Typesetting Papers with LaTeX

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Goal of Today's Tutorial

To enable you to use LaTeX to produce term papers, reports, conference papers, and journal articles in professional quality using existing layouts.

Not Covered

- Designing and defining layouts
- "Drawing" pictures in LaTeX
- Concurrent web/paper publishing
- Most lot of the gory details

Covered

- What is LaTeX and Why Use It?
- Basic LaTeX Syntax
- Tables
- Typesetting Mathematical Formulas
- "Floats" (Figures and Tables)
- Defining Commands and Environments
- Cross-References
- Footnotes
- Citations and Lists of References
- Organizing Large Documents
- Importing Graphics

What is LaTeX?

- *Not* a word processor
  ⇒ can't be compared directly with Word
- Technically, a macro package for D. Knuth's *typesetting system* TeX
- Conceptually, a *document processing system*
  - separates content from presentation
  - good layout is difficult ⇒ leave it to experts
- Best seen as a programming language: A source is compiled into a paper or printable online document.

LaTeX Myths: It's Unix/Linux only

"If LaTeX doesn't run on your machine, your machine is either incredibly old, incredibly new, or unbelievably obscure."

(From one of the many LaTeX FAQs)

LaTeX Myths: It's not WYSIWYG

- The LaTeX 'philosophy' separates content and presentation on purpose. Don't fiddle with layout while you write.
- LaTeX produces postscript and PDF. How much more WYSIWYG do you want?
- How much *synchronous* WYSIWYG you get depends on your choice of editor. There is at least one WYSIWYG frontend for LaTeX called Lyx (`http://www.lyx.org`).

LaTeXMyths: It's Difficult

Hopefully, this tutorial will convince you that it is not.

Why Use LaTeX? — Technical Reasons

- Portable across platforms, i.e., truly device-independent
- Transparent (once you've figured out the gory details)
- Mature, stable, well-maintained
- Able to handle very large documents (e.g., *your thesis*) reliably and gracefully
- Slow versioning cycle (fewer version incompatibilities)
- Huge support community

Why Use LaTeX? — Workflow Reasons

- Explicitly designed for scientific publishing (formulas, citations, references)
- Easy integration of material from other sources (figures, data, code)
- Facilitates modular document design
- De-facto an industry standard in our field; many conferences/publishers use/prefer/require LaTeX
- Facilitates uniform typographic conventions
  - within one document
  - across multiple documents (conference proceedings, journals, multi-authored books)

Why Use LaTeX? — Other Reasons

- Money: FREE!
- Politics/Religion: Open source
- Looks better:

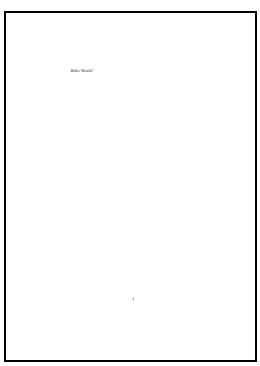
definitions vs. definitions

First Steps in LaTeX: 'Hello World'

```
\documentclass{article}
\begin{document}
Hello World!
\end{document}
```

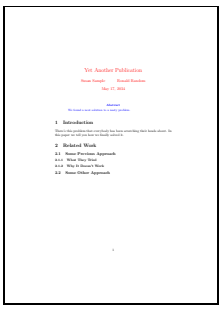
hello-world.tex

```
% latex hello-world
...
% dvips hello-world
...
% gv hello-world &
```



First Steps in LaTeX: Title and Sections

```
\documentclass{article}
\title{Yet Another Publication}
\author{Susan Sample \and Ronald Random}
\date{May 17, 2034} %default:\today
\begin{document}
\maketitle
\begin{abstract}
We found ...
\end{abstract}
\section{Introduction}
There's ...
\section{Related Work}
\subsection{Some Previous Approach}
\subsubsection{What They Tried}
...
```



