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1 In a nutshell

When Donald Knuth (Professor Emeritus, Stanford University) published the second volume of *The Art Of Computer Programming*, the Monotype typecaster technology used in the previous version had become outdated, thereby making his work look awful. This incident motivated him to build TeX. Leslie Lamport then created \LaTeX\ in the early 1980s to provide a higher level language than TeX at many layers of abstractions. Nowadays \LaTeX\ is widely used in scientific documents in many fields, particularly mathematics, physics and computer science.

For more on the history of \LaTeX, take a look at [https://www.sharelatex.com/blog/2012/12/01/the-tex-family-tree-latex-pdftex-xelatex-luatex-context.html](https://www.sharelatex.com/blog/2012/12/01/the-tex-family-tree-latex-pdftex-xelatex-luatex-context.html).
2 Getting started

2.1 Create a project

- On ShareLaTex (https://www.sharelatex.com/), create a new project called “MATH 290”. This is where you will store all of your LaTeX files.

- A first .tex file called main.tex has been created for you. Replace the content of the file with the following:

\begin{verbatim}
\documentclass[12pt]{article}
\usepackage{amsmath, amssymb}
\title{My first \LaTeX\ document}
\author{My Name}
\begin{document}
\maketitle
\end{document}
\end{verbatim}

Your content goes in between \begin{document} and \end{document}.

2.2 Basic rules

- You can enter text normally as you do in any other text editor. However, all of the math formulas and symbols (some of which are listed in the next section) have to be wrapped in either $ $ (for inline display) or \[ \] (for centering).

<table>
<thead>
<tr>
<th>Code</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline: $8 \mid (2n+1)^2 - 1$</td>
<td>Inline: $8 \mid (2n + 1)^2 - 1$</td>
</tr>
<tr>
<td>Centering: $[8 \mid (2n+1)^2 - 1]$</td>
<td>Centering: $8 \mid (2n + 1)^2 - 1$</td>
</tr>
</tbody>
</table>

We use \[ \] very often to improve readability and also emphasize important math formulas.

- To get to a new line, either type \\ at the end of the current line or press Enter twice. The latter will be interpreted as starting a new paragraph, so text on the new line will be indented.
Normally you cannot have multiple lines in math mode because `\` is not allowed in `\[ \]`. To get around this, we use the \texttt{aligned} environment. In this environment (note that it is wrapped in math mode), `\` can be used as a line separator as usual:

\[
\begin{aligned}
\text{line 1} \\
\text{line 2} \\
\vdots
\end{aligned}
\]

Very often when we have multiple lines we want to align them in some way. To do this we use the `&` symbol on each line. Each line has one `&`, and anything after `&` will be aligned. For example, the following code

\[
\begin{aligned}
a^2 + b^2 + 2ab &= (a^2 + ab) + (b^2 + ab) \\
&= a(a + b) + b(a + b) \\
&= (a + b)^2
\end{aligned}
\]

will produce

\[a^2 + b^2 + 2ab = (a^2 + ab) + (b^2 + ab) = a(a + b) + b(a + b) = (a + b)^2\]

There are other kinds of environment that we will discuss later.
• You can structure your document using \section{Section Name}. Note that this is not a math formula and is therefore not wrapped in $ \$ or \[ \]. For your homework, the structure could be as follows:

\begin{document}
\maketitle

\section{Problem 1}

\section{Problem 2}

\section{Problem 3}

\end{document}

There are other kinds of header (chapter, subsection, subsubsection) that we will discuss later.

• Very often a math formula may span several lines (because of fractions or powers), while the enclosing brackets by default do not, resulting in not-so-elegant display. To fix this, we include \left and \right before the opening and closing bracket respectively.

