1 Introduction

\LaTeX\ (variably pronounced as “La-tech” or “Lay-tech”) is an extremely versatile system for typesetting technical documents. Every PhD student in mathematics will use \LaTeX for one or more of the following tasks during their career as graduate students:

- Writing journal articles. Most journals require authors to submit manuscripts as .tex files. (Article or amsart class)
- Writing a dissertation. (Dissertation class)
- Preparing slide show presentations for masters, qualifying exam, and professional talks. (Beamer class)
- Preparing exams, quizzes, worksheets etc. for teaching. (Possibly with exam class)
- Keep track of sources for an article. (Bibtex)
- Preparing assignments and papers for classes. (Article or amsart class)

There is a baffling amount of information about using \LaTeX on the Internet. If you need to learn how to do something new in \LaTeX enter “thing you want to do” + “Latex” into your favorite search engine. Generally, if you learn the basic structures of \LaTeX it is easy to learn how to accomplish more complicated tasks on your own.

2 Basic \LaTeX structures.

2.1 Class

Every document has a class. Most tasks are best accomplished in the article class. Other classes that you might have occasion to use are beamer, exam, and dissertation. After any initial comments, the first line of every \LaTeX file should be a class declaration:
2.2 Document Sectioning

\LaTeX{} can organize, number, and index the sections of your document. The document structure hierarchy for \LaTeX{} is part, chapter, section, subsection, subsubsection, paragraph, and subparagraph. Each level of document structure has a unique heading and numbering, both of which are customizable.

**Example 1.** The first part of this document is partitioned as

\begin{verbatim}
\section{Introduction} ...text.... \\
\section{Basic \LaTeX{} \; structures.} .... text .... \\
\subsection{Document Sectioning} .... text .... \\
\subsection{Math modes} .... text .... \\
\subsubsection{In-line math mode.} .... text .... \\
\subsubsection{Display math.} .... text .... \\
\end{verbatim}

2.3 Math modes

There are two entry modes for mathematical symbols in LaTeX.

2.3.1 In-line math mode.

This mode is introduced with $...$ or $(...)$ and renders mathematics as in-line text. For example the code

Suppose $A$ and $B$ are convex and let $x,y \in A+B$

renders as: Suppose $A$ and $B$ are convex and let $x, y \in A + B$.

2.3.2 Display math.

This mode is introduced with \[\] and renders mathematics centered on a separate line. For example the code

For each fixed sequence $T \in \text{mathcal}(A)$ the map $f_T:O \to X$ given by:

\[f_T(x) = t_1x_1 + \ldots + t_n x_n\]

is continuous since $X$ is a topological vector space.

renders as

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$f_T(x) = t_1x_1 + \ldots + t_n x_n$

is continuous since $X$ is a topological vector space.
2.3.3 Display Style.

Occasionally, you might want in-line math to look more like display math but still stay in-line. For example, \( \sum_{i=1}^{\infty} \frac{a_i}{b_i} \) looks too small in the in-line mode. In this case, precede the in-line math command with \texttt{\textbackslash displaystyle}. Thus, \( \sum_{i=1}^{\infty} \frac{a_i}{b_i} \) is produced by

\[
\sum_{i=1}^{\infty} \frac{a_i}{b_i}
\]

2.4 Environments.

Environments are the standard tools used to accomplish typesetting tasks in \LaTeX. Every environment is implemented by typing \texttt{\textbackslash begin\{#envname\}...\textbackslash end\{#envname\}} where you supply the environment name. This section lists some of the most important \LaTeX environments.

2.4.1 Document.

This environment is where you type the actual text you want \LaTeX to render. Thus, every \texttt{.tex} file should look something like:

\begin{verbatim}
% # Initial comments #
\documentclass[#Paper type]{#class name}
\usepackage{#,#,...,#}
\begin{document}
#body#
\end{document}
\end{verbatim}

where you supply the information represented by \# symbols.

2.4.2 Align.

Use this environment to typeset long equations and formulas with nice alignment.

