Introducing

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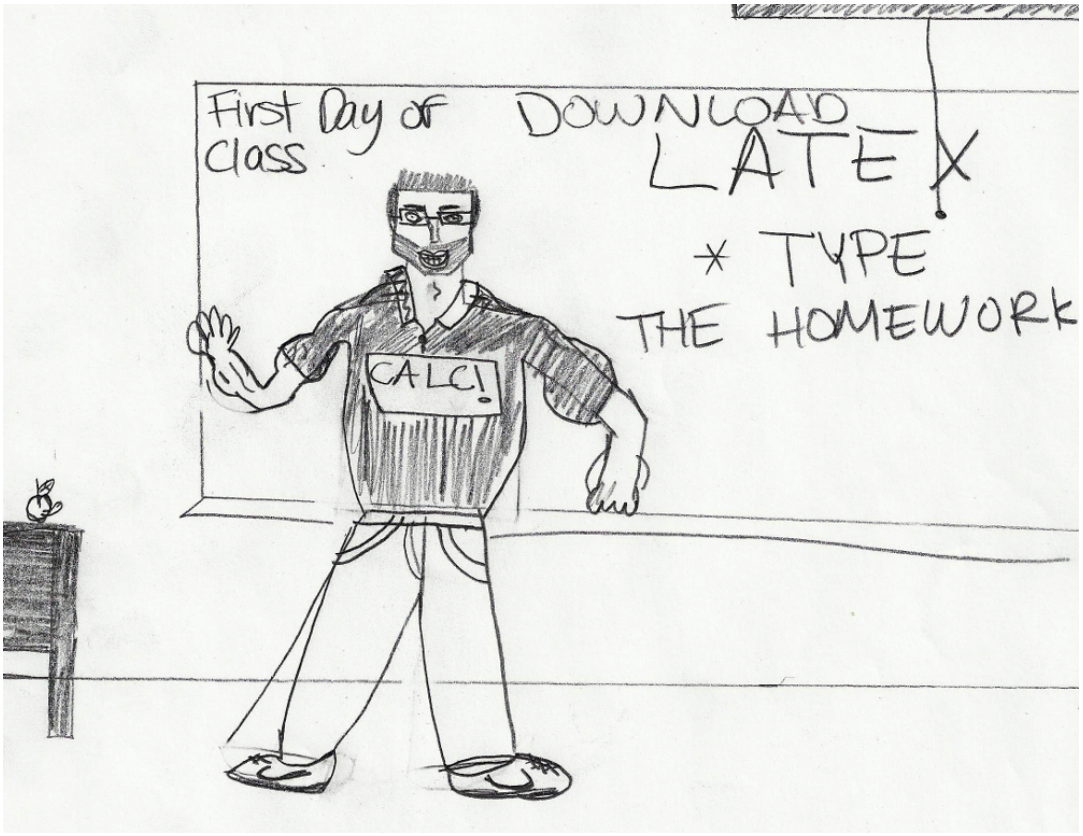
Abstract

This document provides an short introduction to the Latex document preparation system. Its sole purpose is to help readers get started with LaTeXin as little time as possible. Hopefully it will provide enough information for the reader to begin using Latex, and then to research specific details on their own, e.g., using one of the suggested references.



These notes were originally developed for students at California State University, Northridge. This is an approximate document and probably contains typographical errors. Please let me know if you've used these notes for a class and found them useful (or useless). Report any errors to bruce.e.shapiro@csun.edu. All feedback, comments, suggestions for improvement, etc., is appreciated, especially if you've used these notes for a class, either at CSUN or elsewhere, from both instructors and students.

Contents

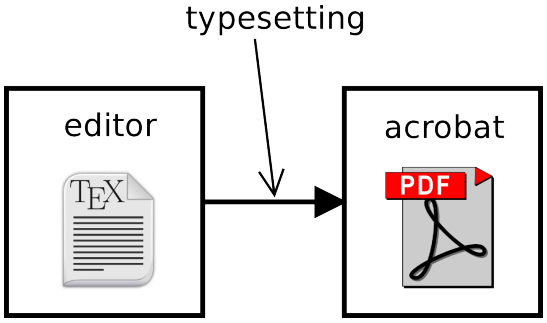
Part I

Before You Use LaTeX the First Time

1 What is LaTeX?

is a **document preparation system for mathematics**. The main things that distinguish it from a word processor (like Microsoft Word) are:

- All documents are stored as **text** files. This means you can always look at them with almost any program that reads text.
- The document you print normally a `.pdf`, `.ps`, or `.dvi` file, is separate from the document you edit, which is called a `.tex` file. Conversion takes place in a process called typesetting.



- Formatting instructions are **visibly embedded** in the text by means of special commands that begin a backslash character (\), e.g.,

```
I \underline{like} onions!
```

. will be typeset as

I like onions!

- LaTeX contains a lot of special commands for making equations look **precisely** the same way they do in textbooks.

To use LaTeXyou must have three things installed on your computer:

1. A LaTeXsystem - this is a large collection of binary and script files that you will never use directly, but will access through (2).
2. A LaTeX editor, such as Texmaker, TeXworks, TeXshop, or WinEdt. (Technically you could use any text editor but then you would have to do your typesetting from the command line.)
3. A pdf file viewer such as Acrobat Reader, Okular, Evince.

2 Where Can I Get LaTeX?

2.1 Use it On Campus

Latex is installed on all computers in the College of Science of Science and Mathematics Computer Labs. Locations and hours are give at http://www.csun.edu/csm/computing.htm.

2.2 Download and Install at Home

Instructions for a Linux Install

Install `texlive` (or `texlive-all`) and `texmaker` from your package manager.

If they are not available, binary and source files can be downloaded from http://www.tug.org/texlive/acquire-netinstall.html and http://www.xm1math.net/texmaker/download.html.

You will be able to use LaTeXvia `Texmaker` from the command line (`$Texmaker`) or you can access the individual commands such as `$pdftex,$latex`,... on the command line. In the later case you may prefer to use `emacs` instead of `Texmaker`.

Instructions for a Mac Install

You should install the following two packages:

1. Download `The MacTex 2011 Distribution` from http://www.tug.org/mactex/2011/. The total download is around 2 GB. After the download is finished, locate the download file and run the installer.

2. Download the latest version of `Texmaker` from http://www.xm1math.net/texmaker/download.html. After the download is finished unpack the zip file and drag the `Texmaker` application to your `Applications` folder.

We will use LaTeX directly from `Texmaker`, which you can access from your `Applications` folder.

Instructions for Windows 7

You should install the following two packages:

1. `MiKTeX` from http://miktex.org/. The `Basic MiKTeX 2.9 Installer` (164 MB) will be enough for most purposes. After you download the file, run the installer. (This version installs essential files only; if you need something special, it will install it later.) If you decide to download the complete system you have download the `MiKTeX 2.9 Installer` (7 MB), and then run the installer **twice**: once to download the software (about 2 GB), then a second time to install the software.

2. `Texmaker` from http://www.xm1math.net/texmaker/download.html. After you download the file, you have to run the installer once; then look for `Texmaker` in your `Start` menu.

3 How Do I Use LaTeX?

There are two ways to use LaTeX:

1. From the command line: (a) edit your documents in a text editor such as `emacs` or `Notepad`; (b) convert your `.tex` files to `.pdf` (or other formats) using a command such as `pdflatex` in the `terminal` (Linux or Macs) or command prompt (Windows); and (c) view or print your `.pdf` file using `Acrobat Reader`, `Preview`, or `Okular`.

2. Using a LaTeX-cognizant text editor such as `Texmaker`. You do everything in step 1 but instead of using the Command Line you use menus to invoke the various options. For example, using `Texmaker`, you would:

   (a) Create a new document using the File/New and then File/Save option on the menu bar. Make sure the file name ends in `.tex`.

   (b) Initialize the document with a basic template using the Wizard/Quick-Start options on the menu bar.

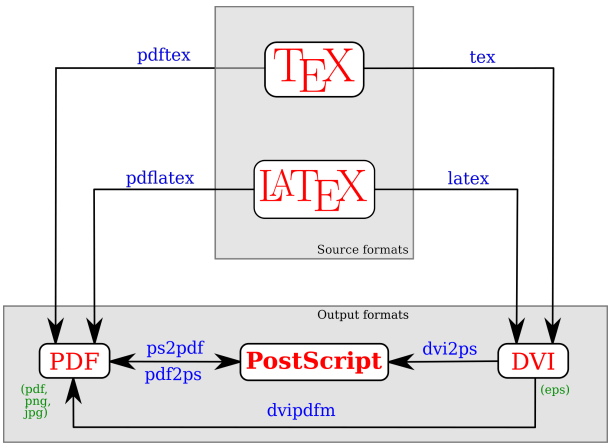
   (c) Edit the document using formatting commands as described in the rest of this document.

