# Fundamentals of LaTeX for High School Science

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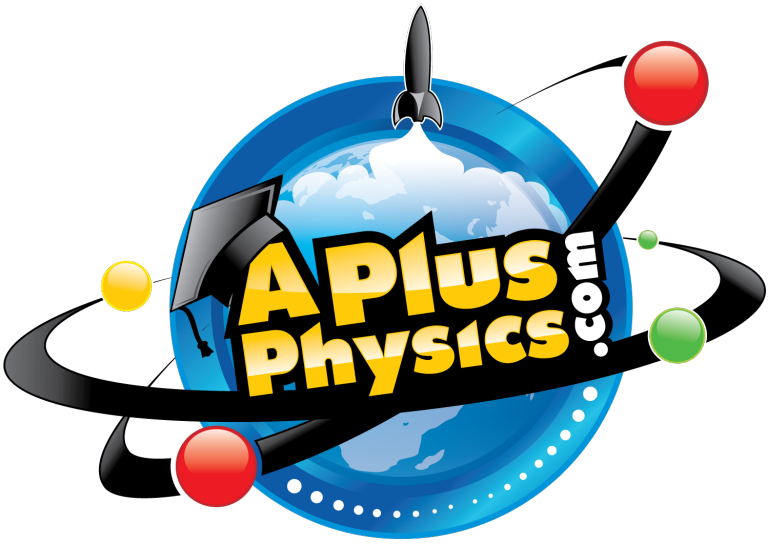


Version 1.0.1

# Contents

# 1 Introduction

LaTeX is a commonly used science, technology, engineering and mathematical (STEM) typesetting program. It is designed to allow writers to focus on content while producing high quality output. Unlike Microsoft Word or Apple Pages, however, it is not a what-you-see is what you get (WYSIWYG) interface, and therefore has a steeper learning curve than some of the more commonly available writing tools. The program is available on a wide variety of platforms, including Windows, Mac OSX, Unix, Linux, and even iOS. For the purposes of getting started, we'll assume you will be using a web-based implementation of LaTeX such as *Overleaf* or *ShareLaTeX*.

Advantages of LaTeX are a clean, crisp output while allowing the writer to focus on writing and content as opposed to appearance of the final document. Students are highly encouraged to focus on writing the entire document first, then coming back later to tweak the stylization and appearance of their final product.

First invented by Don Knuth in 1970, LaTeX was designed as a tool to help publish a computer programming book [1]. Since then, however, it has been built into a wide number of systems and applications, some free, some commercial, and has been expanded with a wide variety of packages which extend the functionality of the typesetting system.

This guide is intended to provide you a starting reference. Although it looks complex and does involve a bit of a learning curve, once you gain a bit of experience you'll find you can write high quality technical documents very quickly. Please note that there are **tons** of additional commands and capabilities built into LaTeX that are extremely accessible with just a bit of *Google*-Fu

# 2 The Basics

Paragraphs are delimited by having a space between lines in your code. You can also start on a new line without a new paragraph using double back slashes "\\". If you don't put a blank line between your paragraphs, LaTeX treats the lines as if they were part of the same paragraph. [2] Note that it is generally considered bad form to regularly use "\\". Instead, if you would like to place a blank line between paragraphs, consider using the parskip package in the preamble to your document, described in more detail in section

In similar fashion, you can use the "\pagebreak" command to start a new page, and the "\noindent" command to avoid indenting the current line.

Standard LaTeX is just text with some extra instructions thrown in. Most of these instructions start with a backward slash "\", and arguments to those instructions are placed in curly brackets "{}". As an example, to put something in italics, we'll use the *emph* instruction.

The code "\emph{This is in italics.}" produces the following output:

*This is in italics.*

Other common typesetting instructions include:

| | |
|---|---|
| \textbf{argument} | **Bold text** |
| \textit{argument} | *italic text* |
| \underline{argument} | underlined text |
| \tiny{argument} | tiny text |
| \small{argument} | small text |
| \large{argument} | large text |
| \huge{argument} | huge text |

Comments in LaTeX are inserted into your code using the percentage sign (%). Anything on a line following a percentage sign is ignored by the LaTeX engine. The following line would be ignored by the engine.

% This would be completely ignored and not show up on the printed page.

# 3 Document Structure

## 3.1 Document Class

Building a LaTeX document requires you to first define the type of document you want to create. This is handled by the \documentclass{argument} command and is the first line in your input file. A vast majority of the documents you'll be creating in this class will be articles, so the first line of your input file should generally read:

\documentclass{article}

Our class lab reports will utilize the IEEE (Institute of Electrical and Electronics Engineers) format [3], so more specifically, our lab report headers will read:

\documentclass[article, 11pt]{IEEETrans}

This tells LaTeXthat we'll be using the IEEE Transactions format, our document is an article, and we want our standard font size to be 11 points.

