An Introduction to Typesetting Math – AP Calc BC – Dr. Horner 2012-13

As you will have noticed, the meaning of symbols in math depends on where the symbols are. For instance $x^2 \neq x2 \neq x_2$. Fractions and square roots make things even more complicated. This means that just typing math the way we type words, while marginally workable, is quite clumsy and very hard to read. So, what do you do when your professor says the homework or the paper or the lab report must be entirely typed? You have some options which, as is common, vary from easy to use but not terribly powerful to quite powerful and smart but requiring a bit of knowledge. We'll start at the simple end and work our way up to a taste of the most powerful tools.

I'm only going to talk about things that exist for at least both Windows and OS X operating systems. I am not coming anywhere near listing all of the possibilities, only the most prominant.

1   Vocabulary

- word processor - software designed to format text; used for writing letters, papers, stories, etc.

- text editor - minimal formatting available (indentation and syntax coloring); usually has very powerful find-replace tools as well as append to beginning/end, collapsing sections and other organizational tools; typically used for programming of some sort or other; intended for structuring rather than beautifying text

- typesetting systems - intended to be more systematic about beautifying text and often with a lot of internal computing to determine the "best" way to lay-out text; text, math, and music get treated very similarly (in fact can all be treated together as I sometimes do)

- WYSIWYG - What You See Is What You Get

- WYSIWYM - What You See Is What You Mean

2   Equation Editors in Word Processors

These days most word processors come with some sort of equation editor built in. These systems are relatively simple to learn - usually they have point-and-click methods for creating equations and nearly instantaneous WYSIWYG. In some cases, these equation editors are subsets of free-standing equation editors which can be added to your system if you need really complicated stuff or really good control of size and spacing.

2.1   freeware

2.1.1   LibreOffice, OpenOffice

Versions for Windows, OS X, and Linux.

These are two, so far fairly similar, forks of OpenOffice which is the descendent of SunOffice. The equation editor has palettes for inserting symbols and structures (fractions, integrals, limits, etc.). The equation editor also permits direct typing of the equation. (This is generally harder to learn, but faster than pointing and clicking for every piece of an equation once learned.) The syntax when typing is very similar, though not identical, to LaTeX. LibreOffice and OpenOffice will open any MS Office file and save to MS Office formats.
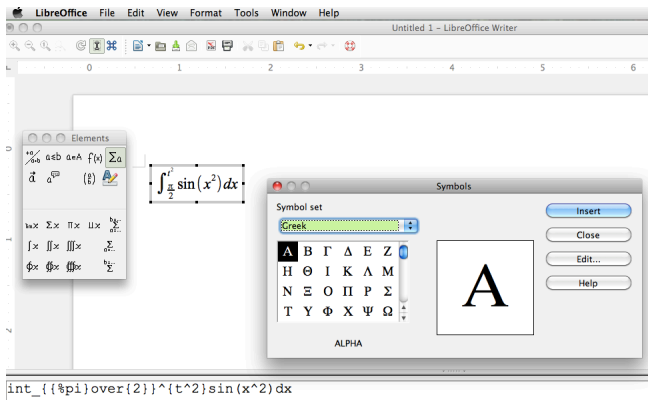
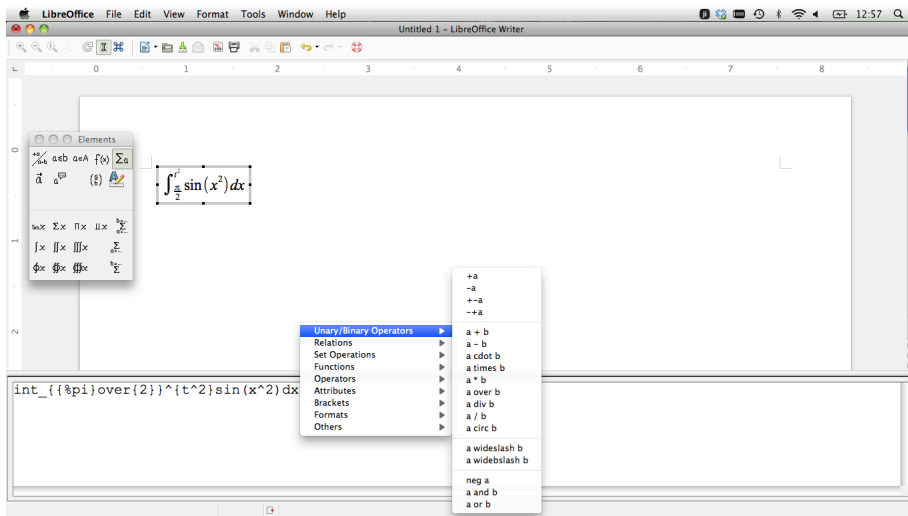**Figure 1:** palette and math editing window in LibreOffice

