Intro to LaTeX

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Software

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- WP which output LaTeX: Lyx, TeXmacs, Scientific Word

A Sample Mathematics Paper

- a LaTeX file is a text file. The file name should end in ".tex"
- https://github.com/scheinerman/SampleMathPaper
- Download the ZIP file containing all the files in the folder.
- Open paper.tex in TeXStudio
- To typeset click the "Build and View" button  in TexStudio.

Skeleton of a LaTeX document

- The first line of a typical LaTeX document is this:

  `\documentclass[options]{class}`

  where class is one of: `article` `report` `letter` `book` `slides` `beamer` etc. and options: `11pt` `12pt` `twoside` `twocolumn` etc.
- The lines following `\documentclass` are known as the preamble. Here you define your own commands `\newcommand{\ZZ}{\mathbb{Z}}`, load optional packages `\usepackage{amsmath}`, etc.
- The main text of the document is enclosed between lines that say `\begin{document}` and `\end{document}`.

Typing

To type ordinary text, simply type what you want. To start a new paragraph, simply skip a line.
Certain characters have special meanings.

- \ is used to begin a command.
- $ any math should begin and end with a $.
- % is used to begin a comment.
- { } start and end of a command argument.
- & used as a column delimiter in certain environments

To use these special characters in your text put a \ before the character.
For \ use the command `\textbackslash\`
because \\ is equivalent to `\newline`.

Quotes

To enclose words in double quotes, begin with two back tick characters and end with two apostrophes. Do not use the double quote key.
Use ``double'' to produce "double".

To enclose words in single quotes, begin with a single back tick character and end with a single apostrophe.
Use `single' to produce 'single'.

Font size and styles

Let the document class and logical structures of LaTeX pick the appropriate size.[1]

Likewise with font style. In general, you do not need to pick the font. Variable names in mathematics mode are automatically typeset in italics as in $x + 1$. Similiarly, the font style in section heads, theorems, etc., are automatically produced for you.

- To typeset in *italics* use `\textit{...}`.
- To typeset in **boldface** use `\textbf{...}`.
- To typeset in san serif use `\textsf{...}`.
- To typeset in `typewriter` use `\texttt{...}`.

The system of fonts used by LaTeX is known as the Computer Modern family. If you prefer Times Roman, include these commands in the preamble of your file:

```
\usepackage{times}
\usepackage{mathptm}
```

[1] For example, text in a footnote is automatically typeset smaller than text in the main body of the document.

Accents

Don’t be naïve, ordering á la carte is expensive. Don’t use ö when you write Erdős. Be honest; don’t put up a façade. Use Hôpital’s rule.

```
Don’t be na\"{\i}ve, ordering \’a la carte is expensive.
Don’t use \"o when you write Erd\H{o}s.
Be honest; don’t put up a fa\c{c}ade. Use H\^opital’s rule.
```

Numbered Lists

This is a numbered list.

1. If you loan money to faculty members, be sure to get an I.O.U.
2. To be sure that students show up for events, serve food.

```
This is a numbered list.
\begin{enumerate}
\item If you loan money to faculty members, be sure to get an I.O.U.
\item To be sure that students show up for events, serve food.
\end{enumerate}
```

Bulleted Lists

This is a bulleted list.

- LaTeX does an excellent job of typesetting mathematics papers.
- LaTeX can easily produce beautiful results that are 99% perfect.
- You can drive yourself crazy on that last 1%. Don't bother.

```
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\begin{itemize}
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  papers.
\item \LaTeX\ can easily produce beautiful results that are 99\%
  perfect.
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\end{itemize}
```

Basic Math

- When typing math within a paragraph of text enclose the math with between single dollar signs \$. For example: If a is an integer, then $2a + 1$ is odd.

[2] This requires the `amsmath` package.

Basic Math

- When typing math within a paragraph of text enclose the math with between single dollar signs `$`. For example: If a is an integer, then $2a + 1$ is odd.
- - use the carat for superscript `$x^2+y^2=1$` to get $x^2 + y^2 = 1$.
  - use the underscore for subscript `$a_n=0$` to get $a_n = 0$.
  - use curly braces to enclose more than one character `$e^{-x}$` to get e^{-x}.

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- Named mathematics operators are usually typeset in roman. Some examples: `$\det A$`, `$\cos\pi$`, and `$\log(1-x)$` produces $\det A$, $\cos \pi$, and $\log(1 - x)$.

