Introducing LaTeX

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This is a DRAFT document. It is not finished.
Please submit suggestions and corrections.

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Abstract

This document provides an general introduction to the Latex document preparation system. It is not a reference document or user's manual. It is intended to provide enough information to get you started using Latex, and then to start learning more specifics on your own using one of the many excellent references that are widely available. It is intendend primarily for Mathematics students at Calfornia State University, Northridge.

Contents

Pleae 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.

1 What is LaTeX?

LaTeX a document preparation system for Mathematics. It was originally developed in the days when computers were command-line based and before things like monitors or WYSIWYG applications were used with computers. It is an example of a *markup* language, like `html`, the languge of the internet. Markup languages provide a way to annotate the contents text document with instructions that indicate the way the text should look (be presented) to the reader. The idea is that these instructions are distinugishable from the content of the document in a way that allows the computer to know the difference.

Markup in LaTeX is provided by a set of special characters. The most important of these is the \(or backslash). Whenever the computer sees a word starting with the \, it knows that the word is a command and not content. Many of these commands have properties, or only apply to certain parts of the text, and other specific characters, notably the {, }, and `$` characters, also have special meanings. We will talk more about this shortly.

Documents for LaTeX are prepared (composed) in a text editor, not a word processor. When you look at a file in a text editor all you is the text contained in the file; there are no fancy additions like boldfacing or underlining, and no distinction between fonts. Text editors are still in wide use today by programmers, because they display the raw text content of a file, not the hidden commands that tell a program what the text will look like. Text editors are concerned with the *content* of a document, not its presentation (what it looks like). You may be familiar with programs like the Windows notepad, which can be used as a text editor. Most LaTeX users prefer to use a specialized text editor that is designed for LaTeX , which provides wizards and buttons for many of the specialized functions that are available in the LaTeX .

All LaTeX systems rely heavily on file types, which are usually identified by a three-letter extension following a period at the end of the file name. Documents are converted from the original source (file type `.tex`) through a sequence of commands to the final portable document format (file type`.pdf`), with the intermediate documents all having the same file name but different file extensions. This may be a bit confusing to some Windows users, as Vista, by default, hides the file extension, so that you end up with several files that

seem to have the same name (but really don't because the differences are hidden).[1]

Traditionally LaTeX documents would be prepared in the text editor, then converted to a *device independent format* (`.dvi`) print document by typing `latex` on the command line. When postscript became a standard format for printers, the program `dvips` became a popular way to convert these files to printable files. More recently, as `pdf` files have become the defacto stanard for typeset documents, the program `ps2pdf` came into use. Nowadays most LaTeX sytems have a `pdftex` or `pdflatex` command that skips all the intermediate steps and automatically generates the `pdf` file from the `tex` file. Even though most LaTeX users never use the command line, they need to know about them because the functions that they provide are usually identified in LaTeX editors (like TexMaker) by their command line name.

LaTeX is based on an earlier language called TeX, developed by Donald Knuth in 1977, and was developed originally by Leslie Lamport in the early 1980's. Both Knuth and Lamport have written popular reference textbooks on their systems. The current version is called LaTeX 2_ε. LaTeX is currently maintained by The Latex Project at http://www.latex-project.org. AMS LaTeX , which you may have heard of, is not actually a separate program, but a set of extensions (packages) developed by the American Mathematical Society that you will often use within latex. One of the best things about LaTeX is that it is free, and available for all common platforms, whether you prefer Linux, Mac, or (ugh) Windows.

This document is only an introduction. It's purpose is to help you understand enough about what LaTeX does to allow you to understand one of the many LaTeX reference manuals. You definitely need to get one of these. My personal favorite is the *Guide to Latex* by Helmut Kopka and Patrick Daly (Addison Wesley, 2003). A good online reference is the *LaTeX Wikibook* at http://en.wikibooks.org/wiki/LaTeX. Many other lists of references are maintained by CTAN, the Comprehensive TeX Archive Network, at http://ctan.org/starter.html, and by the TeX Users Ground at http:\tug.org.

[1] To see the file extensions in Vista, open a folder in Windows explorer, then click Layout > Folder > View > Uncheck "hide extensions for known file types" and click OK.

2 Basic LaTeX Document Structure

One of the best ways to get started with LaTeX is to just plunge in. Try looking at the sample document in Appendix A before continuing here.

A typical LaTeX document looks something like this:

```
\documentclass[12pt,letterpaper]{article}
\usepackage[latin1]{inputenc}
\usepackage{amsmath}
\usepackage{amsfonts}
\begin{document}

This is where you type the contents of your document.

\end{document}
```

The first line in the file should start with `\documentclass`, and the last line of the file should be `\end{document}`. The stuff before the `\begin{document}` is known as the header and consists only of commands that tell LaTeX things like which parts of LaTeX to use, define new commands, and general formatting commands that apply to the entire document. The content of your document goes between the `\begin` and `\end{document}` commands. This area contains both text and markup that tells the system how the text should look. You just type the contents of your document in right there, adding commands such as `\textbf` (which would turn on boldface) to indicate your markup, right where you want them to take effect. In general white space (blanks, tabs, and new lines) are ignored and compressed into whatever space it takes to make the document look nice, but leaving a blank like means to start a newparagraph (which may be indented or have a particular line spacing).

The format of the first line is

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

where *options* can be omitted if you are satisfied with the default options of your installation and *class* is a required string that defines the type of document you are preparing.

