

# L<sup>A</sup>T<sub>E</sub>X – A documentation package for book, article and journal publication

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## Abstract

This is place reserved for Abstract. This samle document describes some general features of L<sup>A</sup>T<sub>E</sub>X, at the same time showing how LHEP template output format when standrad L<sup>A</sup>T<sub>E</sub>Xcommand is used. LHEP cls tried to output section, subsection, figure and table caption to appear in attractive manner using fonts that fits to our requirements.

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## 1. INTRODUCTION TO L<sup>A</sup>T<sub>E</sub>X

- What is L<sup>A</sup>T<sub>E</sub>X?
- Basic usage and syntax
- Modes and environments
- Newcommands
- Cross-referencing
- Packages
- Importing graphics
- Tables and figures
- Pictures
- Where to learn more

## 2. WHAT IS L<sup>A</sup>T<sub>E</sub>X?

*What L<sup>A</sup>T<sub>E</sub>X is NOT:*

- A *word-processor* that allows the user to view a document as it is created in a “*what you see is what you get*” format (e.g., MS-Word)
- A *word-processor* associated with a certain *operating system* (e.g., Windows)
- A *word-processor* in which creation of *highly technical mathematical content* is a big pain in the neck
- A product that the user must *purchase*

*What L<sup>A</sup>T<sub>E</sub>X IS:*

- A *freely-available, powerful typesetting language*
- *Supremely well-suited* to creation of documents with *heavy technical and mathematical content*
- The standard typesetting language used by *major publishers of books* in the sciences (e.g., Springer, CRC Press, Wiley, etc.)
- The standard typesetting language used by most *journals* in the sciences (including *Journal of the American Statistical Association, Biometrics*, etc.)
- The popular way to produce a *dissertation* document in the preferred NCSU format (later...)

*What L<sup>A</sup>T<sub>E</sub>X IS:*

- Versions available for UNIX, Linux, Windows, etc.
- The *overwhelming choice* of most people in math, statistics, physics, computer science, engineering, and many other disciplines to produce articles, reports, books, letters, visual presentation materials, and more

*Basic premise:*

- A L<sup>A</sup>T<sub>E</sub>X document must be *processed* in order for the final version of the document to be viewed
- The user creates a *file* with a *.tex* extension that contains the text of the document and special *commands* that control
  - \* style (e.g., article, letter, report)
  - \* organization into sections, subsections, etc.
  - \* mathematical content (e.g., equations, tables, symbols)
  - \* incorporation of graphics
  - \* automatic cross-referencing of equations, figures, tables, references
  - \* *And MUCH MORE!*
- After the file is processed, the result may be *viewed* (using *freely available* software) and the file modified as necessary

- *Postscript* or *pdf* versions of the final document are easily created

### 3. BASIC USAGE AND SYNTAX

**Some basic steps for creating a document:** On a UNIX or Linux platform

- Create a `.tex` file using any text editor (e.g., `emacs`, `Nedit`); the content should be *plain text*
- Run the file through the  $\LaTeX$  program to create a *device independent* (`.dvi`) file containing the typesetting instructions (can be viewed with a `.dvi` previewer)
- Run a program to convert the `.dvi` file to a postscript file containing the *finished document*, which can be viewed with a postscript viewer or printed
- If desired, convert the postscript file to pdf format
- (Alternatively, a program called `pdflatex` can be used to create pdf documents directly; this is not discussed here)

**For example:** The `.tex` file used to create these slides is called `latex1.tex` (available on the class web page)

**Commands used to process:** To create the `.dvi` file and then a postscript file

```
stat% add tetex
stat% latex latex1
stat% dvips latex1
stat% ghostview latex1.ps &
```

- `add tetex` allows access on unity to a comprehensive distribution of  $\LaTeX$  called `tetex` (optional)
- Here, `ghostview` is used to view the final document
- Using instead `dvips -P pdf latex1` creates a postscript file that is optimal if the a pdf file is to be created, e.g., using `acrobat distiller` or the `ps2pdf` utility

```
stat% distill latex1.ps OR stat% ps2pdf latex1.ps
```