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- Named mathematics operators are usually typeset in roman. Some examples: `$\det A$`, `$\cos\pi$`, and `$\log(1-x)$` produces $\det A$, $\cos \pi$, and $\log(1 - x)$.
- Create your own operator [2] using the `DeclareMathOperator` command. For example, to make `\id` the identity operator:

  ```
  \DeclareMathOperator{\id}{id}
  ```

  Now we can type `$\id(x)$` to produce $\mathrm{id}(x)$. The `\DeclareMathOperator` command must go in the preamble

[2] This requires the `amsmath` package.

Displayed equations

- Display an equation on its on line using the `displaymath` environment or enclose it with `$$`.

```
$$
f(x)= 5x^{10}-9x^9+77x^8+12x^7+4x^6-8x^5+7x^4+x^3-2x^2+3x+11.
$$
```

$$f(x) = 5x^{10} - 9x^9 + 77x^8 + 12x^7 + 4x^6 - 8x^5 + 7x^4 + x^3 - 2x^2 + 3x + 11.$$

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$$f(x) = 5x^{10} - 9x^9 + 77x^8 + 12x^7 + 4x^6 - 8x^5 + 7x^4 + x^3 - 2x^2 + 3x + 11.$$

- For a numbered equation use the `equation` environment.

```
\begin{equation} \label{eq:polynomial}
g(x) = x^{10}+x^9 - x^3 -x -1.
\end{equation}
```

$$g(x) = x^{10} + x^9 - x^3 - x - 1. \tag{1}$$

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$$g(x) = x^{10} + x^9 - x^3 - x - 1. \tag{1}$$

- For a multline equation use the `eqnarray` environment.

align environment

The `align*` environment is superb for lining up equations. (Omit the `*` for numbered equations.)

```
\begin{align*}
3x-y&=0 & 2a+b &= 4 \\
x+y &=1 & a-3b &=10
\end{align*}
```

$$3x - y = 0 \qquad 2a + b = 4$$
$$x + y = 1 \qquad a - 3b = 10$$

text in math

To insert ordinary text inside of mathematics mode, use `\text`:

```
$$
f(x) = \frac{x}{x-1} \text{ for $x\not=1$}.
$$
```

$$f(x) = \frac{x}{x-1} \text{ for } x \neq 1.$$

cases environment

Use the cases environment to define a function piecewise.

```
$$
|x| =
\begin{cases}
x & \text{when $x \ge 0$ and} \\
-x & \text{otherwise.}
\end{cases}
$$
```

$$
|x| = \begin{cases} x & \text{when } x \geq 0 \text{ and} \\ -x & \text{otherwise.} \end{cases}
$$

Theorems

In the preamble

```
\newtheorem{thm}{Theorem}[section]
\newtheorem{lem}[thm]{Lemma}
\newtheorem{prop}[thm]{Proposition}
\newtheorem{cor}[thm]{Corollary}
\newtheorem{conj}[thm]{Conjecture}
```

First line defines the `thm` environment named Theorem with numbering style is based on the `section`.
Second line define the `lem` environment named Lemma sharing the same numbering as `thm`

Theorems

```
\begin{thm}
  A subset of the real line is compact if and only if it is closed and
  bounded.
\end{thm}
\begin{lem}
  In any graph, the sum of the degrees of the vertices is twice the
  number of edges.
\end{lem}
\begin{thm}[Fundamental Theorem of Algebra]
  Let $p$ be a polynomial with complex coefficients. Then there exists
  $z \in \mathbb{C}$ such that $p(z)=0$.
\end{thm}
```

Theorems

Theorem

A subset of the real line is compact if and only if it is closed and bounded.

Lemma

In any graph, the sum of the degrees of the vertices is twice the number of edges.

Theorem (Fundamental Theorem of Algebra)

Let p be a polynomial with complex coefficients. Then there exists $z \in \mathbb{C}$ such that $p(z) = 0$.

Proofs

```
\begin{proof}
Let $X$ be the set of all positive integers that are not
interesting. Suppose, for the sake of contradiction, that
$X\not=\emptyset$. By the well-ordering principle, $X$ contains a
least element $a$. Note that $a$ is the first noninteresting number,
but that's interesting! $\Rightarrow\Leftarrow$. Therefore,
$X=\emptyset$ and so all positive integers are interesting.
\end{proof}
```

Proof.

Let X be the set of all positive integers that are not interesting. Suppose, for the sake of contradiction, that $X \neq \emptyset$. By the well-ordering principle, X contains a least element a. Note that a is the first noninteresting number, but that's interesting! $\Rightarrow\Leftarrow$. Therefore, $X = \emptyset$ and so all positive integers are interesting. $\square$

Cross References

Numbered LaTeX structures can be given a label `\label{structure:cross-ref}` you can refer to that structure with the corresponding ref command

```
\ref{structure:cross-ref}
\pageref{structure:cross-ref}
\eqref{structure:cross-ref}
```

```
Remember the polynomial $g(x)$ in equation~\eqref{eq:polynomial}.
```

Remember the polynomial $g(x)$ in equation (1).