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There's ...
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\subsection{Some Previous Approach}
\subsubsection{What They Tried}
...
```

Yet Another Publicatio

Susan Sample Ronald Rand

May 17, 2034

Abstract

We found a neat solution to a nasty problem.

1 Introduction

There's this problem that everybody has been scratching this paper we tell you how we finally solved it.

2 Related Work

2.1 Some Previous Approach

2.1.1 What They Tried

2.1.2 Why It Doesn't Work

2.2 Some Other Approach

LaTeX Syntax

- Multiple spaces are treated as one
  ⇒ `Hello␣␣␣World` same as `Hello␣World`
- Single EOL char's count as spaces
- `\\` and `\newline` force line break
- `\\*` forces line break but prohibits page break
- One or more empty lines mean 'new paragraph'

LaTeX Syntax

- **Quotes:** `` `single' `` → 'single'
  `` ``double'' `` → "double"
- **Dashes:**

`foo-bar`	→ hyphen	foo-bar
`126\,--134`	→ "en-dash"	126–134
`foo --- bar`	→ "em-dash"	foo — bar

Special Characters

- `%` comment character: everything to the end of line and all leading spaces on the next line are ignored
- `\` commands and declarations start with \
- `{ }` scope delimiters:
  - scope of declarations
  - obligatory arg's of commands
- `~` non-breakable space: LaTeX won't break the line here
- `$` used to enter/exit text style math mode
- `_`, `^` produce $_{\text{subscript}}$ / $^{\text{superscript}}$ in math mode
- `&` 'tab' character in tabular and array environments
- `#` used to distinguish arguments in the definition of commands (macros) and environments

Declarations, Commands, Environments

Declarations

\⟨*name = string of letters*⟩

Commands

\⟨*special char or name*⟩

\⟨*special char or name*⟩ {*mandatory arg1*}{*mand. arg2*}...

\⟨*name*⟩ [*optional arg1*]{*mand. arg2*}...

Environments

```
\begin{name}[opt. arg]{mand. arg}{mand. arg}...
...
\end{name}
```

Declarations

- change the way things look until the end of scope, e.g.

```
{one {two \bfseries three
{\itshape four} \Huge five} six}
```

⇒ one two **three** *four* **five** six

- `\large`, `\Large`, `\huge`, `\Huge`, `\small`, `\footnotesize`, `\tiny`, `\bfseries`, `\itshape`, `\sffamily`, `\rmfamily`, `\centering`, `\raggedright`, `\sloppy`, ...

Commands

- may have optional (`[...]`) and mandatory (`{...}`) arguments
- numerous functions
  - insert stuff (`\LaTeX` → LaTeX)
  - declare new commands, environments, counters, lengths etc. (explained later)
  - set stuff in a certain way, e.g.

```
A\parbox{3mm}{B\\B}C
A\parbox[t]{3mm}{B\\B}C
```

A B B C

A B C B

Environments

```
\begin{quote}
...
\end{quote}
```

LaTeX runs practically everywhere. As one FAQ puts it,

> *"If LaTeX doesn't run on your machine, your machine is either incredibly old, incredibly new, or unbelievably obscure."*
>
> (From one of the many LaTeX FAQs)

Environments

```
\begin{equation}
...
\end{equation}
```

Entropy is defined as

$$H(x) = -\sum_{i=1}^{n} p(x_i) \log_2 p(x_i). \quad (1)$$

The `tabular` and `array` Environments

- `tabular` is for text; `array` for math

```
\begin{tabular}[b]{p{1.5cm}|r@{.}lc}...
```

- **optional argument:** `b`, `t`, or `c`
  - `t` – align top row of table with line
  - `b` – bottom row of table with line
  - `c` – center (default)
- **mandatory argument:** column formatter
  - `l` / `r` / `c` – left/right-aligned/centered column
  - `p{`*width*`}` – fixed-width column of width *width*
  - `|` – vertical line *between* columns
  - `@{...}` – other stuff between col's (on every row!)
  - `*{3}{c|}` – = `c|c|c|`

The `tabular` and `array` Environments

in the table/array body:

- `&` – separates colums; ends formatting scope!
- `\multicolumn{`*num*`}{`*col*`}{`*stuff*`}` – cell spanning *num* columns, containing *stuff*, formatted according to *col*
- `\\` – marks end of row

**add'l specifiers *after* \ **

- `[`*length*`]` – extra vertical space *length*
- `\hline` – creates a horizontal line, two a double line
- `\vline` – creates a vertical line within a cell
- `\cline{`col_1–col_2`}` – creates horizontal line between cols col_1 and col_2

The `tabular` and `array` Environments