**Structure of a `.tex` file:**

- *Preamble*
  - Specify *document class* (article, report, book, letter, etc.)
  - Add any “*packages*” used (e.g., to import graphics, create headers and footers, etc.)
  - Specify *margins*, *indentation*, *spacing*, etc.
  - Define “*new commands*” (coming up...)
- *Document body*
  - The actual document content

**Fun facts:**

- `%` symbol is used to document the file or “*comment out*” text; anything to the right of a `%` does not appear in the document

- $\LaTeX$  commands start with `\`
- $\LaTeX$  is *case sensitive*

**For example:** Here is a sample preamble and document body for an article (See the web page for a full template file)

```
\documentclass[12pt]{article} % type size: also 10pt or 11pt
% commands to set margins and spacing -- all have defaults
\setlength{\textheight}{9in} % height of text on a page
\setlength{\textwidth}{6.5in} % width of text on a page
\setlength{\parskip}{2.3ex} % space between paragraphs
% commands to invoke packages
\usepackage{graphicx,psfig,epsf} % no limit to how many
% user-defined newcommands
\newcommand{\betahat}{\hat{\beta}} % more on this shortly
% start of document body
\begin{document}
\section{Introduction} % sectioning command
This is the introduction...
\end{document}
```

**Syntax:** Some commands have arguments in braces `{ }`, some do not

*Some commands with no argument:*

```
\ldots, \dag, \ddag, \%, \&, \#, \{ \}, \today, \LaTeX
```

```
..., †, ‡, %, &, #, { }, November 20, 2019, \LaTeX
```

**Commands with arguments:** `\setlength{ ... }`,  
`\section{ ... }`, `\subsection{ ... }`, `\hspace{ ... }`,  
`\vspace{ ... }`

### 4. MODES AND ENVIRONMENTS

**Modes:** At any point in a  $\LaTeX$  file, there is a current “*mode*” in effect

- *Paragraph mode* – the default text mode, with line wrap. A space between lines signals the start of a new paragraph
- *Math mode* – math symbols and commands may be used, and mathematical expressions result
- *LR mode* – “left-to-right” mode, lines do not automatically wrap around

**Note on math mode:** Math symbols and commands only work in math mode; if they are used in other modes, an *error* will result

**Environments:** Often, there is also an *environment* in effect that determines how material is displayed – the basic structure is

```
\begin{environment-name}
...
\end{environment-name}
```

**For example:** The math environment

```
the linear model
\begin{math}Y = X\beta + \epsilon\end{math}.
```

the linear model  $Y = X\beta + \epsilon$ .

- The popular shortcuts are to use  $\$ \dots \$$  or  $\langle \dots \rangle$ , e.g.

the linear model  $Y = X\beta + \epsilon$ .

**For example:** Creating a numbered list

```
\begin{enumerate}
\item This is the first entry
\item This is the second entry
\item This is the third entry
\end{enumerate}
```

- This is the first entry
- This is the second entry
- This is the third entry

```
\leq, \subset, \in, \geq, \equiv, \sim, \approx, \neq, \perp
\leq, C, \in, \geq, \equiv, \sim, \approx, \neq, \perp
```

- Arrows

```
\rightarrow, \Leftarrow, \Leftrightarrow, \uparrow
\rightarrow, \leftarrow, \Leftrightarrow, \uparrow
```

- Miscellaneous

```
\forall, \exists, \Re, \sum, \prod, \int
\forall, \exists, \Re, \Sigma, \Pi, \int
```

