A Handy Guide to the basics of LaTeX

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Why learn LaTeX?

- Do you want to make your work look more professional?
- Do you want to be able to do your homework without internet?
- Have you ever wondered how some math professors can make their notes look so good?
- Do you want to make you CV or resumé look more professional?
- Do you plan on doing math research?
- Have you heard people talk about LaTeX and wonder what all the fuss is about?
- Do you plan to take a math class which requires students to type assignments?

If you have answered yes to any of these questions, then it's worth learning about LaTeX.

What is LaTeX?

LaTeX is a better version of Microsoft Word, specially designed for Math Majors.

Taken from Reddit

The following things are possible with LaTeX.

- Making lists!
- Aligning equations!
- Putting memes/pictures into your math homework!
- Constructing rad diagrams for a professional paper!
- Easily cross-reference equations with a paper!
- Easily cite published math articles!

How do I get LaTeX?

Online Version

Recommended for Beginners

1. Create an account on the website below

   http://www.overleaf.com

2. Then, you can select from a variety of templates to start your next LaTeX project.

Off-The-Grid Version

1. Download LaTeX software from the following site.

   https://www.latex-project.org/get/

2. Download a LaTeX editor such as TeXstudio or TeXworks.

How do I use LaTeX?

Key Ideas to Remember:

- Always start with prexisting code from a template or another document (or at least steal the preamble).
- Always code math in between dollar signs.
- Always end every command that you begin.

Google everything else

Online resources are as follows.

- Wikipedia page for TONS of LaTeX symbols
- Detexify: Picture $\longrightarrow$ TeX code
- Stack Exchange: Online LaTeX forum
- Additional resources given by Harvard's library

Taken from LaTeX memes for Well Typeset Teens.

Components of LaTeX code

- Preamble- where commands are enabled
  - Document Class
    - Defines what type of document you are creating, whether it is a paper, poster, slideshow or etc.
  - Packages
    - A collection of commands that are enabled with

      `\usepackage{desiredpackage}`
    - One such package enables you to write a command that can strike through text or math.

      $$x^2 \cancel{-2ab + 2ab} + y^2$$
  - Macro commands
    - Allows you to define a shortcut when coding something later and is of the following form.

```
\newcommand{\shortcut}{\oldcommand}
```

  - An example of a macro-command is as follows.

    ```
    \newcommand{\ndivides}{\centernot\vert}
    ```

  - Thus, one now has a quicker way to code $7 \nmid 13$.

- Body of the code- where commands are used
  - Begin with

    ```
    \begin{document}
    ```

  - Then, type desired code.
  - End with

    ```
    \end{document}
    ```

Coding within the body

Typesetting Equations

- For inline math, surround desired math with singlular dollar signs.
  - `Hence it follows that $(x+2)^2=x^2+4x+4$.`
  - Hence it follows that $(x+2)^2 = x^2 + 4x + 4$.
- For centered math, surround desired math with double dollar signs.
  - `$$(x+2)^2=x^2+4x+4$$`

$$(x+2)^2 = x^2 + 4x + 4$$

- To show a series of steps, use the align(*) environment.
  - Using the align environent **WILL** number each line, while the align* environment will **NOT** number each line.
  - Note: Dollar signs are not needed around math within an align(*) environment as LaTeX already assumes that it is math.
  - The character "&" dictates where each line will be aligned.
    - That is, when viewing the pdf, you can draw a vertical line through where all the &'s lie in the code.
  - The mbox command allows one to include justification of a line.

    ```
    \mbox{by Fermat's Last Theorem}
    ```

  - The use of "\\" ends each line.

```
\begin{align*}
(2+i)^2(5+i)&=(4+4i+i^2)(5+i)\\
&=(3+4i)(5+i)
&\mbox{since $i^2=-1$}\\
&=15+20i+3i+4i^2\\
&=11+23i
&\mbox{since $i^2=-1$.}
\end{align*}
```

$$\begin{aligned}
(2+i)^2(5+i) &= (4+4i+i^2)(5+i) \\
&= (3+4i)(5+i) && \text{since } i^2=-1 \\
&= 15+20i+3i+4i^2 \\
&= 11+23i. && \text{since } i^2=-1
\end{aligned}$$

