\texttt{\LaTeX} I

An Initial Overview

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# Outline

1. Introduction
2. Installation
3. Preamble
4. Text and Spacing
5. Math Mode
6. List Environments
7. Figures
8. Tables
9. Upcoming
What is \LaTeX? 

- Document preparation system and document markup language.
- Used throughout science, especially mathematics and computer science.
- Provides a simple way to typeset complex formulae.
There are many distributions of \LaTeX. I recommend installing the following,

- Windows: MiKTeX
- Mac: MacTeX
- Unix/Linux: TeXLive

You probably don’t need the full distribution as this includes obscure packages you are unlikely to use. A base installation is all that is usually necessary.
Many people like to use an editor specifically built for LateX. However, using a simple text editing program (like notepad) is more than enough to write LateX documents. You can then use the terminal to compile the document.

**Common Editors:**

- TeXmaker (Windows, Mac, Linux)
- TeXworks (Windows, Mac, Linux)
- Kile (Windows, Linux)
- TeXstudio (Windows, Mac, Linux)
- TeXshop (Mac)
- TeXnicCenter (Windows)
In addition to the editors on the previous page, there are some online options. These include

- ShareLaTeX.com
- writeLaTeX.com

These are especially nice for collaborative efforts.
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Preamble Contents

The preamble is contains the following:

- Document Properties
- Package Inclusions
- Title/Author Information
- User-Defined Functions
The first line of a LaTeX document should include a line similar to the following,

\documentclass[10pt]{article}

Article is the document type and 10pt is the font size. You also want to include packages in the preamble.

\usepackage{graphicx}
\usepackage{amsmath, amsthm, amssymb, amsfonts}
$\LaTeX$ can automatically format and create a title.

To do this, the \texttt{\textbackslash maketitle} command is issued in the document contents, but we need to tell $\LaTeX$ about the author and the title of the document,

\begin{verbatim}
\title{How to use LaTeX}
\author{Patrick O’Neil}
\end{verbatim}
Margins

To shrink the size of the margins, use the “fullpage” package. That is, include the following in your preamble,

\usepackage{fullpage}

Margins can also be explicitly set by the user, but this will be covered in the next \LaTeX workshop.
Editing the Contents of the Document

Once we finish our preamble, we can start working on the contents of the document. Everything that will appear in our document needs to be between \begin{document} and \end{document}.

\begin{document}
...
\end{document}
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Writing in \LaTeX is easy. Simply write text as you would in a traditional word processor.

\begin{document}
This is how you insert text into a Latex document.
\end{document}
\LaTeX{} automatically determines the format of the document. However, you can control the layout using spacing commands. These include

<table>
<thead>
<tr>
<th>Spacing Type</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>\vspace{...}</td>
</tr>
<tr>
<td>Horizontal</td>
<td>\hspace{...}</td>
</tr>
</tbody>
</table>
| New Line       | \\\n
The argument of \vspace{} and \hspace{} is the spacing amount. For example \vspace{1cm} would add a vertical space of 1 centimeter.

Another useful example is you want to add in blank lines. To do this, use \vspace{1ex}.
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To insert mathematical formulas and symbols, you need to use **math mode**. There are two versions of math mode,

- In-Line Math Mode
- Display Mode

To see the difference, this is an inline expression $x^2 + 3x + 2 = 0$. This is displayed inline. We can also use display mode, which gives

$$x^2 + 3x + 2 = 0$$

Notice that this is displayed on its own line.
So What’s the Difference?