Standard document classes are `book`, `report`, `article`, and `letter`. Other document classes are provided by some of the many hundreds of add-on LaTeX packages. These classes different primarily in how they handle chapters and sectioning.

The *options* determines things like standard font size, page size, and orientation, among other things. Multiple options may be specified, separted by commas.

Standard font sizes are: `10pt`, `11pt`, and `12pt`.

Standard paper sizes include: `letterpaper`, `legalpaper`, and `A4paper`

The default orientation is portrait, so you don't specifiy that. For landscape orientation, use: `landscape`.

Other standard options include: `onecolum` (one columntext is the default) or `twocolumn`; `oneside`(default) or `twoside`.

Extensions to LaTeX are called *packages*. Packages are loaded with the

`\usepackage{`*package name*`}`

Usually you will want to load several packages; these can be listed in separate `usepackage` commands or combined in single commands with the package names separated by commas. Each package defines additional commands that you will use. To findout what packages are needed, just look up the commands you are using in your reference book.

Some packages are considered part of the normal LaTeX installation and are called core packages. Other packages are written by members of the LaTeX development team who maintain the LaTeX application software, and yet other packages are contributed by members of the LaTeX user community. Many journal publishers will provide you with special packages to format your document to look a certain way. Anybody can write a package; its really just a file with a collection of LaTeX commands and a file type of `.sty`.

If you use any of the major latex distributions like TexLive, MikTek, or MacTex, in all liklihood all the of the packages you will ever need will already be loaded when you install LaTeX if you tell it to do a full installation since the developers of these programs keep themselves aware of what's available in the community. You can also always add packages to your installation at any time.

3 Writing Text & Special Symbols

In LaTeX 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:

- There are certain characters that have special meanings, specifically `#`, `$`, `&`, `~`, `_`, `^`, `%`, `{`, `}`, `\`. There are special commands that let you include those symbols in your document (see table 1).
- You begin new paragraphs by skipping a line. There are commands to change paragraph indentation and spacing. This is discussed in section 5.
- To control formatting you insert either commands (things that look like `\command`) or environments (things that look like `\begin{name} ... \end{name}`). This is discussed in section 4.
- Equations and certain mathematical symbols can only be included by using "math mode." This is discussed in section 9.

In addition there are over 4000 special symbols that can be used in LaTeX 2_ε; 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/. To give you an idea, examples of these symbols include

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

There are also numerous commands that allow you to add non-English characters such as à or ü as well as entire alphabets. Please see your reference book for more details.

Table 1: Characters with special meanings in LaTeX and the commands that can be used to insert them in 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.

4 Commands and Evironments

There are two ways that you tell LaTeXto do something: through commands and environments.

A command is anything that begins with a backshlash (\) like `\pagebreak`, which tells LaTeXto skip to the top of the next page, or `\checkmark`, which tells LaTeXto print the character ✓ right in the spot where you typed the command.

Environments are specific regions of your document that you want to have a specific format, like `\enumerate`, which inserts a numbered list, or `\pmatrix`, which inserts a matrix (but only in math mode). Every environment is delimited by the `\begin` and `\end` command, as in

```
\begin{name-of-environment}
...
\end{name-of-environment}
```

For example, the `\center` environment tells LaTeXto center everything between the `\begin{center}` and `\end{center}`:

```
To center something we use the {\tt center} environment:
\begin{center}
   This text is centered in the page
\end{center}
For some environments, we can also use the following
shorthand form:
{\center So is this!}
```

To center something we use the `center` environment:

This text is centered in the page

For some environments, we can also use the following shorthand form:

So is this!

5 Formatting Your Document

Document Organization

You will probably use the `article` document class most often; articles are divided into `section`, `subsection`, `subsubsection`, and `paragraph`. Books and reports also have `chapter` and optional `part` that is larger than a chapter.

To start a new section (chapter, etc), use the command

```
\section{Section Title}
```

In books and reports, the chapter starts on a new page. In articles, you have to insert pages manually.

Each chapter, section, etc. it numbered sequentially and automatically. In an article, for example, the sections will be numbered 1, 2, 3, etc. Within section 2, the subsections will be numbered 2.1, 2.2., 2.3, etc., an d so forth hierarchically. To suppress section numbering but still generate new sections append an asterisk, as in

```
\section*{Un-numbered Section Title}
```

If you want a table of contents just insert the command `\tableofcontents` in the exact location where you want it placed.

Section Hierarchy.

document class→	`book`	`report`	`article`	`letter`
`\part`	✓	✓		
`\chapter`	✓	✓		
`\section`	✓	✓	✓	
`\subsection`	✓	✓	✓	
`\subsubsection`	✓	✓	✓	
`\paragraph`	✓	✓	✓	
`\subparagraph`	✓	✓	✓	

Paragraph Spacing

Paragraphs in LaTeXare, by default, justified (both the left and right margins are aligned); there is no space between paragraphs; and the first word is indented. If you want to change these defaults, two useful commands to put in your document are the following:

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

The first one controls the paragraph indentation, the second the spacing between paragraphs. Units can be in any of `in, cm, mm, pt, ex, em`. The last two are standard printer's measure: `ex` is the height of the letter x; and `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.

Double Spaced Text

Use command \`doublespace` in package `setspace` to get doublespaced text.