Citations

- Create a bibtex paper.bib file containing all the information about the references but no formatting information.

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- To process the files `paper.tex` and `paper.bib`, run these commands on your computer:

```
pdflatex paper
bibtex paper
pdflatex paper
pdflatex paper
```

Figures

Save figures as .pdf or .png.

```
\begin{figure}[ht]
\begin{center}
\includegraphics[width=0.10\textwidth]{doodle}
\end{center}
\caption{A doodle created with the Xfig program.}
\label{fig:doodle}
\end{figure}
```

Figure: A doodle created with the Xfig program.

Tables

```
\begin{center}
\begin{tabular}{l|c|r}
Left flush & Centered & Right Flush \\
\hline
Row 1 & Middle of row one & right side of row I \\
A second row & row \#2 & R2
\end{tabular}
\end{center}
```

Left flush	Centered	Right Flush
Row 1	Middle of row one	right side of row I
A second row	row #2	R2

Relations and operations

```
\begin{itemize}
\item Equality-like: $x=2$, $x \not= 3$, $x \cong y$, $x \propto y$,
$y\sim z$, $N \approx M$, $y \asymp z$, $P \equiv Q$.
\item Order: $x < y$, $y \le z$, $z \ge 0$, $x \preceq y$, $y\succ z$.
\item Arrows: $x \to y$, $y\gets x$, $A \Rightarrow B$, $A \iff B$,
$x \mapsto f(x)$, $A \Longleftarrow B$.
\item Set stuff: $x \in A$, $b \notin C$, $A \ni x$. Use
  \verb|\notin| rather than \verb|\not\in|.  $A \cup B$,
$X \cap Y$, $A \setminus B = \emptyset$, $A \subseteq B$, $B \supset Z$.
\item Arithmetic: $3+4$, $5-6$, $7\cdot 8 = 7\times8$,
  $3\div6=\frac{1}{2}$, $f\circ g$, $A \oplus B$,
  $v \otimes w$.
\item Mod: As a binary operation, use \verb|\bmod|: $x \bmod M$. As a
  relation use \verb|\mod|, \verb|\pmod|, or \verb|\pod|:
\item Calculus: $\partial F/\partial x$, $\nabla g$.
```

Relations and operations

- Equality-like: $x = 2$, $x \neq 3$, $x \cong y$, $x \propto y$, $y \sim z$, $N \approx M$, $y \asymp z$, $P \equiv Q$.
- Order: $x < y$, $y \leq z$, $z \geq 0$, $x \preceq y$, $y \succ z$.
- Arrows: $x \to y$, $y \leftarrow x$, $A \Rightarrow B$, $A \iff B$, $x \mapsto f(x)$, $A \Longleftarrow B$.
- Set stuff: $x \in A$, $b \notin C$, $A \ni x$. Use `\notin` rather than `\not\in`. $A \cup B$, $X \cap Y$, $A \setminus B = \emptyset$, $A \subseteq B$, $B \supset Z$.
- Arithmetic: $3 + 4$, $5 - 6$, $7 \cdot 8 = 7 \times 8$, $3 \div 6 = \frac{1}{2}$, $f \circ g$, $A \oplus B$, $v \otimes w$.
- Mod: As a binary operation, use `\bmod`: $x \bmod N$. As a relation use `\mod`, `\pmod`, or `\pod`:
- Calculus: $\partial F / \partial x$, ∇g.

Use the right dots

Do not type three periods; instead use `\cdots` between operations and `\ldots` in lists: $x_1 + x_2 + \cdots + x_n$ and $(x_1, x_2, \ldots, x_n)$.

Built up structures

```
\begin{itemize}
\item Fractions: $\frac{1}{2}$, $\frac{x-1}{x-2}$.
\item Binomial coefficients: $\binom{n}{2}$.
\item Radicals: $\sqrt{3}$, $\sqrt[3]{12}$, $\sqrt{1+\sqrt{2}}$.
\end{itemize}
```

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- Binomial coefficients: $\binom{n}{2}$.
- Radicals: $\sqrt{3}$, $\sqrt[3]{12}$, $\sqrt{1+\sqrt{2}}$.

Sums and Products

Do not use \Sigma and \Pi.

```
$$
\sum_{k=0}^\infty \frac{x^k}{k!} \not= \prod_{j=1}^{10} \frac{j}{j+1}.
$$
$$
\bigcup_{k=0}^\infty A_k
\qquad
\bigoplus_{j=1}^\infty V_j
$$
```

$$\sum_{k=0}^{\infty} \frac{x^k}{k!} \neq \prod_{j=1}^{10} \frac{j}{j+1}.$$

$$\bigcup_{k=0}^{\infty} A_k \qquad \bigoplus_{j=1}^{\infty} V_j$$

Integrals

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

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

The extra bit of space before the dx term is created with the `\,` command.

