

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

WHAT IS L^AT_EX ?

LaTeX (pronounced “lay-tek” or “lah-tek”) is a language created for the purpose of typesetting text and mathematical formulas.

What L^AT_EX 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*

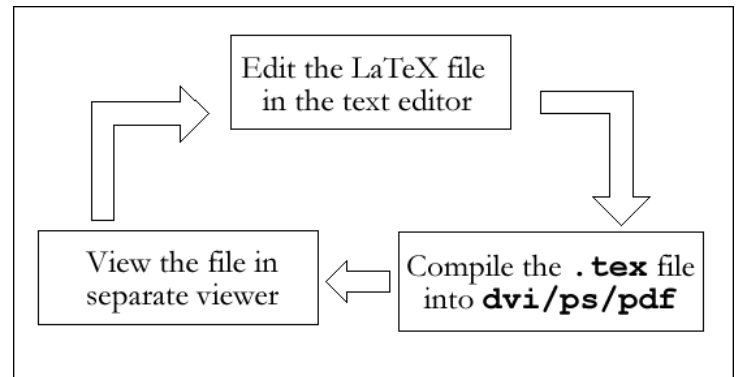
What L^AT_EX IS:

- 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^AT_EX 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 L^AT_EX session looks like:



```

% #####
\texttt{[16 points total]}
Suppose the density function for  $Y$  is given by

\begin{center}
 $h(y) = \begin{cases} kye^{-y/\beta}, & 0 < y \\ 0, & \text{otherwise} \end{cases}$ 
\end{center}
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.
\vspace{3.15in}
% #####

```

```

Output written on exam2a.pdf (5 pages, 81390 bytes).
Transcript written on exam2a.log.

LaTeX-Result: 0 Error(s), 0 Warning(s), 0 Bad Box(es), 5 Page(s)

Build Find 1 Find 2 Parse

```

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

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

Here, β is a positive constant.

Find the value of k which makes h a valid density (express your answer in terms of β). **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.

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Sample LaTeX Document
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Font sizes: 10pt, 11pt, 12pt
% Doc style: article, book, ...

\documentclass[12pt]{article}

% TONS of packages available
% to suit your particular needs

\usepackage{graphicx}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   The Preamble
%   - Adjust page "setlength" values
%     to work with your environment

\setlength{\oddsidemargin}{0.0in}
\setlength{\evensidemargin}{0.0in}
\setlength{\topmargin}{0.5in}
\setlength{\headheight}{0.20in}
\setlength{\headsep}{3ex}
\setlength{\parskip}{2.3ex}
\setlength{\parindent}{0.0in}
\setlength{\baselineskip}{2ex}
\setlength{\textheight}{9in}
\setlength{\textwidth}{6.5in}

%   - Add other customizations above
%     as needed (esp. "newcommand")
%
%   The Preamble
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

\begin{document}
\section{Introduction}
This is the introduction ...

% Lots of impressive math
% expressions to be found here!

\end{document}

```

Some important notes:

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

MODES AND ENVIRONMENTS

Modes: At any point in a L^AT_EX 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 $\backslash(\dots \backslash)$, e.g.

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

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

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

<code>\underline{Sample}</code>	⇒	<u>Sample</u>
<code>\textbf{Sample}</code>	⇒	Sample
<code>\emph{Sample}</code>	⇒	<i>Sample</i>
<code>\textit{Sample}</code>	⇒	<i>Sample</i>
<code>\textsl{Sample}</code>	⇒	<i>Sample</i>
<code>\textsc{Sample}</code>	⇒	SAMPLE
<code>\texttt{Sample}</code>	⇒	Sample

Compositions

<code>\underline{\textbf{Sample}}</code>	⇒	<u>Sample</u>
<code>\emph{\textbf{Sample}}</code>	⇒	<i>Sample</i>
<code>\underline{\textsc{Sample}}</code>	⇒	<u>SAMPLE</u>

<code>\tiny Sample</code>	⇒	Sample
<code>\scriptsize Sample</code>	⇒	Sample
<code>\footnotesize Sample</code>	⇒	Sample
<code>\small Sample</code>	⇒	Sample
<code>\normalsize Sample</code>	⇒	Sample
<code>\large Sample</code>	⇒	Sample
<code>\Large Sample</code>	⇒	Sample
<code>\LARGE Sample</code>	⇒	Sample
<code>\huge Sample</code>	⇒	Sample
<code>\Huge Sample</code>	⇒	Sample

MATH EXPRESSIONS

- *Roots, subscripts, superscripts*

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

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

- *Greek*

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

α , β , γ , δ , ϵ , η , θ , λ

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

Γ , Δ , Θ , Λ , Ω , Σ

- *Roofs*

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

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

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

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

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

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

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

- Can be *overridden* with `textstyle{ }` and `\displaystyle{ }`
- *Products, integrals, unions*

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

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

- *Special functions*

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

`exp(x), log y, sin(kπ), minx 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

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

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)
```

