How To $\LaTeX$

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1 What is LaTeX?

LaTeX is a typesetting language that is often used in technical fields like Computer Science, Mathematics, Chemistry, and Physics. It is particularly useful to easily typeset math (like $\emptyset \subseteq \mathbb{N}$) and chemical formulae (like H_2O).

Unfortunately, LaTeX has a non-trivial learning curve associated with it. This document is intended to lessen your pain in learning how to easily typeset beautiful documents for the rest of your technical career. It is this author's belief that once you learn how to use LaTeX, editors like Microsoft Word become obsolete, even for documents like English papers.

2 Installation and Editors

2.1 Windows

You should download `MiKTeX` from http://miktex.org. `TeXnicCenter` is a good editor to use to write *LaTeX*1000 documents. You can download it here: http://www.texniccenter.org/.

2.2 Mac

You should download `MacTeX` from http://www.tug.org/mactex/2012/. An editor comes with the distribution which you can use; alternatively, most of the common editors for OSX will support writing *LaTeX*1000 documents.

2.3 Linux

If youre using Debian or Ubuntu, try `sudo apt-get install texlive`. Otherwise, you most likely know your system well enough to figure it out.

3 Math Mode

One of the most useful things that LaTeX offers is the so-called "Math Mode." Let's just begin with an example. If you type the following snippet of code:

```
Let $M$ be the number of moons in the Universe, and let $E$ be the number of
moons Earth has. We know from Elementary School that $E=1$, but what can we
say about $M$?  Since Earth is a part of the Universe, we know that $M \geq E$.
Furthermore, Jupiter has at least one moon; so, $M > E$.
```

LaTeX parses it as:

> Let M be the number of moons in the Universe, and let E be the number of moons Earth has. We know from Elementary School that $E = 1$, but what can we say about M? Since Earth is a part of the Universe, we know that $M \geq E$. Furthermore, Jupiter has at least one moon; so, $M > E$.

Isn't that neat? The $'s allow us to seamlessly switch between using Math and English. Sometimes, however, we want to isolate the math to display how important it is. This *LaTeX*1000 mode is called

"Display Mode" and is just as easy to use. Instead of a single $, just double them up.[1] Here's an example:

```
Now that we have determined that $M > E$, we would like to find a simple
unification result for physics.  To do this, we must recall Newton's famous
formula: $$F = ma$$
You see, once we realize its significance, the rest is all simple arithmetic.
```

And the output:

Now that we have determined that $M > E$, we would like to find a simple unification result for physics. To do this, we must recall Newton's famous formula:

$$F = ma$$

You see, once we realize its significance, the rest is all simple arithmetic.

By using display mode, we made several things happen: (1) we entered math mode and (2) we asked LATEX to make sure the content was spaced nicely. You should be careful with math mode and display mode, because, while LATEX will try its best to not let the math run off the side of the page, there are some times when it just doesn't know what else to do:

```
$$a + b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s +
t + u + v + w + x + y + z + 0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 + 11 +
12 + 13 + 14 + 15$$
```

$$a+b+c+d+e+f+g+h+i+j+k+l+m+n+o+p+q+r+s+t+u+v+w+x+y+z+0+1+2+3+4+5+6+7+8+9+10+11+$$

In such a situation, the correct thing to do is use the align* environment which is discussed below.

Occasionally, typesetting something requires being in math mode, but we don't want $alltheletterstoruntogether$ or be in the math $font$. One good example of this is chemical formulae. They require us to typeset superscripts and subscripts, but we want normal letters. How do we fix this?[2] We use the text command! Here's an example:

```
Little Johnny was a chemist.\\
He isn't any more.\\
For what he thought was $\text{H}_2\text{O}$ was $\text{H}_2\text{SO}_4$.
```

And the output:

Johnny was a little chemist.
He isn't any more.
For what he thought was H_2O was H_2SO_4.

That completes the basics of typesetting math in LATEX ; now, we move on to some quirks that are often "gotchas" to people using LATEX for the first time.

1 The *LATEX*1000 purist might yell at me here. Using $$ is not actually the accepted way to enter and leave display mode. It is in fact deprecated, and, instead, you can delimit it by using \[and \].