Environment	Mode	Description
<code>math</code>	math	in-text mathematical expressions
<code>displaymath</code>	math	displayed mathematical expressions
<code>equation</code>	math	displayed expressions w/ line number
<code>eqnarray</code>	math	lines up equal signs, line numbers
<code>eqnarray*</code>	math	lines up equal signs, no line numbers
<code>array</code>	math	matrices and arrays
<code>itemize</code>	paragraph	list with bullets
<code>enumerate</code>	paragraph	list with numbers
<code>description</code>	paragraph	list with indentation
<code>tabular</code>	LR	align text in columns
<code>table</code>	paragraph	number and position table
<code>figure</code>	paragraph	number and position figure
<code>center</code>	paragraph	center text
<code>mbox</code>	LR	write text while in math mode

**Math:**  $\LaTeX$  is *tailor-made* for writing involving high mathematical content! And it's easy!

- Subscripts, superscripts, roots

```
e^y, x_{ij}, \sqrt{x+y}, \sum_{i=1}^n
e^y, x_{ij}, \sqrt{x+y}, \sum_{i=1}^n
```

- Greek

```
\alpha, \beta, \gamma, \delta, \epsilon, \eta, \theta,
\lambda
```

```
\alpha, \beta, \gamma, \delta, \epsilon, \eta, \theta, \lambda
```

```
\Gamma, \Delta, \Theta, \Lambda, \Omega, \Sigma
```

- Roots

```
\hat{\alpha}, \tilde{\alpha}, \dot{x}, \overline{x},
\bar{x}
```

```
\hat{\alpha}, \tilde{\alpha}, \dot{x}, \bar{x}, \bar{x}
```

**Math, continued:**

- Binary operations

```
\pm, \times, \div, \cup, \otimes
```

```
\pm, \times, \div, \cup, \otimes
```

- Relation symbols

**Math, continued:** `textstyle` vs. `displaystyle`

- Math *displayed* as equations may be carried out using the `displaymath`, `equation`, `eqnarray*`, `eqnarray` environments

- Shortcuts when equations are *not* numbered:  $\$ \$ \dots \$ \$$  or  $\langle \dots \rangle$ ; e.g.,

```
\sum_{i=1}^n x_i^2 (Y_{ij} - z_i \beta)
```

$$\sum_{i=1}^n x_i^2 (Y_{ij} - z_i \beta)$$

- Some symbols appear *differently* depending on whether they are in the text or displayed; e.g.,

```
\sum_{i=1}^n VS. \$ \$ \sum_{i=1}^n \$ \$
```

$$\sum_{i=1}^n \quad \text{VS.} \quad \sum_{i=1}^n$$

- Can be *overridden* with `textstyle{ }` and `displaystyle{ }`

**Math, continued:**

- Products, integrals, unions

```
\prod_{j=1}^n, \hspace{0.1in} \int_{-\infty}^{\infty} f(u) du,
\hspace{0.1in} \bigcup_{A: A \in \Omega}
```

$$\prod_{j=1}^n, \int_t^\infty f(u) du, \bigcup_{A: A \in \Omega}$$

- *Special functions*

$\exp(x), \log y, \sin(k\pi), \min_x f(x)$

$\exp(x), \log y, \sin(k\pi), \min_x f(x)$

- Fractions, partial derivatives

$\frac{\exp(x^T \beta)}{1 + \exp(x^T \beta)}, \frac{\partial u}{\partial x}$

$$\frac{\exp(x^T \beta)}{1 + \exp(x^T \beta)}, \frac{\partial u}{\partial x}$$

**Note:** Use `\displaystyle` for fractions; otherwise they are too small

**Math, continued:** There are different ways to present math in **boldface**; here are two

- $\mathbf{X}$ , output  $X$   
 $\Sigma$ , output  $\Sigma$
- $\mathbf{X}$ ,  $\Sigma$