```
\begin{tabular}[b]{p{1.5cm}|r@{.}lc}
foo & 2321 & 23 \\ \cline{1-1}
bar & 3 & 23423 \\ [3ex] \hline
foobar & 2324 & 46423
\end{tabular}
```

foo	2321.23
bar	3.23423
foobar	2324.46423

The `tabular` and `array` Environments

- **line breaks within cells:**
  - Possible only in `p{}` columns
  - Forced linebreak can be tricky if respective column is the last. `\\` is ambiguous; use `\newline` instead.
  - `parbox` / `minipage` allowed only in `p{}` columns
  - nested `tabular` environments allowed everywhere; can be used as a hack to force linebreaks

```
... & \begin{tabular}{@{}l@{}}
      foo\\bar
      \end{tabular} & ...
```


The `tabular` and `array` Environments

line spacing between rows:

- controlled by `arraystretch` command, adjust with `\renewcommand{\arraystretch}{`*number*`}`
- valid within scope, e.g.

```
{\renewcommand{\arraystretch}{2}
\begin{tabular}{ll}
...
\end{tabular}}
```


The `tabular` and `array` Environments

more parameters:

`\tabcolsep`	–	half the space between two tabular columns; margin at the edges of the ta
`\arraycolsep`	–	same thing for arrays
`\arrayrulewidth`	–	thickness of lines created by `\hline` e
`\doublerulesep`	–	space between two adjacent lines

- can be adjusted with `\setlength{`*parameter*`}{`*value*`}`, e.g. `\setlength{\tabcolsep}{2pt}`
- such changes are valid within the current scope; use `{...}` to delimit scope of changes

The `tabular*` Environment

`\begin{tabular*}{`*width*`}[`*pos*`]{`*cols*`}`
produces a table of fixed total width *width*

```
\begin{tabular*}{\linewidth}%
{c@{\extracolsep{\fill}}lr@{\extracolsep{0pt}::}l}
\hline\hline
bla & bla & bla & bla\\
blabla & blabla & blabla & blabla\\\hline
\end{tabular*}
```

bla	bla	bla::bla
blabla	blabla	blabla::blabla

Typesetting Math: Inline/Text Style

- $...$
- `\(...\)`
- `\begin`{math}...`\end`{math}

```
Entropy is defined as
$H(x) = -\sum_{i=1}^n p(x_i) \log_2 p(x_i)$.
```

Entropy is defined as $H(x) = -\sum_{i=1}^{n} p(x_i) \log_2 p(x_i)$.

Typesetting Math: Display Style

- `\begin{displaymath}...\end{displaymath}`
- `\[...\]`

```
Entropy is defined as
\[H(x)=-\sum_{i=1}^n p(x_i) \log_2 p(x_i).\]
```

Entropy is defined as

$$H(x) = -\sum_{i=1}^{n} p(x_i) \log_2 p(x_i).$$

Math Mode: `\textstyle`

```
Entropy is defined as
\[\textstyle
H(x)=-\sum_{i=1}^n p(x_i) \log_2 p(x_i).
\]
```

Entropy is defined as

$$H(x) = -\textstyle\sum_{i=1}^{n} p(x_i) \log_2 p(x_i).$$

The reciprocal command for use between $ ... $ is `\displaystyle`.

Math Mode: `equation` environment

```
Entropy is defined as
\begin{equation}
H(x)=-\sum_{i=1}^n p(x_i) \log_2 p(x_i).
\label{eq-entropy}
\end{equation}
```

Entropy is defined as

$$H(x) = -\sum_{i=1}^{n} p(x_i) \log_2 p(x_i). \quad (2)$$

We can refer to Equation 2 in the text as
`Equation~\ref{eq-entropy}`.

Math Mode: Caveats

- no spaces between 'words'; all letters set in italics
- don't use `$...$` as poor man's italics

`$function$` → $function$

`\textit{function}` → $\textit{function}$

- you can insert plain text in math mode via `\textrm`, `\textsf`, or `\mbox`.

```
$p(n) = \frac{1}{m} for n \leq m$
```

$$p(n) = \frac{1}{m} for n \leq m$$

```
$p(n) = \frac{1}{m} \mbox{ for } n \leq m$
```

$$p(n) = \frac{1}{m} \text{ for } n \leq m$$

Bold Math

- In order to entire formulas in **bold**, declare `\boldmath` *outside* the respective math environment

```
{\boldmath$\sqrt[4]{x^\alpha}$}
```

$\boldsymbol{\sqrt[4]{x^\alpha}}$

```
$\sqrt[4]{x^\alpha}$
```

$\sqrt[4]{x^\alpha}$

- individual words can be set in bold, italics (default anyway), plain text with `\mathbf`, `\mathit`, `\mathrm` / `\mathsf`

Math Mode — Braces, Brackets, etc.