## 3.2 Defining Packages

Following the document class declaration, we need to tell LaTeX what additional extensions, or packages, we'll be using. Though we won't need all of these in all our documents, the following are some packages that may come into play commonly in building lab reports:

```
\usepackage{hyperref}          %Use hyperref package (for hyperlinks)
\usepackage{graphicx}          %Use graphicx package (for images)
\usepackage{float}             %Use float package (place images more easily)
\usepackage{gensymb}           %Use gensymb package (generic symbols)
\usepackage{amsmath}           %Use amsmath package (optimize math formulas)
\usepackage{tikz}              %Use tikz package (for creating graphics)
\usepackage{pgfplots}          %Use pgfplots package (for creating graphics)
\usepackage{pgfplotstable}     %Use pgfplotstable (for linear regression)
```

Additionally, the following packages, though not as common for lab reports, may be useful as you continue using LaTeX [4].

```
\usepackage{parskip}           %skips a line between paragraphs
\usepackage{indentfirst}       %indents the first paragraph in a section
\usepackage{geometry}          %allows you to adjust margins
\usepackage{microtype}         %improves spacing between words and letters
\usepackage{siunitx}           %simplifies use of units
\usepackage{cleveref}          %helpful for cross references
```

### 3.3 Beginning and Ending Your Document

The "meat" of your document is placed between begin and end declarations. You begin the document with the \begin{document} instruction, and end the document with the \end{document} instruction. A very simple LaTeXdocument, therefore, might look like:

```
\documentclass{article}
\begin{document}
Here is my text
\end{document}
```

## 4 Organization

Articles are organized into sections and subsections. LaTeX will automatically number the sections and sub-sections. If you don't want a section or sub-section to be numbered, you'll include an asterisk (*) after the word section or subsection. As an example, I'll place a sub-section titled "Section and Subsection Formatting" below using the command:

\subsection{Section and Subsection Formatting}

### 4.1 Section and Subsection Formatting

If I didn't want that subsection to be numbered, I would have instead use the command:

\subsection*{Section and Subsection Formatting}

That should be enough to get you started with organizing your document.

# 5 Math Expressions

Probably the biggest benefit of using LaTeX to typeset your documents is its ability to render math equations quickly and neatly. For example, the famous equation $E = mc^2$ is very easy to show, as is something a bit more demanding such as $\bar{v} = \frac{d}{t}$. The level of complexity LaTeX can handle is quite astounding. Even equations involving infinite sums such as $\sum_{n=1}^{\infty} 2^{-n} = 1$ are handled with ease.

## 5.1 Inline Equations

Mathematical expressions which are in-line with text are surrounded by dollar sign ($) symbols. A simple equation such as $\vec{F} = m\vec{a}$ can be placed inline using the code:

```
$\vec F = m\vec a$
```

## 5.2 Display Equations

Mathematical expressions which are to be placed on a new line (and typically centered) are called *display equations* and are surrounded by double dollar sign ($$) symbols. The codecogs [5] online equation editor does a fantastic job of allowing you to build your equations graphically, then providing you the LaTeX code you need to reproduce that equation in your document. You can access the editor at `http://www.codecogs.com/latex/eqneditor.php`. The same formula placed inline above can be placed in a display equation just by adding a second dollar sign to the beginning and end, as illustrated below.

$$\vec{F} = m\vec{a}$$

## 5.3 Aligned Display Equations

You can also align *display equations* to present a logic flow of mathematical work using the *align* environment and the **amsmath** package, as demonstrated in the display equations below. In these equations, the alignment point is defined by the ampersand (&) symbol. If you don't want the equation numbers to the right of the equation, use align* instead of just align.

$$f_0 = \frac{6\sqrt[3]{x^6}}{3} \tag{1}$$

$$f_0 = \frac{6x^2}{3} \tag{2}$$

$$f_0 = 2x^2 \tag{3}$$

$$\frac{f_0}{2} = x^2 \tag{4}$$

$$x = \sqrt{\frac{f_0}{2}} \tag{5}$$

Note that all the equations are aligned at the equals sign. This equation was created with the following code:

```
\begin{align}
   {f_0} &= {{6\root 3 \of {{x^6}} } \over 3}\\
   {f_0} &= {{6{x^2}} \over 3}\\
   {f_0} &= 2{x^2}\\
   {{{f_0}} \over 2} &= {x^2}\\
   x &= \sqrt {{{{f_0}} \over 2}}
\end{align}
```

