An Introduction to LaTeX

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What is LaTeX?

- LaTeX is a typesetting system/language used for the production of technical (mathematical) documentation.
- In mathematics, statistics, computer science, engineering, chemistry, physics, economics, quantitative psychology, philosophy, and political science, LaTeX is the standard for the preparation of presentations, publications, and other documents.
- Unlike WYSIWYG word processors like Microsoft Word, LaTeX uses *source files* (.tex files) written in specialized syntax that are then translated by a LaTeX *compiler* into output documents (e.g. .pdf or .dvi files) suitable for publication.
- "Complicated" technical documents are much more easily produced using LaTeX than a traditional word processor.

Obtaining LaTeX

- LaTeX source files can be created using any text editor.
- **MiKTeX** and **TeX Live** are LaTeX compilers freely available online.
- There are also combined editor/compiler packages available:
  - **TeXShop** and **MacTeX** for OS X, or **proTeXt** for Windows can be downloaded for free.
  - **Latexian** for OS X, or **WinEdt** for Windows can be purchased for a small fee.
- For the price of an email address, an online editor/compiler is available through

  www.overleaf.com.

A simple document

After logging in to **overleaf.com**, click on 

and choose the "Blank Paper" template.

You'll then see the following code in the left-hand pane of your window:

```
\documentclass{article}
\usepackage[utf8]{inputenc}
\begin{document}
(Type your content here.)
\end{document}
```

A typeset version of this source code appears in the right-hand pane.

Entering mathematical expressions

Inline mathematical expressions are enclosed by a pair of `$`.

Let $(G, *)$ be a group.

- `Let $(G, \ast)$ be a group.`

Suppose that $f(x) = e^{3x} - x^2 + 3$.

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We claim that $x_n \to 0$ as $n \to \infty$.

- `We claim that $x_n \to 0$ as $n \to \infty$.`

For any $\mathbf{v} \in \mathbb{R}^n$, $\langle \mathbf{v}, \mathbf{v} \rangle \geq 0$.

- `For any $\mathbf{v} \in \mathbb{R}^n$,`

  `$\langle \mathbf{v} , \mathbf{v} \rangle \geq 0$.`

Remarks on math mode

- Macros and special characters have the form `\symbolname`.
- Whitespace is ignored.
- Curly braces `{..}` are used to group symbols, and are not typeset.
- The arguments to superscripts (`^`), subscripts (`_`) and other commands should be enclosed in curly braces:

`e^2x` yields e^2x

`e^{2x}` yields e^{2x}

- To display curly braces, use \{ and \}:

  `$A = { (x,y) | e^{xy} = 1 }$` yields

$$A = (x, y) | e^{xy} = 1$$

  `$A = \{ (x,y) | e^{xy} = 1 \}$` yields

$$A = \{(x, y) | e^{xy} = 1\}$$

- To insert text in math mode, use `\text` or `\mbox`:

  `$E = \{ n \in \mathbb{Z} \, | \, n \text{ is even} \}$`

  yields

$$E = \{n \in \mathbb{Z} \,|\, n \text{ is even}\}$$

Common symbols and functions

- The greek alphabet:

  ```
  $\alpha, \beta, \gamma, \Gamma, \delta, \Delta$
  ```

  $$\alpha, \beta, \gamma, \Gamma, \delta, \Delta$$

- Special functions:

  ```
  $\sin x, \cos x, \log x, \sqrt{x}, \sqrt[n]{x}$
  ```

  $$\sin x, \cos x, \log x, \sqrt{x}, \sqrt[n]{x}$$

- Ellipsis:

  ```
  $a_1, a_2, \ldots, a_n$
  ```

  $$a_1, a_2, \ldots, a_n$$

Large symbols

Expressions including summations, fractions, integrals, etc. can look "uncomfortable" when typeset inline.

```
$\sum_{n=1}^{\infty} \frac{1}{n^2}=\frac{\pi^2}{6}$
```

yields $\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}$. And

```
$\int_{-2}^{10} \frac{x^3}{5} dx$
```

yields $\int_{-2}^{10} \frac{x^3}{5} dx$.

There are two ways around this.

Option 1: Use **display mode** by enclosing expressions between `\[` and `\]`.