**Math, continued:** array and eqnarray environments

- $(2 \times 3)$  matrix:

```
\left( \begin{array}{ccc}
x_{11} & x_{12} & x_{13} \\
x_{21} & x_{22} & x_{23}
\end{array} \right)
```

$$\begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \end{pmatrix}$$

- *Determinant* of  $(2 \times 2)$  matrix:

```
\left| \begin{array}{cc}
a_{11} & a_{12} \\
a_{21} & a_{22}
\end{array} \right|
```

$$\begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix}$$

**Math, continued:** array and eqnarray environments

- *Braces*

```
x = \left\{ \begin{array}{l}
\sin x \text{ if } y < 3, \\
\cos x \text{ if } y \geq 3
\end{array} \right.
```

$$x = \begin{cases} \sin x & \text{if } y < 3, \\ \cos x & \text{if } y \geq 3 \end{cases}$$

- *Binomial coefficients:*  $\binom{N}{y}$

$$\binom{N}{y}$$

**Math, continued:** array and eqnarray environments

- *Equation with several lines, = signs lined up*

```
\begin{eqnarray*}
\Delta_i & = & \sum_j \sum_{k \neq j} \text{Corr}(Y_{ij}, Y_{ik}) \\
& = & \sum_j \sum_{k \neq j} \rho_i^{\|j-k\|} \\
& = & \frac{2\rho_i}{1-\rho_i} \left\{ n_i - 1 - \frac{\rho_i(1-\rho_i^{n_i-1})}{1-\rho_i} \right\}
\end{eqnarray*}
```

$$\begin{aligned} \Delta_i &= \sum_j \sum_{k \neq j} \text{Corr}(Y_{ij}, Y_{ik}) \\ &= \sum_j \sum_{k \neq j} \rho_i^{\|j-k\|} \\ &= \frac{2\rho_i}{1-\rho_i} \left\{ n_i - 1 - \frac{\rho_i(1-\rho_i^{n_i-1})}{1-\rho_i} \right\} \end{aligned}$$

**The tabular environment:**

- As with array, separate elements with `&`, make new line with `\`
- Specify *number of columns* and type of *justification* at top, add *vertical* and *horizontal* lines

```
\begin{tabular}{c|rr}
& \multicolumn{2}{c}{Results} \\
Parameter & \multicolumn{1}{c}{Bias} & \multicolumn{1}{c}{SE} \\
\hline
\beta_0 & -0.030 & 0.12 \\
\beta_1 & 0.002 & 0.07
\end{tabular}
```

Parameter	Results	
	Bias	SE
$\beta_0$	-0.030	0.12
$\beta_1$	0.002	0.07

## 5. NEWCOMMANDS

**Motivation:** In technical typing, the same (nasty) expression may appear *frequently*

- A newcommand is like a “*shortcut*” to produce the expression easily
- `\newcommand{keyword}{text}`
- A newcommand declaration may appear *anywhere* in a  $\LaTeX$  source file (preamble or body) and is defined thereafter
- A newcommand keyword may *not* contain numbers

**Examples:** Some newcommand definitions and their usage

```
\newcommand{\bbeta}{\boldmath $\beta$}
\newcommand{\betahatj}{\widehat{\bbeta}_j}
\newcommand{\var}{\mbox{var}}
\newcommand{\sumjn}{\sum^n_{j=1}}
```

- Note that a *previously-defined* newcommand may be used in defining a *new* newcommand

$\sum^n \text{var}(\hat{\beta}_j)$

$$\sum_{j=1}^n \text{var}(\hat{\beta}_j)$$

## 6. CROSS REFERENCES

**Advantage:** A *built-in* feature of L<sup>A</sup>T<sub>E</sub>X is that it *automatically* keeps track of sections, numbered equations, pages, and so on

- Sections, equations, tables, figures, pages etc. may be *labeled* and referred to by the label
- If new labeled entities are added, L<sup>A</sup>T<sub>E</sub>X *renumbers* them automatically
- It is even possible to generate a *table of contents* and *index* for a document
- To set up cross references correctly, must process a document *twice*

```
\LaTeX Warning: Label(s) may have changed.
Rerun to get cross-references right.
```

**Examples:**

- Numbered equation

```
\begin{equation}
\var(\alpha) = \sum_j \var(\hat{\beta}_j)
\label{eq:alpha}
\end{equation}
```

In equation~\ref{eq:alpha}, we see that...