   (d) Compile the document from to PDF using the PDFLaTeX button on the menu bar.

   (e) Check for any errors in the error window.

   (f) View the PDF file using the View PDF button on the menubar.

Schematic of different LaTeX file conversion commands available at the command prompt. Figure from Wikimedia Commons under the Creative Commons Attribution-Share Alike 3.0 Unported license at http://commons.wikimedia.org/wiki/File:LaTeX_diagram.svg.



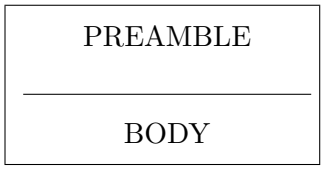
Part II

Typesetting With LaTeX

4 Document Structure

4.1 The Basics

documents are divided into two parts, called the **preamble** and the **body**. We can think of them figuratively like this:



The *preamble* tells information about the entire document, like the page size and which parts of you are going to use. The *body* contains the actual text of your document, along with local (rather than global) formatting commands. For example, the block:

```
\documentclass[12pt,letterpaper]
  {article}
\usepackage[latin1]{inputenc}
\usepackage{amsmath}
\usepackage{amsfonts}
\begin{document}
\begin{center}Quadratics\end{center}
The solution of $$ax^2+bx+c=0$$ is
$$x=\dfrac{-b\pm\sqrt{b^2-4ac}}
{2a}$$
And that's \textit{just}
the way it is.
\end{document}
```

will look something like this, when it is typeset:

Quadratics

The solution of

$$ax^2 + bx + c = 0$$

is

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

And that's *just* the way it is.

The **preamble** starts with `\documentclass` and ends with `\begin{document}`

The **body** starts with the `\begin{document}` and ends with an `\end{document}`

Here is our schematic again:

```
\documentclass
 ... % preamble
\begin{document}
...  % body
\end{document}
```

The format of the `\documentclass` command is

`\documentclass`[*options*]{*class*}

where *options* can be omitted.

Standard *classes* are: `book`, `report`, `article`, `letter` and `beamer` (the last is for presentations).

Typical *options* are font and page size and orientation, such as `10pt`, `11pt`, and `12pt`, `letterpaper`, `legalpaper`,`A4paper`,`landscape` (default is portrait), `onecolum` (default), and `twocolumn`.

Additional sets of commands are enabled by adding specific packages,

`\usepackage`{*package name*}

4.2 Entering Text and Symbols

In you pretty much just type the text content the way you want it just as you would in any word processor, with the following things to remember:

- Some characters have special meanings: `#`, `$`, `&`, `~`, `_`, `^`, `%`, `{`, `}`, `\`
- Begin a new paragraphs by skipping a line. Paragraph indentation and spacing is discussed in section **??**.
- Formatting is controlled by markup with **simple commands** like

  `\command`

  or **command environments**

  `\begin{env}...\end{env}`

  environments (things that look like `\begin{name} ... \end{name}`).

  Commands mean **do something now**, like enter a check mark (`\checkmark`) or insert a page break (`\newpage`).

  Environments mean **enter a new mode** (`\begin{env}`) and **don't leave it until I tell you to** (`\end{env}`), like

  ```
  \begin{center}
  All of this will be
  centered.
  \end{center}
  ```

- Equations and certain mathematical symbols can only be included by using "math mode." This is discussed in section 7.

There are over 4000 special symbols that can be used in LaTeX 2ε; a comprehensive list (over 140 pages) has been compiled by Scott Patkin and is available from CTAN at http://www.ctan.org/tex-archive/info/symbols/comprehensive/. Here are some examples:

©=\copyright	†=\dag	‡= \ddag
✓=\checkmark	§=\S	¶=\P
£=\pounds	✠=\maltese	®=\circledR

There are lots of ways to lots of non-English text characters , such as à or ü, and entire alphabets.

The LaTeX "special" characters, what they are used for, and how you can still manage to add them to your document.

Character	Special Command	Normal Meaning
#	\#	Argument of a user-defined command.
$	\$	Beginning and end of an equation.
&	\&	Tab stop in an array or table.
~	\~	Special accent, eg. `~{o}` gives õ
_	_	Subscript (in math mode), `$a_3$` gives a_3
^	\^	Special accent, eg. `^{e}` gives ẽ
%	\%	Everything after a % is ignored as a comment, through the end of the line
{	\{	Used in pair with } to surround arguments of functions and environments.
}	\}	Used in pair with { to surround arguments of functions and environments.
\	\textbackslash	Used to invoke a command or begin or end an environment.

5 Document Layout

Books, reports and articles are arranged hierarchically into numbered chapters, sections, subsections, sub-subsections, paragraphs, and sub-paragraphs. Books and reports may also be divided into parts, which are larger than chapters. The syntax for starting a new chapter, section, etc, is, e.g.,

```
\section[short-title]{real-title}
```

where *real-title* is the required title of the section, and the optional *short-title* is a shorter title that is used for the table of contents and page headers and footers. Similar commands are used for \part, \subsection, \subsubsection, \paragraph, and \sub-paragraph.

If you want to omit the number, put an asterisk at the end of the command, as in \subsubsection*. This will create the new section, subsection, etc., but omit the number and leave it out of the table of contents.

The command

```
\tableofcontents
```

will automatically generate a table of contents from all the numbered sections, subsections, etc.

Here is an example of sectioning commands. The typeset document is illustrated on the following page.

```
\documentclass
   ...
\title{My Favorite Vaudevillians}
\date{}
\begin{document}
\begin{center}{\LARGE \textbf{My Favorite Vaudevillians}}\end{center}
\section{The Three Stooges}
\subsection{History } The original group was composed of  Moe Howard,  Samuel
("Shemp") Howard and Lary Fine. When Shemp quite, their brother Jerome Howard
("Curly"), joined the group ...
\subsection{Films}
Films included \textit{Turn Back the Clock}, ...
\section{The Marx Brothers}
\subsection{History}The Marx Brothers also started as a Vaudeville group of five
bothers, Chico (Leonard), Harpo (Arthur), Grocho (Julius), Gummo (Milton), and Zeppo
(Herbert) Marx.  Gummu left the act after World War I, so he never appeared in any
films. ...
\subsection{Films} Their film career included \textit{Cocoanuts}(1929), \textit{Animal
Crackers} (1930), \textit{Monkey Business}(1931), ...
  ...
\end{document}
```

5.1 Margins and Text Alignment

The easiest way to control Margins is with the geometry package. Putting

```
\usepackage[left=1.0in, right=1.0in,
  top=1.0in,bottom=1.0in]{geometry}
```

in the preamble will give the entire document one-inch margins all around the page.

By default, text is both right and left justified.

To force all your text to be right-justified,

```
\begin{flushright} text \end{flushright}
```

To be left-justified:

```
\begin{flushleft} text \end{flushleft}
```

To be centered:

```
\begin{center} text \end{center}
```

My Favorite Vaudevillians

1 The Three Stooges

1.1 History

The original group was composed of Moe Howard, Samuel ("Shemp") Howard and Lary Fine. When Shemp quite, their brother Jerome Howard ("Curly"), joined the group ...

1.2 Films

Films included *Turn Back the Clock*, ...

2 The Marx Brothers

2.1 History

The Marx Brothers also started as a Vaudeville group of five bothers, Chico (Leonard), Harpo (Arthur), Grocho (Julius), Gummo (Milton), and Zeppo (Herbert) Marx. Gummu left the act after World War I, so he never appeared in any films. ...

2.2 Films

Their film career included *Cocoanuts*(1929), *Animal Crackers* (1930), *Monkey Business*(1931), ...

5.2 Paragraph Indentation and Spacing

By default, new paragraphs are indented half an inch (except for the first paragraph of a new section, which is not indented), and there is no space between paragraphs.

```
\setlength{\parindent}{0pt}
\setlength{\parskip}{1ex}
```

`\setlength{\parindent}{0pt}` sets the paragraph indentation to zero.

