

Typesetting Papers with L^AT_EX

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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 L^AT_EX?

- *Not* a word processor
⇒ can't be compared directly with Word
- Technically, a macro package for D. Knuth's *typesetting system* T_EX
- 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.

L^AT_EX Myths: **It's Unix/Linux only**

“If L^AT_EX doesn't run on your machine, your machine is either incredibly old, incredibly new, or unbelievably obscure.”

(From one of the many L^AT_EX FAQs)

L^AT_EX Myths: It's not WYSIWYG

- The L^AT_EX 'philosophy' separates content and presentation on purpose. Don't fiddle with layout while you write.
- L^AT_EX 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 L^AT_EX called **Lyx** (<http://www.lyx.org>).

L^AT_EXMyths: **It's Difficult**

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

Why Use L^AT_EX? — 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 L^AT_EX? — 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 L^AT_EX
- Facilitates uniform typographic conventions
 - within one document
 - across multiple documents (conference proceedings, journals, multi-authored books)

Why Use L^AT_EX? — Other Reasons

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

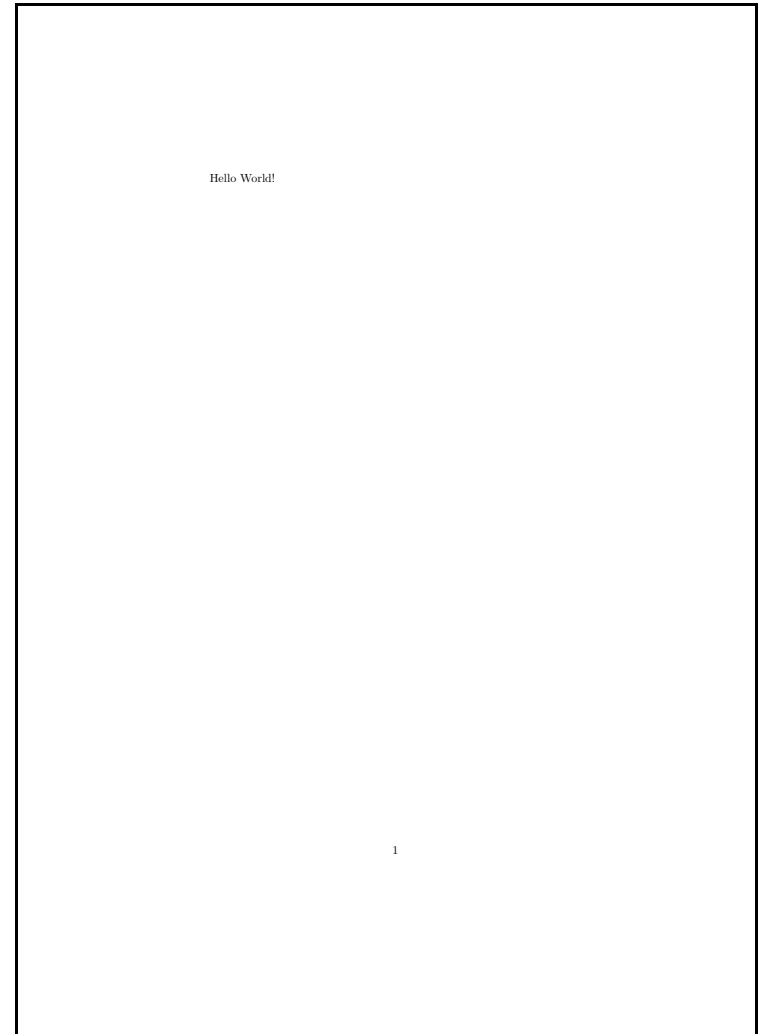
definitions_{vs.} definitions

First Steps in L^AT_EX: ‘Hello World’