**Examples, continued:**

- Section label

```
\section{Introduction}
\label{s:intro}
```

...As discussed in Section~\ref{s:intro}, kurtosis...

- Page label

```
Thus, we see that calculation of the variance is
straightforward \label{p:var}
```

...On page~\pageref{p:var}, the variance calculation...

## 7. PACKAGES

**Useful utilities:** L<sup>A</sup>T<sub>E</sub>X is much more *powerful* than the intrinsic features would suggest

- A *huge* user community
- Contributed *document classes*, “*add-ons*” to allow different capabilities and customization
- “*Packages*”
- Define new commands, syntax, etc.
- Visit CTAN (see slide 7)

**Example:** fancyheadings.sty – make “*fancy*” document headers and footers

- In preamble

```
\usepackage{fancyheadings}
\lhead{\footnotesize \bf CHAPTER \thesection}
\rhead{\footnotesize \bf ST 762, M. DAVIDIAN}
\cfoot{\footnotesize PAGE \rm\thepage}
```

- See [http://www.stat.ncsu.edu/~st762\\_info/](http://www.stat.ncsu.edu/~st762_info/) for results

**Example:** shadow.sty – make “*shadowboxes*”

- In preamble

```
\usepackage{shadow}
```

```
\shabox{This stuff}
```

This stuff

**In addition:** There are also user-defined, alternative *document classes*

- *Journals, book publishers* may have their own class to create articles, pages with a specific format

*Dissertations:*

At NCSU, dissertations may be created in L<sup>A</sup>T<sub>E</sub>X using special a special style; to learn more, visit

<http://www2.acs.ncsu.edu/grad/ETD/tutorial/latex.htm>

[http://www.stat.ncsu.edu/computing/howto/latex/session\\_2/session2.html](http://www.stat.ncsu.edu/computing/howto/latex/session_2/session2.html)

## 8. IMPORTING GRAPHICS

*Numerous options:*

We discuss three of these

- psfig – \usepackage{psfig}

```
\psfig{figure=dental.ps,height=2.5in}
```

- epsf – \usepackage{epsf}

```
\epsfysize=2.5in
\epsfbox{dental.ps}
```

- graphicx – \usepackage{graphicx}

- Can also import other formats (pdf, jpg, etc)

```
\includegraphics[height=2.5in]{dental.ps}
```

## 9. TABLES AND FIGURES

Two standard  $\LaTeX$  environments:

table and figure

- Automatically *numbers* tables and figures
- Allow tables and figures to be formatted and *referenced* within a document
- Allow *captions*

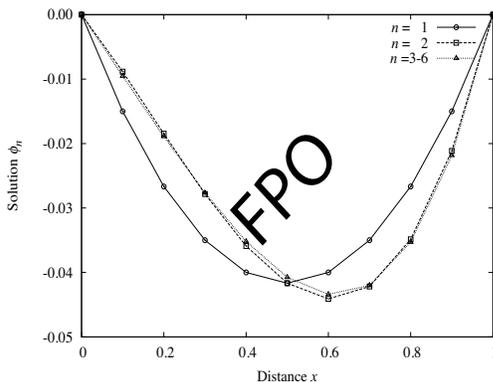
```
\begin{table}[h!]
\tbl{Results of the simulation.\label{t:simresults}}{
\begin{tabular}{crr}
\toprule
& \multicolumn{2}{c}{Results} \\
Parameter & \multicolumn{1}{c}{Bias} & \multicolumn{1}{c}{SE} \\
\colrule
$\beta_0$ & 0.030 & 0.12 \\
$\beta_1$ & 0.002 & 0.07 \\
\botrule
\end{tabular}}
\end{table}
```