<table>
<thead>
<tr>
<th>Code</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 1 + \frac{x^3}{5}} )^7</td>
<td>( (1 + \frac{x^3}{5})^7 ) (eww!)</td>
</tr>
<tr>
<td>\min { x + \frac{1}{x} \Big\vert x &gt; 0 }</td>
<td>( \min{x + \frac{1}{x} \big</td>
</tr>
<tr>
<td>\left( 1 + \frac{x^3}{5} \right)^7</td>
<td>( (1 + \frac{x^3}{5})^7 )</td>
</tr>
<tr>
<td>\min \left{ x + \frac{1}{x} \Big\vert x &gt; 0 \right}</td>
<td>( \min\left{x + \frac{1}{x} \big</td>
</tr>
</tbody>
</table>

3 Math symbol table

### 3.1 Common math symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>\mid</td>
<td>\equiv</td>
<td>\sum</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>\ge</td>
<td>\le</td>
<td>\neq</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\to</td>
<td>\rightarrow</td>
<td>\Rightarrow</td>
<td>\Leftarrow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\vdots</td>
<td>\cdot</td>
<td>\ldots</td>
<td>\infty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>\min</td>
<td>max</td>
<td>\max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\in</td>
<td>\notin</td>
<td>\forall</td>
<td>\forall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\exists</td>
<td>\forall</td>
<td>\emptyset</td>
<td>\emptyset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\times</td>
<td>\emptyset</td>
<td>\cup</td>
<td>\cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\mathbb{N}</td>
<td>\pm</td>
<td>\subseteq</td>
<td>\subset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>{</td>
<td>}</td>
<td>\underbrace</td>
<td>\underbrace</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 Common math expressions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x^{10} )</td>
<td>{10}</td>
<td>( \frac{11}{20} )</td>
<td>{11}{20}</td>
<td>( \sqrt{x^2+y^2} )</td>
<td>{\sqrt{x^2+y^2}}</td>
</tr>
<tr>
<td>( x_{10} )</td>
<td>( \log_{10}100 )</td>
<td>( \log_{10}{100} )</td>
<td>( \lim_{i=1}^{100} )</td>
<td>( \prod_{i=1}^{100} )</td>
<td>( \binom{n+k}{k} )</td>
</tr>
<tr>
<td>( \sqrt[3]{27} )</td>
<td>( \sum_{i=1}^{100} )</td>
<td>( \sum_{i=1}^{100} )</td>
<td>( \prod_{i=1}^{100} )</td>
<td>( \int_0^2 x^2 dx )</td>
<td>( \int_0^2 x^2 dx )</td>
</tr>
<tr>
<td>( \frac{a}{b} )</td>
<td>{a}_{b}</td>
<td>{a}_{b}</td>
<td>{a}_{b}</td>
<td>{a}_{b}</td>
<td>{a}_{b}</td>
</tr>
</tbody>
</table>

In the above operations, the braces {} can be omitted if what is contained in it is a single character. For example, \( x^5 \) is the same as \{5\} or \( \frac{1}{2} \) is the same as \frac{1}{2}. However, \( x^{10} \) yields \( x^{10} \) while \( x^{10} \) yields \( x^{10} \).

### 3.3 Common greek letters

Simply precede a letter’s name by a \. For example: \( \pi, \phi, \ksi, \omega, \sigma, \)
3.4 Fun symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>♥</td>
<td>\heartsuit</td>
<td>□</td>
<td>\box</td>
<td>◊</td>
<td>\Diamond</td>
</tr>
<tr>
<td>★</td>
<td>\bigstar</td>
<td>⊗</td>
<td>\circledast</td>
<td>*</td>
<td>\divideontimes</td>
</tr>
<tr>
<td>©</td>
<td>\copyright</td>
<td>⌲</td>
<td>\LaTeX</td>
<td>▼</td>
<td>\ddot{\bigtriangledown}</td>
</tr>
<tr>
<td>≅</td>
<td>\ddot{\text{frown}}</td>
<td>∼</td>
<td>\ddot{\text{-}}</td>
<td>⌢</td>
<td>\ddot{\text{smile}}</td>
</tr>
</tbody>
</table>