Figure 2: pop-up and math editing window in LibreOffice

1. In LibreOffice, go to File-New-Text Document.

2. Go to Insert-Object-Formula. A new window will appear across the bottom of the screen (see fig. 1). Note the floating palette. The text in the window can be typed or entered by clicking appropriate symbols in the palette.

3. Go to Tools-Catalog to get the palette of Greek characters. Or put them in by typing the % character followed by the name of the Greek letter spelled out. If you want the capital, write the whole name in capitals.

4. When you have finished editing an equation, click back in the main text window. To modify your equation, double-click it. (This will also get you back the floating palette of symbols and relations.)

5. Another way to access the palette information is by right-clicking (control-clicking) in the equation editing menu. (See fig. 2.)

The advantages are that this is free, under active development, straight-forward to install. In addition, I have documents from 2005 that I can still edit the equations in (they weren't turned to pictures). (The file extension has changed, but LibreOffice opens them without issue.) I don't have anything older to check because that's the year I switched to using the LibreOffice ancestor. Finally,
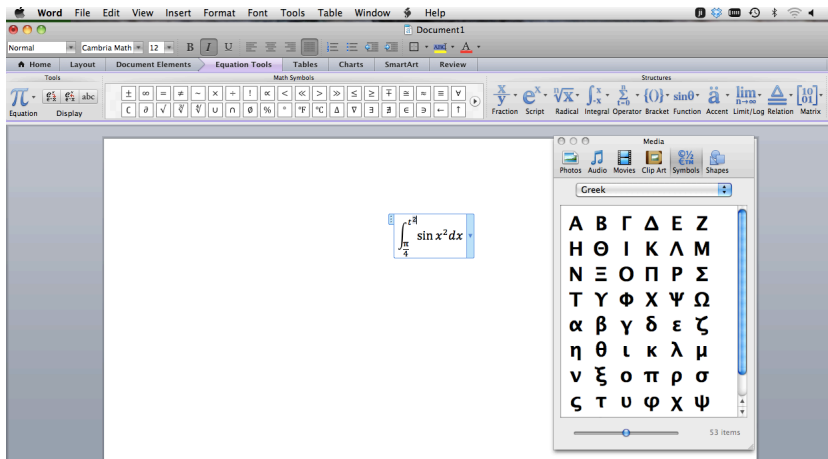
Figure 3: editing equations in MS Word

the ability to input equations with a point-and-click interface or by typing plus the LaTeX-like syntax makes this a nice tool to start with and then grow into.

The disadvantages that I see are things like not being able to much, if any, coloring within an equation or exercise other detailed control over an equation's appearance. In addition, the only way to change the size of equations (or any part thereof: subscripts, symbols, etc.), each equation has to be opened and changed individually. Finally, when I had notes of three or four pages of mostly big math equations, things got a little slow. That was about five years ago, so that may not be as true today.

2.2 Calligra

Versions for Linux, OS X, and Windows.

Calligra has an equation editor as part of the office suite. I haven't used this.

2.3 commercial

2.3.1 MS Word

Versions for Windows, OS X.

This is still probably the most common word processor.

