makes it easier to read and allows for mistakes to be identified more easily than if it is inline.

Text can be used in math mode by including the line `\text{whatever you want to include}`. See the example in the Align environment section above.

5.2 Useful symbols

Here we show by means of examples some useful functions and features for typesetting mathematical content.

5.2.1 Matrices

Matrices can be typeset using the pair `\begin{pmatrix}...\end{pmatrix}`. The columns of the matrix are aligned using & and the rows ended by using a pair `\\`. For example,

```
GL_3(\mathbb{R}) = \left\{ M =
\begin{pmatrix}
    a_{11} & a_{12} & a_{13}\\
    a_{21} & a_{22} & a_{23}\\
    a_{31} & a_{32} & a_{33}
\end{pmatrix}
    : \forall i,j \in \{1,2,3\} a_{ij}\in \mathbb{R}
    \text{ and } \det M \neq 0
    \right\}
```

produces the following

$$GL_3(\mathbb{R}) = \left\{ M = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} : \forall i, j \in \{1, 2, 3\}, a_{ij} \in \mathbb{R} \text{ and } \det M \neq 0 \right\}$$

So what is happening in the above code? The command `\mathbb{R}` is producing the special character normally used to denote the set of real numbers. A similar command will generate the usual symbol for rational numbers and integers if you replace the capital R with a capital Q and Z respectively.

The pair `\left\{ ... \right\}` form the curly braces typically used in denoting a set. Notice the use of the backslashes before the `{` and `}`. Without these backslashes the curly braces will not render! The usual parentheses and square brackets do not require backslashes.

Specifying `\left` and `\right` causes LaTeX to automatically adjust the size of the brackets to produce the best fit. This can be done as well for square braces and for regular parentheses.

Now looking at the elements in the matrix we see that '_' is required to produce subscripts in math mode. Notice that for subscripts with more than one character in it, a set of braces `{...}` are required. The same is true for superscripts!

EXERCISE 6

Try to correct the following:

$$\begin{pmatrix} a_11 & x^23 \\ x^{47} & a_{22} \end{pmatrix}$$

5.2.2 Calculus

The following example shows how some common calculus symbols can be used: The formal definition of a limit of a function of one real variable can be written as

```
\lim_{x \to a} f(x) = L \Leftrightarrow \forall \epsilon>0,
\exists \delta > 0 \text{ such that } |x a|<\delta
\Rightarrow |f(x) L|< \epsilon
```

which renders as

$$\lim_{x \to a} f(x) = L \Leftrightarrow \forall \epsilon > 0, \exists \delta > 0 \text{ such that } |x - a| < \delta \Rightarrow |f(x) - L| < \epsilon$$

We can write single integrals like

```
f(x) = \int_{1}^{x} \frac{du}{\sqrt{u}+\sqrt[3]{u}}
```

which renders to look like

$$f(x) = \int_1^x \frac{du}{\sqrt{u} + \sqrt[3]{u}}$$

It is important here to note the difference between the square root and the cube root. The cube root requires an addition argument `[3]`.

EXERCISE 7

Try reproducing the expression

$$f(x) = \sqrt[7]{\frac{x^2 + x + 1}{x^3 + 3x + 3}}$$

A third useful example is

```
f(z) = \sum_{n=0}^{\infty} a_{n} z^{n}
```

which looks like

$$f(z) = \sum_{n=0}^{\infty} a_n z^n$$

TIP

Bracketing is extremely important while in math mode! Compare the two different lines of and fiugure out where the mistake is!

```
n^{2019}  and  n^2019
```

In addition to getting things to look nice, missing brackets are a common cause of documents not compiling. Try including the code

```
\frac{x^{2019}}{1 + x^2
```

and see what happens and try to correct the mistake!

6 Helpful Resources

Here is a list of some resources/websites that might be helpful on your way to becoming a TEX expert!

Great symbol look-up site: Detexify
General help and questions: TeX StackExchange
Overleaf Documentation
Overleaf Templates
The Comprehensive LATEX Symbol List
The Not So Short Introduction to LATEX 2ε
TUG: The TEX Users Group
CTAN: The Comprehensive TEX Archive Network

7 Conclusion

TEX is an incredibly useful and at some points seemingly overwhelming resource. We tried to touch on the things that we thought we would have liked to know when we got started with using *TEX*. That being said, once you have mastered making simple documents you can explore the endless possibilities of making documents ranging from official reports, resumés, CVs, cover letters, presentations, flyers, and just about anything else you can dream up! It is very helpful to start by looking at some templates (of which Overleaf has many) to get inspiration!

We hope this worksheet/tutorial was helpful and want to thank you for coming out to support our event!