Typing Mathematical Expressions

Numbers, Roman variable names, and most symbols of basic arithmetic may be typed directly:

If $a + 2 = 4 + b$ and $2(3b - a) = 43$, then $b = \frac{47}{4}$.

If $a + 2 = 4 + b$ and $2(3b - a) = 43$, then $b = \frac{47}{4}$.

Spaces are generally ignored in math mode: $abc+def$ and $a\ b\ c\ +\ d\ e\ f$ both make $abc + def$. 
Typefaces in Math Mode

Letters typed in math mode are set in an italic type, as is conventional for Roman variables ($x$, etc.).

But do not use this as a quick way to italicize ordinary text! Words typed in math mode look *really freakin' ugly* (that was $really freakin’ ugly$). Use \emph{...} instead.

For \texttt{sin}, \texttt{cos}, \texttt{lim}, and other notations written in upright type, use commands \texttt{\sin}, \texttt{\cos}, \texttt{\lim}, and so forth.
Symbols in Math Mode

Greek letters: use \texttt{\textbackslash lettername} (e.g., \texttt{\textbackslash alpha}) in math mode. For some you can capitalize the name of the letter to get a capital letter.

Most other useful symbols have associated commands. For example, \texttt{\textbackslash geq} and \texttt{\textbackslash leq} give \( \geq \) and \( \leq \), while \texttt{^\circ} gives a degree symbol: \( ^\circ \).

Examples:

<table>
<thead>
<tr>
<th>Command</th>
<th>Result</th>
<th>Command</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>( \gamma )</td>
<td>$\Gamma$</td>
<td>( \Gamma )</td>
</tr>
<tr>
<td>180$^\circ$C</td>
<td>180(^\circ)C</td>
<td>$x &lt; y \ \text{\textbackslash leq} \ 1$</td>
<td>( x &lt; y \leq 1 )</td>
</tr>
</tbody>
</table>
Common Mathematical Functions

Most common mathematical functions and operators have corresponding commands which are just names of the functions:

- To get a summation sign ($\sum$) use `\sum`.

- To get an integral sign ($\int$) use `\int`.

- `$\lim$, $\log$, $\sin$, $\cos$, $\tan$, $\sec$, $\csc$, $\cot$ yield proper formatting of these common functions.
## Some Examples

<table>
<thead>
<tr>
<th>Command</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>\log (3x + 5)</td>
<td>\log(3x + 5)</td>
</tr>
<tr>
<td>\cos (5x + x^2)</td>
<td>\cos(5x + x^2)</td>
</tr>
<tr>
<td>\sin^2 (4x + 7)</td>
<td>\sin^2(4x + 7)</td>
</tr>
<tr>
<td>\lim \frac{1}{n}</td>
<td>\lim \frac{1}{n}</td>
</tr>
<tr>
<td>\sqrt[n]{3x + 1}</td>
<td>\sqrt[n]{3x + 1}</td>
</tr>
</tbody>
</table>
Matrices (and more complicated-looking equations) can be constructed using commands similar to what we used for tables:

\[ \mathcal{H} = \mathcal{H}^0 + \mathcal{H}' = \begin{pmatrix} -\varepsilon & \Delta \\ \Delta & +\varepsilon \end{pmatrix} \]
More Complicated Equations

\[ V(x) = \begin{cases} 
-V_0, & \text{for } -a/2 < x < a/2, \\
\infty, & \text{for } |x| > a/2.
\end{cases} \]  

Note how similar the setup is to the table environment.
Multiple Line Equations, Part 1

If you have a few equations you want to line up, you can use the \texttt{eqnarray} environment:

\begin{eqnarray}
L_0^0 &=& 1 \quad (3) \\
L_1^0 &=& -x + 1 \quad (4) \\
L_2^0 &=& x^2 - 4x + 2 \quad (5) \\
&\vdots& \\
\end{eqnarray}

LaTeX will put extra white space around the stuff between the &'s, as well as lining it all up.
Multiple Line Equations, Part 2