Limits

```
$$
\lim_{h\to0} \frac{\sin(x+h) - \sin(x)}{h} = \cos x .
$$
Also $\lim_{n\to\infty} a_n$.
```

$$\lim_{h\to 0} \frac{\sin(x+h) - \sin(x)}{h} = \cos x.$$

Also $\lim_{n\to\infty} a_n$.

Matrices

```
$$
  A = \left[\begin{matrix} 3 & 4 & 0 \\ 2 & -1 & \pi
            \end{matrix}\right] .
$$
```

$$A = \begin{bmatrix} 3 & 4 & 0 \\ 2 & -1 & \pi \end{bmatrix}.$$

In line:

```
  $A = \left[\begin{smallmatrix}1 & 0 \\ 0 &
  1\end{smallmatrix}\right]$.
```

$A = \left[\begin{smallmatrix} 1 & 0 \\ 0 & 1 \end{smallmatrix}\right]$.

A big matrix

```
$$ D = \left[ \begin{array}{ccccc}
      \lambda_1 & 0 & 0 & \cdots & 0 \\
      0 & \lambda_2 & 0 & \cdots & 0 \\
      0 & 0 & \lambda_3 & \cdots & 0 \\
      \vdots & \vdots & \vdots & \ddots & \vdots \\
      0 & 0 & 0 & \cdots & \lambda_n
    \end{array} \right].  $$
```

$$D = \left[\begin{array}{ccccc} \lambda_1 & 0 & 0 & \cdots & 0 \\ 0 & \lambda_2 & 0 & \cdots & 0 \\ 0 & 0 & \lambda_3 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & \lambda_n \end{array} \right].$$

Style and decorated letters

- Parentheses and square brackets are easy: $(x-y)(x+y)$, $[3-x]$.
- For curly braces use `\{` and `\}`: $\{x : 3x - 1 \in A\}$.
- Absolute values: $|x-y|$, $\|\vec{x}-\vec{y}\|$.
- Floor and ceiling `$\lfloor \pi \rfloor = \lceil e \rceil$`: $\lfloor \pi \rfloor = \lceil e \rceil$.
- To make delimiters grow so they are properly sized to contain their arguments, use `\left[`, `\right[` `\left\{`, `\right\}`:

$$\left[\sum_{n=0}^{\infty} a_n x^n\right]^2 = \exp\left\{-\frac{x^2}{2}\right\}$$

  Use `\bigl`, `\Bigl`, `\biggl`, and the matching `\bigr`, etc.

$$((x_1+1)(x_2-1)) = \bigl((x_1+1)(x_2-1)\bigr).$$

- Underbraces `$\underbrace{1+1+\cdots+1}_{\text{$n$ times}} = n$`

$$\underbrace{1+1+\cdots+1}_{n \text{ times}} = n\ .$$

Style and decorated letters

- Primes: `$a'$, $b''$` a', b''.
- Hats: `$\bar a$, $\hat a$, $\vec a$, $\widehat{a_j}$`. $\bar{a}$, $\hat{a}$, $\vec{a}$, $\widehat{a_j}$.
- Vectors are often set in bold: `$\mathbf{x}$` $\mathbf{x}$. Don't use `\textbf` in mathematics mode and don't use `\mathbf` in text mode.
- Calligraphic letters (for sets of sets): `$\mathcal{A}$` $\mathcal{A}$.
- Blackboard bold for number systems: `$\mathbb{C}$` $\mathbb{C}$.

Defining your own commands

- For example, if you refer to the positive orthant $\mathbb{R}^n_+$ frequently, put the following line in your preamble:

  ```
  \newcommand{\rnp}{\mathbb{R}^n_+}
  ```

  Type `$\rnp$` instead of `$\mathbb{R}^n_+$`.

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  ```
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  Type `$\rnp$` instead of `$\mathbb{R}^n_+$`.

- For example, suppose your paper uses column vectors frequently. We define a new command named `\col` like this:

  ```
  \newcommand{\col}[1]{\left[\begin{matrix} #1 \end{matrix} \right]}
  ```

  The `[1]` means that `\col` takes one argument. The `#1` shows where that one argument goes. Now we can type

  ```
  $$
  \col{1\\2\\3} + \col{-1\\3\\-2} = \col{0\\5\\1}
  $$
  ```

  easily.

Donald Knuth.
The TEXbook.
Addison-Wesley Professional, 1984.