A Guide to LaTeX

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0 Downloading LaTeX

Follow instructions on the main TeX website: `http://www.ctan.org/starter`

0.1 Mac OS X

MacTeX: `http://tug.org/mactex/`

0.2 Windows

MiKTeX (recommended): `http://www.miktex.org/download`
proTeXt: `http://www.tug.org/protext/`

0.3 Linux

TeX Live: `http://tug.org/texlive/acquire-netinstall.html`

Section 1 and parts of sections 2 and 3 of this document are from Dr. Gregory D. Landweber.

1 A Brief History of Typesetting

1.1 Handwritten manuscripts

Copying books and other manuscripts by hand takes time and produces very few copies. That's good for out-of-work monks, but bad for Sophocles when his plays burned with the library at Alexandria. To this day, the Hebrew Torah is still copied by hand onto a scroll of parchment.

1.2 The printing press (1436)

Good for Gutenberg and the protestant reformation. Prompts monks to pursue other things, like brewing beer. Gives rise to the typesetting industry, putting together printed manuscripts one character at a time.

1.3 The typewriter (late 1800's)

Good for people with bad handwriting. Bad for carpal tunnel.

1.4 The Linotype machine (1880's)

Automates typesetting a whole line o' type (get it? line o' type → linotype) at a time. Great for newspapers and font designers.

1.5 The laser printer (1970's)

Ushers in the age of digital typesetting, and with it the tradition of publishers mangling authors' manuscripts in the typesetting process.

1.6 TEX (1978)

A markup language allowing the author to digitally typeset his own manuscripts. Created by the computer scientist Donald Knuth while on sabbatical from Stanford, as a response to the mangled galley proofs of the second edition of *The Art of Computer Programming* (as well as his disgust with the typesetting in maths journals). Described in *The TEXbook* (1984).

1.7 $\mathcal{AMS}$-TEX (1982–1985)

A macro package written by Michael Spivak and described in *The Joy of TEX*. Simplifies typesetting various mathematical constructions, and used by the American Mathematical Society for its journals. Superseded by $\mathcal{AMS}$-LATEX.

1.8 LATEX (1983–1985)

A high-level language consisting of an extensive set of macros that sits on top of TeX and reorganizes its functionality. Created by Leslie Lamport, who is now at Microsoft Research. Described in *LATEX: A document preparation system* (1985).

1.9 WYSIWYG (1984)

Apple introduces the Macintosh with its graphical user interface and "What You See Is What You Get" word processing. Microsoft releases Word. Popularizes the Geneva, New York, and Chicago fonts, which look awful when printed on a dot matrix printer.

1.10 Desktop publishing (1985)

Apple introduces the LaserWriter, a "personal" laser printer costing $7000 and the first to use Adobe's PostScript page description language. Aldus introduces PageMaker, a graphical layout program.

1.11 $\mathcal{AMS}$-LATEX(1990)

The AMS (American Mathematical Society) ports $\mathcal{AMS}$-TEX's functionality to LATEX, to allow for mathematical typesetting.

1.12 LATEX 2ϵ (1994)

The latest update to LATEX, which re-organizes LaTeX rather significantly. A compatibility mode is provided to process old LATEX.

1.13 $\mathcal{AMS}$-LATEX 1.2 (1995)

The latest update to $\mathcal{AMS}$-LATEX, ported to LATEX 2ϵ.

1.14 TEX 3.141592 (2002)

The latest version of TEX. No bugs found in years!

2 LaTeX Basics

LaTeX takes care of the word wrapping, margin justification, paragraph spacing, and everything else that you would otherwise tweak yourself in a word processor. The algorithms it uses are quite clever. All of the spacing is flexible, and LaTeX adjusts it to make the entire paper look as good as possible. It tries to avoid widows and orphans, i.e., lines with only one word on them, or paragraphs that spill over with just one line on a new page. It keeps track of a measure of "badness", and will make the spacing on one page slightly worse if that improves the spacing on another page significantly. All without any effort on your part. Try that in Microsoft Word!

2.1 The different files

.tex: Where you write up the LaTeX. In this file, the document looks a lot like programming code or HTML.

console: After pressing 'Typeset' (or equivalent for your TeX editor), this will pop up in a window and scroll through a variety of messages. If the program encountered an error while trying to typeset your document, it will appear here.

.aux, .log, .synctex.gz: Generated during typesetting. In general, leave these alone and don't worry about them.

.pdf: The final typeset document.

.cls: 'Class file', a supplementary file that defines the structure of a LaTeX document (examples: letter, article, thesis, ApJ article).

