MAE 301/501 Notes

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1 Introduction

Today's class is a brief overview of LaTeX, which is a flavor of TeX. TeXwas designed as a markup language to format documents which include mathematics and other technical typesetting. It is **not** a word processor like Microsoft Word. You write your document in ordinary text, using any editor (notepad, emacs, or even Word), and then run LaTeX to produce the document. We'll use TeXmaker in class today. This is a free LaTeX editor which integrates many of the tools needed to develop LaTeX documents and runs on Windows, MacOS, and Linux. This combines the editor with the LaTeX tools and previewers so you can just hit a button to produce the document.

If you want to install LaTeX on your computer, I suggest you download proTeXt if you use Windows, or macTeX for MacOS. If you use Linux, there is almost certainly a TeX distribution as a standard package. In all cases I would also recommend you install TeXmaker.

Aside from enabling us to incorporate mathematics much easier than in Word or a non-technical word processor, another big advantage of LaTeX is that it separates the content of the document from much of the formatting decisions. LaTeX uses the idea of *styles* to make many of the decisions about the way a document appears. For example, you can write an exam so that by changing one line, it produces either the exam or the solutions. You can see the LaTeX source file, although this exam uses many subsidiary files (there are lots of pictures); all of the necessary files are at `http://www.math.sunysb.edu/~scott/mae501.spr09/notes/TeX/Exam-example/`. Some much less complicated examples are the notes for several of the meetings of this class:

February 17: PDF and LaTeX source	March 19: PDF and LaTeX source, (also needs other files)
February 19: PDF and LaTeX source	April 14 (what you are reading) and LaTeX source, (also needs other files)

While we will go over some of the basic ideas and features of LaTeX here today, if you are planning to use LaTeX to prepare documents, you should refer to some more complete introductions such as `http://en.wikibooks.org/wiki/LaTeX` or `http://www.math.harvard.edu/texman/` instead. Google can be your friend, too.

What follows is a summary of what we actually discussed during the class (with a few additions). You might find it useful, or not.

2 Some LaTeX

2.1 Getting started

All LaTeX documents have a common format. (TeXmaker can create a basic version of this for us from the "Quick Start" button). Below is an extremely simple, but complete, LaTeX document

```
\documentclass[12pt]{article}
\begin{document}
Here is some text, with some math $\int_0^1 x^2 dx = \frac{1}{3}$.
\end{document}
```

When typeset, we should see a page like

> Here is some text, with some math $\int_0^1 x^2 dx = \frac{1}{3}$.

We should first note that in TeX, anything beginning with a backslash (\) is a command. Curly braces ({ }) are used for grouping, much like parentheses in mathematics. These usually surround arguments to the commands, but are also used in other contexts as well. The square brackets are typically used for optional arguments to the LaTeX command.

In the example above, the first line (`\documentclass[12pt]{article}`) identifies that this document is of the type `article`, a very common type for a short note. The optional argument `[12pt]` tells LaTeX that we'd like to use 12-point type, slightly larger than the usual default of 10-point type.

The actual body of the document comes between `\begin{document}` and `\end{document}`. In this very short example, we have only the one line of text.

The area between the `\documentclass` line and the `\begin{document}` statement is called the *preamble* of the document. It is in this section that we include references to other packages and commands which modify the overall look of the document. I will refer to this section several times below.

2.2 Mathematics

Mathematics is typeset differently that ordinary text, and TeX requires us to surround things we want to treat as math by dollar signs ($). Certain command sequences (like `\int` for an integral or `\frac` for a fraction) only make sense in math mode, and will give an error if you use them in ordinary text.

There are ten characters which TeX treats specially; we've seen some of these already. Here they all are: `# $ % & ~ _ ^ \ { }`. If you want to typeset one of these, you need to treat it specially.

Back to our example, sometimes we want to insert mathematics in the ordinary flow of our text, for example if we want to say something like "if x is a real number, then x^2 cannot be negative". But sometimes we want to set off the mathematics on its own line; this is called a "displayed formula". This is indicated by using either double dollar signs around the math mode, or surrounding it by `\[` and `\]`.

