Chapter 1

A short introduction to LaTeX

As a scientist (or engineer), one of your most important tasks will be to produce quality written documents detailing your work. The quality of the document that has your name attached to it speaks volumes about the type of professional you are. LaTeX is your best friend in this arena.

You can think of LaTeX as almost like a programming language for generating documents. You can create variables, loops, function, and even use if/else statements, all in the context of document production. We won't focus on the most complicated parts of LaTeX here but if you are interested, please come and talk to me. At first glance, LaTeX may seem like a complicated version of Microsoft Word, but as you gain experience using it you will find that it actually simplifies many complicated tasks. It is an especially useful tools when:

1. Your document contains a lot of math equations and you are referring to those equations frequently in the body of your document.
2. Your document has a lot of citations and a bibliography.
3. Your document has a lot of figures/graphics and you are frequently referencing them in the body of your document.
4. You'd like to use your programming skills to build nifty automations when building a document. Here are a few examples
   (a) When I build an exam, I include the questions and the solutions in the same document. By modifying a single variable I can turn those solutions on to build the key and off to build the exam.
   (b) When I build a schedule/calendar, I have a file that lists the correct dates and other date-specific information. When the schedule is built, the dates are read from the file. If I need to modify the schedule, I simply modify the list of dates and recompile.

LaTeX is used heavily in research environments and is a skill that will be an asset to you.

Getting Started

The first thing we ought to learn is how to create a simple document using LaTeX.

P1.1 Open your editor and type the following into the window and press the `Typeset` button.

```
\documentclass{article}
\begin{document}
This is a new document.  I can type whatever I want and it will appear
in the body of the text
\end{document}
```

You probably wouldn't use LaTeX to produce a document this simple, but at least you can see how simple documents are produced. Please note that every document you produce must have these lines:

```
\documentclass{article}
\begin{document}

\end{document}
```

Math

The fun starts when you need to add math to your document. LaTeX is great when it comes to producing great-looking, numbered math equations that can easily be referenced from within the body of the text. Literally any math symbol you could want can be produced if you know the correct syntax. A full listing of the syntax for all of the math symbols will not be provided here but can be easily found with the help of Google.

There are several different ways that you may want to incorporate math into your document. You may just want to add a math equation in the middle of a sentence

P1.2 Type the following into your editor window and press the `Typeset` button.

```
\documentclass{article}
\begin{document}
To find the electric field, we need to evaluate the integral:
$\frac{1}{\alpha} \int_0^{10} \ln(2 x) dx$ and then take the limit as
$\alpha \rightarrow \infty$.
\end{document}
```

Take a second to look at the output and to digest the code. Ask any questions that you may have.

Let me highlight a few things that you should have noticed:

1. When typing math in the middle of a sentence, you must enclose the math expression in $ symbols.
2. Sub- and super- scripts are done just as you would expect. If the sub- or super-script is longer than one character, you must enclose it in curly braces ({}).

3. Common math symbols can be easily produced if you know the syntax. Here we see that `\int` is the syntax for the integral symbol, `\ln` is the syntax for ln, and `\frac{}{}` is the symbol for making fractions. The syntax for other commonly-used math symbols is provided in table 1.1.

4. Greek letters can also be produced if you know the correct syntax. In this example we see that `\alpha` is the syntax for α. The syntax for a few of the other common greek letters is given in table 1.2

Sometimes the math that you want to write down is a little longer and you'd like it to be on it's own line. That's no problem in LaTeX

P1.3 Type the following into your editor windown and push the `Typset` button:

```
\documentclass{article}
\usepackage{amsmath} % Needed to use \eqref
\begin{document}
To find the electric field, we need to evaluate the integral:
\begin{equation}\label{eq:integralEquation}
 \frac{1}{\alpha} \int_0^{10} \ln(2 x) dx
\end{equation}

When we evaluate equation \eqref{eq:integralEquation}, we find that it
equals $0$ because $\alpha = \infty$.

\end{document}
```

Take a second to look at the output and to digest the code. Ask any questions that you may have.

Once again, let me highlight a few things that you should have noticed:

1. When you want an equation to be numbered and located on it's own line you can use the

```
\begin{equation} \label{myLabel}
<equation>
\end{equation}
```

2. The `\label` command can be used to assign a name to your equation.

3. You can use the name you gave to your equation to reference it in the text. This means that you don't need to know the number that it was assigned. This is done like this `\eqref{equationLabel}`. Some commands require that you import an external package. In this case, the `\eqref` command needed the `amsmath` package.

Often you will have multiple lines of math and you want to be very careful about how the lines line up. Let's explore that a little bit.

