These notes are based on a tutorial created by Dr. Marie Davidian at NC State University.

WHAT IS L\TeX? \\

\LaTeX\ is a language created for the purpose of typesetting text and mathematical formulas.

What L\TeX\ 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\TeX\ 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.)

What L\TeX\ IS:

- The popular way to produce a dissertation document.
- A useful way to typeset homework assignments, reports, posters, conference presentations, and of course the senior project.
- Versions available for UNIX, Linux, Windows, Mac, 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
What a typical \LaTeX{} session looks like:

```
\texttt{[16 points total]} \\
Suppose the density function for $Y$ is given by
\begin{center}
Sh(y) = \left\{ \begin{array}{c}
y e^{-y/\beta}, \quad 0 < y \\
0, \quad \text{otherwise}
\end{array} \right. \\
\end{center}
Here, $\beta$ is a positive constant.

Find the value of $k$ which makes $Sh$ a valid density (express your answer in terms of $\beta$). Show all work and mathematical justifications. You may use the back of this sheet if you need more space.
```

[16 points total] Suppose the density function for $Y$ is given by

$$h(y) = \begin{cases} 
    k y e^{-y/\beta}, & 0 < y \\
    0, & \text{otherwise}
\end{cases}$$

Here, $\beta$ is a positive constant.

Find the value of $k$ which makes $h$ a valid density (express your answer in terms of $\beta$). Show all work and mathematical justifications. You may use the back of this sheet if you need more space.
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

**For example:** Here is a sample preamble and document body for an article.

```latex
\documentclass[12pt]{article}
\usepackage{graphicx}
\begin{document}
\section{Introduction}
This is the introduction …
\end{document}
```
Some important notes:

- `%` symbol is used to document the file or “\textit{comment out}” text; anything to the right of a `%` does not appear in the document
- \LaTeX\ commands start with `\`
- \LaTeX\ is \textit{case sensitive}
- To obtain, for example, a 1 inch margin on all sides for your output, appropriate values for the various \texttt{\textbackslash \setlength} statements will depend on your particular computer and printer (experiment with various settings)

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**MODES AND ENVIRONMENTS**

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

- \textit{Paragraph mode} – the default text mode, with line wrap. A space between lines signals the start of a new paragraph
- \textit{Math mode} – math symbols and commands may be used, and mathematical expressions result
- \textit{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 \textit{error} will result

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

\[
\begin{\texttt{environment-name}}
\ldots
\end{\texttt{environment-name}}
\]

**For example:** The \texttt{math} environment

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

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

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\textit{Page 4}
The popular shortcuts are to use $ ... $ or \( ... \), e.g.

\[
y = X\beta + \epsilon
\]

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

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### MAKING LISTS

**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

**For example:** Creating a bulleted list

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

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

---

### TEXT EXPRESSIONS AND SIZES

<table>
<thead>
<tr>
<th>Command</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>\underline{Sample}</td>
<td>Sample</td>
</tr>
<tr>
<td>\textbf{Sample}</td>
<td>Sample</td>
</tr>
<tr>
<td>\textit{Sample}</td>
<td>Sample</td>
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<tr>
<td>\textsc{Sample}</td>
<td>Sample</td>
</tr>
<tr>
<td>\texttt{Sample}</td>
<td>Sample</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compositions</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>\underline{\textbf{Sample}}</td>
<td>Sample</td>
</tr>
<tr>
<td>\underline{\textit{Sample}}</td>
<td>Sample</td>
</tr>
<tr>
<td>\underline{\textsc{Sample}}</td>
<td>Sample</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command</th>
<th>Size</th>
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</thead>
<tbody>
<tr>
<td>\tiny Sample</td>
<td>Sample</td>
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<tr>
<td>\scriptsize Sample</td>
<td>Sample</td>
</tr>
<tr>
<td>\footnotesize Sample</td>
<td>Sample</td>
</tr>
<tr>
<td>\small Sample</td>
<td>Sample</td>
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<td>\normalsize Sample</td>
<td>Sample</td>
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<td>\large Sample</td>
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<td>\Large Sample</td>
<td>Sample</td>
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<td>\huge Sample</td>
<td>Sample</td>
</tr>
<tr>
<td>\Huge Sample</td>
<td>Sample</td>
</tr>
</tbody>
</table>
MATH EXPRESSIONS

- **Roots, subscripts, superscripts**

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

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

- **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**

  \( \hat{\alpha}, \tilde{\alpha}, \dot{x}, \overline{x}, \bar{x} \)