4 Exercises

4.1 Basic practice

Try to produce the following expressions:

\[ 6^{28} \equiv 1 \pmod{29} \]
\[ \left( \frac{x}{p} \right)^4 + \left( \frac{y}{p} \right)^4 = \left( \frac{z}{p^2} \right)^2 \]
\[ \mathbb{N}^+ = \{ n \in \mathbb{N} \mid n > 0 \} \]
\[ \exists c \in (a, b) : f'(c) = \frac{f(b) - f(a)}{b - a} \]
\[ (p - 1)! \equiv -1 \pmod{p} \]
\[ x^2 + x + 1 \geq \frac{3}{4} \forall x \in \mathbb{R} \]
\[ b^2 \pm \sqrt{\Delta} \]
\[ \frac{2a}{2a} \]
\[ \frac{9}{a + b + c} \]
\[ \frac{a}{b} + \frac{b}{c} + \frac{c}{a} \geq 3 \forall a, b, c > 0 \]
\[ e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} \]
\[ b^2 = \sum_{n=0}^{\infty} \frac{x^n}{n!} \]
\[ \frac{1}{a + b} + \frac{1}{c} \geq \frac{9}{a + b + c} \]
\[ \mathbb{N}^+ = \{ n \in \mathbb{N} \mid n > 0 \} \]
\[ x^2 + x + 1 \geq \frac{3}{4} \forall x \in \mathbb{R} \]
\[ \exists c \in (a, b) : f'(c) = \frac{f(b) - f(a)}{b - a} \]
\[ (p - 1)! \equiv -1 \pmod{p} \]
\[ x^2 + x + 1 \geq \frac{3}{4} \forall x \in \mathbb{R} \]
\[ \exists c \in (a, b) : f'(c) = \frac{f(b) - f(a)}{b - a} \]
\[ (p - 1)! \equiv -1 \pmod{p} \]
\[ x^2 + x + 1 \geq \frac{3}{4} \forall x \in \mathbb{R} \]

4.2 Further practice

Practice with writing a complete document by reproducing the file at

Appendix A  Local $\LaTeX$ installation instructions

If you don’t want to deal with technical details, stick to ShareLaTeX (https://www.sharelatex.com/project) as it’s easy to use / collaborate / distribute and requires no installation. However, if you prefer to work offline, you can follow the instructions below.

A.1 For Windows

1. Download MikTeX at http://miktex.org/ Run the .exe file to install.

2. MikTeX comes with a default text editor called TeXworks. However, we recommend that you use Texmaker instead at http://www.xm1math.net/texmaker/download.html.

3. Install and start Texmaker. Use $\text{Ctrl+N}$ to create a new file or $\text{Ctrl+O}$ to open an existing file.

4. Enter code, press $\text{Ctrl+S}$ to save. There are 2 drop-down menus on the toolbar. Pick the one on the left, select $\text{Quick Build}$ and click on the blue arrow next to it. Texmaker will compile your code.

5. Any error or warning will show up on the bottom screen. Otherwise, an output PDF file is generated.

There are many other text editors available on Windows, such as TeXnicCenter at http://www.textriccenter.org/ and TeXstudio at http://www.texstudio.org/.

A.2 For OS X

1. Download MacTeX at https://tug.org/mactex/ and install.

2. MacTeX comes with a default text editor called TexShop, but we also recommend Texmaker. Download the distribution for OS X and follow the instructions above for Windows.

A.3 For Linux

If you work on Linux, it is likely that LaTeX is already installed on your system.

A.4 An environment for geeks

If you work on a Unix (OS X / Linux) operating system and prefer the hacker-ish way, you can write LaTeX code on any plain text editor (emacs, vim, Atom, Sublime Text, ...) and run the code on the terminal:
cd my-workspace  # the folder that contains your tex file
pdflatex myfile.tex  # compile code
open myfile.pdf    # open the output PDF.

Note that the open command may vary depending on the operating system.

We can create an alias in PROFILE so that each time we run LaTeX, only one command is needed:

    cd
    nano .bash_profile  # .bash_profile for OS X, .bashrc for Linux

Enter the following code to .bash_profile:

    alias runtex=latex
    latex(){
        t='.tex'
        p='.pdf'
        pdflatex $1$t
        open $1$p
    }

Compile the file by either entering

    source .bash_profile

or closing and reopening the terminal. From then, you can run LaTeX code (assume you are already in the correct directory) by simply typing

    runtex myfile  # no file extension. It will automatically be appended for you.