1. Open MS Word.

2. Go to Insert-Equation.

3. Go to Insert-Symbol to get a palette including Greek characters which can be dragged into equations.

4. Click in the rest of the text document to stop editing the equation. Double-click on the equation to go back to editing it.

The advantages are that this is common and easy to install. The point-and-click interface makes it a learner-friendly tool. I think, but have not checked that it is still true, that Math Type (also commercial) can be used from within MS Word and will augment the native equation editing.

The disadvantages are essentially the same as with LibreOffice with the addition that there is not, as far as I know, any way to type input which means it is going to be very slow for doing much math. Furthermore, in the last ten to fifteen years I think I have had to retype all my equations in MS Word documents due to changes in the equation editor which caused old equations to be uneditable pictures. There was a period where this sometimes happened between versions for different operating systems though I think that is currently not a problem.

3   Equations in Typesetting Systems

3.1   LaTeX

This is the oldest, most widely-known way of producing text (papers, notes, HW, etc.) with significant mathematical content. It's underlying structure, TeX was created expressly for the purpose of producing mathematic journal articles that were both structurally sane and beautifully laid out. It is free.

There are various ways of creating a LaTeX document.

- For those who are more comfortable with something that looks rather like a word processor, LyX (free and OS X, Windows, Linux) and Scientific Word (commercial and Windows only) exist.

- For those who want control and don't mind not having an instantaneous view of the finished page (which can be pretty slow if there is a lot of math involved), the creation process uses a text editor to create a .tex file which is then processed by LaTeXto produce (these days) a .pdf. This method takes a good bit of learning, but can be coupled with other programs (Lilypond, TikZ, and GraphViz in particular) to incorporate musical notation, drawings, and network graphs into a document wich all the fonts from the various pieces matching. This is the method I use to produce everything I write for my classes. I have exploited a lot of scripting to make the things I routinely do relatively quick and easy. However, I've spent a good bit of time learning how to do so.

- For those who don't want to install anything, there are various web apps. At the moment, the nicest of these options seems to be https://www.writelatex.com/ which shows the output on the right and permits collaborative editing.

The advantages of anything LaTeX-based are longevity of the document (I opened a 1997 document and all the equations are editable; I did have to change the way I wrote derivatives, but that's a find-replace issue.), flexibility (coloring within equations - see fig. 2 - and canceling -see fig. 3), control over spacing. At the document level, LaTeX make it easy to make internal, clickable links to equations, figures, sections, and to or from bibliographies. In addition, there are add-ons that will do things like number my test questions in order and check the point values I enter add up correctly; or automatically copy all the header material when I split exams for extended time testing.

```
\documentclass{article}

\begin{document}

$$ \int_{\frac{\pi}{2}}^{t^2}\cos(x^2) dx $$

\end{document}
```

$$\int_{\frac{\pi}{2}}^{t^2} \cos(x^2)dx$$

Table 1: LaTeX source and output for the same equation demonstrated for other platforms.

$$ \int_{\frac{\pi}{2}}^{t^2} \cos\left(x^2\right)\,dx $$

```
\documentclass{article}
\usepackage{color}

\begin{document}

$$ \int_{\frac{\pi}{2}}^{t^2} \cos\left(
\textcolor{blue}{x}^2
\right) \,d\textcolor{blue}{x} $$

\end{document}
```

Table 2: coloring parts of equations

$$ \cancel{8} + \frac{\bcancel{(x-1)}(x+2)}{(x+3)\bcancel{(x-1)}}\cancelto{1}{\cos(\theta)} - \cancel{8} = \frac{x+2}{x+3} $$

```
\documentclass{article}
\usepackage{cancel}

\begin{document}

$$ \cancel{8} + \frac{\bcancel{(x-1)}(x+2)}{(x+3)\bcancel{(x-1)}}
\cancelto{1}{\cos(0)} -\cancel{8} = \frac{x+2}{x+3} $$

\end{document}
```