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

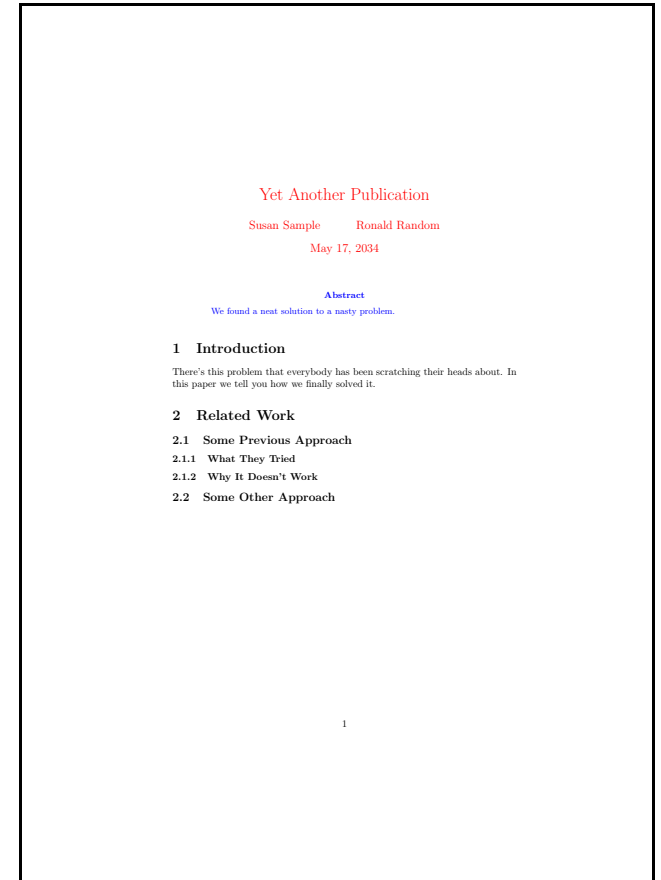
hello-world.tex

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



First Steps in L^AT_EX: 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}
...
```



First Steps in L^AT_EX: Title and Sections

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

Yet Another Publication

Susan Sample Ronald Random

May 17, 2034

Abstract

We found a neat solution to a nasty problem.

1 Introduction

There's this problem that everybody has been scratching their head over. In 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

L^AT_EX 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'

L^AT_EX 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: L^AT_EX won't break the line here

\$ used to enter/exit text style math mode

_ , ^ produce subscript / 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

```
\langle name = string of letters \rangle
```

Commands

```
\langle special char or name \rangle
```

```
\langle special char or name \rangle {mandatory arg1}{mand. arg2}...
```

```
\langle name \rangle [optional arg1]{mand. arg2}...
```

Environments

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

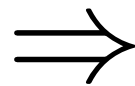
```
...
```

```
\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
ABC B

Environments

\LaTeX runs practically everywhere. As one FAQ puts it,

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

“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 columns; 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{col1-col2}` – creates horizontal line between cols
col₁ and *col₂*

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}{\langle number \rangle}
```

- 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 table
- `\arraycolsep` – same thing for arrays
- `\arrayrulewidth` – thickness of lines created by `\hline` etc.
- `\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

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

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}` → *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 $n \leq m$

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

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

Bold Math

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

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

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

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

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

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

$$3x^2 + 7x = 0$$

$$3x + 7 = 0 \tag{3}$$

$$x = \frac{7}{3} \tag{4}$$

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 $\text{\seq}[k]{1}{n}$ 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.

¹Like this one.

Citations and Bibliographies: **BIB_TE_X**

- `.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 L^AT_EX 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 style}
```

center centering

flushleft flush to the left (like a type writer)

flushright flush to the right

Fine-tuning The Layout: Hyphenation

```
conju\ -gation
```

- tells \LaTeX that where this current word can be hyphenated if needed

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

- declares hyphenation of words in general

Summary

- L^AT_EX 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
```

L^AT_EX Resources

- Leslie Lamport's L^AT_EXBook
- T_EX User Group (<http://www.tug.org>)
 - TexLive CD
 - T_EX Catalogue
- Class file for DCS theses available at
<http://www.cs.toronto.edu/~fpitt/Latex>