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

- *Determinant* of (2×2) matrix:

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

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

- *Braces*

```
f_X(x) = \left\{ \begin{array}{l}
\theta x^{\theta-1}, & 0 < x < 1 \\
0, & \mbox{otherwise} \end{array} \right.
```

$$f_X(x) = \begin{cases} \theta x^{\theta-1}, & 0 < x < 1 \\ 0, & \text{otherwise.} \end{cases}$$

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

```
{n \choose k}
```

$$\binom{n}{k}$$

Math, continued: array and eqnarray environments

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

```

\begin{eqnarray*}
\Delta_i & = & \sum_j \sum_{k \neq j} \mbox{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}{|ccc|} \hline
$X$ & $Y$ & $Z$ \\ \hline
1 & 2 & 12 \\
2 & 4 & 14 \\
3 & 6 & 15 \\
4 & 8 & 20 \\ \hline
\end{tabular}

```

X	Y	Z
1	2	12
2	4	14
3	6	15
4	8	20

```

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

```

Parameter	Results	
	Bias	SE
β_0	-0.030	0.12
β_1	0.002	0.07

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 L^AT_EX 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_{j=1}^n}
\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`

the density of X 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`

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

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

CROSS REFERENCES

Advantage: A *built-in* feature of L^AT_EX 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^AT_EX *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}
\var(\alpha) = \sum_{j=1}^n \var(\hat{\beta}_j)
\label{eq:alpha}
\end{equation}
```

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

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

In equation 0.1, we see that...

Examples, continued:

- Section label

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

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

- Page label

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

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

PACKAGES

Useful utilities: L^AT_EX 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)

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}`

TABLES AND FIGURES

Two standard L^AT_EX 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]
\begin{center}
\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}
\end{center}
\caption{\it Results of the simulation}
\label{t:simresults}
\end{table}
```

Parameter	Results	
	Bias	SE
β_0	0.030	0.12
β_1	0.002	0.07

Table 1: *Results of the simulation.*

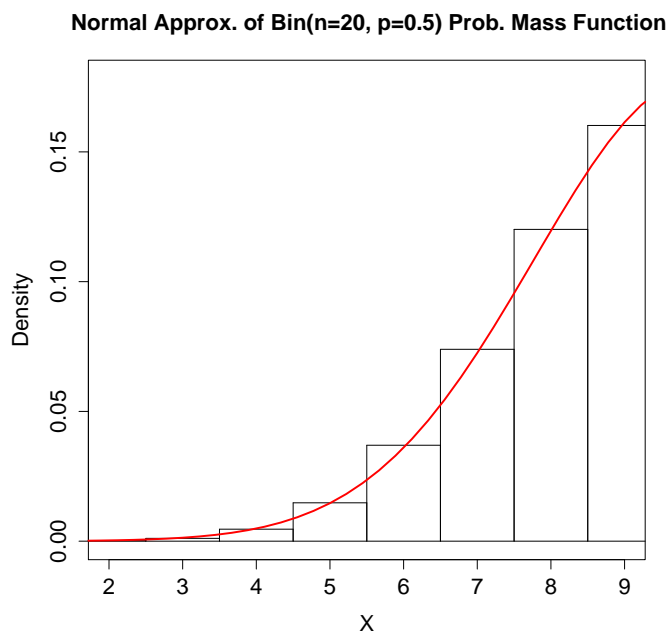
- Reference – In Table~\ref{t:simresults}, we see that...
- In Table 1, we see that...

```

\begin{figure}
\caption{\it Normal Approximation to Binomial}
\label{f:norm_appx}
\begin{center}
\includegraphics[height=2.5in]{C:/images/norm_bin2.pdf}
\end{center}
\end{figure}

```

Figure 1: *Normal Approximation to Binomial*



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

WHERE TO LEARN MORE

Books and guides:

- Lamport, L. (1994) *L^AT_EX: A Documentation Preparation System, User's Guide and Reference Manual* (The creator of L^AT_EX)
- Goossens, M. et al. (1994) *The L^AT_EX Companion*
- Kopka, H. (1999) *A Guide to L^AT_EX: Document Preparation for Beginners & Advanced Users*
- Hahn, J. (1993) *L^AT_EX for Everyone: A Reference Guide and Tutorial for Typesetting Documents Using a Computer*
- Oetiker, T. et al. (2002) *The Not So Short Introduction to L^AT_EX 2_ε* (Widely available online)
- Cal Poly Statistics Faculty (Anytime) *A very accessible group of individuals with extensive experience in L^AT_EX. One of the best ways to learn L^AT_EX is to see sample code from other users ... feel free to ask for help!*