If we change our sample document to look like

```
\documentclass[12pt]{article}
\begin{document}
Here is some text, with some math \[ \int_0^1 x^2 dx = \frac{1}{3}.\]
\end{document}
```

we get

Here is some text, with some math

$$\int_0^1 x^2 dx = \frac{1}{3}.$$

Math in display mode takes up more space than inline math, so, for example, the limits of integration on an integral are placed differently when the integral appears inline and as a display.

2.3 Labels and references

In some cases, we want to number our equations. In this case, we would use something like

```
\begin {equation}
\sum^{\infty}_{i=1} a_i x^i
\end {equation}
```

which produces

$$\sum_{i=1}^{\infty} a_i x^i \tag{1}$$

However, usually we number the equation so that we can refer to it elsewhere. LaTeX allows us to refer to these numbers by a symbolic name, so that if the numbering changes, we don't have to update our document. This is done by inserting a `\label` inside the equation environment, and then refering to that label using `\ref`. For example,

```
\begin {equation} \label{bSeries}
\sum^{\infty}_{i=1} b_i x^i
\end {equation}
The series of interest appears in (\ref{bSeries}).
```

yielding

$$\sum_{i=1}^{\infty} b_i x^i \tag{2}$$

The series of interest appears in (2).

LaTeX calculates the labels for us, so if we insert additional equations, we don't need to renumber things. If you see (**??**) where your reference should be, you just need to run LaTeX again.

In addition, we can label other things. For example, at the start of the current subsection, I typed

```
\subsection{Labels and references}\label{labelSection}
```

This means I can refer to this section as "section 2.3" by typing `section~\ref{labelSection}`.

Refering to items in a bibliography is done by a similar process, using `\cite` and `\bibitem`, but I won't discuss them here.

Finally, you might wonder why my references are colored and act as hyperlinks. This is because I put

```
\usepackage[implicit=true,colorlinks=true]{hyperref}
```

in the preamble (before the `\begin{document}` statement) in these notes, which turns references into hyperlinks. More detailed discussion of the `hyperref` package can be found at http://www.tug.org/applications/hyperref/manual.html.

2.4 Multi-line equations and alignment

If we wanted to typeset a multi-line equation, we could use the `gather` environment. However, often you not only want several lines, but you want to align them in certain places. For that we use the `amsmath` package and the `aligned` environment:

```
\documentclass[12pt]{article}
\usepackage{amsmath}
\begin{document}
We have
\[
\begin{aligned}
\frac{dS}{d\zeta}&= \frac{1}{2\pi i}  \int_{S_r} \frac{1} {z-\zeta}\frac{dz}{z}\\[5pt]
&= \frac{1}{2\pi i}  \int_{S_r}
        \left(\frac{1/\zeta} {z-\zeta}-\frac{1/\zeta}{z}\right)dz\\[5pt]
&=0.
\end{aligned}
\]
\end{document}
```

which looks like

We have

$$\begin{aligned}\frac{dS}{d\zeta} &= \frac{1}{2\pi i}\int_{S_r}\frac{1}{z-\zeta}\frac{dz}{z}\\ &= \frac{1}{2\pi i}\int_{S_r}\left(\frac{1/\zeta}{z-\zeta}-\frac{1/\zeta}{z}\right)dz\\ &= 0.\end{aligned}$$

Here, the `\\` is used to indicate that the line should be broken there, and we indicated that some extra space should be inserted with the `[5pt]` option. In the `aligned` environment (and some others), the ampersand (`&`) is used to indicate where the lines should match up. We could use multiple alignments on each line, if we wanted to, but in this case it wasn't necessary.