Inline mode restricts the formatting to fit inline. Thus, if there are large symbols, they will look quite small. For example, $\int_0^1 x^2 \, dx$ displays poorly because it is inline whereas

$$\int_0^1 x^2 \, dx$$

looks much nicer.
Writing inline and display mode math is also quite easy. Surround inline equations with $ and $ and to use display mode, surround the formula with \[ and \]. For example

The equation $\int_0^1 x^2 \, dx$ looks squished.
\[\int_0^1 x^2 dx\]
looks much nicer.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline</td>
<td>$...$</td>
</tr>
<tr>
<td>Display</td>
<td>[...]</td>
</tr>
</tbody>
</table>
There is another way to enter display math mode. This is the **equation environment**. The equation environment has the added benefit of keeping track of equation numbers. For example,

\[ x^2 + 3x + 2 = 0 \]  \hspace{1cm} (1)

is one equation and

\[ x^2 - 3x + 2 = 0 \]  \hspace{1cm} (2)

is another.
Variables

While in math mode, you may write the variables as you would in plain text. For example,

\[ x = y + 2 \]

is written as

\[ x = y + 2 \]

Note that writing words while in math mode will make each letter appear like variables. For example

hello

will display as

hello
Using Greek letters is simple. You just need to know the name of the letter. For example,

\( \phi^2 + \theta^2 + \gamma^2 \)

produces

\( \phi^2 + \theta^2 + \gamma^2 \)

To create the upper case version of any Greek letter, capitalize the first letter. The above becomes

\( \Phi^2 + \Theta^2 + \Gamma^2 \)
Exponents and Subscripts

Using super-scripts and subscripts is very common in mathematical notation. To use superscripts or subscripts, use the characters $\hat{^}$ and $\_\_$ respectively. For example

$x^2$

is written as

$x^{\hat{^}}$

and

$x_2$

is written

$x_{\_\_}$
Exponents and Subscripts

Notice that if you write

\( x^{22} \)

you will get \( x^{22} \). This is because both superscript and subscript only take the following character. To properly display this you need to use braces

\[
\{ ... \}
\]

That is, you need to write

\( x^{\{22\}} \)

which produces

\( x^{22} \)
Fractions are very common and quite easy in \LaTeX. To display

$$\frac{x + y}{z^2}$$

simply use the \texttt{\frac} command and write

\texttt{\frac{x+y}{z^2}}
Big Symbols

To display things like sums, products, and integrals, you need to use big operators. For example

- **Integration**: Use \( \int \) to create an integral symbol. For example,

\[
\int_0^1 x^2 \, dx
\]

is given by

\( \int_0^1 x^2 \, dx \)

Note that the syntax is identical for inline mode, but this will give

\( \int_0^1 x^2 \, dx \).
**Big Symbols**

- **Summation**: Use the \( \sum \) symbol for summation. For example

\[
\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi}{6}
\]

is written

\[
\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi}{6}
\]

Inline mode displays as: \[ \sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi}{6} \]


**Products:** Use the \prod symbol for summation. For example

\[
\prod_{n=1}^{\infty} \frac{1}{n^2} = 0
\]

is written

\[
\prod_{n=1}^{\infty} \frac{1}{n^2} = 0
\]

Inline mode displays as: \( \prod_{n=1}^{\infty} \frac{1}{n^2} = 0 \)
**Unions and Intersections**: The union and intersection operators are different in that they have an inline symbol and a math mode symbol. For example,

\[
\bigcap_{n=1}^{\infty} X_n \subseteq \bigcup_{n=1}^{\infty} X_n
\]

is written

\[\bigcap_{n=1}^{\infty} X_n \subseteq \bigcup_{n=1}^{\infty} X_n\]

Inline uses \(\cup\) (or \(\cap\)) instead of \(\bigcup\) (or \(\bigcap\)).
Brackets and Braces

- Direct: You can use the braces in an unformatted way by just including the braces, for example, $(x)$ is $(x)$ or $\{x\}$ is $\{x\}$. However, this will not scale for large operators or fractions,

\[
\left(\frac{x}{y}\right)
\]