`\frac{1}{5}`	$\frac{1}{5}$
`\sqrt{5}`	$\sqrt{5}$
`\int`	$\int$
`\ln`	$\ln$
`\oint`	$\oint$
`\sum`	$\sum$
`\infty`	∞
`\nabla`	∇
`\partial`	∂

Table 1.1 Commonly-used LaTeX math symbols.

`\alpha`	α
`\beta`	β
`\gamma`	γ
`\chi`	χ
`\Delta`	Δ

Table 1.2 Commonly-used greek letters in LaTeX.

P1.4 Type the folowing into the editor window and press the `Typeset` button [1]

[1] A copy/p
time.

```
\documentclass{article}
\usepackage{amsmath}
\begin{document}

\begin{equation}\label{kRadius}
k = \sqrt{\frac{2mE_f}{\hbar^2}}
\end{equation}

Now we can re-arrange to solve for $E_f$:

\begin{align}
3 \pi^2 \frac{N}{V} &= \left(\frac{2 m E_f}{\hbar^2}\right)^{3/2}\\
3 \pi^2 n &= \left(\frac{2 m E_f}{\hbar^2}\right)^{3/2}\\
\left(3 \pi^2 n\right)^{1/3} &= \left(\frac{2 m E_f}{\hbar^2}\right)^{1/2}\\
\left(3 \pi^2 n\right)^{1/3} &= \sqrt{\frac{2 m E_f}{\hbar^2}}\\
\end{align}

Comparing to equation \eqref{kRadius} we can conclude that:

\begin{equation}
k = \left(3 \pi^2 n\right)^{1/3}
\end{equation}


\end{document}
```

As before, digest what you see and ask any questions that you may have. What useful bits of information can you extract from this example

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These are just a few ways to produce math equations in your document. As you progress in your abilities, more questions will undoubtedly arise. We'll handle those situations case by case in this class. In conclusion, LaTeX produces beautiful math that is formatted in exactly the way that you want it and can be easily referenced from within the text. It should be your go-to tool anytime you need to produce a document with math in it.

Figures

A key element of any scientific document are graphics. This could be a plot or a chart, or just an image. Regardless, we need to figure out how to include them in our LaTeX document.

P1.5 Download a picture of an elephant and save it to your computer. Then type the folowing into the editor window and press the `Typeset` button [2] [3]

[2] A copy/paste may save you some time.

[3] You may have to fiddle with the `scale=1.2` to get an appropriate size.

```
\documentclass{article}
\usepackage{graphicx}  % You need this anytime you want to include graphics
\begin{document}
```

```
In figure \ref{figLabel} you will find an image of an elephant.
\begin{figure}
\includegraphics[scale = 1.2]{path/to/figure/of/elephant}
\caption{This is the caption to the figure \label{figLabel}}
\end{figure}

\end{document}
```

Look over the code and the output until things start to make sense. Ask any questions that you may have.

Once again, let me highlight a few things that you should have noticed:

1. Anytime you are including graphics in your document you will need the `graphicx` package.
2. Including a graphic is done with the `\includegraphics` command. The required argument to this function (found in curly braces) is the path to the image file. One of the optional arguments (found in square brackets) is `scale = 1.2`, which allows you to specify the size of the image.
3. To label a figure (for referencing in the text) and creating captions you need to place your `\includegraphics` statement in

```
\begin{figure}

\end{figure}
```

Citations and Bibiliography

A key element to any scientific paper are citations and a bibliography page. It is not uncommon for a published paper to have 30-40 citations. Tracking and managing all of these citations manually would be a mind-numbing task. Luckily, LaTeX can handle all of this for you. There are two things that need to be discussed regarding citations: i) finding the information for a source to be cited, ii) citing a source and creating the bibliography.

Finding source information

Google Scholar is a great place to do literature searches and it can help you gather the bibliography information too. But there are some settings that need to be altered.

P1.6 Follow the steps below to enable tex-friendly citation information:

(a) Go to www.google.com/scholar

(b) In the upper left corner, click the drop down menu and click on `Settings`.

(c) Under Bibliography manager, click "Show link to import citations into BibTeX" and click "Save"

(d) Perform a search for "Superalloys", or some other interesting topic of your choosing.

(e) Near the bottom of the first hit, there should be a link entitled "Import into BibTex". Click it. This is the source information that you will need

Citing a source and creating the bibliography

For a scientist that is actively and frequently publishing papers, it is quite common for them to cite the same source(s) in multiple publications. To simplify the citation process, a file that contains all of his frequently-cited sources (commonly referred to as a "bib" file) is maintained.

P1.7 Follow the steps below to create a simple bib file.

(a) Create a new file named `refs.bib`. It needs to have the `.bib` postfix.