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 use package `multicol` and environment `multicols`. The format is

```
\begin{multicols}{2}
...
\end{multicols}
```

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

Adding Vertical and Horizontal Space

The commands

```
\hspace{1in}   % add one inch of horizontal space
\vspace{2.5cm} % add 2.5 centimeters of vertical space
```

are useful for doing this.

Inserting Code

The `verbatim` environment lets you add a block of text exactly the way you type it, with no typesetting or command interpretation. Anything between the \begin{verbatim} and the \end{verbatim} is set in mono-spaced font (i.e., every character is the same width) and is positioned exactly the way you type it. This is useful for including blocks of computer programs, for example, in your text.

Forced Page, Column, and Line Breaks

`\newpage`
`\newcolumn`
Ends a page early and fills the rest of the page with blank space.

`\pagebreak`
`\columnbreak`
Ends a page and attempts to space things out to make it look like a full page.

`\clearpage`
Like `\newpage` but also outputs all pending tables and figures.

`\\`
`\\[d]`
`\\[*d]`
Insert a blank line or inserts a blank distance `d` where `d` is measured in `in,cm,pts`, etc. If the *-form is used, no page breaks will occur with the space d. Instead the current line will be forced to the next page if there is not enouch space to fit the blank space on the current page, and then the space will be inserted.

Headers,Footers,etc.

This is done with the package `fancyhdr`. You have to define a fancy page style and then tell LaTeXto use it. To define a style, put the following in your preamble:

```
\fancypagestyle{mystyle}{
\renewcommand{\footrulewidth}{0.4pt}
\fancyfoot[LO, RE] {Left/odd and right/even page footer}
\fancyfoot[RO, LE] {Right/odd and left/even page footer}
\fancyhead[RO, LE] {Math 462}
\fancyfoot[C]{}
}
\pagestyle{mystyle}
```

The L, C and R stand for the left, center and right header and footer.

E and O stand for even and odd numbered pages. These only apply for two-sided text. If you don't use two-sided pages, leave off the O and E.

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.

Including External Files

`\input{`*filename.tex*`}`
You can put any part of your document into one or more external files. Some

people like to use a standard template for their prologue and save it in a file. Suppose we put all of our prologue in the file `headers.tex`. Then it would be perfectly valid to have a document

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

where `mydocument1.tex`, `mydocument2.tex`, etc., are files in the same folder as your main `tex` document. If you want to refer to other files you can use relative file names such as

```
\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.

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[2]. Each footnote is indented. To remove the indendtation throughout your document put the following in your preamble: `\usepackage[hang,flushmargin]footmisc`. Footnotes are not allowed in certain parts of the document (like the title or inside `\parbox`'s. You can still put a footnotes in these places by using the `\footnotemark` and `\footnotetext` commands.

[2] like this!

6 Lists

Numbered Lists

Numbered lists are created with `enumerate`.

```
\begin{enumerate}
\item The text for the first item ...
\item The text for the second item ...
...
\end{enumerate}
```

Each item in a list must begin with `\item`.

1. The text for the first item ...
2. The text for the second item ...

If you want to start your list with a different number, say 7, then you need to reset the counter. After the `\enumerate` but before the first `\item`, use

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

Lists can be nested. The standard hierarchy of enumeration is: 1., (a), i., A. For example,

1. This is a list
    (a) which has a list
        i. within a list
            A. of lists
            B. and lists
        ii. and lists
    (a) Isn't this fun?

\renewcommand{*label*}{*type*{*counter* }*optional-text*}
If you would rather use a sequence like I., A., 1., a., you need to redefine the enumeration labels using \renewcommand, as in

The first argument, *label*, refers to teh particular list level you are redefining. Values are `labelenumi, labelenumii, labelenumiii, labelenumiv`, for the first four levels; if you go deeper you have to define new label labels (see a latex manual).

The argument *counter* refers to the counter value to use. These are the counters for the different levels. In general will use the counter `enumi` with label `labelenumi`, etc.

The values of type are:

\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.

Bulleted Lists

Bulleted lists used `itemize` instead of `enumerate`.

```
 \begin{itemize}
\item The text for the first item ...
\item The text for the second item ...
...
\end{itemize}
```

- The text for the first item ...
- The text for the second item ...
- ...

7 Tables and Tabbing

\tabbing

Tables can be generated using the \begin{tabbing} and \end{tabbing}. In between individual tab stops are set with the \= and a line is terminated by the double slash \\. After tabs are set in the first line, the jump is made to a tab stop in subsequent lines with the command \>. For example:

```
\begin{tabbing}
   Math \hspace{2in} \= is fun \hspace{1in} \= for everybody \\
   Physics \>is boring \\
   Video Games \> really rock \> my socks off
\end{tabbing}
```

Math	is fun	for everybody
Physics	is boring	
Video Games	really rock	my socks off

\tabular and \array

Tables are generated with these commands. The main difference is that \tabular is used in text mode and \array is used in math mode.

The basic syntax is \begin{tabular}[*columns*] ... \end{tabular}.

where *columns* specifies the number of columns and their alignment. One character is required for each column: `c` (for centered); `l` (for left); `r` (for right); `p` (for justified paragrah). Vertical lines between columns are specified by `|`. Hence {`|ccc|r|r|`} for *columns* means five columns, three are centered adn two right justified. There are lines between the 3rd and 4th columns and 4th and 5th columns, as well as on the outside of the table.

Horizontal lines are placed in tables according to \hline.

Jumping to the next column is specified within a row by `&`.

For example

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

will produce the following centered table (if you don't use the `center` then the table will be on the left-hand side of the page).

Name	Grade
Tom	A
Dick	C
Harry	B+

Floating Tables

Sequentially numbered, captioned tables can be produced usign the `table` environment.

`\begin{table}`[*where*] $\cdots$ *table contents* $\cdots$ `\end{table}`

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

The argument *where* tells LaTeXwhere to put the table. Here are the choices:

`h` here
`t` Top of current page (or next page if no space)
`b` Bottom of current page (or next page if no space)
`p` On a separate page by itself

To get a table number and captions use the `\caption` command. The typical structure is then