`\setlength{\parskip}{1ex}` sets the space between paragraphs to the height of the letter `x`.

Units can be in any of `in, cm, mm, pt, ex, em`. One `ex` is the height of the letter x; one `em` is the width of the letter m. Points (`pt`) are equal to 1/72 of an inch, so `72pt` and `1in` would be identical.

5.3 Double-spacing

To get double spacing, put the line

```
\usepackage{setspace}
```

in your preamble, then put

```
\doublespace
```

where you want to begin double-spacing, and

```
\singlespace
```

where you want to return to single-spacing.

5.4 Multiple Columns

You can switch back and forth between one and two columns by using the commands

```
\twocolumn
\onecolumn
```

but they always skip to the start of the next page before changing the columns.

To change the number of columns anywhere on a page, put

```
\usepackage{multicol}
```

in the preamble, and use the environment

```
\begin{multicols}{2}
```

```
...
\end{multicols}
```

You can replace the 2 with a 3 or 4 for 3 or 4 column text.

5.5 Forcing Page Breaks

There are two types of forced page breaks you can use:

`\newpage` fills up the rest of the current page with blank space and jumps to the top of the next page.

`\pagebreak` will try to spread out existing text to evenly fill out current page (by making paragraph breaks bigger) and then skip to the next page. If you put the command in the middle of a paragraph it will start the new page at the end of the paragraph.

5.6 Vertical and Horizontal Space

`\hspace{1in}` adds an extra inch of horizontal white space.

`\vspace{24pt}` adds an extra 24 points of vertical white space.

Any of the standard units can be used for either command.

`\hfill` adds space to fill up the current line, as in

```
I \hfill Am \hfill Legend
```

will produce

I Am Legend.

`\vfill` adds vertical space to fill up the page.

`\hrulefull` fills up the current line with a horizontal line like this: _____

`\dotfill` fills up the current line with dots that look like this: .....

5.7 Footnotes

Footnotes are inserted with the command `\footnote{`Text of footnote.`}` at the exact position where the footnote marker should be. Footnotes are normally numbered sequentially; to change this you can use the argument *num*, as in `\footnote[`*num*`]{`text of footnote`}`. Footnotes are then placed at the bottom of the page[1]. Each footnote is indented.

To remove the indentation throughout your document put the following in your preamble:

`\usepackage[hang,flushmargin]footmisc`.

[1] like this!

5.8 Inserting Code

The `verbatim` environment lets you add a block of text exactly the way you type it, with no typesetting or command interpretation, as in this example:

```
Here is a Python program for least squares:
\begin{verbatim}
def fit(xd,yd):
  SX=sum(xd)
  SY=sum(yd)
  SX2=sum([x*x for x in xd])
  SXY = sum ([x*y for (x,y) in zip(xd,yd)])
  n=len(xd)
  M = np.array([[n,  SX],\
                [SX, SX2]])
  B = np.array([SY, SXY])
  return(np.linalg.solve(M, B))
\end{verbatim}
```

Here is a Python program for least squares:

```
def fit(xd,yd):
  SX=sum(xd)
  SY=sum(yd)
  SX2=sum([x*x for x in xd])
  SXY = sum ([x*y for (x,y) in zip(xd,yd)])
  n=len(xd)
  M = np.array([[n,  SX],\
                [SX, SX2]])
  B = np.array([SY, SXY])
  return(np.linalg.solve(M, B))
```

If you just want to include a short segment of code like `C123_=A_+B_` you can use the inline version of the `verbatim` environment,

`\verb! code !`

where the exclamation point (!) should be replaced by any character that is not include in *code*. For example, the following are equivalent:

```
\verb.C123_=A_+B_.
\verb^C123_=A_+B_^
```

and each will insert the string C123_=A_+B_ into your document.

5.9 Boxes Around Text

The \fbox is convenient for putting boxes around text; if you typeset \fbox{like this} it will look like this.

Getting boxes around verbatim text is more complicated, but you can use the following template (this is what was used in this document) to make it work. First, include the line

```
\usepackage{fancyvrb}
```

in the preable. The following template will create a three-inch wide box with your code left-justified inside the box. If you want the box to be wider, change the width from 3in to something else. If you don't want the box to be in the center of your page, leave out the center environment.

```
\begin{center}
\begin{minipage}{3in}
\begin{Verbatim}[frame=single]
   %
   % put you code here
   %
\end {Verbatim}
\end{minipage}
\end{center}
```

For more details refer to the Latex reference on minipage and fancyvrb.

5.10 Counters and labels

thepage gives the current page number.

thechapter gives the current chapter number.

thesection gives the current section number.

To refer to a particular section, chapter, etc., you can label it. Immediately after the \section command include a label command, for example,

```
\label{section-Quadratics}
```

Then to refer to that section, use

```
\ref{section-Quadratics}.
```

as in,

```
In section \ref{section-Quadratics}
we will learn how to solve the
quadratic equation (see page
\pageref{page-quad}).
```

To refer to a particular page, use the \pageref command to refer to any label on that page, as in the above example.

5.11 Headers and Footers

By default the page number is printed in the bottom center of the page, with no other headers and footers.a

pagestyle{empty} in the preamble will turn off all headers and footers, including page numbers.

To define your own headers and footers put

\usepackage{fancyhdr}

in the preamble, then define your own style. For single sided documents, still in the preamble:

```
\fancypagesytel{mystyle}{
  \lhead{Text for the top left of the page}
  \chead{Text for the top center of the page}
  \rhead{Text for the top right of the page}
  \lfoot{Text for the bottom left of the page}
  \cfoot{Text for the bottom center of the page}
  \rfoot{Text for the bottom right of the page}
}
\renewcommand{\footrulewidth}{0.4pt}
\renewcommand{\headrulewidth}{0.4pt}
```

The footrulewidth and the headrulewidth give the thickness of lines between the text and the header and footer. By default the headrule is set

to 0.4 pt and the foorule is set to zero. To turn them off set them to 0pt.

To actually use the style, at the beginning of your body include the command

`\pagestyle{mystyle}`

If you have two-sided text, then you have to specify the header and the footer differently for the even and odd numbered pages. The shorthand for this is

```
\fancyfoot[LE,RO]{text}
\fancyhead[LO,RE]{text}
```

and so forth, where `L`, `C`, and `R` mean left, center, and right, and `E` and `O` mean even and odd.

You can insert page numbers with `\thepage`; chapter numbers with `\thechapter`; section numbers with `\thesection`, etc.

If you do not specify anything for the right header, the current section or chapter title will be placed there. If you want to suppress this use

```
\fancyhead[R]{}
```

or to specify your own header there

```
\fancyhead[R]{My Document Header}
```

If you don't want a line between the text and footer and header, sent the `footrulewidth` and `headrulewidth` to zero pt.

5.12 Including External Files

You can put any part of your document, including the preamble, into one or more external files:

`\input{`*`filename.tex`*`}`

For example, you could put all of your files into separate documents in the same folder:

```
\input{headers.tex}
\begin{document}
\input{mydocument1.tex}
\input{mydocument2.tex}
...
\end{document}
```

If they are in different folders you should specify the relative path (if you specify the absolute path it won't work if you move the file to a different machine or are sharing it with a collaborator):

```
\input{../myfile.tex}
\input{../../dir1/dir2/myfile.tex}
\input{./dir1/myfile.tex}
```

where we ".." means one "go up to the enclosing folder" and "." means inside the current folder, so that `./dir1/myfile.tex` means look for `myfile.tex` in the subdirectory `dir1` which is a subdirectory of the same folder where my main document is sitting; and `../myfile.tex` means look in the current folder's parent directory.

5.13 Lists

The `\enumerate` environment produces numbered lists.

Each item in the list begins with the `\item` command, which may span multiple paragraphs. Each **item** is indented.

```
Things I like:
\begin{enumerate}
\item I like onions
\item I like bagels
\item I like toast
\end{enumerate}
```

$\Longrightarrow$

Things I like:

1. I like onions
2. I like bagels
3. I like toast

The `\itemize` environment is used for itemized lists.

```
I am a frog because:
\begin{itemize}
\item I am green
\item I can swim
\item I eat flies
\end{itemize}
```

$\Longrightarrow$

I am a frog because:

- I am green
- I can swim
- I eat flies

Lists may be nested to any depth. Enumerated lists will be numbered like an outline with labels 1., (a), i., A. To change the label on a list, use

`\renewcommand{`*`label`*`} {`*`type`*`{`*`counter`*`}`*`optional-text`*`}`

`label` is the name of list level you are redefining. Values are `labelenumi, labelenumii, labelenumiii, labelenumiv`.

counter is the counter value to use. Normally `enumi` is associated with label `labelenumi`, etc.