Option 2: Use `\displaystyle`.

```
An equation in display mode:
\[
\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}.
\]
```

An equation in display mode:

$$\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}.$$

```
A large inline expression: $\displaystyle \int_{-2}^{10}
\frac{x^3}{5} dx$.
```

A large inline expression: $\displaystyle \int_{-2}^{10} \frac{x^3}{5} dx$.

Templates

There's no need to start a document "from scratch" every time: it's usually more efficient to modify an existing file.

- **overleaf.com** offers a number of document templates and examples of papers, presentations, etc.
- Your professors probably have templates or sample .tex files they may be willing to share...

Today we will be using the file `in-class.tex`.

Uploading a project to **overleaf.com**

- Download the file `in-class.zip` from Dr. Daileda's website:

  `http://gotu.us/drgq2`

- From the "My Projects" page on **overleaf.com**, click the upload button  (next to 

) and select "Upload Zip" from the drop down menu.

- Locate `in-class.zip` and drag it into the pop-up window (or click the "Choose File" button to do it the old fashioned way).

- After a few moments, the editing (left) and preview (right) panes should open automatically.

In-class exercises

After changing the author's name to your own, scroll to the appropriate regions and code the following:

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

- `$f(x) = \sqrt[3]{x^3 + 1}$`

(b) $\displaystyle \frac{dy}{dx} = \tan x + x^{4/3}$

- `$\displaystyle \frac{dy}{dx} = \tan x + x^{4/3}$`

(c) $\displaystyle \Gamma(s) = \int_0^{\infty} e^{-x} x^{s-1} \, dx$

- `$\displaystyle \Gamma(s) = \int_0^{\infty} e^{-x} x^{s-1} \, dx$`

Parentheses

Consider the expression

$$\left(\frac{x}{2} + \frac{y}{3}\right)^2.$$

`\[ \frac{x}{2} + \frac{y}{2} )^2 \]` yields

$$(\frac{x}{2} + \frac{y}{2})^2,$$

which is clearly unsatisfactory.

Use `\left` and `\right` to scale parentheses (and other delimiters):

```
\[  \left( \frac{x}{2} + \frac{y}{3} \right)^2 \]
```

Matrices

A matrix can be built using the `array` environment.

```
\[
\left( \begin{array}{cc}
0 & 1 \\
1 & -q
\end{array} \right)
\]
```

yields

$$\left(\begin{array}{cc} 0 & 1 \\ 1 & -q \end{array} \right)$$

The `&` is an alignment tab, and `\\` indicates the end of a row.

Another exercise

Code the following

$$A = \begin{bmatrix} 1 & 2 & -3 \\ 0 & 0 & a_{23} \end{bmatrix}$$

```
\[
A = \left[ \begin{array}{ccc}
1 & 2 & -3 \\
0 & 0 & a_{23}
\end{array} \right]
\]
```

Theorem environments

Theorem (Bézout's Identity)

Let $m, n \in \mathbb{Z}$. There exist $r, s \in \mathbb{Z}$ so that

$$\gcd(m, n) = rm + sn.$$

```
\begin{thm}[B\'ezout's Identity]
Let $m, n \in \mathbb{Z}$.  There exist $r,s \in
\mathbb{Z}$ so that
\[
\gcd(m,n) = rm+sn .
\]
\end{thm}
```

Another exercise

Code the following.

Theorem (Triangle Inequality)

For any $a, b \in \mathbb{C}$, we have $|a + b| \leq |a| + |b|$.

```
\begin{thm}[Triangle Inequality]
For any $a,b \in \mathbb{C}$, we have $|a+b| \le |a|
+ |b|$.
\end{thm}
```

Inserting figures

Here's a figure:

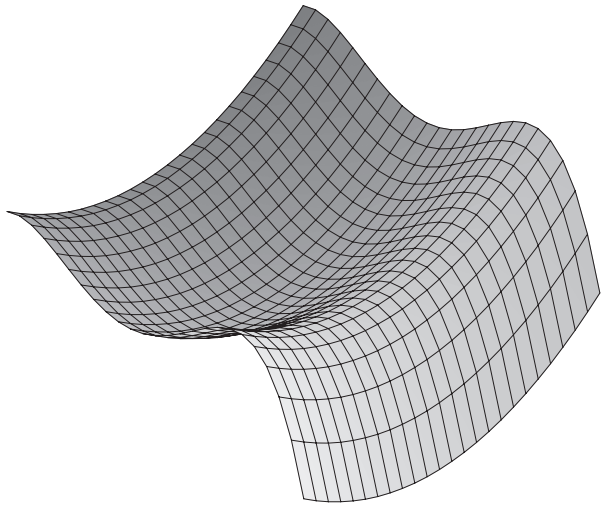

Figure: A surface in $\mathbb{R}^3$

```
\begin{figure}
\includegraphics[width=1.5in]{Mountain_Pass.eps}
\caption{A surface in $\mathbb{R}^3$}
\end{figure}
```

Final exercise

Use the file `dirichlet.eps` to produce the following output.

