Lesson 1: Preparing Documents with LaTeX

1 Introduction

LaTeX is a document preparation system built on Donald Knuth's original 1978 system called TeX. LaTeX is a sophisticated program designed to produce high–quality typesetting, especially for documents with mathematical content.

The creation of a LaTeX document requires two steps:

1. Prepare a source file containing a mixture of content and LaTeX commands. This requires a text editor such as TeXMaker.

2. Process the source file using the LaTeX software. This requires a LaTeX distribution, such as TeXLive.

The result of this two–step process is a beautiful document, such as the one you are now reading. This tutorial assumes that you have TeXMaker and TeXLive (or another LaTeX distribution) installed on your computer.

There are many resources available for LaTeX, including the LaTeX project site

$$http://www.latex-project.org/$$

and the wiki book

$$http://en.wikibooks.org/wiki/LaTeX$$

You can find lists of commands and symbols on the internet as well; see, for example,

$$http://artofproblemsolving.com/wiki/index.php?title=LaTeX:Symbols$$

2 A Simple Example

Let's say you want to prepare a document with a single line that says "Physics is fun, and $e^{i\pi} = -1$". Here's how. In the text editor window of TeXMaker, type the following:

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

Physics is fun, and $e^{i\pi} = -1$.

\end{document}
```
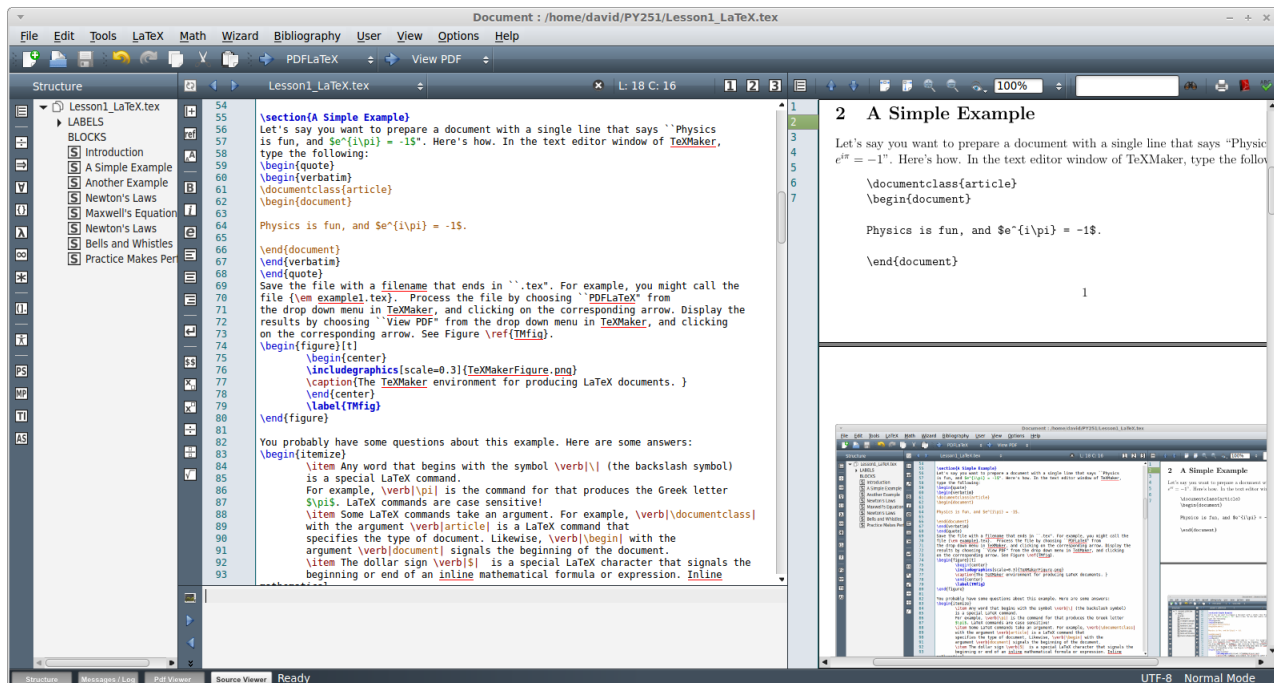
Figure 1: The TeXMaker environment for producing LaTeX documents.

Save the file with a filename that ends in ".tex". For example, you might call the file *example1.tex*. Process the file by choosing "PDFLaTeX" from the drop down menu in TeXMaker, and clicking on the corresponding arrow. Display the results by choosing "View PDF" from the drop down menu in TeXMaker, and clicking on the corresponding arrow. See Figure 2.

You probably have some questions about this example. Here are some answers:

- Any word that begins with the symbol \ (the backslash symbol) is a special LaTeX command. For example, \pi is the command that produces the Greek letter π. LaTeX commands are case sensitive!

- Some LaTeX commands take an argument. For example, \documentclass with the argument article is a LaTeX command that specifies the type of document. Likewise, \begin with the argument document signals the beginning of the document.

- The dollar sign $ is a special LaTeX character that signals the beginning or end of an inline mathematical formula or expression. Inline mathematical formulas are always surrounded by $'s. (An *inline formula* is one that occurs in a line with surrounding text.)

- Within a mathematical formula the caret symbol ^ denotes exponentiation. The caret is also used for superscripts; an underscore symbol _ is used for subscripts.

- Curly braces { and } are used for grouping in LaTeX, and must occur in pairs. For example, in the mathematical formula e^{i\pi}, the argument of the exponential is i\pi.

- Blank spaces are ignored by LaTeX. For example, the spaces around the = sign do not affect the final document.

> Exercise I: Create a document using the simple example above, and view the output *example1.pdf*. Create a new file with the line "`Physics`..." modified to read:
>
> `Physics is {\em really} fun, and $  e^{i  \pi }      =- {1}$.`
>
> Save this file as *example2.tex*. Note the extra spaces before the = sign, and the lack of space after. Also note the extra curly braces around the number 1. The command \em, which stands for "emphasis", tells LaTeX to use italic font. Process this document and compare your result for *example2.pdf* to *example1.pdf*. How has the equation changed? What happens if you remove the curly braces around \em really?

3   A More Complicated Example

Consider this:

```
\documentclass[11pt]{article}
\begin{document}

% Begin discussion of Newton's laws of motion
\section{Newton's Laws}
Newton's first law says: ``Every body continues in its state
of rest, or of uniform motion in a right line, unless it is
compelled to change that state by forces impressed upon it."

Newton's second law is
\begin{equation}
\vec F = m \vec a
\end{equation}
where $\vec F$ is the force on a particle of mass $m$, and
$\vec a$ is the particle's acceleration.

% Begin discussion of Maxwell's equations
\section{Maxwell's Equations}
Maxwell's equations include Gauss's law, which reads
\begin{equation}
\oint \vec E \cdot d\vec a = \frac{Q}{\epsilon_0}
\end{equation}
in integral form.

\end{document}
```

Observe the following features of this example:

- The `\documentclass` command now contains an option `[11pt]` that tells LaTeX to use 11 point font. The default font size is 10 point.

- The command `\section{Newton's Laws}` tells LaTeX to begin a new section with the title "Newton's Laws". Section numbering is automatic.

- The percent sign `%` is used to begin a comment. Comments do not show up in the processed document.

- A *displayed equation* is an equation that occupies its own line in the document. The LaTeX commands `\begin{equation}` and `\end{equation}` surround a displayed equation. Equation numbering is automatic.

- A blank line signals a paragraph break.

- The particle mass m is typeset as a formula, surrounded by `$`'s.

- The LaTeX command `\frac` contains two arguments, which are the numerator and denominator of a fraction.

This example also includes several new LaTeX commands. The command `\vec` tells LaTeX to put a vector arrow over the symbol that follows. The command `\oint` creates a closed–path integral sign. (The ordinary integral sign is `\int`.) The command `\cdot` creates a "centered dot". Can you guess what `\epsilon_0` produces?

Just after the `\begin{document}` command, insert the following:

