SIAM: Getting Started with LaTeX

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What is LaTeX?

- LaTeX is a high-quality typesetting system
- LaTeX markup is converted into nice looking pdf files

```
\documentclass[12pt]{article}
\usepackage{amsmath}
\title{\LaTeX}
\date{}
\begin{document}
  \maketitle
  \section{Introduction}
  \LaTeX{} is a document
  preparation system for the
  \TeX{} typesetting program.
  It offers programmable desktop
  publishing features and
  ...
  \begin{align}
    E &= mc^2 \\
    m &= \frac{m_0}
       {\sqrt{1-\frac{v^2}{c^2}}}
  \end{align}
\end{document}
```

$\longrightarrow$

LaTeX

1   Introduction

LaTeX is a document preparation system for the TeX typesetting program. It offers programmable desktop publishing features and extensive facilities for automating most aspects of typesetting and desktop publishing, including numbering and cross-referencing, tables and figures, page layout, bibliographies, and much more. LaTeX was originally written in 1984 by Leslie Lamport and has become the dominant method for using TeX; few people write in plain TeX anymore. The current version is LaTeX 2_ε.

$$E = mc^2 \tag{1}$$

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{2}$$

Why Use LaTeX?

- Produces high-quality documents
- Offers precise control over how document looks
- Excellent for typesetting mathematics
- Automated references, citations, etc.
- Widely used for academic journals
- Free
- Multi-platform

Compiling

- Installing LaTeX on your computer
  - Mac: from MacPorts, MacTeX, TeXShop
  - Windows: TeXworks, MiKTeX
  - Helpful site: en.wikibooks.org/wiki/LaTeX/Installation
- Use `latexmk` or `pdflatex` or `latex` command on a .tex file to produce output
  - `latex` command is not recommended, since it cannot include .pdf, .jpg, .png image formats and cannot output to .pdf
- Can also compile online at sharelatex.com

Control Sequences

- LaTeX uses control sequences to achieve special functionality
- Control sequences start with a backslash \

```
\documentclass[11pt]{article}    describes appearance of document
                                 (similar to CSS)
\usepackage{amsmath}             include package named amsmath
\begin{document}                 begins document environment
\section{Section Title}          starts a new section
\subsection{Subsection Title}    starts a new subsection
\LaTeX{}                         displays LaTeX
\end{document}                   ends document environment
```

Example Document

- LaTeX document will have information like title and date in top matter
- Contents of document belong in document environment

```
\documentclass[11pt]{article}
\usepackage{amsmath}
\title{\LaTeX}
\author{Your Name}
\date{} % omits date since this is empty
\begin{document}
  \maketitle
  \section{Introduction}
  This is the introduction of my document.
  ...
\end{document}
```

Spaces

```
You can use LaTeX to typeset regular text.  In LaTeX, using
extra      spaces        or       a newline   doesn't matter.

However, using two newlines in a row results in a new
paragraph.

% line comments begin with a percent sign
```

      You can use LaTeX to typeset regular text. In LaTeX, using extra spaces or a newline doesn't matter.

      However, using two newlines in a row results in a new paragraph.

Cross-Referencing

- Many things in LaTeX, such as sections and subsections, are automatically numbered
    - Numbering can be suppressed using asterisk, e.g. \section*{...}
- Automatically numbered entities in LaTeX can be labeled using \label{...}
- Any labeled entity can be referenced using \ref{...}
- Command \ref{...} is often preceded by ~, denoting a space that cannot be a line break

```
\section{Introduction}
\label{sec:intro}
This is the introduction.
\section{Results}
In section~\ref{sec:intro}, we provided introductory
material. Now we will provide results.
```
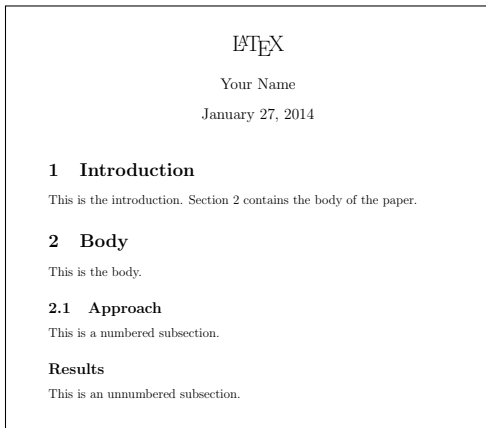
Compiling Multiple Times

- When running `pdflatex` on `example.tex`, multiple files are created
  - `example.pdf`: output file
  - `example.aux`: contains auxiliary about references, etc.
  - `example.log`, `example.synctex.gz`, etc.
- Cross-reference information in .aux file is not ready until after `pdflatex` is run
  - May need to run `pdflatex` twice for references to display correctly
- Using the tool LaTeX-Mk can resolve this issue
  - Use command `latexmk -pdf <filename>.tex` to perform all operations needed to generate final pdf

Exercise 1: Sections

- Create the following document in LaTeX

  ### LaTeX

  Your Name

  January 27, 2014

  1 Introduction

  This is the introduction. Section 2 contains the body of the paper.