Table 3: showing canceling when simplifying equations

$$
\begin{align}
\int_0^\infty e^{-x}\,dx &= \lim_{b \to \infty} \int_0^b e^{-x}\,dx \tag{1}\\
&= \lim_{b \to \infty} -e^{-b} + e^{-0} \tag{2}
\end{align}
$$

```
\documentclass{article}
\usepackage{amsmath, amsthm, mathtools}

\begin{document}

\begin{align}
\int_0^\infty e^{-x} \, dx &= \lim_{b \to \infty} \int_0^b e^{-x} \,dx  \\
&= \lim_{b \to \infty} -e^{-b} +e^{-0}
\end{align}

\end{document}
```

Table 4: more typical of my usage

The disadvantage of LATEX used to be setting it up on your computer. With on-line access, that's no longer necessarily an issue. It is still a non-trivial learning curve. There are, however, many good resources on the web - including many from college depts. which require students to submit work in LATEX - and you are always welcome to contact me about the macros I've developed for myself to make using LATEX effective for me.

In addition to templates and lists of symbols and their commands widely available, there is a very nice web-based tool which lets you draw the symbol you want and will then display the LATEX commands for several symbols that seem to be related to what you drew. You can find it at http://detexify.kirelabs.org/classify.html.

```
\documentclass[12pt]{article}   % use 12pt font instead of default 10pt
\usepackage{amsmath, amsthm, mathtools}   % math
\usepackage[total={7.25in,9.75in}, top=0.5in, left=0.75in]{geometry}
% margin and orientation setting;
\usepackage{sagetex}
% have computer do math for me and insert into correct spots here

\begin{document}

Investigate the convergence of the series
$ \displaystyle \sum_n=2^{\infty} \frac{1}{4^n} $.

\begin{sagesilent}
def a(n):
    return 1/4^n
\end{sagesilent}

the series
\begin{align}
& \sum_{n=2}^{\infty} \frac{1}{4^n} = \sage{a(2)} + \sage{a(3)}
+ \sage{a(4)} + \sage{a(5)} + \sage{a(6)} + \sage{a(7)} + \cdots
\end{align}
the first few partial sums
\begin{align}
& \sum_{n=2}^{2} \frac{1}{4^n} = \sage{a(2)} = \sage{N(a(2))} \\
& \sum_{n=2}^{3} \frac{1}{4^n} = \sage{a(2)} + \sage{a(3)}
= \sage{a(2)+a(3)} = \sage{N(a(2)+a(3))} \\
& \sum_{n=2}^{4} \frac{1}{4^n} = \sage{a(2)} + \sage{a(3)} + \sage{a(4)}
= \sage{a(2)+a(3)+a(4)} = \sage{N(a(2)+a(3)+a(4))} \\
& \sum_{n=2}^{5} \frac{1}{4^n} = \sage{a(2)} + \sage{a(3)} + \sage{a(4)}
+ \sage{a(5)}
= \sage{a(2)+a(3)+a(4)+a(5)} = \sage{N(a(2)+a(3)+a(4)+a(5))} \\
\end{align}

 This is a geometric series with a bit of modification about where it starts.
 The generic version would start as follows.
 \begin{align}
& \sum_{n=1}^{\infty} \( \frac{1}{4} \)^{n-1} = \sage{a(0)}
 + \sage{a(1)} + \sage{a(2)} + \sage{a(3)} + \sage{a(4)} + \cdots
\end{align}
By comparing our series and the generic form, we see that ours can be
written in terms of the generic form by subtracting two terms.
\begin{align}
& \sum_{n=2}^{\infty} \frac{1}{4^n}
= \sum_{n=1}^{\infty} \( \frac{1}{4} \)^{n-1} - \frac{5}{4}
= \frac{1}{1-\frac{1}{4}} - \frac{5}{4}
= \sage{4/3-5/4} = \sage{N(4/3-5/4)}
\end{align}
This series converges pretty rapidly since 5 terms gave us the first
two significant figures correctly.

\end{document}
```

Investigate the convergence of the series $\sum_n = 2^\infty \frac{1}{4^n}$.