(b) Using Google Scholar, search for a few publications and copy their bibTex entry into the file refs.bib. (See previous section) My refs.bib looks like this:

```
@article{caron2000high,
  title={High ysolvus new generation nickel-based superalloys for single cr
  author={Caron, P},
  journal={Superalloys},
  volume={2000},
  pages={737--746},
  year={2000}
}

@article{pettit1984oxidation,
  title={Oxidation and hot corrosion of superalloys},
  author={Pettit, FS and Meier, GH and Gell, M and Kartovich, CS and Brickn
  journal={Superalloys},
  volume={85},
  pages={65},
  year={1984}
}

@article{pollock2006nickel,
  title={Nickel-based superalloys for advanced turbine engines: chemistry,
  author={Pollock, Tresa M and Tin, Sammy},
  journal={Journal of propulsion and power},
  volume={22},
  number={2},
  pages={361--374},
  year={2006}
}
```

(c) Save the file

(d) Create another file in the same directory as the bib file. Put the following into the file

```
\documentclass{article}
\begin{document}

As I discuss superalloys I may need to make a citation
\cite{pollock2006nickel}, or maybe even two at a time \cite{pettit1984oxidation,caron2000high}.

\bibliographystyle{ieeetr}  % There are various styles to choose from.
\bibliography{refs}
\end{document}
```

[4] Study the code and the output until things make sense. Ask any questions that you may have.

[4] The names of your citations will likely be different from mine. You are also free to modify the names in the refs.bib file to be whatever you want.

Miscellaneous

The possible topics relating to LaTeX functionality fills entire books. I will not try to be complete in my coverage. Rather, let me give you a few more handy tidbits that come up frequently. Below you will find

Section Headings

When organizing a document, you will want to use sections and subsections. Here's how to do it.

```
\section{Name of Section}  % Section with numbering
\subsection{Name of Subsection} % Subsection with numbering
\section*{Name of Section}  % Section with no numbering
\subsection*{Name of Subsection} % Subsection with no numbering
```

As mentioned in the comments, adding a will supress the numbering of the sections.

Abstract and Title

Every scientific document has an abstract, or short summary, of the document. Beneath the title of every paper is listed the authors names and affiliations. Here is how all of this is generated in latex: [5]

[5] This is not a complete latex document but only a snippet.

```
\begin{document}
        \title{The effect of variable air density on the trajectory of a cannon shell
        \author{Lance J. Nelson}
        \affiliation{Brigham Young University - Idaho}
%       \author{SECONDARY AUTHOR}
%       \affiliation{SECONDARY AUTHOR's affiliation}
        \date{\today}

\begin{abstract}
  Most projectile motion problems assume that the air density remains
  constant for the duration of the motion.  This is not a bad
  asssumption when the projectiles maximum altitude is relatively
  small.  However, for high altitude projectiles this may be a poor
  assumption.  In this work, we will investigate how a variable air
  density changes the trajectory of a high-altitude projectile.  We
  will also explore the effect of ground temperature on the range of
  these projectiles.
\end{abstract}

\maketitle
```

Including code in your document

In this class, you may want to include some or all of your code and explain what you did. Instead of copying your code into LaTeX (ughh), LaTeX can read your code file and place it into the document, complete with text highlighting specific to the language you are coding in. Here is how you do it: [6]

[6] Pay special attention to the comments for help understanding

```
\documentclass{article}
\pdfoutput=1

\usepackage{fancyvrb}
\usepackage{color}

\definecolor{purple}{rgb}{0.625,0.125,0.9375}
\usepackage{listings}
\lstset{
  frame=lines,  % top and bottom rule only
  framesep=2em, % separation between frame and text
    keepspaces=true,
    aboveskip=0in,
    belowskip=0.2in,
    language=Python, % What language are you coding in
    fancyvrb=true,
    breaklines=false,
    basicstyle=\footnotesize\ttfamily,
    numbers=left,
    stepnumber=1,
    keywordstyle=\color{blue},  %What color for keywords
    identifierstyle=,
    commentstyle=\color{red}, % What color do you want comments.
    stringstyle=\ttfamily\color{purple},
    columns=fullflexible,
    showstringspaces=False,
    caption = {  The following is an example code},
    captionpos = b  % Where do you want the caption located
    }

\begin{document}


\lstinputlisting{testPython.py}  % This is where you specify
                                 % the location of your code file.
\end{document}
```

To say that we have only scratched the surface of what LaTeXcan do would be a huge understatement. However, what we have given you will suffice for the requirements of this class. If your curiosity overwhelms you and you must have more, please feel free to come talk with me one-on-one.

Homework

H1.8 Recreate the document called exampleWriteUp.pdf found on iLearn. The figures used in the document are also found on iLearn. You are free to use copy/paste to help speed up the process.