LaTeX – A documentation package for book, article and journal publication

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Abstract

The ML revolution is in full swing. In fact, the groundwork for it was prepared in the middle of the 20th century, yet, it is only with the ever continuing development of increasingly powerful computers, combined with computational algorithms refined over the past couple of decades, that the world has seen an explosion of applications of ML, in anything from health, to finance down to even autonomous cars!

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1. INTRODUCTION TO LaTeX

- **What is LaTeX ?**
- **Basic usage and syntax**
- **Modes and environments**
- **Newcommands**
- **Cross-referencing**
- **Packages**
- **Importing graphics**
- **Tables and figures**
- **Pictures**
- **Where to learn more**

2. WHAT IS LaTeX ?

What LaTeX 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 LaTeX 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 LaTeX 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 LaTeX 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
```

…, †, ‡, %, &, #, { }, October 13, 2020, 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 `$ ... $` or `\( ... \)`, 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}
```

1. This is the first entry
2. This is the second entry
3. This is the third entry

Some popular environments:

Environment	Mode	Description
`math`	math	in-text mathematical expressions
`displaymath`	math	displayed mathematical expressions
`equation`	math	displayed expressions w/ line number
`eqnarray`	math	lines up equal signs, line numbers
`eqnarray*`	math	lines up equal signs, no line numbers
`array`	math	matrices and arrays
`itemize`	paragraph	list with bullets
`enumerate`	paragraph	list with numbers
`description`	paragraph	list with indentation
`tabular`	LR	align text in columns
`table`	paragraph	number and position table
`figure`	paragraph	number and position figure
`center`	paragraph	center text
`mbox`	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^n_{i=1}
  ```

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

- *Greek*

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

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

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

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

- *Roofs*

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

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

Math, continued:

- *Binary operations*

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

$\pm, \times, \div, \cup, \otimes$

- *Relation symbols*

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

  $\leq, \subset, \in, \geq, \equiv, \sim, \approx, \neq, \perp$

- *Arrows*

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

  $\rightarrow, \Leftarrow, \Leftrightarrow, \uparrow$

- *Miscellaneous*

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

  $\forall, \exists, \Re, \sum, \prod, \int$

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*: `$$ ... $$` or `\[ ... \]`; e.g.,

  ```
  $$\sum^n_{i=1} x_i^2 (Y_{ij}-z_i \beta)$$
  ```

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

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

  `$\sum^n_{i=1}$ VS. $$\sum^n_{i=1}$$`

  $\sum^n_{i=1}$ VS. $\displaystyle\sum^n_{i=1}$

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

Math, continued:

- *Products, integrals, unions*

  ```
  $$\prod^n_{j=1},\hspace{0.1in} \int^\infty_t f(u) du,
  \hspace{0.1in}\bigcup_{A: A \in \Omega}$$
  ```

  $$\prod^n_{j=1}, \hspace{0.1in} \int^\infty_t f(u) du, \hspace{0.1in} \bigcup_{A: A \in \Omega}$$

- *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

- `$\mbox{\boldmath $X$}$`, output $\mbox{\boldmath X}$
  `$\mbox{\boldmath $\Sigma$}$`, output $\mbox{\boldmath Σ}$
- `$\mathbf{X}$, $\mathbf{\Sigma}$`
  $\mathbf{X}$, $\mathbf{\Sigma}$

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

- (2×3) *matrix*:

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

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

- *Determinant* of (2×2) matrix:

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

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

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

- *Braces*

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

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

- *Binomial coefficients*: `\left( \begin{array}{c}N \\ y  \end{array} \right)`

$$\left(\begin{array}{c} N \\ y \end{array} \right)$$

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

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

```
\begin{eqnarray*}
\Delta_i & = & \sum_j \sum_{k \neq j} \mbox{Corr}(Y_{ij},Y_{ik}) \\
 & = & \sum_j \sum_{k \neq j} \rho_i^{\parallel j-k \parallel} \\
 & = & \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*}
```

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

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}
```

	Results	
Parameter	Bias	SE
β_0	-0.030	0.12
β_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}{\mbox{\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`

```
$$\sumjn \var(\betahatj)$$
```

$$\sum_{j=1}^{n} \mathrm{var}(\widehat{\boldsymbol{\beta}}_j)$$

6. CROSS REFERENCES

Advantage: A *built-in* feature of LaTeX 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, LaTeX *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) = \sumjn \var(\betahatj)
\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: LaTeX 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 12)

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/` 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 LaTeX 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
```

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
β_0	0.030	0.12
β_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}
```

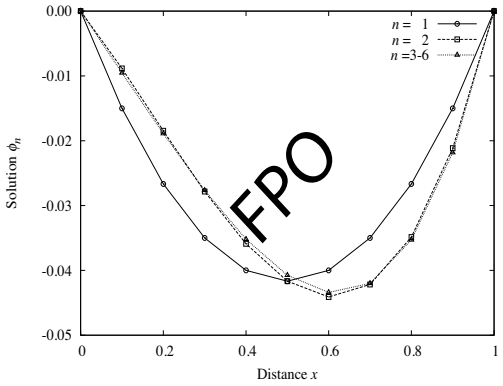


FIGURE 1: The dental data of Pothoff and Roy.

Useful package:

`subfigure` – `\usepackage{subfigure}`

- Create a "*multipanel*" figure from several files with each panel labeled

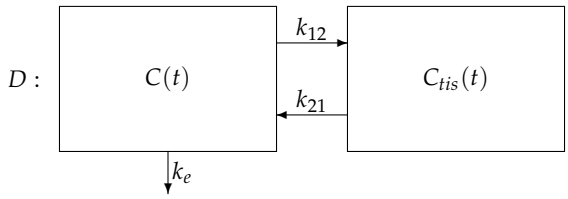
```
\begin{figure}
    \centering \subfigure[]{
        \includegraphics[width=1.5in]{dental.ps}}
        \hspace*{0.1in}
        \subfigure[]{
        \includegraphics[width=1.5in]{dental.ps}}
\caption{(a) The dental data of Pothoff and Roy.  (b) The dental
data of Pothoff and Roy, again.}
\label{f:dental2}
\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_ε (*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` (as `.dvi` or `.ps` files)
- Local intro tutorial `http://www.stat.ncsu.edu/computing/ howto/latex/session_1/`