Tips for typesetting mathematics in LaTeX

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Useful packages.

(1) Put `\usepackage{verbatim}` in your preamble. Throughout this document, I'm using `\verb` and `\begin{verbatim}...\end{verbatim}` extensively. It's also good for documenting code.
(2) Put `\usepackage{a4wide}` in your preamble.
(3) If you're using `\documentclass{article}`, you'll need to load the math packages `\usepackage{amsthm,amssymb,amsfonts}`. If you're using `\documentclass{amsart}`, these are loaded automatically.
(4) The packages `\usepackage{enumerate}` and `\usepackage{enumitem}` clash. Use one, but not both.

Typesetting mathematics in LaTeX.

(1) Use `\colon` for functions and `:` for sets, e.g.,

Right:	$f\colon X \longrightarrow Y$,	and	$\{x \in \mathbb{R} : x > 0\}$
Wrong:	$f : X \longrightarrow Y$,	and	$\{x \in \mathbb{R}\colon x > 0\}$

(2) Use `|` for absolute value, and `\mid` for "divides" and sets, e.g.,

Right:	$\lvert x\rvert > 0$	and	$p \mid n$,	and	$\{x \in \mathbb{R} \mid x > 0\}$
Wrong:	$\lvert\, x \,\rvert > 0$	and	$p\lvert n$,	and	$\{x \in \mathbb{R}\lvert x > 0\}$

(3) Use the correct quotation marks. Left quotes should be two backticks (on the same key as ~), and right quotes should be two apostrophes (same key as the double quotation mark.) If you type how you would in an email, it will look "wrong." Compare this to the "correct" version.
(4) Never write three periods in a row for an ellipsis...it looks bad... this is better.
(5) Choose the right dots: "Low" (`\ldots`) $x_1, \ldots, x_n$, vs. "center" (`\cdots`) $x_1 + \cdots + x_n$ vs. "LaTeX chooses" (`\dots`).
(6) Add a backslash after an abbreviation with a word like a period in the middle of a sentence, so the spacing is normal. No slash looks like etc. and vs. but with a slash that looks like etc. and vs. which has the correct spacing. It's subtle, but still should be done right. Compare: Dr. Who to Dr. Who.
(7) When writing a sentence with variables, always put them in math mode. Compare "let d be a divisor of n," vs. "let d be a divisor of n."
(8) Use the built-in functions, like `\sin` and `\log`, rather than just typing those letters. Compare: $\sin(x)$ and $\log(x)$, vs. $sin(x)$ and $log(x)$.
(9) Don't know how to make a math symbol in LaTeX? Try Detexify (`https://detexify.kirelabs.org/classify.html`). ChatGPT can also be very helpful.
(10) There are built-in commands for itemized lists `\begin{itemize}\end{itemize}` and `\begin{enumerate}\end{enumerate}`. Don't try to do them manually.
(11) There is an enumerate and an enumitem package for customizing lists, but they clash. Pick one. You can customize how nests lists are numbered in your preamble.
(12) Use `\ref{foo}\verb` for theorems, definitions, etc., and `\eqref{foo}\verb`: for equations Eq. 1 vs. Eq. (1).
(13) Use `\DeclareMathOperator`, when appropriate. For example, if you make up a definition, say, then "normal Eulerian form" (NEF) of a permutation π, then typeset it as $\mathrm{NEF}(\pi)$, or as $\mathsf{NEF}(\pi)$, but *not* as $NEF(\pi)$, which just looks bad.

Good practices within your code.

(1) For clarity in your LaTeX file, use spacing like

```
\[
a^2+b^2=c^2
\]
```

rather than just `\[a^2+b^2=c^2\]`, but remember that you can't have a blank line between `\[` and `\]`. Note that if you leave a space after `\]` then it will indent the next paragraph; otherwise it won't.

(2) I like to add commented out lines in my code for organization, e.g., to separate sections or HW problems. Things like this:

```
%%-------------------------------------------------------------------
```

It's also nice to use comments like this to highlight a section. For example:

```
%%====================================
\section{Introduction}\label{sec:intro}
%%====================================
```

(3) Specify in your labels whether you're referring to a definition, equation, theorem, proposition, figure, etc. I like to use, e.g., `\label{def:catalan}`, `\label{eq:recurrence}` `\label{thm:recurrence}`, `\label{prop:recurrence}`, `\label{fig:catalan}`.

(4) Familiarize yourself with the very useful `\iffalse` ... `\fi` commands, which allow you to remove lines or sections quickly, by commenting / uncommenting a single line.

(5) You don't need `{}` around single characters; it only adds clutter in your code. For example, x_2^3 can be typeset as `x_2^3`, whereas x_{20}^{30} indeed requires `x_{20}^{30}`.

Stylistic writing tips.

- Never begin a sentence with a variable.
- If a theorem or proposition is just a formula, make sure you start with an actual sentence; don't only give the formula on its own.
- Be generous with using display mode for long equation (`\[ ... \]`) rather than just putting them in the text (`$ ... $`). It improves readability and presentation.
- Write $x_1, \dots, x_n$ instead of $x_1, x_2, \dots, x_n$. [Up to you if $x_0, \dots, x_n$ or $x_0, x_1, \dots, x_n$ is best.]
- Note the difference in arrows: $\to$ goes between sets, and $\mapsto$ goes between elements. For example,

$$f\colon X \longrightarrow \mathbb{R}, \qquad f\colon x \longmapsto xAx^{-1}.$$

Personally, I like using the ordinary length arrows in a sentence, but the longer arrows when in a "display equation."

