# An Introduction to $\LaTeX$

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Intro to Abstract Math
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# What is LaTeX?

- LaTeX is a typesetting system/language used for the production of technical (mathematical) documentation.
- In mathematics and other disciplines, 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 Mac OS, or **TeXstudio** and **proTeXt** for Windows can be downloaded for free.
  - Other packages, such as **WinEdt** for Windows, can be purchased for a small fee.

# Overleaf

For the price of an email address, an online editor/compiler is available through

**www.overleaf.com**.


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

and choose "Blank Project."

Give your project a name.

A simple generic LaTeX document is created. The source appears on the left, the compiled document on the right.

# “Blank Project” Source

```
\documentclass{article}
\usepackage[utf8]{inputenc}

\title{My Project}
\author{My Name}
\date{February 2020}

\begin{document}

\maketitle

\section{Introduction}

\end{document}
```

# Entering mathematical expressions

Inline mathematical expressions are enclosed by a pair of $.

Let $P$ and $Q$ be statements.

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

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If $a \ne b$, then $\sqrt{ab} < \frac{a+b}{2}$.

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

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

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

- Blackboard bold: $\mathbb{N}, \mathbb{Z}, \mathbb{Q}, \mathbb{R}$

  `$\mathbb{N}, \mathbb{Z}, \mathbb{Q}, \mathbb{R}$`

- Ellipsis: $a_1, a_2, \ldots, a_n$

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

# Large expressions

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 document to **www.overleaf.com**

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

  `ramanujan.math.trinity.edu/rdaileda/abstract`

- Click the upload button (in the top left corner).

- Locate `in-class.zip` and drag it into the pop-up window (or click the "Select from your computer" button and do it the old fashioned way).

- After a few moments, `in-class.zip` will open in the editing (left) pane.

# In-class exercises

After adjusting the title and 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) $\Gamma(s) = \int_0^{\infty} e^{-x} x^{s-1} \, dx$

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

# 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

$$\mathbf{a} \times \mathbf{b} = \left| \begin{array}{ccc} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{array} \right|$$

```
\[
\mathbf{a} \times \mathbf{b} =
\left| \begin{array}{ccc}
\mathbf{i} & \mathbf{j} & \mathbf{k} \\
a_1 & a_2 & a_3 \\
b_1 & b_2 & b_3
\end{array} \right|
\]
```

# 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 $|a + b| \le |a| + |b|$.*

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

# Multiline equations

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

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

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

# Equation references

Suppose we'd like to number and later refer to a displayed equation.

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

Here's a reference to equation (1).

Now we need the `equation` environment in place of `\[...\]`.

```
\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.}
```

# Tables - the tabular environment

Consider the truth table for $P \to Q$:

| $P$ | $Q$ | $P \to Q$ |
|---|---|---|
| $T$ | $T$ | $T$ |
| $T$ | $F$ | $F$ |
| $F$ | $T$ | $T$ |
| $F$ | $F$ | $T$ |

```
\begin{tabular}{c c | c}
$P$ & $Q$ & $P \to Q$ \\ \hline
$T$ & $T$ & $T$ \\
$T$ & $F$ & $F$ \\
$F$ & $T$ & $T$ \\
$F$ & $F$ & $T$
\end{tabular}
```

- The argument `{c c | c}` specifies three (horizontally) **c**entered columns, the last two separated by a vertical bar `|`.
- `&`'s separate entries in a row; `\\` ends a row.
- `\hline` draws a horizontal line below a row.
- Entries in math mode must *all* be enclosed in `$...$`.

# 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!

$$
\begin{array}{ccccccccccc}
 & & & & 1 & & 1 & & 1 & & \\
 & & & & \downarrow & & \downarrow & & \downarrow & & \\
 & & & & \dfrac{N(L^*)K_{\mathfrak{m},1}}{N(L^*)} & \xrightarrow{f_0^*} & \dfrac{N(I_L^{\mathfrak{m}})\iota(K_{\mathfrak{m},1})}{N(I_L^{\mathfrak{m}})} & \xrightarrow{p^*} & \ker d_4 & \longrightarrow & 1 \\
 & & & & \Big\downarrow d_5 & & \Big\downarrow d_6 & & \Big\downarrow d_7 & & \\
1 & \longrightarrow & \ker f_0 & \longrightarrow & \dfrac{K^*}{N(L^*)} & \xrightarrow{f_0} & \dfrac{I_K^{\mathfrak{m}}}{N(I_L^{\mathfrak{m}})} & \xrightarrow{p} & \mathrm{cok}\ f_0 & \longrightarrow & 1 \\
 & & \Big\downarrow d_1 & & \Big\downarrow d_2 & & \Big\downarrow d_3 & & \Big\downarrow d_4 & & \\
1 & \longrightarrow & \ker g & \longrightarrow & \dfrac{K^*}{N(L^*)K_{\mathfrak{m},1}} & \xrightarrow{g} & \dfrac{I_K^{\mathfrak{m}}}{N(I_L^{\mathfrak{m}})\iota(K_{\mathfrak{m},1})} & \xrightarrow{p'} & \mathrm{cok}\ g & \longrightarrow & 1 \\
 & & \downarrow & & \downarrow & & \downarrow & & \downarrow & & \\
 & & 1 & & 1 & & 1 & & 1 & &
\end{array}
$$