2 It is worthy of note that `H$_2$SO$_4$` would also work, but text is also useful in other places.

4 Some LaTeX Quirks and Misconceptions

One of the common misconceptions that people using LaTeX for the first time have is that they think of it as more like Microsoft Word than Java. LaTeX is, first and foremost, a programming language, and you should think of it that way. The way LaTeX works is that you describe how you want your output to look and LaTeX figures out what it thinks will look best given your constraints.

4.1 Whitespace

As a direct result of LaTeX's methodology, it is not very sensitive to whitespace. Think about when the last time Java cared if you put one or two spaces between `public` and `void` was. Take a look:

```
I      like     my words  to have     varied                    spaces
between them.  I also
like
     lots
          of
             new
                lines.
```

Note how LaTeX ignores my tastes in spacing:

I like my words to have varied spaces between them. I also like lots of new lines.

The good news is that if you are really insistent, LaTeX will let you do it:

```
A\;B\;\;\;C\quad D\qquad E
```

A B   C   D   E

```
You can\\force new lines\\ as well.
```

You can
force new lines
as well.

If you put a blank line between two paragraphs, LaTeX assumes that they are paragraphs and will correctly indent the next one. Lastly, to tell *LaTeX*1000 you want a new page use the `newpage` command. That is, type \newpage.

4.2 Escape Characters?

Like most programming languages, LaTeX has a bunch of characters that must be "escaped" to be written literally, like $\backslash n$ in Java or C. Here is a list of common characters, their uses in LaTeX and how to write them literally:

Character	Usage in LaTeX	Literal
\	Signifies that what is coming next is a command	`$\backslash$`
$	Enter/exit math mode	`\$`
#	Macro arguments	`\#`
&	Delimits cells in tabulars	`\&`
%	Comments out the rest of the line after it	`\%`
_	Displaying subscripts	`\_`
^	Displaying superscripts	`\verb!^!`
{	Delimits various environment and macro bodies	`\{`
}	Delimits various environment and macro bodies	`\}`

4.3 "Quotes"

This oddity is easier to show than explain:

```
Using "double quotes" and 'single quotes' will not come out like you expect.
```

And the output:

Using ”double quotes” and ’single quotes’ will not come out like you expect.

Instead, to get the right output, use backticks, which are on the key to the left of '1', to open quotes and single quotes to close them.

4.4 ¡ ¿

If you are seeing ¡ or ¿ randomly in your output, you probably meant to use $<$ or $>$. To display either of those you must be in math mode.

5 How Do I Make that Symbol?

This section is intended to be a reference for common symbols and constructs that you will probably use fairly often.

5.1 Basic Math

Description	Example	LaTeX Code
Composition	$\circ$	`\circ`
Superscript	x^{n+3}	`x^{n+3}`
Subscript	y_{n+4}	`y_{n+4}`
Fraction	$\frac{a+b}{c+d}$	`\frac{a+b}{c+d}`
Binomial Coefficient	$\binom{n}{k}$	`\binom{n}{k}`
Greek Letter	δ, Δ	`\delta , \Delta`
Greek Letters (Styled)	ε	`\varepsilon`
Large Parentheses	$d\left(\frac{a-b}{c}\right)$	`d\left(\frac{a-b}{c}\right)`
Modular Equivalence	$x \equiv 1 \mod 5$	`x \equiv 1 \mod 5`
Infinity	∞	`\infty`
$\leq$	$x \leq y$	`x \leq y`
$\geq$	$x \geq y$	`x \geq y`
$\neq$	$x \neq y$	`x \neq y`
$\langle, \rangle$	$\langle 1, 2 \rangle$	`\langle 1,2 \rangle`
$\lfloor, \rfloor$	$\left\lfloor \frac{1}{2} \right\rfloor$	`\left\lfloor \frac{1}{2} \right\rfloor`
$\lceil, \rceil$	$\left\lceil \frac{1}{2} \right\rceil$	`\left\lceil \frac{1}{2} \right\rceil`
$\rightarrow$	$x \rightarrow y$	`x \rightarrow y`
$\leftrightarrow$	$x \leftrightarrow y$	`x \leftrightarrow y`
$\times$	$A \times B$	`A \times B`
$\cdot$	$A \cdot B$	`A \cdot B`