- Make sure that you add proper punctuation, like commas and periods, to sentence that have equations in them. For example, if

$$f(x) = \sum_{n=0}^{\infty} a_i x^i \qquad \text{and} \qquad g(x) = \sum_{n=0}^{\infty} b_j x^j,$$

then their product is the convolution

$$f(x)g(x) = \sum_{n=0}^{\infty} c_n x^n \qquad \text{where} \qquad c_n = \sum_{k=0}^{n} a_k b_{n-k}.$$

- Don't number equations unless you plan to reference them. Adding a * in, e.g., `\begin{align*}`, represses numbers. Or you can use `\nonumber` on individual lines.

- The alignat packages comes with amsmath. It's very good for making multiline equation with an extra column for explanations, like this:

$$\begin{aligned} T_G(1,1) &= T_{G/e}(1,1) + T_{G-e}(1,1) && \textit{since } e \textit{ is neither a bridge nor loop} \\ &= t(G/e) + t(G-e) && \textit{by induction} \\ &= t(G) && \textit{recursive property of spanning trees.} \end{aligned}$$

Theorem, definition, and proof environments.

(1) Never manually write, e.g., "**Theorem**"; there is a customizable built-in package for this. However, you have to set it up in your preamble. Here is the most common:

```
% 1. Plain style for major results (e.g., theorems, lemmas, corollaries).
% The body of the text will be italicized.
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}[section] % Resets the counter at each new section.
\newtheorem{lemma}[theorem]{Lemma}     % Shares same counter as the theorem.
\newtheorem{corollary}[theorem]{Corollary}
\newtheorem{proposition}[theorem]{Proposition}
\newtheorem{conjecture}[theorem]{Conjecture}

% 2. Definition style for descriptive and non-italicized text.
% The body of the text will be in an upright (roman) font.
\theoremstyle{definition}
\newtheorem{definition}[theorem]{Definition}
\newtheorem{example}[theorem]{Example}
\newtheorem{remark}[theorem]{Remark}

% 3. Remark style for notes and commentary (also upright text).
% By default, this has less space above and below the environment.
\theoremstyle{remark}
\newtheorem*{note}{Note} % The * creates an unnumbered environment.
```

(2) Similarly, never manually write "**Proof**." Use the `\begin{proof}...\end{proof}` environment for proofs. It also adds a □ at the end automatically.

(3) A good rule of thumb for theorem vs. proposition vs. lemma is:
   - Theorem: for a main result.
   - Proposition: for a stand-alone results of lesser impact.
   - Lemma: a result whose primary purpose is to prove a bigger result. When deciding whether to use lemma or proposition, ask yourself questions like: "*if it wasn't for the bigger result, would we be highlighting this?*"
   - Corollary: for a result whose proof follows (usually) easily from a theorem or proposition.

(4) Never "hard code" references to theorems, etc. That is, always use a reference, like `\label{thm:infinite-primes}`, and then type `Theorem~\ref{thm:infinite-primes}`, rather than `Theorem 1`.

(5) A tilde is a space that prevents a line break. For example, `Theorem \ref{thm:foo}` and `Theorem~\ref{thm:foo}` will look the same, but the latter will always keep the number on the same line as "Theorem."

(6) I often seen people putting more things in environments like **Remark** and **Example**, etc. than are needed. Though these have their place, often it's just easier to write them directly in the text.

Miscellaneous tips.

(1) Personally, I don't like how either $\sum_{i=1}^{\infty} x^i$ or $\sum_{i=1}^{\infty} x^i$ looks when in the main body—the first is too small, and the second is too big. However, there is another alternative: $\sum\limits_{i=1}^{\infty} x^i$. This uses the `\limits` command. I use the following macro, and also do it for product, limit, union, and intersection. `\def\Sum{\sum\limits}`.

(2) Sometimes, it's nice to stretch the rows or columns of a table or array. You can do that with the following commands:

```
\renewcommand{\arraystretch}{1.4}     % stretch the rows by a factor of 1.4
\setlength{\tabcolsep}{9pt}           % stretch the columns; 6pt is default
```

LaTeX macros.

Use macros for convenience. For example, I use the following:

```
\def\<{\langle}
\def\>{\rangle}
\def\longto{\longrightarrow}
\newcommand{\C}{\mathbb{C}}     %% Some people prefer \CC or \CCC or \bbC
\newcommand{\F}{\mathbb{F}}
\newcommand{\N}{\mathbb{N}}
\newcommand{\Q}{\mathbb{Q}}
\newcommand{\R}{\mathbb{R}}
\newcommand{\Z}{\mathbb{Z}}
\def\And{\wedge}
\def\Or{\vee}
\def\Not{\neg}
%% \def\Not[1]{\overline{#1}}      %% Uncomment this for an alternative
\DeclareMathOperator{\lcm}{lcm}
\newcommand{\Red}[1]{\textcolor{red}{#1}}
\newcommand{\Blue}[1]{\textcolor{blue}{#1}}
\newcommand{\vv}[2]{\begin{bmatrix} #1 \\ #2 \end{bmatrix}}
\newcommand{\vvv}[3]{\begin{bmatrix} #1 \\ #2 \\ #3 \end{bmatrix}}
\newcommand{\vvv}[4]{\begin{bmatrix} #1 \\ #2 \\ #3 \\ #4 \end{bmatrix}}
\newcommand{\ceil}[1] {\left\lceil #1 \right\rceil}
\newcommand{\floor}[1] {\left\lfloor #1 \right\rfloor}
\DeclareMathOperator{\Span}{Span}
\DeclareMathOperator{\Trace}{tr}
\def\normal{\lhd}
\def\normaleq{\unlhd}
\def\nnormal{\ntriangleleft}
\def\nnormaleq{\ntrianglelefteq}
```