the series

$$\sum_{n=2}^{\infty} \frac{1}{4^n} = \frac{1}{16} + \frac{1}{64} + \frac{1}{256} + \frac{1}{1024} + \frac{1}{4096} + \frac{1}{16384} + \cdots \tag{1}$$

the first few partial sums

$$\sum_{n=2}^{2} \frac{1}{4^n} = \frac{1}{16} = 0.0625000000000000 \tag{2}$$

$$\sum_{n=2}^{3} \frac{1}{4^n} = \frac{1}{16} + \frac{1}{64} = \frac{5}{64} = 0.0781250000000000 \tag{3}$$

$$\sum_{n=2}^{4} \frac{1}{4^n} = \frac{1}{16} + \frac{1}{64} + \frac{1}{256} = \frac{21}{256} = 0.0820312500000000 \tag{4}$$

$$\sum_{n=2}^{5} \frac{1}{4^n} = \frac{1}{16} + \frac{1}{64} + \frac{1}{256} + \frac{1}{1024} = \frac{85}{1024} = 0.0830078125000000 \tag{5}$$

$$\tag{6}$$

This is a geometric series with a bit of modification about where it starts. The generic version would start as follows.

$$\sum_{n=1}^{\infty} \frac{1}{4}^{n-1} = 1 + \frac{1}{4} + \frac{1}{16} + \frac{1}{64} + \frac{1}{256} + \cdots \qquad default$$

By comparing our series and the generic form, we see that ours can be written in terms of the generic form by subtracting two terms.

$$\sum_{n=2}^{\infty} \frac{1}{4^n} = \sum_{n=1}^{\infty} \frac{1}{4}^{n-1} - \frac{5}{4} = \frac{1}{1-\frac{1}{4}} - \frac{5}{4} = \frac{1}{12} = 0.0833333333333333 \qquad default$$

This series converges pretty rapidly since 5 terms gave us the first two significant figures correctly.

1

Table 5: LaTeX can call Sage - a symbolic math program - directly (requires some extra steps to produce the pdf but I have those automoated so it's not more effort once set up than anythign else I do)

```latex
\documentclass[12pt]{article}  % use 12pt font instead of default 10pt
\usepackage{amsmath, amsthm, mathtools}    % math
\usepackage{siunitx}  % unitalicized units in math modes,
%non-breaking space between number and units everywhere,
%fractions in units w/o going into math mode
\usepackage[total={7.25in,9.75in}, top=0.5in, left=0.75in]{geometry}
% margin and orientation setting;

\begin{document}
Assuming that the lower note in this interval is tuned to
\SI{440}{\hertz}, determine the frequency of the upper note
assuming first a perfect interval and second equal-temperament.
\begin[notime, fragment]{lilypond}
\relative {\clef treble \key a \major  <a' e'>}
\end{lilypond}

Frequencies of notes an interval of a pure fifth apart are in a
$ 3:2 $ ratio.
\begin{align}
& f_E=\frac{3}{2}\SI{440}{\hertz} = \SI{660}{\hertz}
\end{align}

There are seven half-steps in the interval of a fifth.  At each
half-step up, the frequency increases by a factor of $ 2^{1/12} $
so that frequency doubles after the twelve half-steps in an octave.
\begin{align}
& f_E=2^{7/12}( \SI{440}{\hertz} ) = \SI{659.255}{\hertz}
\end{align}

\end{document}
```

Assuming that the lower note in this interval is tuned to $440\,\text{Hz}$, determine the frequency of the upper note assuming first a perfect interval and second equal-temperament.

