\LaTeX Example

ECS 120

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Non-numbered section

Sections are a good way to break up homework solutions by problem.

1 Numbered section

Or you can use a numbered section.

2 How to do things that are easy in a word processor

Normal text appears mostly as you type it. A notable exception is “quotation marks”; the left ones are wrong if you use the ”normal quotes”. Whitespace is ignored, but you can introduce more spaces between words if you want. I like to keep sentences on separate lines in the \LaTeX code, but this will not introduce a new paragraph.

To start a new paragraph, you need two newlines in the \LaTeX code.

You can also force text to appear on the next line in the same paragraph.

You can make text \textbf{bold}, or in \textit{italics}, or \underline{underlined}. Instead of italics, I prefer to use \textit{emphasis}, because of Theorem 5.4.

You can create numbered lists:

1. first numbered list item
2. By using labels, you can reference the list numbers so they automatically update if you add or delete items.
3. This is a reference to the labeled list item, which is number 2. You may have to compile twice to get the number correct.

You can also create bullet-point lists:

- first bullet list item
- second bullet list item

The \texttt{verbatim} environment is good for writing code, not only because it uses a fixed width font, but also because nothing in it is interpreted as a \LaTeX command:
int x = 5; // \texttt{initial} position
double y = x*x;

You can also use it \textit{inline}, but often what you really want instead is merely \texttt{fixed width font}, in which you can still have \LaTeX \texttt{commands such as \textit{italics}}.

Hyperlinks show up in PDF documents compiled from \LaTeX: link to course page
You can also just display a URL that is itself a link (for some reason this displays tilde characters better than the previous): https://smartsite.ucdavis.edu/portal/site/fall2015ecs120

3 How to write mathematics

Readable mathematical notation is the main reason to use \LaTeX instead of a word processor. There’s much more to math in \LaTeX than this, but I want to give just the basics that will be most of what is needed for this course.

You can put math in the same line as the text like this: $x = 5$. Or you can put it on its own line like this:

\begin{align*}
x &= 5.
\end{align*}

You can also number equations:

\begin{align*}
x &\neq 6. \tag{1}
\end{align*}

Now we can reference equation (1).

Multiline equations are also useful:

\begin{align*}
x &= y + z \\
&\leq 2y \\
&< 3y \quad \text{if } y > 0
\end{align*}

It’s possible to number these also, or number only some of them:

\begin{align*}
x &= y + z \tag{2} \\
&\leq 2y \\
&< 3y \tag{3}
\end{align*}

And we can make a reference to inequality (3).

Here’s a list of common useful math symbols:

\begin{itemize}
\item $x^2$. Use curly braces to superscript multiple characters, so you get $x^{100}$ instead of $x^{100}$.
\item $n_2$, $x_n^2$, $x_n^2$, $O(n \log n)$, $\hat{x}$, $\overline{A}$, $x'_1$, $x''_n$
\item Plain text in math mode: $\{ p \in \mathbb{N} \mid p \text{ is prime} \}$
\item Spaces in math mode: $\{ p \in \mathbb{N} \mid p \text{ is prime} \}$
\item $\frac{\pi^2}{6} = \sum_{n=1}^{\infty} \frac{1}{n^2}$
\item $\zeta(z) = \prod_{n=1}^{\infty} \frac{1}{1-p_n^{-z}}$
\end{itemize}
• \( N = \{0,1,2,\ldots\} = \mathbb{Z} \setminus \{-1,-2,\ldots\} \subseteq \mathbb{Z} \subset \mathbb{Q} \subset \mathbb{R} \not\subseteq \mathbb{R}^+ \)

• Greek letters: \( \alpha, \beta, \gamma, \Gamma, \delta, \Delta, \epsilon, \zeta, \eta, \theta, \Theta, \kappa, \lambda, \Lambda, \mu, \nu, \xi, \Xi, \pi, \Pi, \rho, \sigma, \tau, \phi, \Phi, \chi, \psi, \Psi, \omega, \Omega \)

• complexity classes: \( P, \text{NP}, \text{DTIME}(n^3) \)

• \( \Sigma^*, \{0,1\}^* \)

• \( \delta : Q \times \Sigma \to Q \)

• \( (\forall X) |\mathcal{P}(X)| > |X| \)

• \( \lim_{n \to \infty} \frac{1}{n} = 0 \)

• \( (\forall n \in \mathbb{N})(\exists m \in X)m > n \iff |X| = \infty \implies |X| \geq |\mathbb{N}| \)

• \( A \cup (B \cap C) = (A \cup B) \cap (A \cup C) \)

• \( \Sigma^* = \bigcup_{i=0}^\infty \Sigma^i \)

Note how ugly this looks:
\[
\left( \frac{1}{n^2} \right)
\]

Use \texttt{\left} and \texttt{\right} to make pairs of matching delimiters big enough for the text they contain:
\[
\left( \frac{1}{n^2} \right)
\]

For defining sets where you want the vertical line in the middle to scale with the text size, it is useful to have a “phantom delimiter” (represented by a period):
\[
X = \left\{ n^2 \middle| n \in \mathbb{N} \right\}
\]

Of course this only works if you guess properly whether the left or right is bigger, which failed here:
\[
X = \left\{ n \middle| \frac{n^2}{2^{n^3}} \geq \frac{1}{10} \right\}
\]

4 Commands

You can define commands that act like macros. These both look the same, but one is easier to type: \texttt{NP} and \texttt{NP}. If \LaTeX{} complains that the command is already defined, redefine it.

And then use it: \texttt{NP}

Commands can take arguments. We can make a command for the “make set delimiter big enough for the left-hand text” idea, which takes two arguments whose names are \#1 and \#2,

and then we can call it with two arguments: \( X = \left\{ \frac{n^2}{2^{n^3}} \middle| n \in \mathbb{N} \right\} \)

In this document I’m defining commands as we go, but the normal way to do it would be to define them in the preamble (the part before \texttt{\begin{document}}).
5 Theorems/Lemmas/Definitions/etc.

Using the package `amsthm` alone does not provide environments for theorem/lemma/definition/etc. You have to define your own using the `\newtheorem` command.

**Definition 5.1.** Given \( n \in \mathbb{N} \), let \( \pi(n) = |\{ p \in \mathbb{N} | p \leq n \text{ and } p \text{ is prime }\}|. \)

**Theorem 5.2.** \( \lim_{n \to \infty} \frac{\pi(n)}{\ln n} = 1. \)

**Proof.** I don’t remember. \( \square \)

The following is a corollary of Theorem 5.2:

**Corollary 5.3.** There are an infinite number of primes.

**Theorem 5.4.** In an environment where the text is already italicized, using the italics command will not change it, but it can still be emphasized with the command `\emph`.

6 Figures

To include a figure that is a PDF file or a PNG file, use the `figure` environment. It is famously difficult in \( \LaTeX \) to get figures to go where you want them to; that’s why it’s important to label them so you can refer to them, such as Figure 1.