Exercise 0.1. *Code the following sequence of equalities in a separate document.*

$$\begin{aligned}
(x+3)^2(x+2) &= (x^2+6x+9)(x+2) \\
&= x^3+6x^2+9x+2x^2+12x+18 \\
&= x^3+8x^2+21x+18.
\end{aligned}$$

Exercise 0.2. *Code the following sequence of equalities in a separate document.*

$$\begin{aligned}
\rho &= \lim_{n\to\infty} \frac{9n^3+5n^2}{27n^3+27n^2+60n+6} \\
&= \lim_{n\to\infty} \frac{9+5n^{-1}}{27+27n^{-1}+60n^{-2}+6n^{-3}} && \text{by multiplying the fraction by } \tfrac{n^3}{n^3} \\
&= \frac{9}{27} && \text{by evaluating the limit.} \\
&= \frac{1}{3}.
\end{aligned}$$

Exercise 0.3. *Code the following sequence of equalites and inequalities in a separate document.*

$$\begin{aligned}
|x_{n+1}-x_n| &= \left|\frac{1}{2}(x_n+x_{n-1})-x_n\right| && \text{by definition of the sequence } \{x_n\} \\
&= \left|\frac{1}{2}x_n+\frac{1}{2}x_{n-1}-x_n\right|
\end{aligned}$$

$$
\begin{aligned}
&= \left| \frac{1}{2}(x_{n-1} - x_n) \right| \\
&= \frac{1}{2}|x_{n-1} - x_n| \\
&= \frac{1}{2}|x_n - x_{n-1}| \\
&\leq \frac{1}{2}|x_n - x_{n-1}|.
\end{aligned}
$$

Typesetting Lists

To create a bulleted list, use the "itemize" enviornment as follows.

```
\begin{itemize}
\item 2021-2022 UWEC Math Club Officers
\begin{itemize}
\item Grace Liebl (President)
\item Maria Cruciani (Vice Prez)
\item Maddy St. Pierre (Treasurer)
\item Ethan Olerich (Secretary)
\end{itemize}
\end{itemize}
```

- 2021-2022 UWEC Math Club Officers
  - Grace Liebl (President)
  - Maria Cruciani (Vice Prez)
  - Maddy St. Pierre (Treasurer)
  - Ethan Olerich (Secretary)

To create an ordered list, use the "enumerate" enviornment as follows.

```
\begin{enumerate}
\item 2021-2022 UWEC Math Club Officers
\begin{enumerate}
\item Grace Liebl (President)
\item Maria Cruciani (Vice Prez)
\item Maddy St. Pierre (Treasurer)
\item Ethan Olerich (Secretary)
\end{enumerate}
\end{enumerate}
```

1. 2021-2022 UWEC Math Club Officers

(a) Grace Liebl (President)

(b) Maria Cruciani (Vice Prez)

(c) Maddy St. Pierre (Treasurer)

(d) Ethan Olerich (Secretary)

Exercise 0.4. *Create an unordered list of as many gas station companies that you can think of. Then, create an ordered list ranking them.*

Exercise 0.5. *Code the following list. (You may need an additional package)*

a. Canada

1. Alberta
2. British Columbia
3. $\cdots$

b. United States

1. Alabama
2. Alaska
3. $\cdots$

Typesetting Theorems, Lemmas, Conjectures, ...

After pasting the following code into the preamble of your document, theorem, lemma, proposition, corollary, exercise, claim and conjecture environments become defined.

```
\newtheorem{theorem}{Theorem}[section]
\newtheorem{lemma}[theorem]{Lemma}
\newtheorem{corollary}[theorem]{Corollary}
\newtheorem{conjecture}[theorem]{Conjecture}
\newtheorem{claim}[theorem]{Claim}
\newtheorem{proposition}[theorem]{Proposition}
\newtheorem{exercise}[theorem]{Exercise}
```

Then, we may code any of these possibilities as follows.

```
\begin{conjecture}
Let $\gcd(G_0,G_1)=1$. Then, the period of the Generalized Fibonacci sequence
modulo $m$ is even for all $m>2$.
\end{conjecture}
```

Conjecture 0.6. *Let* $\gcd(G_0, G_1) = 1$. *Then, the period of the Generalized Fibonacci sequence modulo* m *is even for all* $m > 2$.