Frequencies of notes an interval of a pure fifth apart are in a $3:2$ ratio.

$$f_E = \frac{3}{2} 440\,\text{Hz} = 660\,\text{Hz} \tag{1}$$

There are seven half-steps in the interval of a fifth. At each half-step up, the frequency increases by a factor of $2^{1/12}$ so that frequency doubles after the twelve half-steps in an octave.

$$f_E = 2^{7/12}(440\,\text{Hz}) = 659.255\,\text{Hz} \tag{2}$$

1

Table 6: LaTeX can also call Lilypond - a music typsetter - directly to typeset music

4   External Equation Editors

There are lots of these. Some you install on your computer; some are web-based. Some retain links to the equation when you drag the pdf/gif/jpg into your main document so that equations can be edited later; others do not. Some of them are LaTeX-based, but not all. Some will also produce MathML for web pages or ePub ebooks. One of the nice LaTeX, on-line examples is at http://www.codecogs.com/latex/eqneditor.php. One of the features I like in this particular one is having the symbol palette for learning, but being able to type known things quickly. Like using LyX, it makes it easier to learn the LaTeX syntax.

5   Exercises

5.1   Word

Open a MS Word document and do the following.

1. Write a paragraph and insert $x^2 \cos(\theta)$ **inline** in the paragraph. (I don't care if the paragraph makes sense.)

2. Create two lines of math displayed as a 2D object on its own line centered on the page.

3. Create an equation containing a fraction of a fraction.

4. Create an equation containing an improper indefinite integral.

5. Create an inequality.

5.2   Equations Only to Cut-and-Paste

(Actually, you would probably Insert rather than Paste.)

Go to http://www.codecogs.com/latex/eqneditor.php.

1. Create an expression involving a trig function.

2. Create the same two lines of math as above.

3. Create the same equation containing a fraction of a fraction as above.

4. Create the same equation containing an improper indefinite integral as above.

5. Create the same inequality you had above.

5.3   LaTeX document

Go to https://www.writelatex.com and then click on Create a new paper in the upper right of the screen. A brief example of a research paper should open automatically.

1. Somewhere in the model paper provided, insert `\begin{align}` on one line and then two lines later insert `\end{align}`.

2. Between your align statements, insert the same five math statements as before.

3. Notice the `\label` command inside the table. Specifically, it is inside the `\caption` which is the best place to put the label of a figure or a table. Equations and sections can also be labeled. The example document illustrates a standard labeling scheme (convenient for the human writing the paper; completely unnecessary for the computer) of prefixing labels with something that indicates what kinds of thing is being labeled: eq, tab, fig, sec. Labels permit references within a document, for example: `as figure \ref{fig:genomicsData} shows`. Create a label in one of the section headings and in one line of the equations you inserted. Refer to those labels elsewhere in the paper. It doesn't matter whether the references are before or after the labels.

4. Now add an equation before your labeled equation and a section before your labeled section. Notice what happens to all of the numbering.

5. At the top of the article, **at the end** of other `\usepackage` statements, add `\usepackage{hyperref}`. Wait for the spinning dial to stop and check the output (on the right) for what has happened to your reference to an equation and a section.

6. Change the line you just inserted to read `\usepackage[colorlinks=true,linkcolor=blue]{hyperref}`. The stuff in square brackets controls options in the hyperref package. What happens to all the references in the paper when you do this?

7. Type a paragraph into the `abstract` section of the paper.

8. Just above the `\end{document}` command, insert the following brief bibliography. (The blank lines matter - they separate paragraphs.)

```
\begin{thebibliography}{99}

\bibitem{ab59} Y.\ Aharonov and D.\ Bohm, {\it Phys.\ Rev.\ } {\bf 115}, 485 (1959).

\bibitem{HG} M.\ L. Horner and A.\ S. Goldhaber, {\it Am.\ J.\ Phys.\ }{\bf 64}, 1237 (1996).

\end{thebibliography}
```

Then somewhere in the paper insert `\cite{HG}`. Several other places in the paper insert `\cite{ab59}`. Finally, modify the call to the hyperref package again so that it reads `\usepackage[pagebackref=true,colorlinks=true,linkcolor=blue]{hyperref}`. How do bibliographic citations differ from internal links? What do the numbers after the entries in the bibliography mean? (Other bibliographic and citation styles exist. This is the default. There is software designed specifically for managing databases of bibliographic citations and restyling them to each journals specifications.)

9. Click on the pdf icon in the toolbar at the top of the window. That should download a pdf of the paper. Open it and click on things that are blue.