.sty: 'Style file', a supplementary file containing information about how LaTeX should format the structure document. This is like the 'form' component to a class file's 'function' component. Both class files and style files are frequently referred to as 'packages'.

The 'Typeset' button, or [command T]/[control T] shortcut, is what turns the .tex file into a .pdf. This is sometimes referred to as 'compiling', since LaTeX is reminiscent of computer code.

2.2 The basic `.tex` document structure

A simple LaTeX document has the following fundamental structure:

- specify document class
- import/use packages
- define title (not always needed)
- begin document (you really do need to tell it every little thing)
- make title (not always needed)
- text, body of the document
- end document (if it's begun, it must end!)

MacTEX comes pre-loaded with templates, which have this already laid out. You can even make your own template! A basic .tex document looks like this:

```
\documentclass[12pt]{article}
\usepackage{geometry}
\geometry{a4paper}
\usepackage{graphicx}
\usepackage{amssymb,amsmath}
\title{Title here}
\author{Your name here}
\date{\today}
\begin{document}
\maketitle
Body text here.
\end{document}
```

Commonly used packages that I've put into my own template are 'latexsym', 'MnSymbol', 'marvosym', 'url', 'ulem', 'comment', 'epstopdf', 'tabularx', 'amsfonts', 'setspace', 'cite', and 'mathtools'. I'm fairly certain that all of these came with MacTEX.

2.3 List styles and formatting

The 'enumerate' environment is used for numbered lists:

1. This is something.
2. So is this.

```
\begin{enumerate}
\item This is something.
\item So is this.
\end{enumerate}
```

The 'itemize' environment is used for point lists:

- Hey look it's a point-form list.
- This is fun.

```
\begin{itemize}
\item Hey look it's a point-form list.
\item This is fun.
\end{itemize}
```

The 'description' environment is used for customized lists:

a. Here's the first line.

$\Psi_{\odot}$ And another line.

Thirdly, The last line.

```
\begin{description}
\item[a. ] Here's the first line.
\item[$\downpitchfork_{\odot}$] And another line.
\item[Thirdly,] The last line.
\end{description}
```

Section 2.1 above uses the 'description' environment. Lists will nest, so you can have bullet points as one item in a numbered list. In general, 'enumerate' and 'itemize' are indented, while 'description' is not, as you see in the examples above.

Documents can be structured using `\section{Section title}`, `\subsection{Subsection title}`, and `\subsubsection{Subsubsection title}`. These are automatically numbered, and subsections are numbered within the section. You may also be interested in the 'align' environment for tables and matrices. The LaTeX wikibook has an excellent demonstration of this.

2.4 Helpful tips

- If a symbol won't typeset (i.e., you get an error in the console), try making it in math mode (explained below) and/or putting a backslash `\` in front of it. Or Google the character name and "LaTeX". Maybe turn 'safe-search' on first though.
- Line breaks: an empty line gives a paragraph break, or you can force it with `\\` at the end of the text. Sometimes the console complains about this, so if that happens, take the line break out.
- Keep in mind that LaTeX decides how it wants to space out the words in a line, and it can be difficult to force specific spacing.
- Beginning quotes use two ` keys, next to the 1 on most laptop keyboards. Ending quotes are the standard '.
- Comments are indicated by a preceding % key. This will turn the comment text red in TeXShop. Anything commented out will be ignored when typesetting.
- LaTeX commands are case-sensitive.
- Things that have a `\begin{ }` and `\end{ }` are called 'environments'.

3 Typesetting Mathematics

In-line equations use `$` *math* `$`. This I will refer to as 'math mode'. Displaymath mode, where the equation is centered in its own line, uses `$$` *math* `$$`.

3.1 A simple in-line equation

$y = mx + b$

```
$ y = mx + b $
```

3.2 Fractions

$$\frac{1}{\beta+\eta}$$

```
$ \frac{1}{\beta + \eta} $
```

$$\frac{1}{\alpha + \Phi}$$

```
$$ \frac{1}{\alpha + \Phi} $$
```

3.3 Sub- and superscripts

$$E_i = m_i c^2$$

```
$$ E_{i} = m_{i} c^{2} $$
```

3.4 Summation

$$y = \sum_{i=1}^{10} 2^i$$

```
$$ y = \sum_{i=1}^{10} 2^{i} $$
```

3.5 Integration

$$F(b) - F(a) = \int_a^b f(x)\,dx$$

```
$$F(b) - F(a) = \int_{a}^{b} f(x) dx $$
```