Exercise 0.7. *State Fermat's Last Theorem and leave the proof as an exercise for the reader.*

Cross-referencing

- Results

  1. Label the result that you wish to reference later with \label{}.
  2. Reference the the desired result with \ref{}.
  3. Note: \WWTS{} is defined as a macro-command within the preamble.

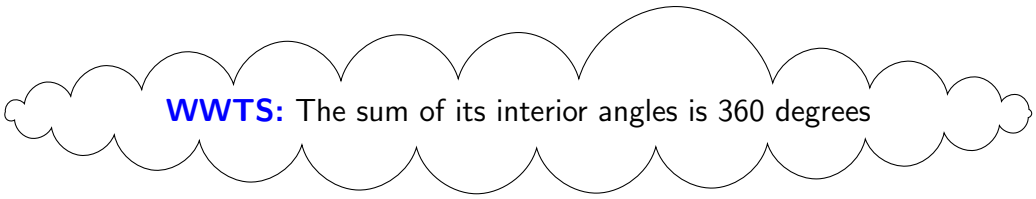
```
\begin{lemma}\label{Euclid?}
The sum of the interior angles of a triangle is 180 degrees.
\end{lemma}
\begin{proof}
This proof is left as an exercise for the reader.
\end{proof}
\begin{theorem}
The sum of the interior angles of a parallelogram is 360 degrees.
\end{theorem}
\begin{proof}
Consider a parallelogram.
\WWTS{The sum of the interior angles is 360 degrees}
Draw a line connecting two opposing points.
Now, the parallelogram is divided into two triangles.
Notice that the sum of the interior angles of the parallelogram
is equal to the sum of the interior angles of the two triangles.
By Lemma~\ref{Euclid?}, we know that the sum of the interior
angles of the parallelogram is $2 \cdot 180 = 360$ degrees.
\end{proof}
```

Lemma 0.8. *The sum of the interior angles of a triangle is 180 degrees.*

Proof. This proof is left as an exercise for the reader. □

Theorem 0.9. *The sum of the interior angles of a parallelogram is 360 degrees.*

Proof. Consider a parallelogram.



Draw a line connecting two opposing points. Now, the parallelogram is divided into two triangles. Notice that the sum of the interior angles of the parallelogram is equal to the sum of the interior angles of the two triangles. By Lemma 0.8, we know that the sum of the interior angles of the parallelogram is $2 \cdot 180 = 360$ degrees. □

- Equations
  1. Label the result that you wish to reference later with \label{}.
  2. Reference the the desired result with \eqref{}.

```
\begin{lemma}
For all $j \geq 0$, the following identities hold:
\begin{align}
    F_{j+2}&=F_{j+1}+F_{j}\label{eq:rr}\\
    F_j L_j &= F_{2j}\label{eq:Vajda_1}
\end{align}
\end{lemma}

\begin{proof}
Equation~\eqref{eq:rr} comes from the definition of the Fibonacci numbers.
The proof of Equation~\eqref{eq:Vajda_1} is left as an exercise.
\end{proof}

\begin{lemma}\label{lem:Koshy_identities}
For all $j \geq 0$, the following identity holds
    $$F_{4j+1} - 1 = F_{2j} L_{2j+1}\label{eq:Koshy_1}$$
\end{lemma}

\begin{proof}
Consider the following sequence of equalities.
\begin{align*}
F_{4j+4} - 1 &=F_{2j+2}L_{2j+2}-1
&\mbox{by Equation~\eqref{eq:Vajda_1}}\\
&=(F_{2j+3}-F_{2j+1})(L_{2j+1}+L_{2j})-1
&\mbox{by Equation~\eqref{eq:rr}}\\
&= \cdots\\
&= F_{2j} L_{2j+1}.
\end{align*}
Hence we have proven that $F_{4j+4} - 1 = F_{2j} L_{2j+1}$.
\end{proof}
```

Lemma 0.10. *For all $j \geq 0$, the following identities hold:*

$$F_{j+2} = F_{j+1} + F_j \tag{1}$$
$$F_j L_j = F_{2j} \tag{2}$$

Proof. Equation (1) comes from the definition of the Fibonacci numbers. The proof of Equation (2) is left as an exercise. □

