LaTeX by Example

The ideal method for producing a document with mathematics is LaTeX. In text mode, use of special commands in curly braces can make text **bold face** or *italicized*. Source is typed in a plain text file and a PDF is produced. To try this out without the need to install anything on your computer[1], open a free account at `www.sharelatex.com`. Follow the source code with the rendered PDF side-by-side, keeping in mind the curly braces are used by the system to group a single entity together.

A completely empty line in the source will create a new paragraph (with indentation). Small snippets of math such as $a^m \cdot a^n = a^{m+n}$ or $\sqrt{x-y} \neq \sqrt{x} - \sqrt{y}$ are in math mode and can be typed within dollar signs. Other examples include something like the following: if $p \leq q$, then $-p \geq -q$ and $\frac{1}{p} \geq \frac{1}{q}$, though for notation incorporating more involved fractions such as

$$\sin^2 \theta = \frac{1 - \cos(2\theta)}{2}$$

it may help to use the *other* math mode (using backslash and square brackets in the source) which makes a larger fraction with all the notation center-aligned. Since there was no completely empty line in the source before or after the trig identity, all of this content is part of the second paragraph, which we end now.

Even based on the examples thusfar, your guesses for commands are probably correct. For instance, the exponential property presented earlier implies $\log_a(s) + \log_a(t) = \log_a(st)$ and by substituting a base of e, one obtains $\ln(s) + \ln(t) = \ln(st)$ as a special case. As another example, the Pythagorean Theorem leads to the distance formula of $\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$. Completing the square on $ax^2 + bx + c = 0$ leads to

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

Subscripts and other items which appear "below" usually use an underscore (and often, if multiple items are needed, they are grouped using curly braces.) For example, if $f(x) = x^2$, then

$$f'(x) = \lim_{h \to 0} \frac{(x+h)^2 - x^2}{h} = \lim_{h \to 0} \frac{x^2 + 2xh + h^2 - x^2}{h} = \lim_{h \to 0} \frac{h(2x + h)}{h} = \lim_{h \to 0} (2x + h) = 2x.$$

The example above demonstrates the "as h approaches 0" text beneath the limit notation. Some notation lends itself to both "subscripts" and "superscripts" such as with endpoints of definite integrals like

$$\int_{-1}^{0} \frac{1}{1 + x^2} \, dx = \tan^{-1}(0) - \arctan(-1) = \frac{\pi}{4},$$

since $\tan^{-1}(-1)$ is equal to $-\frac{\pi}{4}$. Another setting where "subscripts" and "superscripts" are useful is with summation notation:

$$\sum_{n=1}^{\infty} \frac{1}{n^3} < \frac{\pi^2}{6}.$$

Here is a new paragraph. (Notice the indentation in the PDF.) There is notation for essentially all math. Here's cross product: $\langle 1, 2, 3 \rangle \times \langle 4, 5, 6 \rangle = \langle -3, 6, -3 \rangle$. The math used can range from elementary such as $6 \div 3 = 2$ to intermediate like $\nabla f = \langle \frac{\partial f}{\partial x}, \frac{\partial f}{\partial y} \rangle$ to something more advanced such as $U \otimes W \subseteq V \otimes W$ if $U \subseteq V$ or $\forall x \in A, \exists y \in B$ such that $x * y \notin \{z \in C \cup D : G_\star^{30°}(z) \equiv \Gamma_+^{z, \tau, \lambda}\}$. This one-page PDF doesn't show everything, but gives a sense of what can be done, and more importantly, how. Additional symbols can be found using the website `detexify`. Some symbols require a `usepackage` line: our example uses just the `geometry` package. We end this paragraph with a matrix:

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

Why use LaTeX instead of Word? Finding the symbols in Word's Equation Editor is time-consuming. Because your documents are probably thematic, it's much faster to know the popular math-mode commands in your subject area and *type* what you need instead! LaTeX is free, files are small, and the same files work seamlessly across different operating systems. Word files end up reformatting themselves when moving between different versions and operating systems.

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[1] Easy install options include TeXShop after installing MacTeX on Mac, or TeXworks after installing MiKTeX on Windows.