```
\title{This is the title}
\date{}
\author{This is the author's name}
\maketitle
```

These commands create the title and author. The command `\date{}` tells LaTeX to leave the date empty.

Exercise II: Create a source file for the example above. Add a title and author, and process the document.

- Remove the $ signs from around m. How does this change the document?

- Create a new paragraph with a statement of Newton's third law.

- Add a sentence to the section on Maxwell's equations, and include Faraday's law

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi}{dt}$$

  as a displayed equation. (The symbol Φ is the capital Greek letter Phi. Can you guess how it is created? If not, look it up on the internet.)

- Add a sentence to the section on Maxwell's equations that includes Ampere's law in differential form,

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

  as a displayed equation. (The command for the "del" symbol ∇ is \nabla. Can you guess the command for the "times" symbol $\times$? How about the "partial" symbol ∂? How about the Greek letter μ?)

- Add one more sentence that includes the final Maxwell equation $\vec{\nabla} \cdot \vec{B} = 0$ as an inline formula.

4   Figures

Immediately after the \documentclass command, insert the following lines:

```
\usepackage{graphicx}
\newcommand\be{\begin{equation}}
\newcommand\ee{\end{equation}}
```

The \usepackage command tells LaTeX to load a package that extends its functionality. The graphicx package allows us to insert figures into the document. The \newcommand command defines a shortcut. We can now write \be in place of the cumbersome command \begin{equation}. Likewise, \ee is now a shortcut for \end{equation}.

Exercise III: Process your file and make sure there are no errors. Try replacing some of the \begin{equation} commands with the shortcut \be. You can also use \ee. Try commenting out the command \date{} to see what happens. What if you leave \date{} uncommented, but place some text between the curly braces?
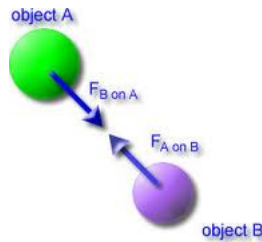
Figure 2: Newton's third law.

Now place the figure "N3L.jpg" in the same directory as your source document. Add the following lines just below your statement of Newton's third law:

```
\begin{figure}
\includegraphics[scale=0.5]{N3L.jpg}
\caption{Newton's third law.}
\end{figure}
```

Exercise IV: Process the document. It should contain Figure 2 with a caption. Can you see what the `scale` option does to the `\includegraphics` command? Note that LaTeX does not necessarily place the figure precisely where the `\begin{figure}` command occurs in the source file. Instead, LaTeX tries to place the figure at the top or bottom of a page, close to the corresponding text.
Your figure is probably off center. Place the command `\centering` just after `\begin{figure}`. Now is it centered?

5 Equation Labels

LaTeX supports an important feature that allows you to label equations for later reference.

Exercise V: Modify the text that produces Newton's second law to the following:

```
\vec F = m \vec a \label{Newton2}
```

The new feature here is the label command, which has attached the label "Newton2" to this equation. Now somewhere in your document add the line

```
Newton's second law (\ref{Newton2}) allows us to predict
the future.
```

It is important to note that the document must be processed *twice*. This is because LaTeX cannot know which numbers correspond to which labels until after it has completely examined the document once.

The ability to reference equations with labels is an important feature of LaTeX. Why? Imagine that your document contains 73 references to equation (1), and then you decide to add another displayed equation *before* equation (1)!

6   Practice Makes Perfect

Homework: Create a LaTeX document. The content can be nonsense—use a short poem or a fun quote or a few lines from a book or movie. Your document should include the following features:

- A title, author, and at least 2 sections.

- At least one word or phrase in italics, and at least one word or phrase in boldface type.

- The inline equation $ax^2 + bx + c = 0$, with some surrounding text.

- The following displayed equation with a label:

$$\int \left(\frac{(x-1)}{\sqrt{x^2+1}} + \sqrt{x^2+1} \right) dx = \left(1 + \frac{x}{2}\right) \sqrt{x^2+1} - \frac{1}{2} \arcsin x + C \qquad (1)$$

Hints:

  - The square root command is \sqrt. It takes an argument.
  - How should you typeset arcsin?
  - Large parentheses can be created with the commands \left(and \right). The size is adjusted automatically.

- Some text with a reference to the displayed equation.

- A figure with a caption. (Your LaTeX software might not support all graphics types. It should support at least pdf and jpg.)