  2 Body

  This is the body.

  2.1 Approach

  This is a numbered subsection.

  Results

  This is an unnumbered subsection.

- Helpful sites:
  - http://en.wikibooks.org/wiki/LaTeX/Document_Structure
  - http://en.wikibooks.org/wiki/LaTeX/Labels_and_Cross-referencing

Exercise 1: Sections (Solution)

```
\documentclass[12pt]{article}
\title{\LaTeX}
\author{Your Name}
\begin{document}
  \maketitle
  \section{Introduction}
  This is the introduction.  Section~\ref{sec:body} contains
  the body of the paper.
  \section{Body}
  \label{sec:body}
  This is the body.
    \subsection{Approach}
    This is a numbered subsection.
    \subsection*{Results}
    This is an unnumbered subsection.
\end{document}
```

Figures

- Figures can be created using the figure environment
- Various options for placing figures
    - `h`: here, approximately
    - `t`: top
    - `b`: bottom
    - `p`: on its own page with other such figures
    - For example, `begin{figure}[ht]`... will place the figure approximately where it is listed in the markup and at the top of a page
- Figures can include a caption and be labeled

Figures

- The figure below was made with the following code:

```
\begin{figure}
  \includegraphics[width=.6\textwidth]{siebel.jpg}
  \label{fig:siebel}
  \caption{A picture of Siebel Center}
\end{figure}
```


Figure 1: A picture of Siebel Center

BibTeX

- BibTeX is a tool used to cite articles/books and automatically form a bibliography
- Use `cite` command to cite something in your paper
    - Example: \cite{greenwade93}
- Use \bibliographystyle and \bibliography commands at the end of document where bibliography should be
    - Example: \bibliographystyle{plain}
      \bibliography{references}{}
- Make a .bib file (called references.bib in our example) that describes each source

BibTeX

- Example .bib file:

```
@article{greenwade93,
    author  = "George D. Greenwade",
    title   = "The {C}omprehensive {T}ex {A}rchive {N}etwork
               ({CTAN})",
    year    = "1993",
    journal = "TUGBoat",
    volume  = "14",
    number  = "3",
    pages   = "342--351"
}
@book{goossens93,
    author   = "Michel Goossens and Frank Mittelbach and
                Alexander Samarin",
    title    = "The LaTeX Companion",
    year     = "1993",
    publisher = "Addison-Wesley",
    address  = "Reading, Massachusetts"
}
```

Math Mode

- Text between dollar signs $...$ will use math mode
- Many control sequences only work in math mode
- Can use ^ for superscripts and _ for subscripts

```
$y = 3x - 4$                        →   y = 3x − 4
$\theta \Theta \omega \Omega$       →   θΘωΩ
$\sqrt{x} = x^{1/2}$                →   √x = x^{1/2}
$\min \{ x_1, x_2, x_3 \}$          →   min{x₁, x₂, x₃}
```

Displayed Math

- Example: `f(x) = \sum_{i=1}^{\infty} \frac{1}{g_i(x)}`
- Use dollar signs `$...$` for inline math
    - The equation $f(x) = \sum_{i=1}^{\infty} \frac{1}{g_i(x)}$ is displayed inline
- Use escaped brackets `\[...\]` to display math on its own line

$$f(x) = \sum_{i=1}^{\infty} \frac{1}{g_i(x)}$$

- Use `\begin{equation}...\end{equation}` for automatically numbered equations

$$f(x) = \sum_{i=1}^{\infty} \frac{1}{g_i(x)} \tag{1}$$

Exercise 2: Definition of Derivative

- Produce the following equation in LaTeX:

$$\frac{\mathrm{d}f(x)}{\mathrm{d}x} = \lim_{\delta \to 0} \frac{f(x + \delta) - f(x)}{\delta}$$

- Start from the following:

```
\documentclass[11pt]{article}
\usepackage{amsmath}
\begin{document}
  % add your content here
\end{document}
```