Parameter	Results	
	Bias	SE
$\beta_0$	0.030	0.12
$\beta_1$	0.002	0.07

**TABLE 1:** Results of the simulation.

- Reference – In Table~\ref{t:simresults}, we see that...
- In Table 1, we see that...

```
\begin{figure}
\centering
\includegraphics[height=2in]{fpo.eps}
\caption{The dental data of Pothoff and Roy.}
\label{f:dental}
\end{figure}
```



**FIGURE 1:** The dental data of Pothoff and Roy.

Useful package:

```
subfigure – \usepackage{subfigure}
```

- Create a “multipanel” figure from several files with each panel labeled

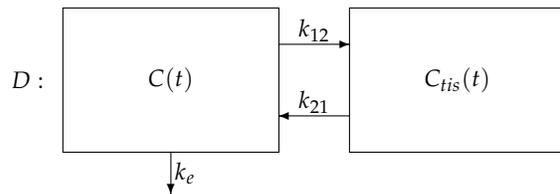
```
\begin{figure}
\centering \subfigure[] {
\includegraphics[width=1.5in]{dental.ps}
\hspace*{0.1in}
\subfigure[] {
\includegraphics[width=1.5in]{dental.ps}
}
\caption{(a) The dental data of Pothoff and Roy. (b) The dental data of Pothoff and Roy, again.}
\label{f:dental2}
\end{figure}
```

## 10. PICTURES

$\LaTeX$  can “draw”:

- picture environment
- The following is a *simple* picture – circles, curves, ovals, etc are also possible (see the documentation)

Two-compartment open model with IV administration:



$$\frac{dC(t)}{dt} = k_{21}C_{tis}(t) - k_{12}C(t) - k_eC(t),$$

$$\frac{C_{tis}(t)}{dt} = k_{12}C(t) - k_{21}C_{tis}(t), C_{tis}(0) = 0$$

Picture was made with:

```
\setlength{\unitlength}{1in}
\begin{picture}(5,1)
\put(0.5,0.5){\framebox(1.5,1){$C(t)$}}
\put(2,1.25){\vector(1,0){0.5}}
\put(2.25,1.35){\makebox(0,0){$k_{12}$}}
\put(2.5,0.75){\vector(-1,0){0.5}}
\put(2.25,0.85){\makebox(0,0){$k_{21}$}}
\put(2.5,0.5){\framebox(1.5,1){$C_{tis}(t)$}}
\put(0.25,1){\makebox(0,0){$D:$}}
\put(1.25,0.5){\vector(0,-1){0.3}}
\put(1.35,0.35){\makebox(0,0){$k_e$}}
\end{picture}
\end{center}
```

Other “drawing” resources:

- The pstricks package – really *intricate stuff* like grids, plots of functions, etc (see class web page for link to documentation)
- xfig

## 11. WHERE TO LEARN MORE

### *Books and guides:*

- Lamport, L. (1994) *LaTeX: A Documentation Preparation System, User's Guide and Reference Manual* (The creator of LaTeX)
- Goossens, M. et al. (1994) *The LaTeX Companion*
- Kopka, H. (1999) *A Guide to LaTeX: Document Preparation for Beginners & Advanced Users*
- Hahn, J. (1993) *LaTeX for Everyone: A Reference Guide and Tutorial for Typesetting Documents Using a Computer*
- Oetiker, T. et al. (2002) *The Not So Short Introduction to LaTeX 2<sub>ε</sub>* (Available on the class web page)

### *Resources online and on the Web:*

- The *Comprehensive TeX Archive Network* (CTAN) <http://www.ctan.org> – a repository of tons of style files, packages, etc.
- Several *free* guides available on unity at [/afs/bp.ncsu.edu/contrib/tetex107/share/texmf/doc/latex/general](http://afs/bp.ncsu.edu/contrib/tetex107/share/texmf/doc/latex/general) (as .dvi or .ps files)
- Local intro tutorial [http://www.stat.ncsu.edu/computing/howto/latex/session\\_1/](http://www.stat.ncsu.edu/computing/howto/latex/session_1/)