### 5.4 Units

Utilizing the **siunitx** package extension to LaTeX, Système Internationale (SI) units (the modern form of the metric system)[6] become a breeze. The command for using SI units is \SI{}{}. The numerical value is placed inside the first set of curly brackets, and the units are placed inside the second set of curly brackets. For example, the acceleration due to gravity on the surface of the earth is $9.8\,\mathrm{m/s^2}$ or $9.8\,\frac{\mathrm{m}}{\mathrm{s^2}}$. This was created using the code:

```
\SI{9.8}{m/s^2} or
\SI[per-mode=fraction]{9.8}{\meter\per\second\squared}
```

## 6 Cross References and Hyperlinks

### 6.1 Cross References

Cross references and hyperlinks are another strong suit of LaTeX. First, I'd recommend using the **cleveref** package to simplify your work. With that package defined in your document preamble (see section 3.2), you start by labeling a portion of the document with the \label{} command, where the label

you want to create for the reference is placed between the curly brackets. You can then later refer to that label with \cref{labelname} command, where *labelname* is what you previously named that section.

The cross-reference in the preceding paragraph, specifically "see section 3.2", is created by first having a line in the code at section 3.2 which states "\labelpackages". Then, to show the section, the text "\cref{packages}" is used to generate the cross-reference. Note that for electronic documents in formats that permit the capability, such as PDF, the cross-references are hyperlinks taking you to that section of the document.

### 6.2 Hyperlinks

Hyperlinks, or links to web addresses, are also supported in /LaTeX. A simple url can be inserted in a document with the \url{} command, where the web address, including the http:// portion, is placed within the curly brackets. The web link `http://aplusphysics.com` is created using the code \url{http://aplusphysics.com}. Note that the inserted url is an active link in a PDF document that supports the feature.

There may also be times where you want to place the title of a link in the document, and have a click on the title take you to a specific url, without placing the entire url in your document. This can be accomplished with the **hyperref** package and the \href{}{} command, where the url goes inside the first set of curly brackets, and the text you want displayed goes inside the second set of curly brackets. Creating a hyperlink to APlusPhysics.com simply requires the following code: \href{http://aplusphysics.com}{APlusPhysics.com}.

You can even place a hyperlink to your e-mail address. A link to send an e-mail to my e-mail address would look like this in the text: info@aplusphysics.com and is created by the code \href{mailto:info@aplusphysics.com}{info@aplusphysics.com}.

## 7 Lists

There are three main types of lists you'll be dealing with in your writing, numbered lists, bulleted lists, and descriptive lists.

### 7.1 Numbered Lists

Numbered lists are known in LaTeX as enumerated lists. These are often used in the procedure section of a lab report, or in the analysis section when answering specific assigned questions. You create an enumerated list using the begin{enumerate} command, as shown below.

1. Begin each enumerated list with a begin{enumerate} command.
2. Add your list items using the list command.
3. Don't forget to end your list.

The list above was created with the following code:

```
\begin{enumerate}
\item Begin each enumerated list with a begin{enumerate} command.
\item Add your list items using the list command.
\item Don't forget to end your list .
\end{enumerate}
```

## 7.2 Bulleted Lists

Alternately, sometimes you want a bulleted list, known as an itemized list. These are common for lists of materials. Bulleted lists function in a similar fashion as enumerated lists.

- Begin each bulleted list with a begin{itemize} command.
- Add your list items using the list command.
- Don't forget to end your list.

The list above was created with the following code:

```
\begin{itemize}
\item Begin each bulleted list with a begin\{itemize\} command.
\item Add your list items using the list command.
\item Don't forget to end your list.
\end{itemize}
```

## 7.3 Description Lists

Description lists aren't as common in lab reports, though you do see them in technical writing, as in a vocabulary section.

**Bulleted Lists** Useful for lists of materials

**Numbered Lists** Useful for procedures

**Description Lists** Useful for vocabulary

This description list was created with the following code:

```
\begin{description}
\item[Bulleted Lists] Useful for lists of materials
\item[Numbered Lists] Useful for procedures
\item[Description Lists] Useful for vocabulary
```

```
\end{description}
```

# 8 Tables

Tables are created using the *tabular* command. For best results, however, I'd recommend placing your entire table inside a {table} environment. This allows you to center the table if you'd like, add a caption, a label, and in general, make it easier to reference your table elsewhere in your report. Columns in your table are separated by the ampersand symbol "&" symbol. If you'd like a vertical separator between your columns, you place a vertical separator symbol "|" between your justification marks.