```
\begin{table}[h]
\caption{ ... }
\begin{tabular}{...}
\end{tabular}
\end{table}
```

This places the caption at the top of the table; to get it at the bottom of the table place it after the `\end{tabular}` commands.

If you want to refer to the table elsewhere in the document place the `\label` command immediately after the `\caption`. For example, put `\label{table:grades}` after the `\caption{···}`; then anywhere in your document you will get the table number by using `\ref{table:grades}`. Here is an example.

Table 2: This is a sample table.

Period	Class	Room
1	Science	H7
2	Geography	L23
3	Math	J6

To refer to table 2 you would use `\table{table:sample-table}` to print the table number. Here is the LaTeX for table 2:

```
\begin{table}[h]
  \caption{This is a sample table.}\label{table:sample-table}
  \begin{center}
  \begin{tabular}{|c|l|c|}
     \hline Period & Class & Room \\
     \hline 1  & Science & H7\\
     \hline 2  & Geography & L23\\
     \hline 3  & Math & J6\\
     \hline
  \end{tabular}
  \end{center}
\end{table}
```

8 Figures

The easiest way to get a picture in your document is to use `\includegraphics`.

In your preamble: `\include{graphicx}`

The syntax is `\includegraphics`[*size*]{*filename*}

The *size* parameter can be something like `width=3in`, `scale=.5`, or `height=43mm`.

The *filename* is specified relative to directory that your `.tex` file is sitting in. (Some oeprating systems allow you to specify absolute locations, for for transferability this not recommended.) If you don't specify a file time, different versions of latex will look for a default file. For example, `pdftex` assumes you figures are in `pdf` format, and `latex` assumes they are in `eps` (postscript) format. Most versions of latex will accept `jpg`, `tif`, or `png` files, but it depends on the implementation and operating system you are using.

For example, to place the file `fred.png` at the current location in the file and make it one inch wide, assuming that `fred.png` is sitting in a folder `pictures`,

```
\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.

9 Writing Equations

When you include an equation in your document you must tell LaTeX that it is an equation. This puts LaTeX into "Math" mode. You only have access to the mathematical symbols like $\sum$ and $\int$, and can only use precise mathematical typesetting in math mode. You tell LaTeX whether or not you are in math mode by marking *both* the beginning and end of the equation with a special symbol such as $ or a command.

There are two basic types of equations in LaTeX: *inline* equations and *display* equations.

An *inline* equation is one that is part of the text of a sentence, like $ax^2 + bx + c = 0$. Whenever LaTeXsees a $, it thinks you are telling it that you are entering math mode, and everything between that $ and the next $ it sees are interpreted as a single equation. The equation is included in the text of the paragraph you are writing. For example, to write the paragraph:

> An equation of the form $y = ax^2+bx+c$, where $a, b, c \in \mathbb{R}$, is called a quadratic polynomial.

This could be written with the following LaTeX:

```
An equation of the form $y=ax^2 + bx + c$, where
$a,b,c\in\mathbb{R}$, is called a quadratic polynomial.
```

In *display* mode an equation is centered horizontally on the page and some blank space is place before and after the equation to make it look like a separate paragrah. To print the equation in display mode, instead of using a single $ at the beginning and end of the equation, use a double-$:

```
An equation of the form $$y=ax^2 + bx + c,$$ where
$a,b,c\in\mathbb{R}$, is called a quadratic polynomial.
```

which will look like:

> An equation of the form
>
> $$y = ax^2 + bx + c,$$
>
> where $a, b, c \in \mathbb{R}$, is called a quadratic polynomial.

Note that for a display quation, if you want it to be immediately followed by a comma, you have to move the comma to the inside of the equation; otherwise the comma will be printed on the next line of text after the equation. Only the material between the two pairs of `$$`'s be centered in the page. Another way to write a display equation is with the commands `\[` and `\]`, as in

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

which is typeset as

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

If you want to assign numbers to your equations, as with

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

latex can do this for you automatically with

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

Use the tt boxed command to put a box around an equation:

The quadratic equation is given by:

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

where a, b, and c are the coefficients of x^2, x, and the constant term.

```
The quadratic equation is given by:
\begin{equation}
```

```
  \boxed{\label{eq:quad}x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}}
\end{equation}
where $a$, $b$, and $c$ are the coefficients of $x^2$, $x$,
and the constant term.
```

The \begin{equation} and \end{equation} serve the same function as the beginning and ending $$ or the \[··· \] operators.

All equations that are demarcated with the \begin{equation} and the \end{equation} commands are numbered sequentially. Equations that are set off using the $$ or \[operators are not numberd and are not included in the numbering. If you add an additional equation before a numbered equation with the equation command then all equations will be automatically re-numbered for you.