  \( \hat{\alpha}, \tilde{\alpha}, \dot{x}, \overline{x}, \bar{x} \)

- **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.,

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

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

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

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

- Products, integrals, unions

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

- Special functions

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

- Fractions, partial derivatives

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

Note: Use \displaystyle for fractions; otherwise they are too small
Math, continued: There are different ways to present math in \textbf{boldface}; here are two

- $\mbox{\boldmath $X$}$, $\mbox{\boldmath $\Sigma$}$
- $\mathbf{X}$, $\mathbf{\Sigma}$

Math, continued: array and eqnarray environments

- $(2 \times 3)$ matrix:

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

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

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

- Braces

\[
f_X(x)= \left\{ \begin{array}{cl}
  \theta x^{\theta -1}, & 0 < x < 1 \\
  0, & \text{otherwise}
\end{array} \right.
\]

- Binomial coefficients: With the package statement \usepackage{amssymb, amsmath} (to be discussed later) we can create “$n$ choose $k$” easily:

\[
\binom{n}{k}
\]

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*}

The \texttt{tabular} environment:

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

\begin{tabular}{|ccc|} 
\hline 
$X$ & $Y$ & $Z$ \\
\hline 
1 & 2 & 12 \\
2 & 4 & 14 \\
3 & 6 & 15 \\
4 & 8 & 20 \\
\hline 
\end{tabular}

\begin{tabular}{|c|rr|} 
\hline 
Parameter & Bias & SE \\
\hline 
$\beta_0$ & $-0.030$ & 0.12 \\
$\beta_1$ & 0.002 & 0.07 \\
\hline 
\end{tabular}
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}}
\newcommand{\npdf}{\frac{1}{\sqrt{2\pi}\sigma}e^{-(x-\mu)^2/2\sigma^2}}

- The following text leads to a convenient shortcut:

  the density of $X$ is given by $\npdf$

  \[
  \text{the density of } X \text{ is given by } \frac{1}{\sqrt{2\pi}\sigma}e^{-(x-\mu)^2/2\sigma^2}
  \]

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

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

  \[
  \sum^n_{j=1} \var(\hat{\beta}_j)
  \]
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 compile a document *twice*

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

**Examples:**

- Numbered equation

  \begin{equation}
  \text{var(}\alpha\text{)} = \sum_{j=1}^{n} \text{var(}\hat{\beta}_j\text{)}
  \label{eq:alpha}
  \end{equation}

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

  \begin{equation}
  \text{var}(\alpha) = \sum_{j=1}^{n} \text{var}(\hat{\beta}_j)
  \end{equation} \tag{0.1}

  In equation 0.1, we see that...

**Examples, continued:**

- Section label

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

  ...As discussed in Section~\ref{s:intro}, kurtosis...
Thus, we see that calculation of the variance is straightforward \label{p:var}

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

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**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 page 15)

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**IMPORTING GRAPHICS**

Numerous options: We discuss three of these

- **psfig** – `\usepackage{psfig}`
  
  `\psfig{figure=C:/images/mygraphic.ps,height=2.5in}`

- **epsf** – `\usepackage{epsf}`
  
  `\epsfysize=2.5in`
  
  `\epsfbox{C:/images/mygraphic.ps}`

- **graphicx** – `\usepackage{graphicx}`
  
  Can also import other formats (pdf, jpg, png, etc)
  
  `\includegraphics[height=2.5in]{C:/images/mygraphic.ps}`
Two standard \LaTeX{} environments: \texttt{table} and \texttt{figure}

- Automatically \textit{numbers} tables and figures
- Allow tables and figures to be formatted and \textit{referenced} within a document
- Allow \textit{captions}

\begin{table}[h]
\centering
\begin{tabular}{c|rr}
\hline
Parameter & \multicolumn{1}{c}{Bias} & \multicolumn{1}{c}{SE} \\
\hline
$\beta_0$ & 0.030 & 0.12 \\
$\beta_1$ & 0.002 & 0.07 \\
\hline
\end{tabular}
\caption{Results of the simulation}
\label{t:simresults}
\end{table}

Table 1: Results of the simulation.