Table 1: Common Tabular Commands

| Code | Justification Type |
|---|---|
| l | justify left |
| r | justify right |
| c | justify center |
| \hline | horizontal separator |
| \| | vertical separator |

The table above was created using the following code. Recall that the percent sign (%) allows us to insert documentation that is ignored by the compiler:

```
\begin{table}[H]                    % start table environment
\centering                          % center table
\caption{Common Tabular Commands}   % caption table
\vspace {2mm}                       % create a vertical space of 2 mm
\label{JustTable}                   % call the table "JustTable"
\begin{tabular}{|l|l|}              % 2 cols, justify left, vert bars
\hline                              % insert a horizontal line
Code & Justification Type \\        % separate columns with &
\hline                              % horizontal line
l & justify left \\                 % lines of text
r & justify right \\                % lines of text
c & justify center \\                % lines of text
\hline & horizontal separator \\     % lines of text
| & vertical separator\\            % lines of text
\hline                              % horizontal line
\end{tabular}                       % end printed table
\end{table}                         % end table environment
```

# 9 Figures

Figures are created using the *figure* environment and the \includegraphics [ ]{} command, where the size of your graphic is placed inside the square brackets, and the filename is placed inside the curly brackets. A [h] modifier after the \begin{figure} command tells LaTeX to place the picture at that specific point in your document. It is also recommended that you use a \label and \caption command to properly format your figure. A properly inserted figure is shown below.

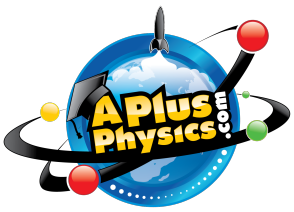


Figure 1: APlusPhysics Logo

This graphic was inserted using the following code:

```
\begin{figure}[H]
       \centering
       \includegraphics[width=1.5in]{APlusPhysics_Logo_HDef}
       \caption{APlusPhysics Logo}
       \label{logodiagram}
    \end{figure}
```

# 10 Graphs

Graphs are an important part of many lab reports. There are a number of tools and packages to create lab reports, and probably the easiest way to place a graph in your document is to use a separate program such as Microsoft Excel, LoggerPro, or an online tool such as Desmos to create a graphics file that you insert into your document using the instructions in the Figures section.

Creating graphs directly in LaTeX does have some advantages, however. The formatting of your graph will be consistent, and changes to your data can be immediately incorporated into your updated graphs. Building graphs in LaTeX requires the use of the *pgfplots* package, which is based on the *tikz* package.

We'll illustrate the use of inline graph creation in /LaTeX  using an example of basic data kept in a separate data file, titled "CircleData.dat". This file is a plain text file with the following information:

```
x y
11.7 37.8
17.1 54
8.4 26.6
6.6 21.2
7.4 23.4
6.6 21.2
7.9 25.6
15.8 50.6
8.8 28.5
1.9 7
```

You'll notice that the data headers are in the first row, and the data itself is in the remaining rows, separated by a space. Once the data is in that data file, it's time to create the figure. Begin with a begin{figure} command, then a begin{tikzpicture} command. The title and axis labels are then created with the begin{axis} command. In this example, I'm also including a best-fit line determined by linear regression. For anything more complex than this, I'd likely go to another graphing program.

The addplot command plots the points from the data table, and the second addplot command takes care of the linear regression, using the same data from the table. The addlegendentry command shows the slope value on the graph. Graph of our circle is shown below.