5.2 Logical Symbols

Description	Example	LaTeX Code
And	$p \wedge q$	`p \wedge q`
Equivalence	$p \leftrightarrow q$	`p \leftrightarrow q`
Implication	$p \rightarrow q$	`p \rightarrow q`
Not	$\neg p$	`\neg p`
Inclusive Or	$p \vee q$	`p \vee q`
Exclusive Or	$p \oplus q$	`p \oplus q`
Quantifiers	$\forall, \exists$	`\forall , \exists`

5.3 Set Symbols

Description	Example	LaTeX Code
Blackboard Style	$\mathbb{N}$	`\mathbb{N}`
Dleftrightarrowerence	$A \setminus B$	`A \setminus B`
Element Of	$x \in A$	`x \in A`
Empty Set	$\varnothing$	`\varnothing`
Intersection	$A \cap B$	`A \cap B`
Not Element Of	$x \not\in A$	`x \not\in A`
Subset	$A \subseteq B$	`A \subseteq B`
Superset	$B \supseteq A$	`B \supseteq A`
Union	$A \cup B$	`A \cup B`

5.4 Sequences, Summations, and Products

Description	Example	LaTeX Code
Centered Ellipses	$1 + 2 + \cdots + n$	`1 + 2 + \cdots + n`
Ellipses	$1, 2, \dots, n$	`1, 2, \dots, n`
Product	$\displaystyle\prod_{k=0}^{n}{k^2}$	`\prod_{k=0}^{n}{k^2}`
Summation	$\displaystyle\sum_{k=0}^{n}{k^2}$	`\sum_{k=0}^{n}{k^2}`

5.5 Text Styles

Description	Example	LaTeX Code
Blackboard Style	$\mathbb{N}$	`\mathbb{N}`
Bold	**OMG**	`\textbf{OMG}`
Code	`int counter`	`\texttt{int counter}`
Italics	*OMG*	`\emph{OMG}`
Script Style	$\mathcal{R}$	`\mathcal{R}`
Truth Values	$\textsf{T}, \textsf{F}$	`\textsf{T}, \textsf{F}`

5.6 Piecewise Functions

```
$$\text{abs}(x) =
    \begin{cases}
    x  & \text{if $x \geq 0$}\\
    -x & \text{if $x < 0$}
    \end{cases}$$
```

$$\text{abs}(x) = \begin{cases} x & \text{if } x \geq 0 \\ -x & \text{if } x < 0 \end{cases}$$

5.7 Still Cant Find It?

There is a great tool online called detexify. You draw the symbol you are looking for, and it gives you the LaTeX command that it thinks most closely represents it. You can find it at http://detexify.kirelabs.org/classify.html.

6 Some Useful Environments

6.1 Centering Text

\begin{center}[⟨*options*⟩] ⟨*environment contents*⟩ \end{center}

This environment is used for centering a section of your document.

```
\begin{center}
    This text is centered.  I am a silly example.\\
    She sells sea shells by the sea shore.
\end{center}
```

This text is centered. I am a silly example.
She sells sea shells by the sea shore.

6.2 Tables

\begin{tabular}[⟨*options*⟩] ⟨*environment contents*⟩ \end{tabular}

options	usage
column horizonatal alignment	c,l,r separated by | for grid lines

This environment nicely typesets tables. It allows you to choose where (and if) you want grid lines in your table.

```
\begin{tabular}{l|c|r}
First Column & Second Column & Third Column\\
\hline
Cell 1,0 & Cell 1,1 & Cell 1,2\\
Cell 2,0 & Cell 2,1 & Cell 2,2
\end{tabular}
```

First Column	Second Column	Third Column
Cell 1,0	Cell 1,1	Cell 1,2
Cell 2,0	Cell 2,1	Cell 2,2

