Charley's* LaTeX Handout!

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Getting Started

Visit http://www-personal.umich.edu/∼kochsc/295F2018.html and click the link "Intro to LaTeX" for instructions on installation. This resource also includes explanations on various terminology and a few commands to get started. However as noted in the final section, there is far too much to cover in one short PDF guide. LaTeXis something you learn through doing. Reading a manual for hours on end might help you get started, but the best way to learn is through using it often. Also, use Google. If there is something you want to do with LaTeX, it is almost certainly doable by just searching hard enough.

To get started, you should know the different typing modes. If you just type like normal into the document, it will come out as normal text when you compile the code, almost as if you are typing into Word. If you want to type math symbols, like $\mathbb{R}, \cup, \cap, \star$, you have a few main ways to do it. First is in-line math, which will place the symbols in line with the text like this: Let $\alpha = 1$. To do this, type a dollar sign, then the command for the symbol(s) you want, then place another dollar sign. So it should look something like this:

```
$C = A \cup B$
```

A second way is math display mode, which places the symbols on a new line in larger font. This is useful for more complicated notation that would become jammed if crammed onto one line. To use display mode, the preferred method is to type a backslash followed by an open square bracket, then type the commands you want, then type a backslash followed by a closed square bracket. It should look like this

```
\[C = A \cup B\]
```

The third main way is to use the **align** environment. This is useful for performing manipulations of an equation because it allows you to cleanly spread it over multiple lines instead of trying to jam everything onto one line. For example,

$$\begin{aligned}
\left((A \cup B) \cap \bigcup_{i=1}^{k} \bigcap_{j=1}^{i} U_i \cap V_j\right)^C &= (A \cup B)^C \cup \left(\bigcup_{i=1}^{k} \bigcap_{j=1}^{i} U_i \cap V_j\right)^C \\
&= (A^C \cap B^C) \cup \bigcap_{i=1}^{k} \left(\bigcap_{j=1}^{i} U_i \cap V_j\right)^C \\
&= (A^C \cap B^C) \cup \bigcap_{i=1}^{k} \bigcup_{j=1}^{i} (U_i \cap V_j)^C \\
&= (A^C \cap B^C) \cup \bigcap_{i=1}^{k} \bigcup_{j=1}^{i} U_i^C \cup V_j^C
\end{aligned}$$

*Charles Devlin VI was the 295 CA last year. He made this document for his students and future generations of 295ers.

The code for this is

```
\begin{align*}
\left((A \cup B) \cap \bigcup_{i=1}^k \bigcap_{j=1}^i U_i \cap V_j \right)^C
&= (A \cup B)^C \cup \left(\bigcup_{i=1}^k \bigcap_{j=1}^i U_i \cap V_j \right)^C \\
&= (A^C \cap B^C) \cup \bigcap_{i=1}^k \left(\bigcap_{j=1}^i U_i \cap V_j \right)^C \\
&= (A^C \cap B^C) \cup \bigcap_{i=1}^k \bigcup_{j=1}^i (U_i \cap V_j)^C \\
&= (A^C \cap B^C) \cup \bigcap_{i=1}^k \bigcup_{j=1}^i U_i^C \cup V_j^C
\end{align*}
```

You use the & symbol to tell TeX where to align the lines. In this example, I aligned along the equal signs. When I wanted to move to a new line, I typed a double backslash \\, which tells TeX to move to the next line. The "\begin{align*}" and "\end{align*}" tell TeX where the code begins and ends. The asterisk is optional - it removes the equation number that appears in the margin.

A Couple of Useful Packages

The preamble is the section before beginning a document in which you specify font and margin sizes, the type of document, and importing packages. Professor Koch includes a template you can download from the link in the first section to get started, but it includes only a few packages. I'll list a few more which you may want to include in your preamble. Of course, more can be added at any time.
The package **stackrel** is used often when you need to place symbols on top of one another. For example, if you wanted to justify a logical step that utilized the triangle inequality, then instead of writing "by the triangle inequality" you can omit that statement and instead show it with the symbol $\stackrel{\Delta}{\leq}$. You need to add the package to your preamble to use something like this. If you add it, the command is

```
\stackrel{\Delta}{\leq}
```

The symbol you want on top goes in the first pair of brackets, and the one you want on the bottom goes in the secong pair of brackets. **amsfonts** is another package which is useful. It gives a wider range of fonts for you to use, for example $\mathfrak{mathfrak}$. This is useful mainly for when you have alot of different variables and want to give them all understandable names. The commands for these have the form

```
\mathfrak{hello}
```

where you replace "mathfrak" with the name of the font you want to use, and the letter(s) you want in that font go in the brackets.