Since LaTeX keeps track of equation numbers you can refer to equations in your document. To connect to an equation, you have to label it:

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

Then to display

> We can use equation 2 to figure out the roots of any quadratic.

we would use the following:

```
We can use equation \ref{eq:myequation} to figure
out the roots of any quadratic
```

The label is the defined by the \label command, and is referenced by the \ref command. Any string can be used as a label, although some symbols like $ are not allowed by most LaTeX systems. In our example the label is "tteq:myequation". you do not have to preface your labels by "eq:" - this is just a standard that some people like to use, since you can also number

figures, tables, theorems, definitions, and pretty much anything else you can think of, in LaTeX .

If you want to line up a sequence of equations you can use the `align` command.

$$x = 1 \tag{3}$$
$$y = 2 + x \tag{4}$$
$$z = 3 + 2x + y \tag{5}$$

can be written using

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

If you want to suppress all of the equation numbers use `align*` instead of `align`. To suppress only one (or a subset) of the equation numbers, use the command `\nonumber` on each line where you want to suppress the numbers. You can also assign labels to specific lines within an `align` sequence using the `label` command as you did with the `equation` command.

10 Equation Tips and Tidbits

Superscripts and Subscripts

These are produced in math mode with the ^ (superscripts) and _ symbols. If there is more than one character in the exponent or subscript it must be surrounded in curly brackets {, }, as in

```
$$x_{i+j,k} = \frac{x^i x^j}{x_k}$$
```

$$x_{i+j,k} = \frac{x^i x^j}{x_k}$$

Fractions

\frac{*numerator*}{*denominator*}
\dfrac{*numerator*}{*denominator*}
\tfrac{*numerator*}{*denominator*}

Use \frac for normal-sized fractions, \dfrac for display-size fractions, and \tfrac for tiny fractions.

If you use frac as part of a larger expression such as a matrix element or the numerator of a bigger fraction, it will be reduced in size. To force it to full (display) size, used dfrac.

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

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

Use tfrac to force the smaller size:

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

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

Integrals, Sums, Limits and Roots

```
\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`).

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

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

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

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

```
\sum
\prod
```

```
\lim
```

\sqrt{*argument*}
\sqrt[n]{*argument*}

$$\sqrt[3]{2}$$

Dots, Arrows, and Text over Expressions

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

These provide variable length arrows that are over or under the desired expression.

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

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

\overline{*expression*}
We use `overline` to draw a line over 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
$$\overline{z}=\overline{a+bi}=a-bi$$
```

Chemical Reactions and Expressions Over Arrows

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`

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

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

Large Parenthesis and Delimiter Matching

Larger brackets, parenthesis, etc, as in

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

use `\left` and `\right` as in

```
$$\left[
    \sqrt{\frac{p}{q}} +
       \left(
```

```
        \frac{a+b}{c}
      \right)
  + d
\right]$$
```

They must come in matching pairs, one right for each left, or you will get an error message. You can mix and match the brackets, i.e., pair a `\right]` with a `\left(` if you want to get something like

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

Use `\left.  ...  \right]` to only get one bracket (match tne bracket with a period) and use `\{` to get the curly-bracket.

Text Inside of an Equation

To get text inside of an equation use `\text`, as in

```
\begin{equation}
{x=\frac{-b\pm\sqrt{b^2-4ac}}{2a} \text{ by equation } \ref{eq:1}
\end{equation}
```

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \text{ by equation } ?? \tag{6}$$

Use `align` to get a seqence of annotated equations,

```
\begin{align}
     a&=b+c  &\text{by Tom's theorem} \\
     b&=17   &\text{by Larry's lemma} \\
     c&=0    &\text{by Cory's corollary}
\end{align}
```

$$
\begin{aligned}
a &= b + c && \text{by Tom's theorem} && (7)\\
b &= 17 && \text{by Larry's lemma} && (8)\\
c &= 0 && \text{by Cory's corollary} && (9)
\end{aligned}
$$

Multiple Cases in an Equation

Use `array` and `\left.`

```
$$f(x)=
  \left\{
          \begin{array}{ll}
           x^3-\sqrt{x}, & \text{ if } x<25 \\
           x^2 + 23,     & \text{ if } x\ge 25
          \end{array}
   \right.$$
```

to get aligned multiple case equations:

$$
f(x) = \begin{cases} x^3 - \sqrt{x}, & \text{if } x < 25 \\ x^2 + 23, & \text{if } x \geq 25 \end{cases}
$$

Boxed Equations

Use `\boxed` inside of mathmode around the part of the equation that you want boxed:

```
The determinant of a matrix $M$ is defined as
$$\boxed{\det M = \begin{vmatrix}a&b\\c&d\end{vmatrix}=ad-bc}$$
```

The determinant of a matrix M is defined as

$$
\boxed{\det M = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc}
$$

Matrices

In general we can write matrices with the `matrix` command family.

```
$$ \begin{pmatrix} a & b \\ c & d \end{pmatrix}, % parenthesis
   \begin{Bmatrix} a & b \\ c & d \end{Bmatrix}, % { Brackets
   \begin{bmatrix} a & b \\ c & d \end{bmatrix}, % [ brackets
   \begin{vmatrix} a & b \\ c & d \end{vmatrix}, % | vertical
   \begin{Vmatrix} a & b \\ c & d \end{Vmatrix}, % || Vertical
   \begin{matrix}  a & b \\ c & d \end{matrix}$$ % no delimiter
```

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

Partitioned Matrix:

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

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

Special 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

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

Appendix A: A Sample Document

This is a sample document that was written by the original lead developer of LaTeX . One of the best ways to get started with LaTeX is to just copy this document into you text editor and start playing with it. It was designed for just that purpose.

```
% This is a sample LaTeX input file.  (Version of 12 August 2004.)
%
% A '%' character causes TeX to ignore all remaining text on the line,
% and is used for comments like this one.

\documentclass{article}      % Specifies the document class

                             % The preamble begins here.
\title{An Example Document}  % Declares the document's title.
\author{Leslie Lamport}      % Declares the author's name.
\date{January 21, 1994}      % Deleting this command produces today's date.

\newcommand{\ip}[2]{(#1, #2)}
                             % Defines \ip{arg1}{arg2} to mean
                             % (arg1, arg2).

%\newcommand{\ip}[2]{\langle #1 | #2\rangle}
                             % This is an alternative definition of
                             % \ip that is commented out.

\begin{document}             % End of preamble and beginning of text.

\maketitle                   % Produces the title.

This is an example input file.  Comparing it with
the output it generates can show you how to
produce a simple document of your own.

\section{Ordinary Text}      % Produces section heading.  Lower-level
                             % sections are begun with similar
                             % \subsection and \subsubsection commands.
```

```
The ends  of words and sentences are marked
  by   spaces. It  doesn't matter how many
spaces    you type; one is as good as 100.  The
end of   a line counts as a space.

One   or more   blank lines denote the  end
of  a paragraph.

Since any number of consecutive spaces are treated
like a single one, the formatting of the input
file makes no difference to
      \LaTeX,                % The \LaTeX command generates the LaTeX logo.
but it makes a difference to you.  When you use
\LaTeX, making your input file as easy to read
as possible will be a great help as you write
your document and when you change it.  This sample
file shows how you can add comments to your own input
file.

Because printing is different from typewriting,
there are a number of things that you have to do
differently when preparing an input file than if
you were just typing the document directly.
Quotation marks like
       ``this''
have to be handled specially, as do quotes within
quotes:
       ``\,`this'            % \, separates the double and single quote.
        is what I just
        wrote, not  `that'\,''.

Dashes come in three sizes: an
       intra-word
dash, a medium dash for number ranges like
       1--2,
and a punctuation
       dash---like
```

```
this.

A sentence-ending space should be larger than the
space between words within a sentence.  You
sometimes have to type special commands in
conjunction with punctuation characters to get
this right, as in the following sentence.
       Gnats, gnus, etc.\ all  % `\ ' makes an inter-word space.
       begin with G\@.         % \@ marks end-of-sentence punctuation.
You should check the spaces after periods when
reading your output to make sure you haven't
forgotten any special cases.  Generating an
ellipsis
       \ldots\                % `\ ' is needed after `\ldots' because TeX
                              % ignores spaces after command names like \ldots
                              % made from \ + letters.
                              %
                              % Note how a `%' character causes TeX to ignore
                              % the end of the input line, so these blank lines
                              % do not start a new paragraph.
                              %
with the right spacing around the periods requires
a special command.

\LaTeX\ interprets some common characters as
commands, so you must type special commands to
generate them.  These characters include the
following:
       \$ \& \% \# \{ and \}.

In printing, text is usually emphasized with an
       \emph{italic}
type style.

\begin{em}
   A long segment of text can also be emphasized
   in this way.  Text within such a segment can be
   given \emph{additional} emphasis.
```

```
\end{em}

It is sometimes necessary to prevent \LaTeX\ from
breaking a line where it might otherwise do so.
This may be at a space, as between the ``Mr.''\ and
``Jones'' in
       ``Mr.~Jones'',        % ~ produces an unbreakable interword space.
or within a word---especially when the word is a
symbol like
       \mbox{\emph{itemnum}}
that makes little sense when hyphenated across
lines.

Footnotes\footnote{This is an example of a footnote.}
pose no problem.

\LaTeX\ is good at typesetting mathematical formulas
like
       \( x-3y + z = 7 \)
or
       \( a_{1} > x^{2n} + y^{2n} > x' \)
or
       \( \ip{A}{B} = \sum_{i} a_{i} b_{i} \).
The spaces you type in a formula are
ignored.  Remember that a letter like
       $x$                   % $ ... $  and  \( ... \)  are equivalent
is a formula when it denotes a mathematical
symbol, and it should be typed as one.

\section{Displayed Text}

Text is displayed by indenting it from the left
margin.  Quotations are commonly displayed.  There
are short quotations
\begin{quote}
   This is a short quotation.  It consists of a
   single paragraph of text.  See how it is formatted.
\end{quote}
```

```
and longer ones.
\begin{quotation}
   This is a longer quotation.  It consists of two
   paragraphs of text, neither of which are
   particularly interesting.

   This is the second paragraph of the quotation.  It
   is just as dull as the first paragraph.
\end{quotation}
Another frequently-displayed structure is a list.
The following is an example of an \emph{itemized}
list.
\begin{itemize}
   \item This is the first item of an itemized list.
         Each item in the list is marked with a ``tick''.
         You don't have to worry about what kind of tick
         mark is used.

   \item This is the second item of the list.  It
         contains another list nested inside it.  The inner
         list is an \emph{enumerated} list.
         \begin{enumerate}
            \item This is the first item of an enumerated
                  list that is nested within the itemized list.

            \item This is the second item of the inner list.
                  \LaTeX\ allows you to nest lists deeper than
                  you really should.
         \end{enumerate}
         This is the rest of the second item of the outer
         list.  It is no more interesting than any other
         part of the item.
   \item This is the third item of the list.
\end{itemize}
You can even display poetry.
\begin{verse}
   There is an environment
    for verse \\             % The \\ command separates lines
```

```
   Whose features some poets % within a stanza.
   will curse.

                            % One or more blank lines separate stanzas.

   For instead of making\\
   Them do \emph{all} line breaking, \\
   It allows them to put too many words on a line when they'd rather be
   forced to be terse.
\end{verse}

Mathematical formulas may also be displayed.  A
displayed formula
is
one-line long; multiline
formulas require special formatting instructions.
   \[  \ip{\Gamma}{\psi'} = x'' + y^{2} + z_{i}^{n}\]
Don't start a paragraph with a displayed equation,
nor make one a paragraph by itself.

\end{document}              % End of document.
```