```
\[
f(x) = \left\{%
\begin{array}{ll}
1 & \mbox{for } x\geq 3 \\
0 & \mbox{otherwise}
\end{array}\right.
\]
```

`\right.` matches any single open `\left(`, `\left[`, etc.

$$f(x) = \begin{cases} 1 & \text{for } x \geq 3 \\ 0 & \text{otherwise} \end{cases}$$

Math Mode — eqnarray(*)

```
\begin{eqnarray}
3x^2 + 7 x & = & 0 \nonumber\\
3x + 7 &=& 0 \\
x &=& \frac{7}{3} \label{james}
\end{eqnarray}
```

$$3x^2 + 7x = 0$$
$$3x + 7 = 0 \quad (3)$$
$$x = \frac{7}{3} \quad (4)$$

Math Mode — eqnarray(*)

```
\begin{eqnarray}
3x^2 + 7 x & = & 0 \nonumber\\
3x + 7 &=& 0 \\
x &=& \frac{7}{3} \label{james}
\end{eqnarray}
```

- `\nonumber` suppresses equation number
- We can refer to the last row via `\ref{james}`
- `\eqnarray*` environment never prints equation numbers; `\label{...}` makes no sense in that case.

Figures and Tables

```
\begin{figure}[t]
put your figure stuff here
\caption[text for list of figures]{caption text here\label{...}}
\end{figure}
```

```
\begin{table}[t]
\caption[text for list of tables]{caption text here \label{...}}
put your table stuff here
\end{table}
```


Figures and Tables

- optional location parameter specifies where to put the figure/table:
  `\begin{figure}[loc]`
  - `h` – right here (does not work for `figure*` / `table*` environments in two-column mode!)
  - `!` – really right here; try harder!
  - `t` – top of page
  - `b` – bottom of page
  - `p` – separate page with figures and tables only
- default is `[tbp]`
- create lists of tables/figures with `\listoffigures` / `\listoftables` where you want them

Figures and Tables

- The `figure*` and `table*` environments create full-width figures/tables in articles with two-column format.
- `\renewcommand{\topfraction}{val}`, $0 \leq val \leq 1$ in the *document preamble* sets the fraction of the page that can be used for figures and tables; `\bottomfraction`, `\textfraction` work the same way

Defining Commands

`\newcommand{name}[args][default]{definition}`

- defines new command

`\renewcommand{name}[args][default]{definition}`

- re-defines existing command

`\providecommand{name}[args][default]{definition}`

- defines existing command unless it exists

Defining Commands

```
\newcommand{\seq}[3][x]{%
\ensuremath{#1_{#2},\dots,#1_{#3}}}
```

```
...  the sequence \seq[k]{1}{n} is...
```

...the sequence $k_1, \dots, k_n$ is ...

Defining Environments

\newenvironment{*name*}[*args*][*default*]{*begdef*}{*enddef*}

- defines new environment

\renewenvironment{*name*}[*args*][*default*]{*begdef*}{*enddef*}

- redefines existing environment

```
\newenvironment{itquote}%
{\begin{quote}\itshape}%
{\end{quote}
```


Theorem-like Environments

```
\newtheorem{lemma}{Lemma}[chapter]
⋮
\begin{lemma}
$\mathcal{K}$ is transitive.
\label{K-transitive}
\end{lemma}
```

Lemma 3.1 *$\mathcal{K}$ is transitive.*

Theorem-like Environments

\newtheorem{*name*}{*text*}[*within*]

\newtheorem{*name*}[*like*]{*text*}

name	–	name of the environment
text	–	text displayed before the counter
within	–	counts within a certain section such as chapter (theses), section, etc.
like	–	use the same counter as some other theorem-like environment

Theorem-like Environments