Defining Commands

On her website, Professor Koch includes a link to Detexify. Here, you can look up commands you don't know. Some of these commands can be long and tedious to write every time you want to use them. For example, throughout 295 (and your entire mathematics career, most likely) you will write the symbol $\mathbb{R}$ hundreds of times. Its not fun to write out "\mathbb{R}" every time you want to do this. So lets make this easier on ourselves by going to our preamble and including the text

```
\newcommand{\RR}{\mathbb{R}}
```

Now, if you type \RR, you will get the symbol $\mathbb{R}$. You can define anything this way. Just put what you want to type for the command in the first pair of brackets, and which command it is in the second pair of brackets. Just be careful, because if the new name you are trying to give to a command is already the name of another command, you will receive an error when you compile.

Practice

Try typing the following statements using the correct symbols. Ask me or Google for the symbols you don't know commands for. Note that if you are trying to type the { or } symbols, you will need to type \ or \. There are other symbols that are like this as well, such as $.

1. If $N = \{a, b, c\}$ and $M = \{1, 2, 3\}$ then $N \cap M = \emptyset$ but $N \cup M = \{a, b, c, 1, 2, 3\}$.
2. Every element of $\emptyset$ is a prime number!
3. The set $\{\mathbb{R}\}$ is finite.
4. We can place a very strange order structure on $\mathbb{Q}[\sqrt{2}]$.
5. If $\forall x \in \mathbb{R} \exists y \in \mathbb{R}$ with $x = y^2$, then $0 \neq \zeta(\frac{\pi}{2} + ie^{\alpha^{\beta_\gamma}}) + \Gamma^{-1}(\pm 4^{4^{4^4}})$.
6. Let $f : [0, 1] \to \mathbb{R}$ be defined by $f(x) = x^2$. Then $\forall \epsilon > 0 \exists \delta > 0$ such that $\forall x, y \in \mathbb{R}$ with $|x - y| < \delta \implies |f(x) - f(y)| < \epsilon$.
7. $\left| \rotatebox{90}{$\overline{\lceil \lfloor | 1 | \rfloor \rceil}$} \right|^{11} = \overline{\lceil \lfloor | 1 | \rfloor \rceil}$.
8. Try putting parentheses around $\frac{\frac{2}{15}}{\frac{80000000}{10^{2000}}}$ normally. Now, instead of putting parentheses around it, try typing "\left(", immediately before it and "\right)". We can do this with all sorts of things! Absolute value bars |, brackets [,], squiggly brackets {, }. Its really quite nice!
9. The binomial coefficient $\binom{n}{k}$ gives the number of ways to choose k objects from a collection of n objects.
10. If X is a set, a <u>topology</u> on X is a set $\tau \subset \mathcal{P}(X)$ of subsets of X such that the following hold:
    (a) $X \in \tau$ and $\emptyset \in \tau$.
    (b) τ is closed under arbitrary unions. That is, if $A \subset \tau$ is a set of elements of τ (so A is a set of subsets of X, and A may contain infinitely many elements), then $\bigcup_{U \in A} U$ (the set obtained by taking all elements of every set in A) is an element of τ.
    (c) τ is closed under finite intersections. That is, if $N \in \mathbb{N}$ is a natural number and $U_1, U_2, \ldots, U_N$ are all in τ, then $\bigcap_{k=1}^{N} U_k$ (the set of all elements which are in every one of the U_k) is an element of τ.

    We call the pair (X, τ) a <u>topological space</u> and the elements of τ are called the <u>open subsets of X</u>.
11. Let G be a set and let $\star : G \times G \to G$ be a binary operation on G. The pair $(G, \star)$ is called a <u>group</u> provided that the following three statements hold:
    (a) $\star$ is associative. In other words, if $g_1, g_2, g_3 \in G$, then $(g_1 \star g_2) \star g_3 = g_1 \star (g_2 \star g_3)$.
    (b) There is an element $e \in G$ satisfying $g \star e = g = e \star g$ for all $g \in G$. e is called an <u>identity</u> of G.
    (c) For every $g \in G$ there is an element $h \in G$ such that $h \star g = e = g \star h$. h is called an <u>inverse</u> of g.

    There are lots of groups! For example, the set $(\mathbb{R}, +)$ where $+$ is the binary operation of addition you are used to using (so $1 + 1 = 2$, etc.). 0 is an identity of $\mathbb{R}$, and if $a \in \mathbb{R}$, then an inverse for a is the element $-a$. As an exercise, try to show that an identity element of a group is unique. That is, show that if $(G, \star)$ is a group and e, e' are identity elements of $(G, \star)$, then $e = e'$.