- Formatted: Instead you should use \(\left\) and a matching \(\right\). For example, \(\left(\frac{x}{y}\right)\) produces,

\[
\left(\frac{x}{y}\right)
\]
Brackets and Braces

<table>
<thead>
<tr>
<th>Command</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(</td>
<td>(</td>
</tr>
<tr>
<td>[</td>
<td>[</td>
</tr>
<tr>
<td>{</td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>|</td>
<td>|</td>
</tr>
<tr>
<td>\langle</td>
<td>\langle</td>
</tr>
<tr>
<td>\rangle</td>
<td>\rangle</td>
</tr>
<tr>
<td>\lfloor</td>
<td>\lfloor</td>
</tr>
<tr>
<td>\lceil</td>
<td>\lceil</td>
</tr>
<tr>
<td>\lceil</td>
<td>\lceil</td>
</tr>
<tr>
<td>|</td>
<td>|</td>
</tr>
<tr>
<td>\l angle</td>
<td>\rangle</td>
</tr>
<tr>
<td>\r angle</td>
<td>\rangle</td>
</tr>
<tr>
<td>\lfloor</td>
<td>\lfloor</td>
</tr>
<tr>
<td>\l ceil</td>
<td>\l ceil</td>
</tr>
</tbody>
</table>
Sometimes you need to use the name of an operator. For example, the gradient of a function $f$ may be written as $\text{grad}(f)$.

If you just write $\text{grad}(f)$ then you get $\text{grad}(f)$. Instead, you should use $\text{operatorname}$\{grad\}(f). For example, $\text{grad}(f)$ is written as $\text{operatorname}{\text{grad}}(f)$.
mathbb and mathcal

Producing fancy typeset symbols can be accomplished with \textbackslash mathbb and \textbackslash mathcal. For example

$\mathbb{R}, \mathbb{Q}, \mathbb{C}$

is produced with

\texttt{\usepackage{amssymb}}

\texttt{\mathbb{R}, \mathbb{Q}, \mathbb{C}}

and

$\mathcal{R}, \mathcal{Q}, \mathcal{C}$

is produced with

\texttt{\usepackage{amssymb}}

\texttt{\mathcal{R}, \mathcal{Q}, \mathcal{C}}
## Assorted Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Result</th>
<th>Command</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\infty)</td>
<td>(\infty)</td>
<td>(\rightarrow)</td>
<td>(\rightarrow)</td>
</tr>
<tr>
<td>(\sqrt{x})</td>
<td>(\sqrt{x})</td>
<td>(\Rightarrow)</td>
<td>(\Rightarrow)</td>
</tr>
<tr>
<td>(\sqrt[3]{x})</td>
<td>(\sqrt[3]{x})</td>
<td>(\Leftarrow\Rightarrow)</td>
<td>(\Leftarrow\Rightarrow)</td>
</tr>
<tr>
<td>(\cdot)</td>
<td>(a \cdot b)</td>
<td>(\vec{x})</td>
<td>(\vec{x})</td>
</tr>
<tr>
<td>(\prime)</td>
<td>(\ˈ)</td>
<td>(\subseteq)</td>
<td>(\subseteq)</td>
</tr>
<tr>
<td>(\sim)</td>
<td>(\tilde{e})</td>
<td>(\geq)</td>
<td>(\geq)</td>
</tr>
<tr>
<td>\emptyset</td>
<td>\emptyset</td>
<td>(\leq)</td>
<td>(\leq)</td>
</tr>
</tbody>
</table>
Combining Commands

When these commands are combined, complex formulas can be written fairly easily. For example

\[ f(x, y) = \left( \frac{x^2 + 3y + 6\sqrt{x}}{x + y^{\frac{2}{3}}} \right) - \sum_{n=1}^{\infty} \frac{x - y}{n^2} \]

is written as

\[
\[ f(x,y) = \left(\frac{x^2 + 3y + 6\sqrt{x}}{x + y^{\frac{2}{3}}}\right) - \sum_{n=1}^{\infty} \frac{x - y}{n^2} \]
\]
Aligned Mode