**Example 2.** In the align environment you type your equation using \texttt{\\} to break lines and & as the alignment point for each line. The code

\begin{verbatim}
\begin{align*}
v_1(x) & \leq \max_{\partial B(0,1)} v_1(x) \\&\leq \max_{\partial B(0,1)} \left( g + \frac{M(|x|^2-1)}{2n} \right) \\&\leq \max_{\partial B(0,1)} |g|.
\end{align*}
\end{verbatim}

renders as
$$v_1(x) \leq \max_{\partial B(0,1)} v_1(x)$$

$$= \max_{\partial B(0,1)} \left(g + \frac{M(|x|^2 - 1)}{2n}\right)$$

$$\leq \max_{\partial B(0,1)} |g|.$$ 

Thus:

$$u(x) \leq \max_{\partial B(0,1)} |g| + \frac{M(|x|^2 - 1)}{2n}$$

$$\leq \max_{\partial B(0,1)} |g| + \frac{1}{2n} \max_{B(0,1)} |f|.$$ 

### 2.4.3 Array.

Typeset matrices and other objects which have an array like structure. The array environment has a sensitive syntax and can only be used in math mode. You must declare the number and alignment of the columns by typing

\begin{array}{ccrl} ...... \end{array}

Here the ccrl tells \LaTeX\ that the matrix has 2 centered columns, 1 right aligned column, and one left aligned column.

**Example 3.** The matrix

$$T_N = \begin{pmatrix} 2 & -1 & & 0 \\ -1 & \ddots & \ddots & \\ & \ddots & \ddots & -1 \\ 0 & & -1 & 2 \end{pmatrix}.$$ 

is produced from the code

\begin{verbatim}
[T_N = \left( \begin{array}{cccc} 2 & -1 & & 0 \\ -1 & \ddots & \ddots & \\ & \ddots & \ddots & -1 \\ 0 & & -1 & 2 \end{array} \right) .]
\end{verbatim}

One way to produce the piecewise defined function

$$f(x) = \begin{cases} x^2 & x < 1 \\ x & x \geq 1 \end{cases}$$

is

\begin{verbatim}
[f(x) = \left\{ \begin{array}{cc} x^2 & x < 1 \\ x & x \geq 1 \end{array} \right. .]
\end{verbatim}

The AMS-math package also has an environment called matrix which handles the spacing in matrices a bit better than array.
2.4.4 Enumerate.

Enumerate is used to make numbered lists. Each item in your list is introduced with `\item` command. You can nest enumerations to create detailed outlines. There are various ways to adjust the numbering in enumerate (search “latex and enumerate” in Google.)

Example 4. The code

\begin{enumerate}
\item Conceptual Understanding:
  \begin{enumerate}
  \item Define the terms `power series`, `radius of convergence`, and `interval of convergence`.
  \item Find a formula for the coefficients $c_i$ of the power series
  \[
  \frac{1}{0!} + \frac{2}{1!}x + \frac{3}{2!}x^2 + \frac{4}{3!}x^3 + \ldots
  \]
  \end{enumerate}
\item Consider the function $f(x) = \displaystyle\frac{5}{1-x}$.
Find a power series which is equal to $f(x)$ for every $|x|<1$.
\end{enumerate}

renders as

1. Conceptual Understanding:
   a.) Define the terms `power series`, `radius of convergence`, and `interval of convergence`.
   b.) Find a formula for the coefficients $c_i$ of the power series
   \[
   \frac{1}{0!} + \frac{2}{1!}x + \frac{3}{2!}x^2 + \frac{4}{3!}x^3 + \ldots
   \]
1. Consider the function $f(x) = \frac{5}{1-x}$. Find a power series which is equal to $f(x)$ for every $|x|<1$.

2.4.5 Itemize.

This environment is basically the same as enumerate except it inserts bullets or symbols instead of numbering.

Example 5. \begin{itemize}
\item First bullet
\item["\$\subset\$"] Second bullet point replaced with a "\$\subset\$" symbol.
\item["\$\Leftarrow\$"] Third bullet point replaced with a "\$\Leftarrow\$" symbol.
\end{itemize}

- First bullet

"\$\subset$" Second bullet point replaced with a "\$\subset$" symbol.

"\$\Leftarrow$" Third bullet point replaced with a "\$\Leftarrow$" symbol.

2.4.6 Proof.

Put all your proofs in this environment. You get the □ symbol for free!