The starting value of the `enumerate` list counter can be reset to any value. After the `\enumerate` but before the first `\item`, use

```
\setcounter{enumi}{6}
```

will start the list at item 7.

type is taken from the following table:

type	Values
`\arabic`	1, 2, 3, 4, ...
`\Roman`	I, II, III, IV, ...
`\roman`	i, ii, iii, iv, ...
`\alph`	a, b, c, d, ...
`\ALPH`	A, B, C, D, ...

Thus

```
\renewcommand{\labelnumii}{\Alph{enumii}.}
```

changes the second level numbering to an upper-case alphabet character followed by a period.

Example of nested lists:

```
\begin{enumerate}
 \item Frogs
  \begin{enumerate}
   \item Green
   \item Eat flies
   \item Swim
  \end{enumerate}
 \item Apples
  \begin{enumerate}
   \item Red
   \item Fruit
   \item Juicy
  \end{enumerate}
\end{enumerate}
```

$\Longrightarrow$

1. Frogs
   (a) Green
   (b) Eat flies
   (c) Swim
2. Apples
   (a) Red
   (b) Fruit
   (c) Juicy

6 Tabs, Tables, and Figures

6.1 Tabbing

The `\tabbing` environment sets tab stops and can be used to generate simple tables.

The first line of the `\tabbing` environment defines the tab stops.

Each tab stop is defined by `\=` and the line is terminated by the double slash `\\`

After the first line tab jumps are indicated by `\>`.

Each subsequent line of the `\tabbing` environment must also be terminated by `\\`.

For example:

```
\begin{tabbing}
Math \hspace{2cm} \= is \hspace{1cm} \= kool \\
Physics \>is \>boring \\
Video Games \> rock \> my socks off
\end{tabbing}
```

Math	is	kool
Physics	is	boring
Video Games	rock	my socks off

6.2 Tabular Arrays

The `\tabular` environment generates aligned columnar arrays in text mode. The `\array` environment works the same way, but in math mode.

`\begin{tabular}{`*columns*`} ... \end{tabular}`

columns=xxx...x where each x=`r`, `l`, or `c`, to indicate whether or not the corresponding column should be right justified, left justified, or centered.

The vertical line character (—) may be used to indicate that lines should be placed between the columns, thus

```
\begin{tabular}{|l|l|ccc|} ... \end{tabular}
```

denotes a 5-column table where the first two columns are left justified, the right 3 columns are centered, and there are lines between the 1st and 2nd columns, the 2nd and 3rd columns, and on the left and right hand edge of the table.

`\hline` can be used to place horizontal lines between rows in the table.

Jumping to the next column is specified within a row by `&` (Ampersand character).

A table may be centered on a page or column by using the \center environment.

For example

```
\begin{tabular}{|c|c|}
\hline Name & Grade \\
\hline Tom & A\\
\hline Dick & C\\
\hline Harry & B+\\
\hline
\end{tabular}
```

$\Longrightarrow$

Name	Grade
Tom	A
Dick	C
Harry	B+

6.3 Floating Tables

Sequentially numbered, captioned tables are produced by wrapping `tabular` environments with the `table` environment.

```
\begin{table}[where]
\caption{caption-text}
\begin{tabular}{···}
...
tablar contents
...
\end{tabular}
\end{table}
```

This places the caption at the top of the table; it can also be placed at the bottom of the table, immediately following the \end{tabular}.

To refer to the table number elsewhere in the document insert a \label command immediately after the \caption.

Tables are numbered sequentially through the document (or chapter).

where may contain any of the following: `h` = here (put the table here); `t` = top (at the top of the current page, or the next page if it won't fit); `p` = page (on a separate page); `b` = bottom (on the bottom of the current page).

6.4 Inserting Pictures

Put the following in your preamble:

```
\include{graphicx}
```

Then at the exact spot where you want to include your picture, put

```
\includegraphics[size]{filename}
```

size options are `width=3in`, `scale=.5`, or `height=43mm`.

filename should be specified relative to directory that your `.tex` file is sitting in. While in theory you could use an absolute file name, if you were to zip the folder and mail the package to a collaborate then it wouldn't work.

The type of graphics format varies from system to system. Generally `.png`, `.tif`, and `.jpg` work everywhere. If you are using `PDFLaTeX` you can also use `.pdf` files as pictures. If you are using pure `latex` (which converts files to `.dvi` format, and not to `.pdf`) it will also accept encapsulated postscript files, `.eps`.

The following example will insert the file `pictures/fred.png` in your document and make it one-inch wide:

```
\includegraphics[width=1in]{pictures/fred.png}
```

You can add a caption and a figure number to a picture the same way as with a table by using the `figure` environment.

```
  \begin{figure}[h]
    \caption{...}
    \label{figure:my-figure}
    \begin{center}
    \includegraphics[width=2.54cm]{fred.png}
    \end{center}
  \end{figure}
```

The location can be `h` (here); `p` (page); `t` (top); or `b` (bottom) and mean the same thing as with a `table` environment.

The `wrapfigure` environment will allow you to wrap text around a figure. To do so, put

```
\usepackage{wrapfig}
```

in the preamble, then

```
\begin{wrapfigure}{r}{1.1in}
  \begin{center}
    \includegraphics[width=1in]
      {happy.png}
  \end{center}
  \caption{A happy computer!}
\end{wrapfigure}
```

Alignment can normally be either `l` for left, or `r` for right. Lowercase l or r forces the figure to start precisely where specified (and may cause it to run over page breaks), while capital L or R allows the figure to float.

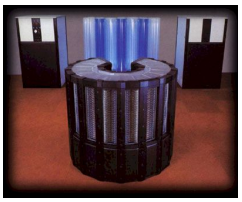
Figure 1: A happy computer!

If you defined your document as twosided, the alignment can also be i for inside or o for outside, as well as I or O. The width is, of course, the width of the figure. In most cases `wrapfigure` adds too much vertical spacing, which you can reduce by adding appropriate \vspace{*x*} commands with negatives arguments in the desired locations. A negative vertical space means reduce the vertical space.

You can include multiple graphics in the same figure by using the \subfigure command:

```
\begin{wrapfigure}{l}{4.2in}
   \subfigure[Cray 2.]{\includegraphics[height=1in]{Cray.jpg}}
   \subfigure[Apple 1.]{\includegraphics[height=1in]{Apple.jpg}}
   \subfigure[IBM PC.]{\includegraphics[height=1in]{IBMPC.jpg}}
   \caption{Three computers.}
\end{wrapfigure}
```

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Quisque porttitor fringilla nisi nec tempus. Fusce ac est arcu, sodales scelerisque sapien. Nulla facilisi. Phasellus eu elit massa. Etiam quis hendrerit elit. Nunc commodo dignissim pretium. Aenean neque enim, pretium a placerat vel, venenatis id nulla. In eget diam turpis. Donec tempus placerat nunc ut fringilla. Integer aliquam, urna non pellentesque interdum, mauris neque consectetur nisi, ut aliquam odio augue eu sapien. Donec mattis iaculis nunc id vestibulum. Quisque ultrices ultricies libero sed luctus. Curabitur commodo, dolor vitae bibendum lacinia, neque ante ultricies neque, et gravida dolor arcu eu eros. Nunc eget justo et ipsum sollicitudin imperdiet. Nullam et diam erat. Sed mattis ligula in magna dictum porta. Quisque a adipiscing tellus. Sed hendrerit, urna quis facilisis condimentum, leo nunc sollicitudin nisi, a ornare urna purus quis eros. Ut id erat at nunc rutrum varius. Vivamus ac turpis at enim pulvinar ultrices nec et libero. Phasellus ut nibh nibh. Fusce tincidunt purus ac sem lobortis porttitor. Morbi in risus eros, eu egestas neque.



(a) Cray 2.

(b) Apple 1.

(c) IBM PC.

Figure 2: Three computers.

---

7 Math Mode

LaTeXhas two modes: **text** mode and **math** mode. All equations are written in **math** mode. All text is written in **text** mode.