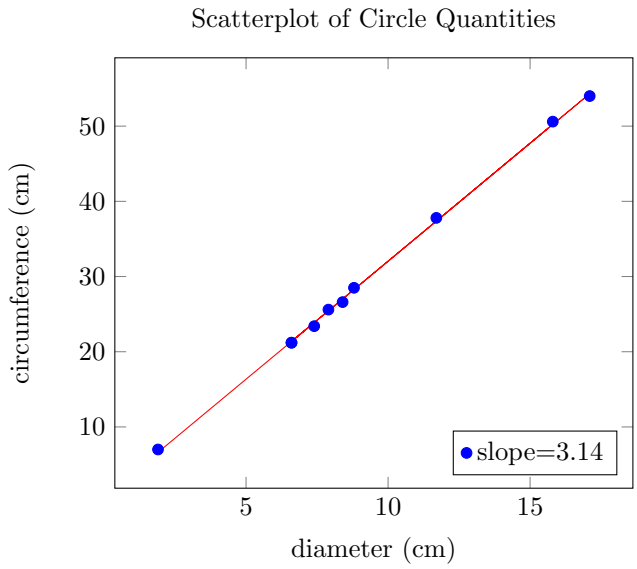


Figure 2: Scatterplot of Circle Quantities

This graph was created using the following code:

```
\begin{figure}[H]
```

```
\centering
\begin{tikzpicture}
\begin{axis}[
   title=Scatterplot of Circle Quantities,  %Title of graph
   xlabel={diameter (cm)},                  %label the x-axis
   ylabel={circumference (cm)},             %label the y-axis
   legend pos=south east,                   %put slope in SE corner]
\addplot[blue, only marks] table {CircleData.dat};  %plot points
\addplot [red] table [y={create col/linear regression={y=y}}] {CircleData.dat};
\addlegendentry{slope=$\pgfmathprintnumber{\pgfplotstableregressiona}$}
\end{axis}
\end{tikzpicture}
\caption{Scatterplot of Circle Quantities}\label{diagram1}
\end{figure}
```

# 11 Helpful Links

**How to TeX** `http://www.howtotex.com`

**APlusPhysics** `http://aplusphysics.com`

**CodeCogs** `http://www.codecogs.com/latex/eqneditor.php`

**ShareLaTeX** `https://www.sharelatex.com`

**Overleaf** `https://www.overleaf.com`

**LaTeX on Wikibooks** `https://en.wikibooks.org/wiki/LaTeX`

**LaTeX Video Tutorials** `http://quicklatex.blogspot.com`

**LaTeX Cheat Sheet** `http://wch.github.io/latexsheet/`

**Using BibTeX** `http://www.bibtex.org/Using/`

**Getting to Grips with LaTeX** /urlhttp://www.andy-roberts.net/writing/latex

**Essential LaTeX ++** `http://www.stat.pitt.edu/stoffer/freetex/latex%20basics.pdf`

# 12 Citations

A major selling point for using LaTeX is the easy with which it handles citations. Specifically, we'll focus on using the standard *BibTeX* extension, which is incorporated in most implementations of LaTeX. In the main LaTeX file itself, whenever we want to cite a reference, we'll use the \cite command, with an argument where we'll give a brief one-word name to the reference. For example, a great resource for using BibTeX is the BibTeX site [7].

This reference was created using the following code:

```
... is the BibTeX site \cite{bibtex}.
```

We'll put the information about the citation into a text file in the same folder, titled mybib.bib. This file includes basic information about the types of citations we're using. For example, the citation in mybib.bib corresponding to our BibTeX citation is as follows:

```
@misc{bibtex,
      author = "Alexander Feder",
      title = "BibTeX.org",
      year = "2006",
      howpublished = {\url{http://www.bibtex.org}},
      }
```

Many websites even include built-in citation information for BibTeX. Wikipedia, for example, includes a "Cite this page" link on the left sidebar of their entries (under *Tools*, which includes information you can copy and paste directly into your mybib.bib file.

Once your paper is complete, you can have LaTeX and BibTeX work together to create the final bibliography automatically. Just before the end of the document, you'll place two lines into your code, one calling for the bibliography section (using your text file), and a second bibliographystyle command that will allow you to alter the formatting of your bibliography. The bibliography for this document is created with the following commands:

```
\bibliography{mybib}{}
\bibliographystyle{unsrt}
```

The first command calls up the references section, and the second command tells LaTeX that we want the bibliography sorted by the order in which the references are used.

# 13 Sample Lab Report

A sample lab report and associated files are included as a .ZIP package. This package is provided to give you a starting point for building your first LaTeX lab report. Inside you'll find the main .tex file, as well as the subsidiary graphics, data, and bibliography files. Instead of starting your report from scratch, you can use this as a template for your work, changing the content of the file to fit your report, and allowing you to focus on the content of your lab report, rather than the stylization. You can access this document in the APlusPhysics Community Download Area (http://aplusphysics.com/community/index.php?/files/file/155-measuring-circles-latex-lab-report/).

# References


[1] Silmaril Consultants. Latex formatting information. http://latex.silmaril.ie/formattinginformation/index.html, 1999.

[2] David Xiao. A beginner's guide to latex. http://www.cs.princeton.edu/courses/archive/spr10/cos433/Latex/latex-guide.pdf, 2005.

[3] IEEE. Article templates and instructions. http://www.ieee.org/publications_standards/publications/authors/author_templates.html, 2016.

[4] Frits Wenneker. 9 essential latex packages everyone should use. http://www.howtotex.com/packages/9-essential-latex-packages-everyone-should-use/, 2012.

[5] Zyba Ltd. Codecogs.org. http://www.bibtex.org, 2016.

[6] Wikipedia. International system of units — wikipedia, the free encyclopedia, 2016. [Online; accessed 20-May-2016].

[7] Alexander Feder. Bibtex.org. http://www.bibtex.org, 2006.