3.6 Combining equation commands

$$\frac{2\,G\,M}{R\,c^2} = \frac{2M_{gr}}{R_{gr}}$$

$$\chi^2 = \sum_{i=1}^{N} \left(\frac{F_{i,a} - F_{i,b}}{\sigma_i}\right)^2$$

$$v = \frac{2\pi\nu_\star\, R\,\sin\theta}{\sqrt{1\,-\,2M/R}}$$

$$E_\mathrm{g} = -\int_{m_1}^{m_2} \frac{Gm}{r}\,dm$$

```
$$ \frac{2 G M}{R c^2} = \frac{2M_{gr}}{R_{gr}} $$

$$ \chi^{2} = \sum_{i=1}^{N} \left(\frac{F_{i,a} - F_{i,b}}{\sigma_i}\right)^{2} $$

$$ v = \frac{2\pi\nu_{\star} R \sin\theta}{\sqrt{1-2M/R}} $$

$$ E_{\text{g}} = -\int^{m_{2}}_{m_{1}} \frac{G m}{r} dm $$
```

Note that math mode doesn't require `$` or `$$` notation — for example, you could use the 'equation' environment or `\[`. Find one that works for you and use it consistently. Also, LaTeX ignores spaces when in math mode, and line breaks in the wrong places while in math mode can confuse it and give you errors.

3.7 Aligning equations and matrices

Another cool math feature is aligning equations:

$$x + y = 1$$
$$x - y = 3$$

is written as

```
\begin{align}
x + y &= 1 \\
x - y &= 3
\end{align}
```

where `&` is the alignment character and `\\` denotes the end of a line.

Other handy math environments are 'matrix', 'bmatrix', and 'pmatrix', for matrices without delimiters, with square brackets, and with parentheses, as in

$$\begin{matrix}1&2\\3&4\end{matrix} \quad \begin{bmatrix}1&2\\3&4\end{bmatrix} \quad \begin{pmatrix}1&2\\3&4\end{pmatrix}$$

written as

```
$$
\begin{matrix}1&2\\3&4\end{matrix}
\begin{bmatrix}1&2\\3&4\end{bmatrix}
\begin{pmatrix}1&2\\3&4\end{pmatrix}
$$
```

Again, this uses `&` as the alignment character to separate the columns, and `\\` to separate the rows.

4 Intermediate and Advanced Commands

4.1 Referencing equations and figures

You can label equations (if you use `\begin{equation}` and `\end{equation}`, not `$$ $$`) and figures (see next section) to reference later on! LaTeX will link them via the label name and update the reference number automatically. You can even label sections or subsections. All of this is done with the `\label{label_here}` command in the object, and `\ref{label_here}` command wherever you want to reference it. For example,

$$C = 2\pi r, \tag{4.1}$$

written as `\begin{equation}\label{eqn:circle} C = 2 \pi r \end{equation}`, can be referenced here as equation (4.1) using the command `(\ref{eqn:circle})`. You usually need to typeset a few times for LaTeX to sort out the labels and references.

Additionally, LaTeX likes to automatically number displayed equations, figures, and the like. To suppress this, the `\begin` and `\end` environment commands should have an asterisk in them, such as `\begin{equation*}` and `\end{equation*}`. It takes this:

$$e^{i\,\pi} + 1 = 0 \tag{4.2}$$

```
\begin{equation} e^{i\,\pi} + 1 = 0 \end{equation}
```

to this:

$$e^{i\,\pi} + 1 = 0$$

```
\begin{equation*} e^{i\,\pi} + 1 = 0 \end{equation*}.
```

4.2 Inserting images

The basic format for inserting images is:

```
\begin{figure}[t] \centering  % centers the image on the top of the page
\includegraphics[width=1.0\textwidth]{image.jpg}  % specifying size and filename
\caption{\label{fig:figure_label} Caption goes here.}
\end{figure}
```

The commonly accepted image formats are .jpg, .png, and .pdf. Inserting images requires the 'graphicx' package and, if using a .eps figure, 'epstopdf' package. If you want to customise the caption, you may also need the 'caption' package. In general, all images you want to include must be saved to the same folder as the .tex file, and there can't be any spaces in the file names.