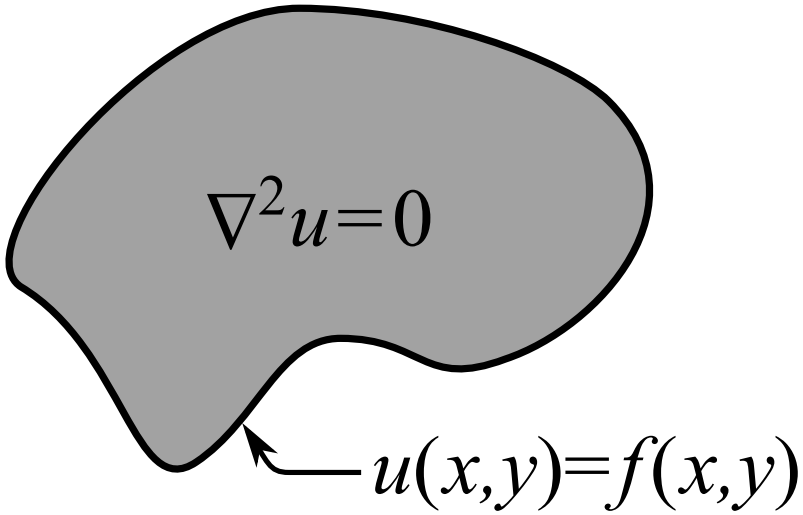

Figure: A generic Dirichlet problem in $\mathbb{R}^2$

```
\begin{figure}
\includegraphics[width=2in]{dirichlet.eps}
\caption{A generic Dirichlet problem in $\mathbb{R}^2$}
\end{figure}
```

Multiline equations

The `split` environment is one way to align multiple display mode equations.

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

```
\[
\begin{split}
\frac{x^3 - 1}{x-1} &= \frac{(x-1)(x^2 + x + 1)}{x-1} \\
          &= x^2 + x + 1
\end{split}
\]
```

Equation references

Suppose we'd like to number and later refer to an inset equation.

$$g(n) = \sum_{d|n} f(d) \tag{1}$$

Here's a reference to equation (1).

```
\begin{equation}\label{divisorsum}
g(n) = \sum_{d|n} f(d)
\end{equation}
Here's a reference to equation \eqref{divisorsum}.
```

LaTeX automatically keeps track of and increments equation labels.

If g is defined by (1) then

$$f(n) = \sum_{d|n} \mu(d) g\left(\frac{n}{d}\right). \tag{2}$$

Equation (2) is called the *Möbius inversion formula.*

```
If $g$ is defined by \eqref{divisorsum} then
\begin{equation}\label{inversion}
f(n) = \sum_{d|n} \mu(d) g\left( \frac{n}{d} \right).
\end{equation}
Equation \eqref{inversion} is called the
\em{M\"{o}bius inversion formula.}
```

Beamer

- Beamer is a LaTeX document style used to create presentations.
- Each slide is enclosed by `\begin{frame}` and `\end{frame}`.
- Items can be subsequently revealed on a slide in various ways, e.g. `\pause`, `\onslide`, `\only`, etc.
- One can also easily include figures using `\includegraphics`.

Sample beamer slide
with a subtitle

This is a slide.

- First item
- Second item

Sample slide code

```
\begin{frame}

\frametitle{Sample beamer slide}
\framesubtitle{with a subtitle}

This is a slide.  \pause

\begin{itemize}

\item  First item  \pause

\item  Second item

\end{itemize}

\end{frame}
```

Need more help?

We've only scratched the surface of LaTeX's capabilities. If you need additional help:

- **Online:** try googling "latex (command name)."
- **In person:** ask your peers or any math professor!

Anything you're trying to do with LaTeX someone else has probably already done. Don't reinvent the wheel!