Below is an example with multiple points of alignment.

```
We want to solve $x^2 -1 = 0$. Thus,
\[\begin{aligned}
      &&    x^2 - 1 &= 0   &&   \\
      &&  (x+1)(x-1)&= 0   &&   \\
 x+1&=0&       \text{or} &&    x-1&=0 \\
  x&=-1&       \text{or} &&      x&=1 \\
\end{aligned}\]
```

We want to solve $x^2 - 1 = 0$. Thus,

$$\begin{aligned}
x^2 - 1 &= 0 \\
(x+1)(x-1) &= 0 \\
x+1 = 0 \quad &\text{or} \quad x-1 = 0 \\
x = -1 \quad &\text{or} \quad x = 1
\end{aligned}$$

2.5 Macros

One very useful thing in TeX is the ability to define your own command sequences. Doing this can make your document much easier to type, and make the LaTeX source more readable. For example, to typeset the usual notation for the real numbers ($\mathbb{R}$), we would use `$\mathbb R$`. Besides being a little unwieldy to type, it is hard to read in a statement like

```
We have the function $f:{\mathbb R}^2\rightarrow{\mathbb R}^2$.
```

I usually insert the line

```
\newcommand{\R}{\ensuremath{\mathbb R}}
```

(along with several similar lines) in the preamble so that I can just type `\R` to get $\mathbb{R}$. The `\ensuremath` will switch into math mode if the command is invoked outside of math mode, but won't do anything in math mode, so that I can also type `$\R^2$` to get $\mathbb{R}^2$. One can create much more elaborate macros with `\newcommand`, but that's enough for now.

2.6 Graphics

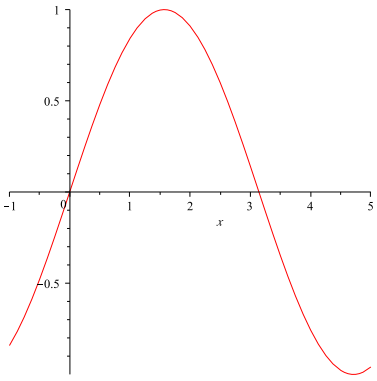
Often we want to insert pictures into our documents. This is easiest to do using the `graphicx` package in LaTeX. This lets us include graphics in several formats, although if you are using pdfLaTeX, you probably want to use PDF graphics.

For example, we produced a graph of the sine function in Maple, and exported it as an EPS file and converted it to PDF (Maple won't write PDF files directly, but conversion is easy). Doing something like the following

```
\documentclass[12pt]{article}
\usepackage{graphicx}
\begin{document}
Here is a graph of $\sin(x)$:
\begin{center}\includegraphics[height=2in]{sin.pdf}\end{center}
\end{document}
```

will give us

Here is a graph of $\sin(x)$:



I specified the desired height of the figure (I could specify the width if I prefered.)

2.7 Minipages

Sometimes you want to typeset two (or more) paragraphs side by side. This is done with the `minipage` environment. For example, to produce the following

Euler's identity (right) relates the five most important numbers (0, 1, e, i, and π), and has been described as one of the most beautiful formulae in all of mathematics.

$$e^{i\pi} - 1 = 0$$

I used

```
\begin{minipage}{4.5in}
Euler's identity (right) relates the five most important numbers
(0, 1, $e$, $i$, and $\pi$), and has been described as
one of the most beautiful formulae in
```

```
all of mathematics.
\end{minipage}
\quad
\begin{boxedminipage}{1.25in}
\[
 e^{i\pi} - 1 = 0
\]
\smallskip
\end{boxedminipage}
```

A minipage is a section of your document that is typeset like a page on its own, and inserted like a big character. While the previous example is fairly contrived, minipages are particularly useful for putting pictures or tables next to some text, or several pictures side-by-side. For example,

At right is a picture of a sign pointing out a fact that is ignored all too often.

I used

```
\begin{minipage}{2.5in}
At right is a picture of a sign pointing out a fact that is
ignored all too often.
\end{minipage}\qquad
\begin{minipage}{2in}
\includegraphics[width=2in]{alcohol-impairs.jpg}
\end{minipage}
```

(Actually, all of the samples in this document are inside a `boxedminipage` environment, which puts a minipage inside a box.)

3 KThnxBye!

That should be enough information to get you going. But the best way to use LaTeX is just to start. Take an existing document that does some of what you want, and just start going with it. You will certainly get some error messages, but when you do, don't just give up. It will be worth it in the end.