4.3 Text styles

LaTeX allows for the basic text styles *italics* (`\textit{words}`), **bold** (`\textbf{words}`), sans-serif (`\textsf{words}`), SMALL CAPS (`\textsc{words}`), and `teletype` (`\texttt{words}`). There are additional fonts, like $\mathcal{MATHCAL}$, $\mathfrak{Mathfrak}$, and $\mathbb{MATHBB}$ (used in math mode), which can be used for specific letters as a symbol or variable. In general, you want to let LaTeX typeset things the way it thinks will be best, but you can force some things, like nested bracket sizing. These are normal brackets [ ], and bigger outer brackets like $\big[[ ] \big]$ are given with `\big[ [ ] \big]`. You can also use this with other delimiters and some other symbols, as well as other sizes like 'bigger'. In math mode, the commands `\left(` and `\right)` automatically size the brackets. Also, to get LaTeX to appear typeset in this style, type `\LaTeX` with an extra backslash on the end if it's in a line of text, to give it a little space between it and the next word.

4.4 More useful commands

- `\clearpage` and `\newpage`
- Forcing a new line to indent: `\indent`
- Forcing a new line to not indent: `\noindent`
- Vertical space filling: `\vfill`
- Horizontal space filling: `\hfill`
- Making something appear text-style while in math mode: `\text{ }`
- Hyphens [-], n-dashes[–], and m-dashes [—], using 1, 2, or 3 '-' characters in a row.
- Small spaces using `\, \: \;` (for example: 1 1, 1 1, 1 1)
- The ~ key provides a non-breaking space, so that LaTeX doesn't split up the word before and after the ~ onto two different lines. This is useful when referencing things: equation 4.1 is written as `equation~\ref{eqn:circle}`.
- Making your own commands using `\newcommand{ }{ }` and `\renewcommand{ }{ }`. This is useful for defining commonly-used specific symbols like `\Msun`: `\newcommand{\Msun}{\text{M}_{\odot}}`. This goes after the packages in the header.

- Line spacing: `\linespread{1.0}` gives single-spacing, `\linespread{1.5}` gives 1.5 spacing, `\linespread{2.0}` gives double-spacing, etc. This goes in the header after the packages before defining the title.

4.5 Beamer presentations

It is possible to make presentations in LaTeX using the 'beamer' packages. The LaTeX wikibook is a good resource for implementing this. Depending on the content of your presentation, though, beamer may be more trouble than it's worth.

5 Good LaTeX Habits

- As soon as you `begin` an environment, `end` it so that you don't forget to later. Same with brackets: as soon as you begin a bracket, end it. Then go back and write your expression inside it.
- Typeset early and often.
- Use `\,dx` (where x is your integrating variable) at the end of the integrand, to space it out slightly from the rest of the integrand.
- When making labels for figures, equations, and tables, use a labelling system like 'all equation labels start with `eqn:`, all figure labels start with `fig:`, and all table labels start with `tab:`', to reduce label crossing and confusion.
- Put the TeX markup for displayed equations (i.e., `$$` *math* `$$`) in a new line.
- Don't be afraid to use comments!
- Write out math properly. Don't start sentences with mathematical symbols/variables/ expressions or numbers, and use proper punctuation.
- Learn the tricks and shortcuts of your TeX editor — it will save you time and frustration!

6 Troubleshooting Common Errors

6.1 `Runaway argument? File ended while scanning use of` something

You forgot to close a bracket or `\end` an environment.

6.2 `Missing $ inserted` or `Missing $$ inserted`

You didn't close a math environment, or the symbol you want to use only works in math-mode (so put `$` around it).

6.3 `Undefined control sequence`

The command you want to use doesn't exist. Either you mis-typed it (remember, LaTeX is case-sensitive), you need to import another package to use that command, or you need to define it using `\newcommand` or `\renewcommand`.

6.4 '??' where you want a reference number to an object

Try running 'Typeset' two or three more times. If that doesn't sort it out, double-check that the label in the object and the label you are referencing are spelled exactly the same (again, LaTeX is case-sensitive).

6.5 `There's no line here to end`

Remove the `\\`. LaTeX doesn't think there should be a bigger line break there.

7 References

- If you don't already have the complete LaTeX symbol list, download it! This lengthy document tells you the packages needed and commands for every symbol that can be typeset by LaTeX such as: ⋆ ↯ ☎ ✉ ⊞ ∼ ♣ ♭ ∡ $\hat{a}$
  Available here: `http://www.tex.ac.uk/tex-archive/info/symbols/comprehensive/symbols-a4.pdf`
- `http://en.wikibooks.org/wiki/LaTeX` — BY FAR the most useful guide I know
- `http://www.ctan.org` — the comprehensive TeX archive network
- `http://tex.stackexchange.com/` — a question and answer forum
- Your peers/colleagues
- Google, combined with trial and error, critical thinking, and common sense

Good luck and have fun!