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

- In Figure 1, we see that...
WHERE TO LEARN MORE

Books and guides:

- Goossens, M. et al. (1994) The $\LaTeX$ Companion
- Oetiker, T. et al. (2002) The Not So Short Introduction to $\LaTeX$ 2ε (Widely available online)
- Cal Poly Statistics Faculty (Anytime) A very accessible group of individuals with extensive experience in $\LaTeX$. One of the best ways to learn $\LaTeX$ is to see sample code from other users ... feel free to ask for help!

Resources online and on the Web:

- The Comprehensive $\TeX$ Archive Network (CTAN) www.ctan.org – a repository of tons of style files, packages, etc.
- Tutorial at NCSU www.stat.ncsu.edu/computing/howto/latex/session_1/ – for UNIX/LINUX focus
- Google ‘Groups’ groups.google.com – Search site with keywords ... many answers available here!
- TeXnic Center toolscenter.org – Freeware text editor specifically for $\LaTeX$
- Crimson Editor crimsoneditor.com – Freeware text editor – great for editing $\LaTeX$, SAS, Splus, C++, ...
- Tex FAQ Site www.tex.ac.uk/faq
SOFTWARE DISCUSSION

We will be using MikTeX as the \LaTeX ‘engine’ which compiles the file containing the \LaTeX code. TeXnic Center will be the program we use to edit the \LaTeX code files. Any text editor can be used to edit the file, but TeXnic Center is useful since it can be customized to conveniently launch commands to compile and view your document. Another nice feature about TeXnic Center is that it is freeware!

Installing the software from the CDROM

A CDROM containing the necessary programs to work on \LaTeX on your home computer will be available from the Stat Lab. Please be sure to return the CDROM when you are finished.

1. **MikTeX:** Go into the MikTeX directory on the CDROM and double click setup.exe. If your hard drive has limited space, install using the minimal install option. If you have sufficient space, the full install is helpful since it contains just about all the extra features (especially ‘packages’) you will ever need. The full install requires 400 – 500 MB.

2. **Ghostview:** Go into the Ghostview directory on the CDROM and double click (one at a time) the two .exe files you will find. Both programs are needed to view and print ‘postscript’ format files. Accept the default directories suggested through the installation process.

3. **Acroread:** Go into the Acroread directory on the CDROM and double click the .exe file to install Adobe Reader (to read PDF files). Accept the default directories suggested through the installation process.

4. **TeXnic Center:** Go into the TeXnic Center directory on the CDROM and double click on the .exe file.

1 **Simple \LaTeX Session: Using the DVI Viewer**

- Most simple way to run a session
- Swap back and forth between text editor and the DVI viewer
- When ready to print your finished product, convert the file into either a ‘postscript’ or ‘PDF’ format and print using the appropriate application (see below).

2 **\LaTeX Session: Postscript Method**

- Swap back and forth between the text editor and Ghostview which is a postscript file application
- Involves an extra step where the file is first compiled with \LaTeX, then converted to postscript format, and then finally viewed with Ghostview
- Use the Postscript method if importing postscript graphic images
- Use Ghostview to print your finished product
3 \LaTeX{} Session: PDF Method

- Swap back and forth between the text editor and Adobe Reader which is a PDF file application
- Involves an extra step where the file is first compiled with \LaTeX{}, then converted to PDF, and then finally viewed with Adobe Reader
- Use the PDF method if importing JPG or PNG graphic images
- Use Adobe Reader to print your finished product

You can run into many problems trying to import .jpg format images through the postscript instructions given above.

4 Using TeXnic Center

- Choose one of the methods above (DVI, PS, PDF) by selecting the appropriate option from the toolbar:

- To compile the \LaTeX{} file, click on the icon from the toolbar above, use the default hotkey combo [Ctrl+F7], or go to the menu and choose Build -> Current File -> Build:
• To view the converted (DVI, PS, PDF), click on the icon from the toolbar above, use the default hotkey combo [F5], or go to the menu and choose Build -> View Output:

![Image showing the Build menu with View Output selected]

• To compile and view the in one step (combining both steps above), click on the icon from the toolbar above, click on the default hotkey combo [ ], or go to the menu and choose Build -> Current File -> Build and View:

![Image showing the Build and View menu]

• Customizations: Choose Tools -> Customize to access some convenient options –
  – Toolbars – Add/remove any particular buttons on the toolbar
  – Keyboard – Make your own hotkey combinations for special functions (such as those functions above)

• Block Commenting/Uncommenting – Under the Edit menu, use the option to comment/uncomment rows of your \LaTeX code to help in debugging (very useful!)

• Spell Check – choose Tools -> Spelling to do a check on spelling before printing the final product!