When equations span multiple lines, aligning them helps improve readability. For example

\[(x + 3)(x + 2)(x + 1) = (x^2 + 3x + 2x + 6)(x + 1)\]
\[= (x^2 + 5x + 6)(x + 1)\]
\[= x^3 + 5x^2 + 6x + x^2 + 5x + 6\]
\[= x^3 + 6x^2 + 11x + 6\]
This is written,

\[
\begin{aligned}
(x+3)(x+2)(x+1) &= (x^2+3x+2x+6)(x+1) \\
&= (x^2+5x+6)(x+1) \\
&= x^3+5x^2+6x+x^2+5x+6 \\
&= x^3+6x^2+11x+6
\end{aligned}
\]
Array Mode: Matrices

Array mode can be used to typeset matrices. The usage is as follows:

\[
A = \begin{pmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1 \\
\end{pmatrix}
\]

is written as

\[A = \begin{pmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1 \\
\end{pmatrix}\]
Array Mode: Piecewise Functions

The array environment can be pretty useful when used properly. For example, piecewise functions can be written using array:

\[
  f(x) = \begin{cases} 
    x^2 & x < 0 \\
    \frac{1}{2}x & x \geq 0 
  \end{cases}
\]

is written

\[
  \left[ \\
  f(x) = \\
  \begin{array}{ll} 
    x^2 & x < 0 \\
    \frac{1}{2}x & x \geq 0 
  \end{array} \\
  \right. \\
  \]

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Creating Lists

When listing things, you can use the “Itemize” environment and the “Enumerate” environment.

**Itemize:**
- Item I
- Item II
- Item III

**Enumerate:**
1. Item I
2. Item II
3. Item III
Itemize

To use the itemize environment, use `\begin{itemize}` and for each line, use `\item`. For example

```
\begin{itemize}
\item Item I
\item Item II
\item Item III
\end{itemize}
```

produces

- Item I
- Item II
- Item III
Enumerate

To use the enumerate environment, use \begin{enumerate} and for each line, use \item. For example,

\begin{enumerate}
\item Item I
\item Item II
\item Item III
\end{enumerate}

produces

1. Item I
2. Item II
3. Item III
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To add graphics to a \LaTeX document, you need to include the “graphicx” package. Thus, add the line

`\usepackage{graphicx}\`

Then when you want to add an image, you need to enter “figure” mode and then use the `\includegraphics` command. For example

```
\begin{figure}
\includegraphics[\textwidth=0.5]{balloon}
\caption{Balloon Image}
\end{figure}
```
Figure: Balloon Image
Aligned Figures

Using the previous method, you can insert images into your document. If you want to add multiple images, you may want to put the images side-by-side. This requires some additional packages,

\usepackage{graphicx}
\usepackage{caption}
\usepackage{subcaption}
Aligned Figures

Example:

(a) Balloon Image

(b) Map Image

**Figure:** Subfigure Images
Aligned Figures

The code to produce this is,

\begin{figure}
  \centering
  \begin{subfigure}[b]{0.25\textwidth}
    \includegraphics[width=\textwidth]{balloon}
    \caption{Balloon Image}
  \end{subfigure}
  \hspace{10ex}
  \begin{subfigure}[b]{0.25\textwidth}
    \includegraphics[width=\textwidth]{map}
    \caption{Map Image}
  \end{subfigure}
  \caption{Subfigure Images}
\end{figure}
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Tabular Environment

Tables are created in a very similar way to the array environment. You can create,

\begin{tabular}{|l|l|l|}
\hline
User & Street Number & Street Name \\
\hline
Patrick & 4400 & University Drive \\
John & 4200 & University Drive \\
Kathy & 12432 & Innovation Drive \\
\hline
\end{tabular}
# Tabular Environment

This is created using,

```
\begin{center}
\begin{tabular}{|c|cc|}
\hline
User & Street Number & Street Name \\
\hline
Patrick & 4400 & University Drive \\
John & 4200 & University Drive \\
Kathy & 12432 & Innovation Drive \\
\hline
\end{tabular}
\end{center}
```
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Upcoming Topics

- User-defined commands
- Custom environments
- Typesetting Algorithms
- Theorems and Proofs
- Advanced use of common commands
- Advanced document organization
- Creating diagrams (for example, commutative diagrams)
- Beamer (creating presentations)