```
\begin{lemma}[\citealp{key}]
$\mathcal{K}$ is transitive.
\label{K-transitive}
\end{lemma}
```

Lemma 3.2 (Author, Year) *$\mathcal{K}$ is transitive.*

Cross-References

- refer to figures, tables etc. with \ref{*label*}
- works for all labeled and numbered thingies: figures, tables, footnotes, equations, sections (put label in the argument of the \section{...} command), etc.
- you can put a \label{...} everywhere and refer to the page with \pageref{...}

Footnotes

- insert `\footnote{...}` command where you want the footnote in the text

```
... when used sparingly.%
%
\footnote{Like this one.}
%
In \LaTeX, ...
```

While excessive use of footnotes should be avoided, they can be useful when used sparingly.[1] In LaTeX, you can just insert them into the source text wherever you want them to appear.

[1] Like this one.

Citations and Bibliographies: BibTeX

- `.bst` file specifies the *bibliography style*
  - how citations appear in the text ([1] , Author (2004) , [AUT04] , etc.)
  - what the entries in the list of references look like
- `.bst` file usually provided by someone else (e.g., publisher)
- `.bib` files contain the bibliographic data

.bib files

```
@String{PoPM = {Publish or Perish Magazine}}

@Book{sample00,
  author =  {Susan Sample},
  title =   {A General Solution to All Problems},
  publisher =   {Random University Press},
  year =   2000,
  address =  {Springfield, Idaho}
}
@Article{user97,
  author =   {Joe User},
  title =   {Yet Another Publication},
  journal =   PoPM,
  year =   1997,
  volume =  23,
  number =  4,
  pages =  {23--35}
}
```


.bib Files: Caveats

- Titles of journal articles, conference papers, etc. are often automatically lowercased, regardless of what's in the `.bib` file. Enclosing stuff in `{...}` protects against that:

```
title = {Reinventing {C}anada}
```

- Accented characters should also be enclosed in `{...}`

```
title = {G{\"{o}}del's Theorem}
```


Citations

- standard latex provides the command `\cite{`*key*`}`
- default citation style is bla bla bla [1] bla bla
- list of references is created like this:

```
\bibliography{DataFile1,DataFile2}
\bibliographystyle{StyleFile}
```

- *DataFile** are the names of the `.bib` files (without the extension)
- *StyleFile* is the name of the `.bst` file
- I highly recommend using the `natbib` package for citations

This Just In: Loading Packages

- packages provide additional functionality and can change the layout
- many conferences provide packages rather than classes
- packages are loaded with `\usepackage` in the preamble

```
\documentclass[options]{article}
\usepackage[options]{natbib}
\bibliographystyle{plainnat}
\begin{document}
...
\bibliography{biblio.bib}
```

- package options are separated by commas

The Natbib Package

- accomodates all major citations styles
  ([1] , Author (Year) , [CITEKEY])
- provides several citation commands, most importantly

`\citet{`*key*`}`	Author (Year)
`\citep[see also][:24]{`*key*`}`	(see also Author, Year:24)
`\citealt{`*key*`}`	Author Year
`\citealp{`*key*`}`	Author, Year

`\begin{lemma}[\citealp{key}]`

Lemma 3.3 (Author, Year) *$\mathcal{K}$ is transitive.*

The Natbib Package

- is well documented and offers many customization options; `\usepackage[`*options*`]{natbib}`

default	→	[Autor1, 1997, Author2, 2000]
`[round,colon]`	→	(Autor1, 1997; Author2, 2000)
`[numbers]`	→	[23,21]

Including Other LaTeX Files

`\input{`*file*`}` – Include *file.tex* at this point

`\include{`*file1*, *file2*, ...`}`

- Include contents of *file1.tex*, *file2.tex*, ... with page-breaks at the beginning and end, and between files
- `\include` commands cannot be nested

`\includeonly{`*file1*, *file2*, ...`}` in preamble!

- Only those specified with `\includeonly` are processed and produce output.
- Allows you to print a single chapter with correct cross-references (provided the excluded files have not changed since last processed)

Sample Thesis Master File

```
\documentclass{ut-thesis}
\usepackage[round,colon]{natbib}
...
\input{preamble} % all the preamble definitions like title, author, etc.
\includeonly{Intro,Conclusions} % print only Intro and Conclusions
\begin{document}
\include{Title-Stuff} % title page, dedication, table of content,
                      % lists of figures and tables, preface, etc.
\include{Intro}
\include{Theory}
\include{RelWork}
\include{Implementation}
\include{Evaluation}
\include{Conclusions}
\include{Appendices}
\include{Bibliography}
\end{document}
```


Sample Article Master File