An Example Document

Leslie Lamport

January 21, 1994

This is an example input file. Comparing it with the output it generates can show you how to produce a simple document of your own.

1 Ordinary Text

The ends of words and sentences are marked by spaces. It doesn't matter how many spaces you type; one is as good as 100. The end of a line counts as a space.

One or more blank lines denote the end of a paragraph.

Since any number of consecutive spaces are treated like a single one, the formatting of the input file makes no difference to LaTeX, but it makes a difference to you. When you use LaTeX, making your input file as easy to read as possible will be a great help as you write your document and when you change it. This sample file shows how you can add comments to your own input file.

Because printing is different from typewriting, there are a number of things that you have to do differently when preparing an input file than if you were just typing the document directly. Quotation marks like "this" have to be handled specially, as do quotes within quotes: "'this' is what I just wrote, not 'that'".

Dashes come in three sizes: an intra-word dash, a medium dash for number ranges like 1–2, and a punctuation dash—like this.

A sentence-ending space should be larger than the space between words within a sentence. You sometimes have to type special commands in conjunction with punctuation characters to get this right, as in the following sentence. Gnats, gnus, etc. all begin with G. You should check the spaces after periods when reading your output to make sure you haven't forgotten any special cases. Generating an ellipsis ... with the right spacing around the periods requires a special command.

LaTeX interprets some common characters as commands, so you must type special commands to generate them. These characters include the following: $ & % # { and }.

In printing, text is usually emphasized with an *italic* type style.

A long segment of text can also be emphasized in this way. Text within such a segment can be given additional *emphasis.*

It is sometimes necessary to prevent LaTeX from breaking a line where it might otherwise do so. This may be at a space, as between the "Mr." and "Jones" in "Mr. Jones", or within a word—especially when the word is a symbol like *itemnum* that makes little sense when hyphenated across lines.

Footnotes[1] pose no problem.

LaTeX is good at typesetting mathematical formulas like $x - 3y + z = 7$ or $a_1 > x^{2n} + y^{2n} > x'$ or $(A, B) = \sum_i a_i b_i$. The spaces you type in a formula are ignored. Remember that a letter like x is a formula when it denotes a mathematical symbol, and it should be typed as one.

2 Displayed Text

Text is displayed by indenting it from the left margin. Quotations are commonly displayed. There are short quotations

> This is a short quotation. It consists of a single paragraph of text. See how it is formatted.

and longer ones.

> This is a longer quotation. It consists of two paragraphs of text, neither of which are particularly interesting.
>
> This is the second paragraph of the quotation. It is just as dull as the first paragraph.

Another frequently-displayed structure is a list. The following is an example of an *itemized* list.

- This is the first item of an itemized list. Each item in the list is marked with a "tick". You don't have to worry about what kind of tick mark is used.
- This is the second item of the list. It contains another list nested inside it. The inner list is an *enumerated* list.
  1. This is the first item of an enumerated list that is nested within the itemized list.
  2. This is the second item of the inner list. LaTeX allows you to nest lists deeper than you really should.

  This is the rest of the second item of the outer list. It is no more interesting than any other part of the item.
- This is the third item of the list.

You can even display poetry.

[1] This is an example of a footnote.

There is an environment for verse
Whose features some poets will curse.

For instead of making
Them do *all* line breaking,
It allows them to put too many words on a line when they'd rather
be forced to be terse.

Mathematical formulas may also be displayed. A displayed formula is one-line long; multiline formulas require special formatting instructions.

$$(\Gamma, \psi') = x'' + y^2 + z_i^n$$

Don't start a paragraph with a displayed equation, nor make one a paragraph by itself.

Appendix B: Math Symbols

These tables are derived from *LaTeX Math Symbols* by David Carlisle, Manchester University, as revised by L. Kocbach. http://web.ift.uib.no/Teori/KURS/WRK/TeX/symALL.html

Greek Letters:

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

Binary Operators:

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

Variable Size Symbols:

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

Arrows:

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

Miscellaneous Symbols in Math Mode:

$\ldots$	\ldots	$\cdots$	\cdots	$\vdots$	\vdots	$\ddots$	\ddots
$\aleph$	\aleph	$\prime$	\prime	$\forall$	\forall	∞	\infty
$\hbar$	\hbar	$\emptyset$	\emptyset	$\exists$	\exists	$\Box$	\Box^b
$\imath$	\imath	∇	\nabla	$\neg$	\neg	$\Diamond$	\Diamond^b
$\jmath$	\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	$\heartsuit$	\heartsuit
$\Im$	\Im	$\angle$	\angle	∂	\partial	$\spadesuit$	\spadesuit
$\mho$	\mho^b	.	.	$\|$	|	\	\backslash
$\lfloor$	\lfloor	$\rfloor$	\rfloor	$\langle$	\langle	$\rangle$	\rangle
$\lceil$	\lceil	$\rceil$	\rceil				