7.1 Inline Equations

An equation that is included in the flow of text, without breaking to a new line, is called an **inline equation**. Inline equations must begin and end with a dollar sign, `$`.

An examples of inline equations is $y = \int_a^b e^{-\alpha x^2} dx$. For example, one can typeset

> Functions of the form $f(t) = 1(1 + e^{-t})$ are known as *sigmoid* functions. Sigmoidal functions have the interesting property that they satisfy the *logistic differential equation* $y' = y(1 - y)$

with

```
Functions of the form $f(t)=1(1+e^{-t})$
are known as \textit{sigmoid} functions.
Sigmoidal functions have the interesting
property that they satisfy the
\textit{logistic differential equation}
$y'=y(1-y)$
```

Even to insert special characters like $\sum$ or $\int$ you need to use math mode, e.g., as `$\sum$` or `$\int$`.

7.2 Display Equations

In **display** mode an equation is placed on a line by itself surrounded by white space. By default, it is centered in the middle of the line, although equations can be optionally right or left justified.

There are two ways to insert display equations; there is no advantage to either of these over the other. You can either surround your display equation by double-dollar-signs, e.g., `$$` at both the beginning and the end of the equation, or you can begin the equation with `\[` and end it with `\]`. Thus to typeset

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

you can use either

```
\[x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}\]
```

or

```
$$x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$$
```

7.3 Numbered Equations

Equations can be automatically numbered with the `equation` environment:

```
\begin{equation}
\label{eq-quad}
x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}
\end{equation}
```

which will be typeset as:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{1}$$

To suppress the equation number use `\begin{equation*}`$\cdots$`\end{equation*}`, which is equivalent to `$$`$\cdots$`$$`.

The argument to `\label` can be any string; it is standard practice to preface it with something like `eq` or `equation` so that it will be easy to identify as an equation in the source code.

To refer to equation 1 use either `\ref{`*label*`}` or `\eqref{`*label*`}`. The `eqref` command automatically includes parenthesis, so that `\eqref{eq-quad}` looks like (1), while `\ref{eq-quad}` looks like 1.

The global properties of equations are controlled by arguments to the `\documentclass` command in the preamble:

`leqno` will put all equation numbers on the left-hand margin (by default they are on the right).

`fleqn` will make all equations flush-left (by default they are centered)

7.4 Boxed equations

To put a box around an inline equation like $\boxed{y = \int f(x)dx}$ use

```
\fbox{$y=\int f(x)dx$}
```

To put a box around a display equation, as in

$$\boxed{u = \int f(x)dx}$$

use `\boxed{$y=\int f(x)dx$}`.

`\boxed` works with both numbered and unnumbered equations.

7.5 Aligned and Multi-line Equations

7.5.1 The `align` Environment

There are several ways to align equations vertically. The simplest is with the `align` environment. For example,

$$x = 1 \tag{2}$$
$$y = 2 + x \tag{3}$$
$$z = 3 + 2x + y \tag{4}$$

where all the equal signs are aligned vertically, can be typeset using `align` as can be written using

```
\begin{align}
x&=1\\
y&=2+x\\
z&=3+2x+y
\end{align}
```

The ampersand `&` is used as an alignment character (like a tab stop) inside and `align`.

The double-backslash `\\` is used to indicate the start of a new line inside the `align`.

To suppress all of the equation numbers use `\align*` instead of `align`.

`\nonumber` will suppress the specific equation number of the line on which it is placed (and the equation counter will not be incremented).

7.5.2 The `split` Environment

Long equations that require more than one line can be typeset with `split`. The ampersand `&` and double-backslash `\\` are used for alignment and line splitting within the `split environment`:

```
\begin{equation}
  \begin{split}
  \sum_{n=0}^\infty ar^n &=
    a + ar + ar^2 + ar^3 + \cdots \\
    & = \dfrac{a}{1-r}
  \end{split}
\end{equation}
```

Note that only one equation number is assigned to a split equation

$$\begin{aligned}\sum_{n=0}^{\infty} ar^n &= a + ar + ar^2 + ar^3 + \cdots \\ &= \frac{a}{1-r}\end{aligned} \tag{5}$$

The `split` environment can only be used within the `equation` or `equation*` environments, not the shorthand `$$...$$` or `\[ ... \]` forms

7.5.3 The `cases` Environment

The `cases` environment is used when the right-hand side of an equation has multiple cases:

$$|x| = \begin{cases} -x, & x < 0 \\ x, & x \geq 0 \end{cases} \tag{6}$$

As with `split` and `align` the ampersand `&` and double-backslash `\\` are used for alignment and new line. Use `\text` to include text in the equation:

```
\begin{equation}
  \int x^n \: dx =
  \begin{cases}
  \dfrac{x^{n+1}}{n+1} + C,
     &\text{ if } n\neq -1\\
  \lng{x} + C, &\text{ if } n = -1
  \end{cases}
\end{equation}
```

which is typeset as

$$\int x^n\,dx = \begin{cases} \dfrac{x^{n+1}}{n+1} + C, & \text{if } n \neq -1 \\ \ln x + C, & \text{if } n = -1 \end{cases} \qquad (7)$$

7.6 Superscripts and Subscripts

Use the carat ^ for superscripts, shift-6 on US-keyboards, as in `$x^2$` for x^2.

Use the underscore _ for subscripts, e.g., `$Y_3$` for Y_3.

If the subscript or superscript is longer than a single character it must be enclosed in curly brackets, e.g., `$x^a+b$` gives $x^a + b$ while `$x^{a+b}$` gives x^{a+b}.

Subscripts or superscripts on subscripts are denoted by appropriate nesting of curly brackets.

```
$$x_{i+j,k_i} = \frac{p^i q^j}{r_{k_i}}$$
```

$$x_{i+j,k_i} = \frac{p^i q^j}{r_{k_i}}$$

7.7 Roots and Fractions

`\sqrt{x}` gives $\sqrt{x}$.

`\sqrt[n]{x}` gives $\sqrt[n]{x}$.

`\frac{`*numerator*`}{`*denominator*`}` gives text-size fractions, as in $\frac{a+b}{c+d}$.

`\dfrac{`*numerator*`}{`*denominator*`}` enlarges the numerator and denominator so that each is text-sized, as in $\dfrac{a+b}{c+d}$.

`\tfrac{`*numerator*`}{`*denominator*`}` gives text-sized equations in a display equation,

$$\text{tfrac} = \tfrac{a+b}{c+d} = \frac{a+b}{c+d} = \text{frac}$$

They can also be nested in display equations,

$$\frac{a+\frac{p}{q}}{c+d} = \frac{a+\dfrac{p}{q}}{c+d}$$

which was typeset with

```
\frac{a+\frac{p}{q}}{c+d}
```

on the left side of the equation and

```
\frac{a+\dfrac{p}{q}}{c+d}
```

on the right.

Roots and fractions can be combined, as in

```
$$\sqrt{1+\frac{1}{x}}=
  \sqrt{1+\tfrac{1}{x}}$$
```

$$\sqrt{1+\frac{1}{x}} = \sqrt{1+\tfrac{1}{x}}$$

or

```
$$\frac{a}{\sqrt{b+\frac{c}{d}}} =
  \frac{a}{\sqrt{b+\dfrac{c}{d}}},$$
```

$$\frac{a}{\sqrt{b+\frac{c}{d}}} = \frac{a}{\sqrt{b+\dfrac{c}{d}}},$$

7.8 Integrals

`\int`	`\oint`
`\iint`	`\iiint`
`\iiint`	`\limits`

These are used for single, double, and triple integrals.

Limits are specified as subscripts or superscripts. To get the limit to be beneath the integral sign (e.g., for a volume or surface multiple integral) use `\limits` (which means to interpret the subscript the way it is interpreted for `\lim`).

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

$$\oint_\Gamma g(\lambda)\,d\lambda = \int_0^1 \int_{-x}^{x} \int_0^{1-x^2-y^2} f(x,y,z)dzdydz$$

$$\iiint_V dV = \frac{4}{3}\pi r^3$$

which can be typeset with the following:

```
$$\int_a^b f(x) dx = F(b)-F(a)$$
$$\oint_{\Gamma}  g(\lambda)
  d\lambda = \int_0^1 \int_{-x}^{x}
  \int_0^{1-x^2-y^2} f(x,y,z) dz dy dz$$
$$\iiint\limits_V dV =
  \frac{4}{3}\pi r^3$$
```

7.9 Sums and Products

\sum gives a summation.