Resources online and on the Web:

- The *Comprehensive T_EX 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 L^AT_EX
- Crimson Editor crimsoneditor.com – Freeware text editor – great for editing L^AT_EX, SAS, Splus, C++, ...
- Tex FAQ Site www.tex.ac.uk/faq

SOFTWARE DISCUSSION

We will be using **MikTeX** as the L^AT_EX ‘engine’ which compiles the file containing the L^AT_EX code. **TeXnic Center** will be the program we use to edit the L^AT_EX 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 L^AT_EX 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 L^AT_EX 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 L^AT_EX 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 L^AT_EX, 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

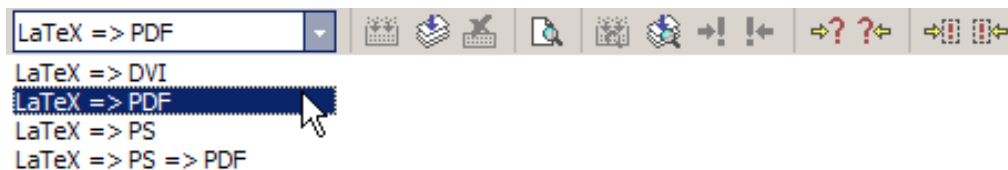
3 L^AT_EX Session: PDF Method


- 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 L^AT_EX , 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

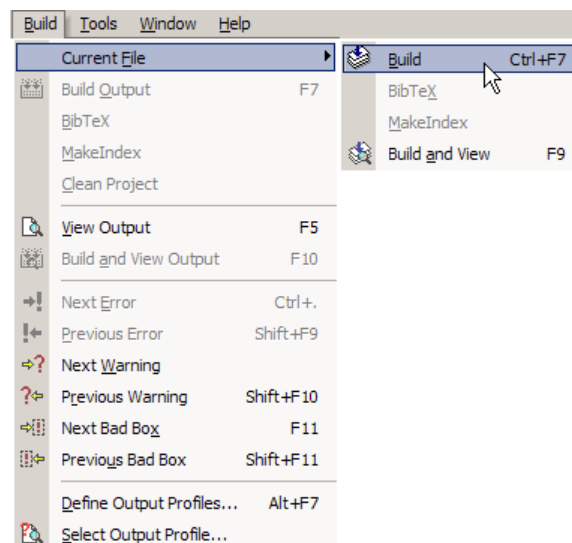
You can run into many problems trying to import jpg format images through the postscript instructions given above.


4 Using TeXnic Center

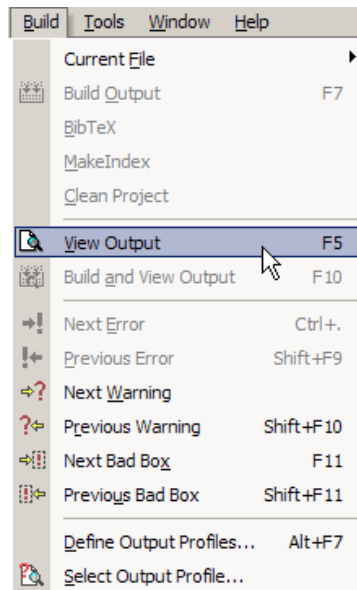
- Choose one of the methods above (DVI, PS, PDF) by selecting the appropriate option from the toolbar:




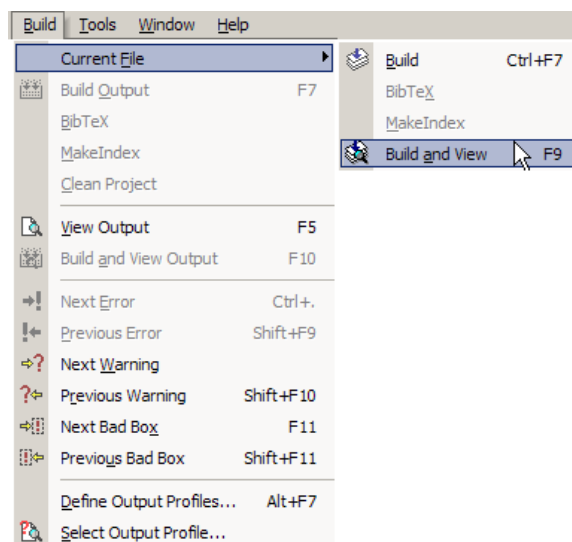
- To compile the L^AT_EX file, click on the  icon from the toolbar above, use the default hotkey combo [Ctrl+F7], or go to the menu and choose Build -> Current File -> Build:



- 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**:



- 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**:



- 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 L^AT_EXcode to help in debugging (very useful!)
- Spell Check – choose **Tools -> Spelling** to do a check on spelling before printing the final product!