Example 6.
\begin{proof}[Proof of the Major Theorem.] This proof’s names is changed from the default of “proof.” to “Proof of the Major Theorem.” \end{proof}

Proof of the Major Theorem. This proof’s names is changed from the default of “proof.” to “Proof of the Major Theorem.”

2.4.7 Figure.

This is the general tool for inserting graphics into a document. Loading graphics into a document can be tricky. Typically, you’ll need to load the graphicx package (\usepackage{graphicx} in the preamble). If your graphic is a .eps file (as it should be) you will also need to compile your .tex file with latex (not PDFlatex) and then convert the output to a pdf.

Example 7. \begin{figure}
\centering
\scalebox{.4}{\includegraphics{3c.eps}}
\caption{Error plots for part (c)}
\end{figure}

Figure 1: Error plots for part (c)

2.4.8 Theorem environments.

These are user specified environments that insert theorems, definitions, examples, etc. They are named and numbered according to user instructions.

Example 8. Here we will create and use a “proposition” environment. To do this, you must load the package amsthm and define the theorem environment in the preamble (before the begin document command). We also define a counter named “stuff” which tells \LaTeX{} how to number the theorem.

\usepackage{amsthm}

\newcounter{stuff}
\newtheorem{prop}[stuff]{Proposition}

\begin{document}
\begin{prop} Laplace’s equation $\Delta u=0$ is rotation invariant. \end{prop}
\end{document}
\begin{proof} ... \end{proof}
\end{document}

**Proposition 1.** Laplace’s equation $\Delta u = 0$ is rotation invariant.

3 Referencing

Many \LaTeX objects, such as equations, theorems, and bibliographic data, are numbered automatically by \LaTeX. In writing, it is often useful to refer to these objects by there number, e.g. equation number (5). \LaTeX makes this easy, dynamic, and hyperlinkable.

If you have a numbered object which you want to refer to later in the document, place the \texttt{\label{\textit{name}}} command by the object. To refer back at a later time to the object named “name” type \texttt{\ref{\textit{name}}} in your document and \LaTeX will print the number of the object “name”. The hyperref package can be used to make these references clickable.

**Example 9.**

\begin{equation} \label{myeq}
    T_N = \left[ \begin{matrix}
        2 & -1 & 0 & \ldots \\
        -1 & \ddots & & \\
        \ddots & \ddots & \ddots & \\
        0 & & -1 & 2
    \end{matrix} \right]
\end{equation}

The matrix (1) is tridiagonal.

You should use the bibtek package to keep track of bibliographic information. This amazing package takes your bibliographic data in database form and automatically creates a reference list in whatever bibliographic standard you specify. Like most \LaTeX objects bibliographic entries can be labeled and dynamically referenced.

4 Beamer

Beamer is a \LaTeX package for creating technical slide show presentations. Beamer is remarkably versatile and customizable. To use beamer simply declare beamer as the document class:

\texttt{\documentclass[english,11pt]{beamer}}.

Create slides with the \texttt{\begin{frame}...\end{frame}} environment. Virtually anything you can compile in standard \LaTeX can be put into a beamer presentation. Some tips for using Beamer
1. Use the `\section{}` and `\subsection{}` commands to index the themes and subtopics of your presentation.

2. `\frametitle{}` titles the slides in your presentation.

3. Themes and colors are customizable with the `\usetheme{}` and `\usecolortheme{}` commands. Search for the names of a theme and color theme in Google and supply these commands in the preamble of your beamer file.

4. Use the `\pause` command to change how information is revealed on a slide.

**Example 10.** Here is an example of how to use pause.

```latex
\begin{frame}
  \frametitle{Not all items are seen at first.}
  \pause % Slide show only the title
  \begin{enumerate}
    \item Click once to reveal the first item \pause
    \item Click twice to reveal the second item.
  \end{enumerate}
\end{frame}
```

5. Dynamically label slides with `\label{}` command. Dynamically reference labeled slides with the `\ref{}` command.

6. You can hyperlink beamer slides with

   `\hyperlink{slidename}{\beamergotobutton{Go!}}`.

   This will produce a button on the slide which links to the slide labeled “slidename”. The command `\hyperlink{return2last}{\beamerreturnbutton{Return!}}`

   creates a return button which links to the slide labeled “return2last”.

7. Virtually anything you want to do in a slide show is possible with beamer. Many internet references are available.

5 References