\prod gives a product.

Begin and end values are specified as subscripts (begin values) and superscripts (end values).

For display mode, start and end values are automatically placed below and above the sybmol, so that `$$\sum_{k=1}^{\infty}p_k$$` becomes

$$\sum_{k=1}^{\infty} p_k$$

while in text mode, they are placed in normal subscript mode, and `$\sum_{k=1}^{\infty}p_k$` becomes $\sum_{k=1}^{\infty} p_k$ (there was only a single dollar sign around the second form; otherwise they were identical).

The format for sums and products is the same, so that `$$\prod_{k=1}^{10}\dfrac{k+1}{k+2}$$` becomes

$$\prod_{k=1}^{10} \frac{k+1}{k+2}$$

7.10 Limits

\lim is used for a limit.

The target of a limit is specified as a subscript using the underscore. In text mode

```
$$\lim_{x\to\infty}
   \frac{3x^2+4x}{7x^2+2}=\frac{3}{7}$$
```

looks like $\lim_{x\to\infty} \frac{3x^2+4x}{7x^2+2} = \frac{3}{7}$, while in display mode it becomes

$$\lim_{x\to\infty} \frac{3x^2+4x}{7x^2+2} = \frac{3}{7}$$

7.11 Lines Above and Below Expressions

\overline{*expression*} draws a line over an expression.

\underline{*expression*} draws a line under an expression

We define by $\overline{AB}$ the line segment connecting points A and B.

We denote the complex conjugate of $z = a+bi$ by

$$\overline{z} = \overline{a+bi} = a-bi$$

```
We define by $\overline{AB}$ the line segment
connecting points $A$ and $B$.

We denote the complex conjugate of $z=a+bi$ by
$$\overline{z}=\overline{a+bi}=a-bi$$
```

7.12 Text Above and Below Expressions

\overbrace{*expression*} puts a horizontal brace above an expression. Superscripted \text expressions will be written above the brace.

\underbrace{*expression*} puts a horizontal brace below an expression. Subscripted \text expressions will be written below the brace.

For example,

```
f(x) = f(a) +
\underbrace{(x-a)f'(a)}_{\text{Linear Term}} +
\overbrace{\frac{1}{2}(x-a)^2
     f''(a)}^{\text{Quadratic Term}} + \cdots
```

will be typeset as

$$f(x) = f(a) + \underbrace{(x-a)f'(a)}_{\text{Linear Term}} + \overbrace{\frac{1}{2}(x-a)^2 f''(a)}^{\text{Quadratic Term}} + \cdots$$

7.13 Arrows Above & Below Expressions

The following provide variable length arrows above or below *expression*:

\overleftarrow{*expression*}
\overrightarrow{*expression*}

\overleftrightarrow{*expression*}
\underleftarrow{*expression*}
\underrightarrow{*expression*}
\underleftrightarrow{*expression*}

For example

```
$$\overleftrightarrow{APBXC} =
  \overleftarrow{APB} +
  \overrightarrow{BXC}$$
```

gives

$$\overleftrightarrow{APBXC} = \overleftarrow{APB} + \overrightarrow{BXC}$$

7.14 Chemical Reactions

Rate constants in simple chemical reactions can be attached to arrows with `overset` and `underset`:

$$X + Y \underset{k_2}{\overset{k_1}{\rightleftharpoons}} Z, A + B \overset{k_3}{\rightarrow} C$$

```
$$X+Y \underset{k_2}{\overset {k_1}
        {\rightleftharpoons}} Z,
   A+B  \overset{k_3}{\rightarrow} C$$
```

Longer expressions can use `xleftarrow` and `xrigharrow`

$$A + B \xrightarrow{\text{combine to form}} C$$

```
$$A+B \xrightarrow{
    \text{combine to form}}C$$
```

7.15 Large Parenthesis

Variable size parenthesis (or brackets) as in

$$\left[\sqrt{\frac{p}{q}} + \left(\frac{a+b}{c} \right) + d \right]$$

use pairs of `\left` and `\right` commands.

```
$$\left[ \sqrt{\frac{p}{q}} +
   \left( \frac{a+b}{c} \right)
        + d    \right]$$
```

Every `\left` must have a `\right`.

The argument of the `\right` corresponding to a particular `\left` can be different. This allows one to open a pair with a different type of bracket than it is closed with, e.g.,

$$\left(\frac{a+b}{c} \right] + d$$

Use `\left. ... \right]` to only get one bracket. For example,

$$\int_a^b 2x dx = x^2 \Big|_a^b$$

matches the `\right|` with a `\left.` in

```
$$\left.\int_a^b 2x dx = x^2\right|_a^b$$
```

Use `\{` to get the curly-bracket.

7.16 Matrices and Arrays

The `matrix` family gives a number of shorthand matrix environments:

```
$$\begin{pmatrix} a & b \\ c & d \end{pmatrix},
\begin{Bmatrix} a & b \\ c & d \end{Bmatrix},
\begin{bmatrix} a & b \\ c & d \end{bmatrix},
\begin{vmatrix} a & b \\ c & d \end{vmatrix},
\begin{Vmatrix} a & b \\ c & d \end{Vmatrix},
\begin{matrix}  a & b \\ c & d \end{matrix}$$
```

produces

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}, \begin{Bmatrix} a & b \\ c & d \end{Bmatrix}, \begin{bmatrix} a & b \\ c & d \end{bmatrix}, \begin{vmatrix} a & b \\ c & d \end{vmatrix}, \begin{Vmatrix} a & b \\ c & d \end{Vmatrix}, \begin{matrix} a & b \\ c & d \end{matrix}$$

In each of these environments, elements are centered in their appropriate columns, the ampersand `&` is used to skip to the next element and the double backslash is used to indicate the end of a line.

For more precise control, the `array` environment may be used. Its structure is identical to the `tabular` environment, except that `tabular` may only be used in text mode and `array` may only be used in math mode. Fore example, the partitioned matrix

$$\left(\begin{array}{cc|c} a & b & c \\ p & q & r \\ \hline x & y & z \end{array} \right)$$

can be typeset with `array`,

```
$$\left(
    \begin{array}{cc|c}
        a & b & c \\
        p & q & r \\
        \hline
        x & y & z
    \end{array}
  \right) $$
```

A Symbol Tables

A.1 Math Fonts

\mathbb

$$\mathbb{A}, \mathbb{B}, \mathbb{C}, \mathbb{D}, \mathbb{E}, \mathbb{F}, \mathbb{G}, \mathbb{H}, \mathbb{I}, \mathbb{J}, \mathbb{K}, \mathbb{L}, \mathbb{M}, \mathbb{N}, \mathbb{O}, \mathbb{P}, \mathbb{Q}, \mathbb{R}, \mathbb{S}, \mathbb{T}, \mathbb{U}, \mathbb{V}, \mathbb{W}, \mathbb{X}, \mathbb{Y}, \mathbb{Z}$$

\mathcal

$$\mathcal{A}, \mathcal{B}, \mathcal{C}, \mathcal{D}, \mathcal{E}, \mathcal{F}, \mathcal{G}, \mathcal{H}, \mathcal{I}, \mathcal{J}, \mathcal{K}, \mathcal{L}, \mathcal{M}, \mathcal{N}, \mathcal{O}, \mathcal{P}, \mathcal{Q}, \mathcal{R}, \mathcal{S}, \mathcal{T}, \mathcal{U}, \mathcal{V}, \mathcal{W}, \mathcal{X}, \mathcal{Y}, \mathcal{Z}$$

\mathfrak

$$\mathfrak{A}, \mathfrak{B}, \mathfrak{C}, \mathfrak{D}, \mathfrak{E}, \mathfrak{F}, \mathfrak{G}, \mathfrak{H}, \mathfrak{I}, \mathfrak{J}, \mathfrak{K}, \mathfrak{L}, \mathfrak{M}, \mathfrak{N}, \mathfrak{O}, \mathfrak{P}, \mathfrak{Q}, \mathfrak{R}, \mathfrak{S}, \mathfrak{T}, \mathfrak{U}, \mathfrak{V}, \mathfrak{W}, \mathfrak{X}, \mathfrak{Y}, \mathfrak{Z}$$