6.3 Math Align

\begin{align*}[⟨*options*⟩] ⟨*environment contents*⟩ \end{align*}

*This environment allows you to write out aligned columns of text and math. It is particularly useful for writing out proofs with justifications to the right. Note the * on the end of the name. Also note that each row of the* **align*** *can have an arbitrary number of & signs which are alignment points.*

```
\begin{align*}
\neg ((p \vee \neg q) \vee (q \vee \neg p)) \leftrightarrow & (\neg p \wedge q)
                        \wedge (\neg q \wedge p) && \text{[DeMorgan's Laws]} \\
\leftrightarrow &
\neg p \wedge p \wedge \neg q \wedge q && \text{[Associativity and Commutativity]}\\
\leftrightarrow & \textsf{F} && \text{[Any value of $p$ will lead to $\textsf{F}$]}
\end{align*}
```

$$\begin{align*}
\neg ((p \vee \neg q) \vee (q \vee \neg p)) \leftrightarrow & (\neg p \wedge q) \wedge (\neg q \wedge p) && \text{[DeMorgan's Laws]} \\
\leftrightarrow & \neg p \wedge p \wedge \neg q \wedge q && \text{[Associativity and Commutativity]}\\
\leftrightarrow & \textsf{F} && \text{[Any value of p will lead to $\textsf{F}$]}
\end{align*}$$

6.4 a, b, c, 1, 2, 3

\begin{enumerate}[⟨*options*⟩] ⟨*environment contents*⟩ \end{enumerate}

options	default	usage
`item display`	1.	Use this argument to change the appearance of the item. You can use 1, i, a, etc.

This environment allows you to typeset numbered or lettered lists. Make sure to use `\usepackage{enumerate}` *if you want to change the look of the item display.*

```
\usepackage{enumerate} %Put this line at the beginning of your document
\begin{enumerate}[(a)]
\item This is the first item.
\item This is the second item.
\item This is the third item.
\end{enumerate}
```

(a) This is the first item.

(b) This is the second item.

(c) This is the third item.

6.5 Bullet Points

\begin{itemize}[⟨*options*⟩] ⟨*environment contents*⟩ \end{itemize}

This environment allows you to typeset bullet pointed lists.

```
\begin{itemize}
\item This is the first item.
\item This is the second item.
\item This is the third item.
\end{itemize}
```

- This is the first item.
- This is the second item.
- This is the third item.

6.6 Custom Lists

\begin{description}[⟨*options*⟩] ⟨*environment contents*⟩ \end{description}

This environment allows you to typeset lists with completely custom items displays. This is really nice for induction proofs.

```
\begin{description}
\item[First Item.] This is the first item.
\item[Second Item.] This is the second item.
\item[Third Item.] This is the third item.
\end{description}
```

First Item. This is the first item.

Second Item. This is the second item.

Third Item. This is the third item.

6.7 Matrices

\begin{bbmatrix}[⟨*options*⟩] ⟨*environment contents*⟩ \end{bbmatrix}

This environment allows you to typeset matrices. Note that the matrix must be in math mode!

```
$\begin{bmatrix}
1 & 2 & 3\\
4 & 5 & 6\\ 7&8&9
\end{bmatrix}$
```

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

6.8 Code and WYSIWYG

\begin{verbatim}[⟨*options*⟩] ⟨*environment contents*⟩ \end{verbatim}

This environment allows you to typeset words in a WYSIWYG fashion. Note that it will ignore all tabs, so you will want to use spaces instead.

```
\begin{verbatim}
    I want this text
       to  look
          exactly as I put it.
def hello():
    return "Goodbye"
\end{verbatim}
```

```
    I want this text
       to  look
          exactly as I put it.
def hello():
    return "Goodbye"
```

7 Using the Homework Template

\begin{question}[⟨*options*⟩] ⟨*environment contents*⟩ \end{question}

options	usage
question name	The name of the question being answered.