If you just have one really long expression that’s just too cool to fit on only one line, you can split it up using the `split` environment. It lines up the &s and breaks lines at the \\s:

\[
\psi_{4,3,\pm 1} = \frac{1}{768\sqrt{35}} a^{-3/2} \left(\frac{r}{a}\right)^2 \exp(-r/4a) \\
\times \mp \left(\frac{21}{64\pi}\right)^{1/2} \sin \theta (5\cos^2 \theta - 1)e^{\pm i\phi}
\]

\begin{equation}
\psi_{4,3,\pm 1} = \frac{1}{768\sqrt{35}} a^{-3/2} \left(\frac{r}{a}\right)^2 \exp(-r/4a) \\
\times \mp \left(\frac{21}{64\pi}\right)^{1/2} \sin \theta (5\cos^2 \theta - 1)e^{\pm i\phi}
\end{equation}

\begin{verbatim}
begin{equation}\label{H-43pm1}
\begin{split}
\psi_{4,3,\pm 1}=&\frac{1}{768\sqrt{35}} a^{-3/2} \left(\frac{r}{a}\right)^2 \exp(-r/4a) \\
&\times \mp \left(\frac{21}{64\pi}\right)^{1/2} \sin \theta (5\cos^2 \theta - 1)e^{\pm i\phi}
\end{split}
\end{equation}
\end{verbatim}
Making It Look Nice: Variables

In general, it should be possible to get \LaTeX{} to look like stuff would if you were writing it out by hand, if not better.

If you’re going to decorate your $i$’s and $j$’s, use $i$ and $j$ instead. That’s: $\imath$ and $\jmath$. And for the obligatory example... $\vec{E} = \rho \vec{j}$ is given by $\vec{E} = \rho \vec{j}$.

Also, be aware of $l$ vs. $\ell$, and $\phi$ vs. $\varphi$, etc. (That’s $l$ vs. $\ell$, and $\phi$ vs. $\varphi$, etc.)

\LaTeX{} also knows about $\hbar$. (You guessed it—that’s $\hbar$!)
Making It Look Nice: Spacing

These two slides include some pointers for how to space things out so everyone can breathe. For example,

\[
\int e^{i(m_j-m_k)\phi} d\phi \neq 0 \quad \text{if and only if} \quad m_j = m_k \quad \text{and} \quad l_j \neq l_k. \quad (7)
\]
is given by

\[
\begin{equation}
\label{condition}
\int e^{i(m_j-m_k)\phi} \mathrm{d}\phi \neq 0 \quad \text{if and only if} \quad m_j = m_k \quad \text{and} \quad l_j \neq l_k.
\end{equation}
\]

A \texttt{quad} is pretty long. A \texttt{quad} is a bit shorter. Then there are the little spaces. A \texttt{,} is the shortest at 3/18 of a \texttt{quad}. As you might expect, the \texttt{:} and \texttt{;} are slightly longer at 4/18 and 5/18 of a \texttt{quad} respectively. \texttt{!} gives a negative amount of space (3/18 of a \texttt{quad}).
More Spacing

Scrunched-up formulas are ugly and difficult to read. Often, your fractions and squareroots (as well as other functions), just need more personal space. You can use the \texttt{displaystyle} command to help them out. Consider this:

\[
\frac{\sqrt{2x^3}}{\pi r^2} \quad \text{versus} \quad \frac{\sqrt{2x^3}}{\pi r^2}
\]

The second expressions is given by:
\[
\frac{\text{\texttt{displaystyle} \sqrt{2x^3}}}{\pi r^2}\text{\texttt{displaystyle} \pi r^2}
\]
Common Error Messages

! Missing $ inserted.

\begin{verbatim}
<inserted text>

\$ 

1.8 

？
\end{verbatim}

You have forgotten to end math mode. The line number after the “1.” (in this case “8”) is the first line at which \LaTeX has realized that you have forgotten to end math mode; it is usually the end of the paragraph the error is in.

Common cause: Forgetting to put a \ before a %.\/
Common Error Messages

! Missing $ inserted.
<inserted text>

\$ 

1.6 30^\circ
\textcircled{}
?

You have used a command (in this case ^\circ) which \LaTeX{} knows belongs only in math mode. The line number given is the location of the command in question.
Common Error Messages

! LaTeX Error: \begin{displaymath} on input line 8 ended by \end{document}.

See the LaTeX manual or LaTeX Companion for explanation. Type H <return> for immediate help.

l.10 \end{document}

?

You have forgotten to end display math mode. The line number on which math mode began is listed (in this case, “input line 8”).
Common Error Messages

! LaTeX Error: \mathbb allowed only in math mode.

See the LaTeX manual or LaTeX Companion for explanation.
Type `H <return>` for immediate help.
...

1.6 \mathbb

    {stuff}

? 

The command in question (in this case \mathbb) is only allowed in math mode and you have tried to use it outside of math mode.