```
\documentclass{article}
\usepackage[numbers]{natbib}
...
\title{...}
\author{...}
\begin{document}
\maketitle
\input{abstract}
\input{intro}
...
\input{conclusions}
\bibliographystyle{plainnat}
\bibliography{biblio}
\end{document}
```


Including `.eps` Graphics

```
\usepackage{graphicx}
⋮
\begin{document}
⋮
\includegraphics[opt1,opt2,...]{file}
```

Includes encapsulated postscript file *file.eps*.

\includegraphics Options

`scale=`*scale*	scale by factor *scale*
`width=`*w*	scale picture to have width *w*
`height=`*h*	scale picture to have height *h*
`angle=`*angle*	rotation angle
`origin=`*org*	origin for rotation, default is center (c)
`keepaspectratio`	If both `width` and `height` are specified, keep aspect ratio and scale to *at most* *w* and *at most* *h*

\includegraphics Options

`viewport=` *llx lly urx ury*	override bounding box (BB)
`trim =` *l b r t*	reduce BB by *l,b,r,t* on the left, bottom, right, top; *l,b,r,t* are length measures
`clip`	clip picture at bounding box/viewport; `\includegraphics*` has the same effect

List-making Environments

```
\begin{itemize}
\item ...
  \begin{itemize}
  \item ...
  \end{itemize}
\item ...
\end{itemize}
```

- Gnus
  - Green Gnus
- Gnats

List-making Environments

```
\begin{enumerate}
\item ...
  \begin{enumerate}
  \item ...
  \end{enumerate}
\item ...
\end{enumerate}
```

1. Gnus
   (a) Green Gnus
2. Gnats

List-making Environments

```
\begin{description}
\item[Gnus] ...
  \begin{description}
  \item[Green Gnus] ...
  \end{description}
\item[Gnats] ...
\end{description}
```

Gnus bla bla bla bla bla bla bla ...

Green Gnus bla bla bla ...

Gnats bla bla bla ...

Fine-tuning The Layout: Spaces

`\noindent`	insert at beginning of paragraph; blocks paragraph indentation
`\vspace{...}`	insert vertical space; no effect at top/bottom of page, use `\vspace*{...}` to force extra space at beginning/bottom of page
`\hspace{...}`	same thing for horizontal space
`~`	non-breakable space
`\␣`	force space (e.g., after commands)
`\,` , `\!` , `\:` , `\;`	thin / negative thin / medium / thick space

Fine-tuning The Layout: Breaks

`\newline`, `\\`, `\\*`	line break
`\newpage`	column break (in two-column mode); page break otherwise
`\clearpage`	page break plus print all floats declared so far
`\cleardoublepage`	like `\clearpage`; start new page on a new sheet of paper

Fine-tuning The Layout: Alignment

`\begin{`*alignment style*`}` . . . `\end{`*alignment stype*`}`

`center`	centering
`flushleft`	flush to the left (like a type writer)
`flushright`	flush to the right

Fine-tuning The Layout: Hyphenation

`conju\-gation`

- tells LaTeXthat where this current word can be hyphenated if needed

`\hyphenation{hy-phe-na-tion con-ju-ga-tion}`

- declares hypenation of words in general

Summary

- LaTeX syntax
- Tabular and Array Environments
- Typesetting Math
- Floats
- Defining Commands and Environments
- Theorems
- Cross-References
- Citations and Bibliographies
- Working with Multiple Files
- Integrating Postscript Figures
- List Environments
- Tweaking the Layout

Document Compilation Revisited

- run `latex` once → writes `.aux` file with citation keys and label locations
- run `bibtex` to produce `.bbl` file
- run `latex` twice more to insert citations and get cross-references right
- use `dvips` to produce postscript; `dvipdf` to produce PDF
- `pslatex` and `pdflatex` produce these files directly; doesn't always work

```
% latex thesis
% bibtex thesis
% latex thesis
% latex thesis
```


LaTeX Resources

- Leslie Lamport's LaTeXBook
- TeX User Group (`http://www.tug.org`)
  - TexLive CD
  - TeX Catalogue
- Class file for DCS theses available at `http://www.cs.toronto.edu/~fpitt/Latex`