\mathbf

$$\mathbf{A}, \mathbf{B}, \mathbf{C}, \mathbf{D}, \mathbf{E}, \mathbf{F}, \mathbf{G}, \mathbf{H}, \mathbf{I}, \mathbf{J}, \mathbf{K}, \mathbf{L}, \mathbf{M}, \mathbf{N}, \mathbf{O}, \mathbf{P}, \mathbf{Q}, \mathbf{R}, \mathbf{S}, \mathbf{T}, \mathbf{U}, \mathbf{V}, \mathbf{W}, \mathbf{X}, \mathbf{Y}, \mathbf{Z}$$

A.2 Math Accents

$\hat{a}$	\hat{a}	$\acute{a}$	\acute{a}	$\bar{a}$	\bar{a}
$\dot{a}$	\dot{a}	$\breve{a}$	\breve{a}	$\check{a}$	\check{a}
$\grave{a}$	\grave{a}	$\vec{a}$	\vec{a}	$\ddot{a}$	\ddot{a}
$\tilde{a}$	\tilde{a}				

A.3 Greek Letters

α	\alpha	κ	\kappa	σ	\sigma
β	\beta	λ	\lambda	ς	\varsigma
γ	\gamma	μ	\mu	τ	\tau
δ	\delta	ν	\nu	υ	\upsilon
ϵ	\epsilon	ξ	\xi	ϕ	\phi
ε	\varepsilon	o	o	φ	\varphi
ζ	\zeta	π	\pi	χ	\chi
η	\eta	ϖ	\varpi	ψ	\psi
θ	\theta	ϖ	\varpi	ω	\omega
ϑ	\vartheta	ρ	\rho		
γ	\gamma	ϱ	\varrho		
Γ	\Gamma	Ξ	\Xi	Φ	\Phi
Δ	\Delta	Π	\Pi	Ψ	\Psi
Θ	\Theta	Σ	\Sigma	Ω	\Omega
Λ	\Lambda	Υ	\Upsilon		

A.4 Variable Size Symbols

$\sum$	\sum	$\bigcap$	\bigcap	$\bigodot$	\bigodot
$\prod$	\prod	$\bigcup$	\bigcup	$\bigotimes$	\bigotimes
$\coprod$	\coprod	$\bigsqcup$	\bigsqcup	$\bigoplus$	\bigoplus
$\int$	\int	$\oint$	\oint	$\biguplus$	\biguplus
$\bigvee$	\bigvee	$\bigwedge$	\bigwedge		

A.5 Named Math Functions

\arccos	\cos	\csc	\exp	\ker	\limsup
\arcsin	\cosh	\deg	\gcd	\lg	\ln
\arctan	\cot	\det	\hom	\lim	\log
\arg	\coth	\dim	\inf	\liminf	\max
\min	\Pr	\sec	\sin		
\sinh	\sup	\tan	\tanh		

A.6 Brackets

The \left and \right commands may be applied to each of these symbols.

(	(	/	/	$\uparrow$	\uparrow	|	|
)	)	\	\backslash	$\downarrow$	\downarrow	$\|$	\\|
[	[	$\lfloor$	\lfloor	$\updownarrow$	\updownarrow	$\langle$	\langle
]	]	$\rfloor$	\rfloor	$\Uparrow$	\Uparrow	$\rangle$	\rangle
{	\{	$\lceil$	\lceil	$\Downarrow$	\Downarrow		
}	\}	$\rceil$	\rceil	$\Updownarrow$	\Updownarrow		

A.7 Relational Symbols

$\leq$	\le	$\geq$	\ge	$\neq$	\neq
$\leq$	\leq	$\geq$	\geq	$\doteq$	\doteq
$\ll$	\ll	$\gg$	\gg	$\approx$	\approx
$\subset$	\subset	$\supset$	\supset	$\cong$	\cong
$\subseteq$	\subseteq	$\supseteq$	\supseteq	$\equiv$	\equiv
$\sqsubset$	\sqsubset	$\sqsupset$	\sqsupset	$\propto$	\propto
$\sqsubseteq$	\sqsubseteq	$\sqsupseteq$	\sqsupseteq	$\sim$	\sim
$\in$	\in	$\ni$	\ni	$\simeq$	\simeq
$\vdash$	\vdash	$\dashv$	\dashv	$\parallel$	\parallel
$\models$	\models	$\perp$	\perp	$\parallel$	\\|
$\asymp$	\asymp	$\bowtie$	\bowtie	$\mid$	\mid
$\succ$	\succ	$\succeq$	\succeq	$\frown$	\frown
$\prec$	\prec	$\preceq$	\preceq	$\smile$	\smile

A.8 $\mathcal{AMS}$ Relational Symbols

Requires \usepackage{amssymb}

$\leqq$	\leqq	$\supset$	\supset	$\circeq$	\circeq
$\leqslant$	\leqslant	$\supseteqq$	\supseteqq	$\triangleq$	\triangleq
$\eqslantless$	\eqslantless	$\precapprox$	\precapprox	$\thicksim$	\thicksim
$\lesssim$	\lesssim	$\vDash$	\vDash	$\thickapprox$	\thickapprox
$\lessapprox$	\lessapprox	$\Vvdash$	\Vvdash	$\vartriangleleft$	\vartriangleleft
$\approxeq$	\approxeq	$\smallsmile$	\smallsmile	$\trianglelefteq$	\trianglelefteq
$\lessdot$	\lessdot	$\smallfrown$	\smallfrown	$\sqsupset$	\sqsupset
$\lll$	\lll	$\bumpeq$	\bumpeq	$\succcurlyeq$	\succcurlyeq
$\lessgtr$	\lessgtr	$\Bumpeq$	\Bumpeq	$\curlyeqsucc$	\curlyeqsucc
$\doteqdot$	\doteqdot	$\geqq$	\geqq	$\succsim$	\succsim
$\between$	\between	$\geqslant$	\geqslant	$\succapprox$	\succapprox
$\pitchfork$	\pitchfork	$\eqslantgtr$	\eqslantgtr	$\vartriangleright$	\vartriangleright
$\backsim$	\backsim	$\gtrsim$	\gtrsim	$\trianglerighteq$	\trianglerighteq
$\backsimeq$	\backsimeq	$\gtrapprox$	\gtrapprox	$\preccurlyeq$	\preccurlyeq
$\subseteqq$	\subseteqq	$\gtrdot$	\gtrdot	$\curlyeqprec$	\curlyeqprec
$\Subset$	\Subset	$\ggg$	\ggg	$\shortparallel$	\shortparallel
$\sqsubset$	\sqsubset	$\gtrless$	\gtrless	$\risingdotseq$	\risingdotseq
$\Vdash$	\Vdash	$\gtreqless$	\gtreqless	$\fallingdotseq$	\fallingdotseq
$\shortmid$	\shortmid	$\gtreqqless$	\gtreqqless	$\varpropto$	\varpropto
$\precsim$	\precsim	$\eqcirc$	\eqcirc	$\blacktriangleleft$	\blacktriangleleft
$\therefore$	\therefore	$\because$	\because	$\backepsilon$	\backepsilon

A.9 Binary Operations

$\pm$	\pm	$\cap$	\cap	$\circ$	\circ
$\mp$	\mp	$\cup$	\cup	$\bullet$	\bullet
$\times$	\times	$\uplus$	\uplus	$\diamond$	\diamond
$\div$	\div	$\sqcap$	\sqcap	$\lhd$	\lhd
$\cdot$	\cdot	$\sqcup$	\sqcup	$\rhd$	\rhd
$\star$	\star	$\vee$	\vee	$\unlhd$	\unlhd
$*$	\ast	$\wedge$	\wedge	$\unrhd$	\unrhd
$\dagger$	\dagger	$\oplus$	\oplus	$\oslash$	\oslash
$\ddagger$	\ddagger	$\ominus$	\ominus	$\odot$	\odot
$\amalg$	\amalg	$\otimes$	\otimes	$\bigcirc$	\bigcirc
$\Box$	\Box	$\Diamond$	\Diamond	$\bigtriangleup$	\bigtriangleup
$\wr$	\wr	$\triangleleft$	\triangleleft	$\bigtriangledown$	\bigtriangledown
$\setminus$	\setminus	$\triangleright$	\triangleright		