Lemma 0.11. *For all $j \geq 0$, the following identity holds*

$$F_{4j+1} - 1 = F_{2j} L_{2j+1}$$

Proof. Consider the following sequence of equalities.

$$\begin{aligned} F_{4j+4} - 1 &= F_{2j+2} L_{2j+2} - 1 && \text{by Equation (2)} \\ &= (F_{2j+3} - F_{2j+1})(L_{2j+1} + L_{2j}) - 1 && \text{by Equation (1)} \\ &= \cdots \\ &= F_{2j} L_{2j+1}. \end{aligned}$$

Hence we have proven that $F_{4j+4} - 1 = F_{2j} L_{2j+1}$ for all $j \geq 0$. □

Spacing

The following commands are used to create adequate spacing between objects within your document.

- The center environment can be used to center text, figures or images.
- The command \hfill denotes "horizontal fill", which produces white space for the rest of the line.
- The command \hspace{1cm} denotes "horizontal space", which produces a desired amount of horizontal space (such as 1cm).
- The command \vfill denotes "vertical fill", which produces enough white space below the line to fill out the page.
- The command \vspace{1cm} denotes "vertical space", which produces a desired amount of vertical space below a given line (such as 1cm).

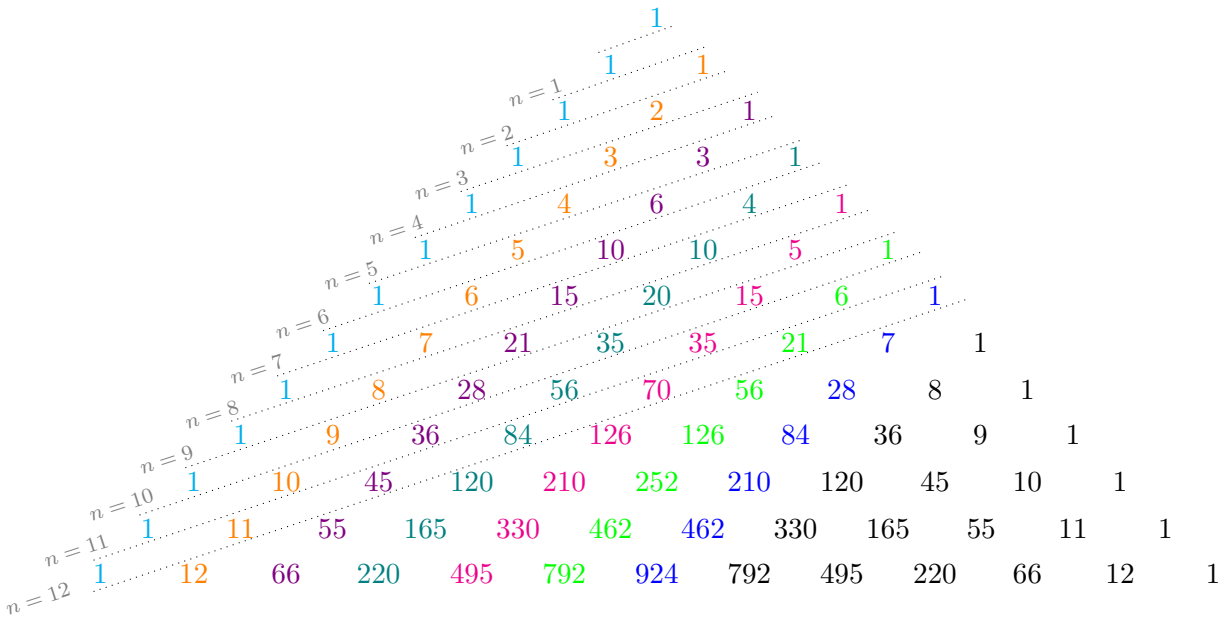
Inserting Images

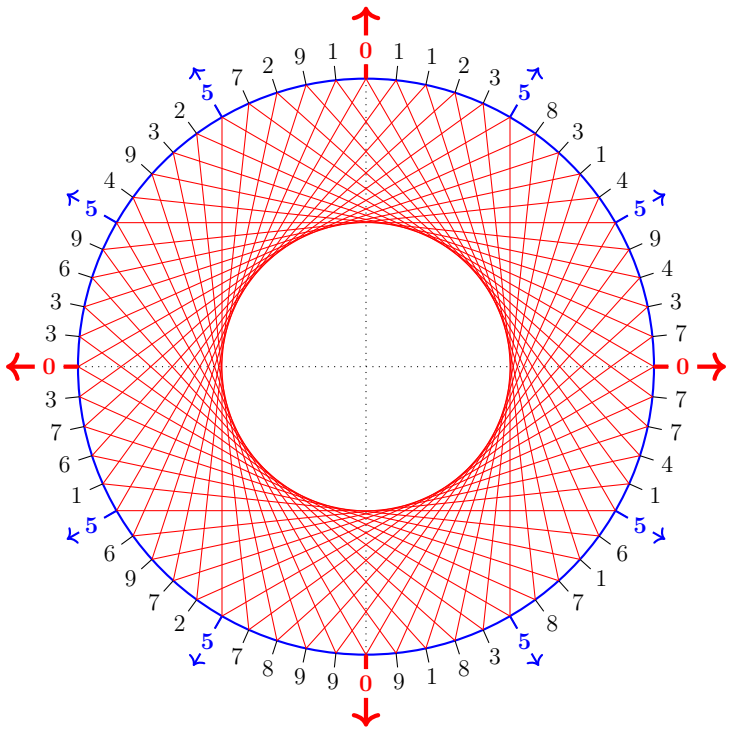
1. Include \usepackage{graphicx} within your preamble.
2. For Overleaf users, upload your desired image into your overleaf file.
3. For offline users, save your desired image within the same folder as your .tex file.
4. Use the \includegraphics[sizing]{file name} command to include the image in your document.

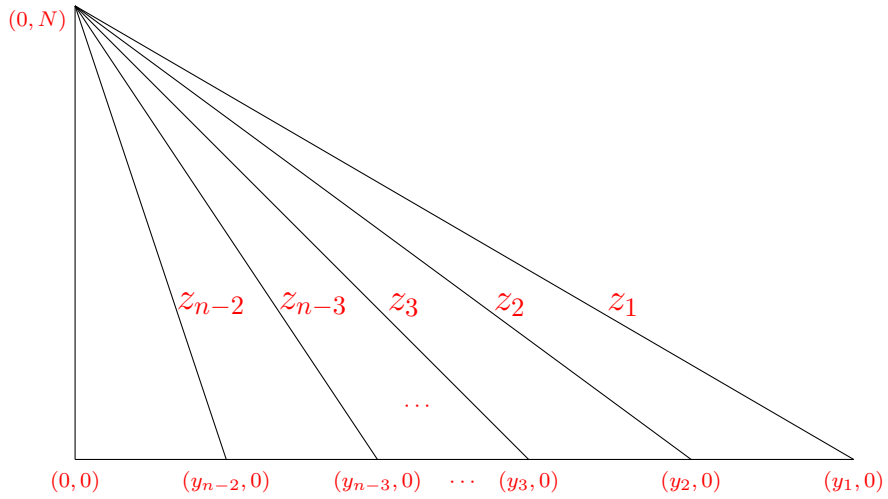
```
\begin{center}
    \includegraphics[scale=0.35]{powerofanal.jpg}
\end{center}
```

TikZ Examples

Using \usepackage{tikz}, you can create super cool diagrams such as the ones below (First two were coded by UWEC alumn Emily Gullerud, the third was coded by me).


n = 1
1
1 1
n = 2
1 2 1
n = 3
1 3 3 1
n = 4
1 4 6 4 1
n = 5
1 5 10 10 5 1
n = 6
1 6 15 20 15 6 1
n = 7
1 7 21 35 35 21 7 1
n = 8
1 8 28 56 70 56 28 8 1
n = 9
1 9 36 84 126 126 84 36 9 1
n = 10
1 10 45 120 210 252 210 120 45 10 1
n = 11
1 11 55 165 330 462 462 330 165 55 11 1
n = 12
1 12 66 220 495 792 924 792 495 220 66 12 1





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