- Helpful sites:
  - en.wikibooks.org/wiki/LaTeX/Mathematics
  - ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf

Exercise 2: Definition of Derivative (Solution)

- Produce the following equation in LaTeX:

$$\frac{\mathrm{d}f(x)}{\mathrm{d}x} = \lim_{\delta \to 0} \frac{f(x + \delta) - f(x)}{\delta}$$

- Solution:

```
\[
  \frac{\mathrm{d}f(x)}{\mathrm{d}x}
  = \lim_{\delta \to 0} \frac{f(x + \delta) - f(x)}{\delta}
\]
```

- Do the ds in your solution look different?
  - \mathrm displays upright characters in math mode

Array-Like Environments

- Use `array` environment or one of the matrix environments to make table of information
- Matrix environments include delimiters for convenience
  - `pmatrix` (), `bmatrix` [], `Bmatrix` {}, `vmatrix` ||, `Vmatrix` ||||
- Columns separated with &, rows separated with \\

```
A = \begin{pmatrix}
    2  & -1 & 0  \\
    -1 & 2  & -1 \\
    0  & -1 & 2
   \end{pmatrix}
```

$\rightarrow$

$$A = \begin{pmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{pmatrix}$$

Align Environment

- Use `align` environment to line up multiple equations
- Left and right sides of equation separated with `&`
- Equations separated with `\\`
- Using `align*` instead of `align` will suppress equation numbers

```
\begin{align}
  x & = \cos(\theta(t)) \\
  y & = \sin(\theta(t)) \\
  \theta(t) &
     = \omega t + \phi
\end{align}
```

$\rightarrow$

$$x = \cos(\theta(t)) \quad (2)$$
$$y = \sin(\theta(t)) \quad (3)$$
$$\theta(t) = \omega t + \phi \quad (4)$$

Resizing Delimiters

- The `\left`, `\right`, and `\middle` commands are used to automatically resize delimiters like parenthesis based on content
- Period `.` denotes an omitted left or right delimiter
- The `\big`, `\Big`, `\bigg`, and `\Bigg` commands can be used to manually resize delimiters

`$\left(\frac{x^2}{y+x}\right)^2$` $\rightarrow$ $\left(\dfrac{x^2}{y+x}\right)^2$

`$P\left(X=1 \middle|` `\frac{X}{Y} \geq 2 \right)$` $\rightarrow$ $P\left(X=1\,\middle|\,\dfrac{X}{Y} \geq 2\right)$

`$\left.2x-\frac{2}{x^3}\right|_0^1$` $\rightarrow$ $\left.2x-\dfrac{2}{x^3}\right|_0^1$

`$( \big( \Big( \bigg( \Bigg($` $\rightarrow$ $(\big(\Big(\bigg(\Bigg($

Math Accents

- Special accents over variables/expressions may be used in math mode

`$\bar{x}$`	$\rightarrow$	$\bar{x}$	`$\vec{x}$`	$\rightarrow$	$\vec{x}$
`$\dot{x}$`	$\rightarrow$	$\dot{x}$	`$\hat{x}$`	$\rightarrow$	$\hat{x}$
`$\ddot{x}$`	$\rightarrow$	$\ddot{x}$	`$\tilde{x}$`	$\rightarrow$	$\tilde{x}$
`$\acute{x}$`	$\rightarrow$	$\acute{x}$	`$\grave{x}$`	$\rightarrow$	$\grave{x}$

Exercise 3: More Math

- Produce the following equations in LaTeX:

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

$$\hat{x}_i = x_i \left(\sum_{j=0}^{\infty} x_j \right)^{-1}$$

- Helpful sites:
  - en.wikibooks.org/wiki/LaTeX/Mathematics
  - ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf

Exercise 3: More Math (Solution)

- Produce the following equations in LaTeX:

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

$$\hat{x}_i = x_i \left(\sum_{j=0}^{\infty} x_j \right)^{-1}$$

- Solution:

```
\begin{align*}
  \begin{vmatrix} a & b \\ c & d \end{vmatrix} & = ad - bc \\
  \hat{x_i} & = x_i \left(\sum_{j=0}^\infty x_j \right)^{-1}
\end{align*}
```

If You Want to Know More . . .

- *en.wikibooks.org/wiki/LaTeX/* : Excellent reference for LaTeX in general
- *www.ctan.org* : CTAN stands for the Comprehensive TeX Archive Network, and contains many standard LaTeX packages