You should use this environment to typeset the answers to the questions we assign you. Each answer should be wrapped in this environment.

```
\begin{question}{This is a test question}
This is a solution to the test question
\end{question}
```

0: This is a test question

This is a solution to the test question

\begin{part}[⟨*options*⟩] ⟨*environment contents*⟩ \end{part}

You should use this environment to surround the individual parts of questions we assign you.

```
\begin{question}{This is a test question}
\begin{part}
This is the solution to the first part
\end{part}
\begin{part}
This is a solution to the second part
\end{part}
\end{question}
```

1: This is a test question

(a) This is the solution to the first part

(b) This is a solution to the second part

We complete this tutorial with a real-world example:

```
\begin{question}{Little Gauss Formula}
    \begin{part}
        We use small examples to attempt to derive a formula for the sum of
        first $n$ numbers. Listing out the first few examples, we see the
        following:
        \begin{center}
        \begin{tabular}{|c|r|c|}
            \hline
            $n$ & \multicolumn{2}{c|}{Sum} \\\hline
            0 & 0 & 0\\\hline
            1 & $0+1$ & 1\\\hline
            2 & $0+1+2$ & 3\\\hline
            3 & $0+1+2+3$ & 6\\\hline
            4 & $0+1+2+3+4$ & 10\\\hline
        \end{tabular}
        \end{center}
        Clearly, this increases more quickly than a linear function; so,
        we guess that it might be quadratic.  A function that matches
        these values and is quadratic is $\frac{n(n+1)}{2}$. That is,
        we guess that the following equation holds:
        $$\sum_{i=0}^{n}{i} = \frac{n(n+1)}{2}$$
    \end{part}
    \begin{part}
        Now, we prove the equality using induction as follows:
        \begin{description}
            \item[Base Case.] $n=0$: $0 = \frac{0(1)}{2}=0$.
            \item[Induction Hypothesis.] Assume the equality holds for some
                                         $k \geq 0$.
            \item[Induction Step.] For $n=k+1$, we have
                $$\sum_{i=1}^{k+1} i = (k+1) + \sum_{i=1}^{k}{i}$$
                Using the induction hypothesis, we can substitute for the
                second term on the right-hand side:
                \begin{eqnarray*}
                    \sum_{i=1}^{k+1}{i} &=& (k+1) + \frac{k(k+1)}{2}\\
                                        &=& \frac{2k+2 + k(k+1)}{2}\\
                                        &=& \frac{k^2 + 3k + 2}{2}\\
                                        &=& \frac{(k+1)(k+2)}{2}
                \end{eqnarray*}
        \end{description}
        The last line shows that when $n=k+1$, the equality that we guessed
        holds.  Since we proved the base case, and weve shown that if it
        holds for $n=k$ it must hold for $n=k+1$, it must hold for all $n$.
    \end{part}
\end{question}
```

2: Little Gauss Formula

(a) We use small examples to attempt to derive a formula for the sum of first n numbers. Listing out the first few examples, we see the following:

n	Sum	
0	0	0
1	$0+1$	1
2	$0+1+2$	3
3	$0+1+2+3$	6
4	$0+1+2+3+4$	10

Clearly, this increases more quickly than a linear function; so, we guess that it might be quadratic. A function that matches these values and is quadratic is $\frac{n(n+1)}{2}$. That is, we guess that the following equation holds:

$$\sum_{i=0}^{n} i = \frac{n(n+1)}{2}$$

(b) Now, we prove the equality using induction as follows:

Base Case. $n = 0$: $0 = \frac{0(1)}{2} = 0$.

Induction Hypothesis. Assume the equality holds for some $k \geq 0$.

Induction Step. For $n = k + 1$, we have

$$\sum_{i=1}^{k+1} i = (k+1) + \sum_{i=1}^{k} i$$

Using the induction hypothesis, we can substitute for the second term on the right-hand side:

$$\begin{aligned}
\sum_{i=1}^{k+1} i &= (k+1) + \frac{k(k+1)}{2} \\
&= \frac{2k+2+k(k+1)}{2} \\
&= \frac{k^2+3k+2}{2} \\
&= \frac{(k+1)(k+2)}{2}
\end{aligned}$$

The last line shows that when $n = k + 1$, the equality that we guessed holds. Since we proved the base case, and weve shown that if it holds for $n = k$ it must hold for $n = k + 1$, it must hold for all n.