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}

Math Function Names:

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

Some Other Useful Math Symbols:

$\widetilde{abc}$	`\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}`

Math Expressions with Overscripts/Underscripts:

$$\int_a^b f(x)dx$$

```
\int_a^b f(x) dx
```

$$\sum_{i=1}^{\infty} f(i)$$

```
\sum_{i=1}^{\infty}f(i)
```

$$\overbrace{a+b+c}^{\text{first part}} + \underbrace{p+q}_{\text{the rest}}$$

```
\overbrace{a+b+c}^{\text{first part}}
+ \underbrace{p+q}_{\text{the rest}}
```

$$\lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

```
\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}
```

Installing LaTeX

You will need (a) a Latex distribution; (b) a Latex Editor; and (c) a postscript or pdf file reader.

There are many free latex packages. See CTAN (the comprehensive TeX archive network, http://www.ctan.org/) or TUG (The TeX user's group, http://www.tug.org/) if you want to find out more about them. Here are instructions for the versions I use.

Linux

Install Texmaker (http://www.xm1math.net/texmaker/) and TeX Live (http://www.xm1math.net/texmaker/) using your package manager or download them directly from the websites.

Mac

Follow the instructions at http://www.tug.org/mactex/ to get the MacTeX-2009 distribution. A latex editor is included, or you can also use Texmaker.

Windows

You will need to know whether you have 32-bit or 64-bit version of Windows installed. If you are not sure, the 32 bit versions of the programs will usually work on 64-bit systems.

You can get the Texmaker editor from http://www.xm1math.net/texmaker/.

You can get a pdf reader from Adobe at http://www.adobe.com/products/acrobat/readstep2.html

For reading postscript you will need ghostscript and ghostview; both are available from http://pages.cs.wisc.edu/~ghost/. First you need to download an installer file; then you need to locate the installer on your computer and run the installer.

For the Latex distribution, I would suggest MikTeX, which you can get at http://miktex.org/. You have to first download an installer program which

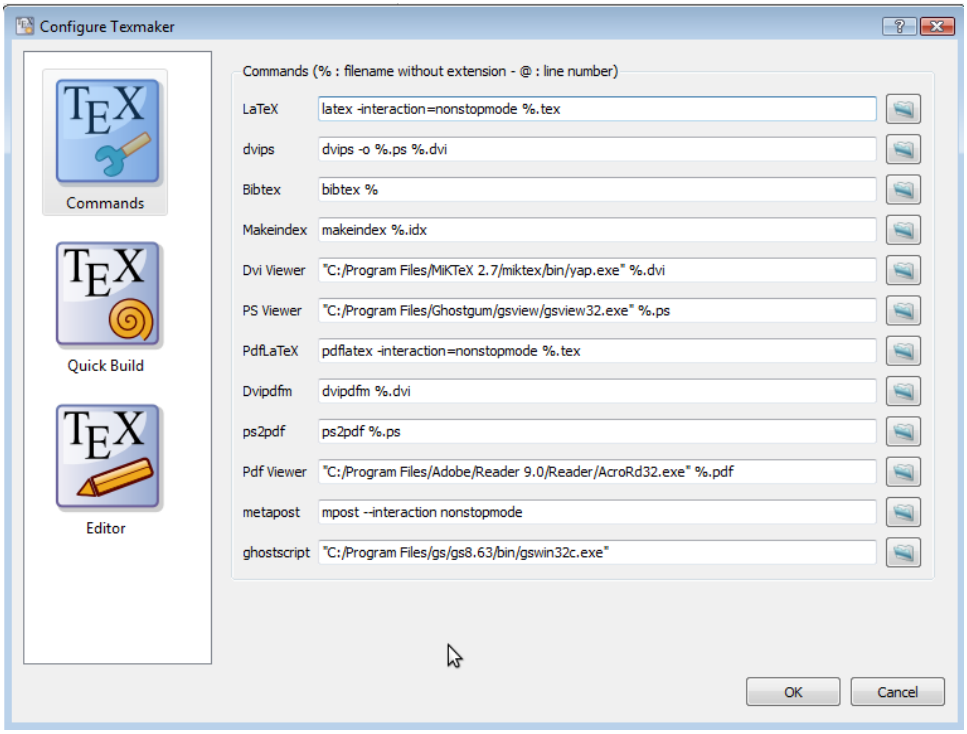
will then download the reset of the packages you need. If space is limited you can install a basic installation, or you can install a full installation, which is around 700MB. The full installation is recommended because the basic does not include all the math support that you will need. Here are the steps:

1. Download the installer - it will have a name like "setup2.7.3224.exe" or something similar to that.

2. After the download, run the setup program you just downloaded. This will download the latex installation. When prompted, select "download" MikTex (NOT install). Be patient. This will take a long time.

3. After the download is complete, run the installer a second time. This time, when prompted, select "install" and "full version." This will actually install latex.

Then you will need to configure TexMaker. See the following figure for typical locations.



Appendix: 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://www.ctan.org/tex-archive/info/lshort/

Print References

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

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

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