A.10 $\mathcal{AMS}$ Binary Operations

Requires \usepackage{amssymb}

$\dotplus$	\dotplus	$\curlywedge$	\curlywedge	$\boxminus$	\boxminus
$\Cap$	\Cap	$\Cup$	\Cup	$\boxdot$	\boxdot
$\barwedge$	\barwedge	$\circledcirc$	\circledcirc	$\divideontimes$	\divideontimes
$\intercal$	\intercal	$\rtimes$	\rtimes	$\doublebarwedge$	\doublebarwedge
$\boxtimes$	\boxtimes	$\ltimes$	\ltimes	$\smallsetminus$	\smallsetminus
$\boxplus$	\boxplus	$\circleddash$	\circleddash	$\curlyvee$	\curlyvee
$\veebar$	\veebar	$\circledast$	\circledast	$\rightthreetimes$	\rightthreetimes
$\boxminus$	\boxminus	$\centerdot$	\centerdot	$\leftthreetimes$	\leftthreetimes

A.11 Standard Arrows

$\leftarrow$	\leftarrow	$\longleftarrow$	\longleftarrow
$\Leftarrow$	\Leftarrow	$\Longleftarrow$	\Longleftarrow
$\rightarrow$	\rightarrow	$\longrightarrow$	\longrightarrow
$\Rightarrow$	\Rightarrow	$\Longrightarrow$	\Longrightarrow
$\leftrightarrow$	\leftrightarrow	$\longleftrightarrow$	\longleftrightarrow
$\Leftrightarrow$	\Leftrightarrow	$\Longleftrightarrow$	\Longleftrightarrow
$\mapsto$	\mapsto	$\longmapsto$	\longmapsto
$\hookleftarrow$	\hookleftarrow	$\hookrightarrow$	\hookrightarrow
$\leftharpoonup$	\leftharpoonup	$\rightharpoonup$	\rightharpoonup
$\leftharpoondown$	\leftharpoondown	$\rightharpoondown$	\rightharpoondown
$\rightleftharpoons$	\rightleftharpoons	$\leadsto$	\leadsto
$\uparrow$	\uparrow	$\downarrow$	\downarrow
$\Uparrow$	\Uparrow	$\Downarrow$	\Downarrow
$\uparrow$	\uparrow	$\Uparrow$	\Uparrow
$\downarrow$	\downarrow	$\Downarrow$	\Downarrow
$\updownarrow$	\updownarrow	$\Updownarrow$	\Updownarrow
$\nearrow$	\nearrow	$\searrow$	\searrow
$\updownarrow$	\updownarrow	$\Updownarrow$	\Updownarrow

A.12 $\mathcal{AMS}$ Arrows

$\dashrightarrow$	\dashrightarrow	$\dashleftarrow$	\dashleftarrow
$\leftleftarrows$	\leftleftarrows	$\leftrightarrows$	\leftrightarrows
$\Lleftarrow$	\Lleftarrow	$\looparrowleft$	\looparrowleft
$\leftrightharpoons$	\leftrightharpoons	$\curvearrowleft$	\curvearrowleft
$\downdownarrows$	\downdownarrows	$\curvearrowright$	\curvearrowright
$\upuparrows$	\upuparrows	$\upharpoonleft$	\upharpoonleft
$\downharpoonleft$	\downharpoonleft	$\upharpoonright$	\upharpoonright
$\leftrightsquigarrow$	\leftrightsquigarrow	$\rightrightarrows$	\rightrightarrows
$\rightleftarrows$	\rightleftarrows	$\twoheadrightarrow$	\twoheadrightarrow
$\rightarrowtail$	\rightarrowtail	$\looparrowright$	\looparrowright
$\rightleftharpoons$	\rightleftharpoons	$\Lsh$	\Lsh
$\circlearrowright$	\circlearrowright	$\Rsh$	\Rsh
$\circlearrowleft$	\circlearrowleft	$\multimap$	\multimap
$\downharpoonright$	\downharpoonright	$\rightsquigarrow$	\rightsquigarrow

A.13 Miscellaneous Math Symbol

$\ddots$	\ddots	$\cdots$	\cdots	$\vdots$	\vdots
$\ldots$	\ldots	$\aleph$	\aleph	$\prime$	\prime
$\forall$	\forall	∞	\infty	$\hbar$	\hbar
$\emptyset$	\emptyset	$\exists$	\exists	$\Box$	\Box
$\imath$	\imath	∇	\nabla	$\neg$	\neg
$\Diamond$	\Diamond	$\jmath$	\jmath	$\surd$	\surd
$\flat$	\flat	$\triangle$	\triangle	ℓ	\ell
$\top$	\top	$\natural$	\natural	$\clubsuit$	\clubsuit
$\wp$	\wp	$\bot$	\bot	$\sharp$	\sharp
$\diamondsuit$	\diamondsuit	$\Re$	\Re	$\|$	\\|
$\backslash$	\backslash	$\heartsuit$	\heartsuit	$\Im$	\Im
$\angle$	\angle	∂	\partial	$\spadesuit$	\spadesuit

A.14 Special Math Typesetting

$\widetilde{abc}$	`\widetilde{abc}`	$\widehat{abc}$	`\widehat{abc}`
$\overleftarrow{abc}$	`\overleftarrow{abc}`	$\overrightarrow{abc}$	`\overrightarrow{abc}`
$\overline{abc}$	`\overline{abc}`	$\underline{abc}$	`\underline{abc}`
$\overbrace{abc}$	`\overbrace{abc}`	$\underbrace{abc}$	`\underbrace{abc}`
$\sqrt{abc}$	`\sqrt{abc}`	$\sqrt[n]{abc}$	`\sqrt[n]{abc}`
f'	`f'`	$\frac{abc}{xyz}$	`\frac{abc}{xyz}`

A.15 Text Accents

These may only be used in text mode, and are not valid in math mode.

ó	`\'{o}`	ò	`\`{o}`	ô	`\^{o}`	ö	`\"{o}`	õ	`\~{o}`
ō	`\={o}`	ȯ	`\.{o}`	ŏ	`\u{o}`	ǒ	`\v{o}`	ő	`\H{o}`
o͡o	`\t{oo}`	ǫ	`\c{o}`	ọ	`\d{o}`	o̲	`\b{o}`	ů	`\r{o}`

A.16 Special Symbols in Text Mode

œ	`\oe`	Œ	`\OE`	æ	`ae`	Æ	`\AE`	å	`\aa`
Å	`\AA`	ø	`\o`	Ø	`\O`	ł	`\l`	Ł	`\L`
ß	`ss`	SS	`\SS`	¡	`!‘`	¿	`?‘`	†	`\dag`
§	`\S`	‡	`\ddag`	¶	`\P`	&	`\&`	€	`\texteuro`
¥	`\yen`	$	`\$`	%	`\%`	_	`\_`	£	`\pounds`

©	`\copyright`	ↄ	`\textcopyleft`
®	`\textregistered`	₩	`\textwon`
฿	`\textbaht`	⋆	`\textborn`
°	`\textdegree`	🍃	`\textleaf`
£	`\textlira`	⚮	`\textmarried`
♪	`\textmusicalnote`	№	`\textnumero`

A.17 Text Font Styles

`\rm`	Roman	`\it`	*italic*	`\sc`	Small Caps
`\bf`	**boldface**	`\sl`	*slanted*	`\sf`	Sans Serif
`\tt`	`typewriter`				

A.18 Font Sizes

`\tiny`	the quick brown fox
`\scriptsize`	the quick brown fox
`\footnotesize`	the quick brown fox
`\small`	the quick brown fox
`\normalsize`	the quick brown fox
`\large`	the quick brown fox
`\Large`	the quick brown fox
`\LARGE`	the quick brown fox
`\huge`	the quick brown fox
`\Huge`	the quick brown fox

B References

Online References: There are many good online references for LaTeX. Because of the fluidity of the internet, the URL's may change.

The LaTeX Reference Manual: http://home.gna.org/latexrefman/

Latex Reference Pages: http://herbert.the-little-red-haired-girl.org/html/latex2e/

The LaTeX Tutorial: http://www.tug.org/tutorials/tugindia/

The LaTeX Wikibook: http://en.wikibooks.org/wiki/LaTeX

The Not So Short Introduction to LaTeX http://tobi.oetiker.ch/lshort/

Print References

These are just a couple that I like; there are lots of good ones.

Grätzer G, *More Math into LaTeX, 4th Edition*, Springer (2007).

Kopka H and Daly P. *A Guide to LaTeX2e*. Addison Wesley (2003).

Mittelback F et. al. *The LaTeX Companion*. Addison Wesley (2004).