

INTRODUCTION TO L^AT_EX

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

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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.)
- The popular way to produce a *dissertation* document in the preferred NCSU format (later...)

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WHAT IS L^AT_EX ?

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*

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What L^AT_EX 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

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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

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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
```

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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)

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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*

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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}
```

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

Some commands with no argument:

```
\ldots, \dag, \ddag, \%, \&, \#, \{ \}, \today, \LaTeX
..., †, ‡, %, &, #, { }, November 18, 2004, LATEX
```

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

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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

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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 `$Y = X\beta + \epsilon$`.

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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

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Math: L^AT_EX is *taylor-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*

α , β , γ , δ , ϵ , η , θ , λ

α , β , γ , δ , ϵ , η , θ , λ

Γ , Δ , Θ , Λ , Ω , Σ

Γ , Δ , Θ , Λ , Ω , Σ

- *Roofs*

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

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

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Some popular environments:

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

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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

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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.,

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

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

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

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

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

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

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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

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Math, continued:

- *Products, integrals, unions*

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

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

- *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

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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:

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

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

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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.
```

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

- *Binomial coefficients:*

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

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

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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}{1-\rho_i} \left\{ \sum_{k \neq j} \rho_i^{\|j-k\|} \right\}
\end{eqnarray*}
```

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

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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
β_0	-0.030	0.12
β_1	0.002	0.07

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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

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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}
```

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

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

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

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Examples:

- Numbered equation

```
\begin{equation}
\var(\alpha) = \sumjn \var(\betahatj)
\label{eq:alpha}
\end{equation}
```

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

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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 process a document *twice*

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

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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...

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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 slide 51)

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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

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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

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Dissertations: At NCSU, dissertations may be created in L^AT_EX 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

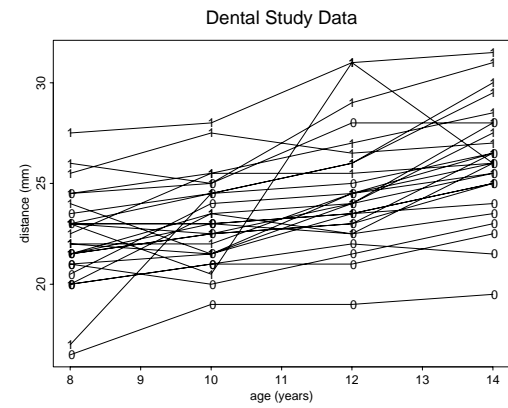
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IMPORTING GRAPHICS

Numerous options: We discuss three of these

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

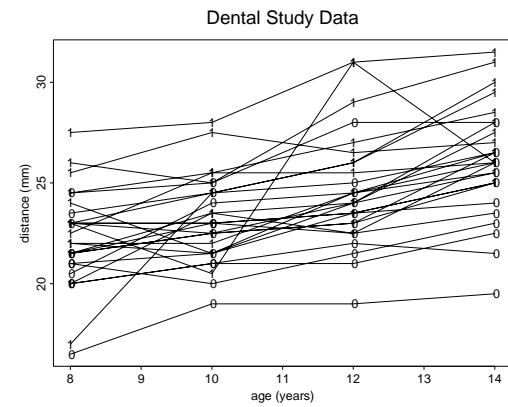
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- `epsf` – `\usepackage{epsf}`
`\epsfsize=2.5in`
`\epsfbox{dental.ps}`

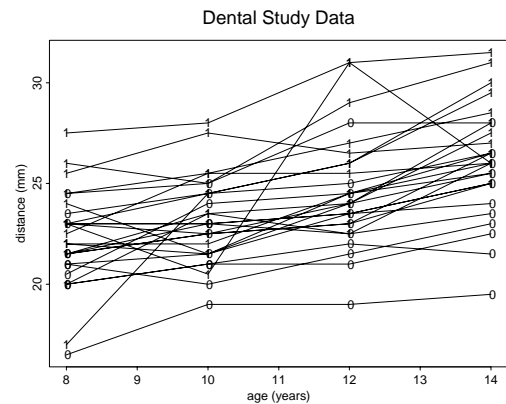
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- `graphicx` – `\usepackage{graphicx}`
- Can also import other formats (pdf, jpg, etc)
`\includegraphics[height=2.5in]{dental.ps}`

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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*

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```

\begin{table}
\begin{center}
\begin{tabular}{c|rr}
& \multicolumn{2}{c}{Results} \\ \hline
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}

```

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Parameter	Results	
	Bias	SE
β_0	0.030	0.12
β_1	0.002	0.07

Table 1: *Results of the simulation.*

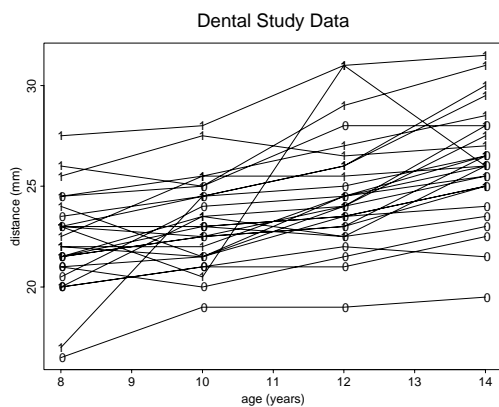
- Reference – In Table~\ref{t:simresults}, we see that...
- In Table 1, we see that...

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```
\begin{figure}
\caption{\it The dental data of Pothoff and Roy.}
\label{f:dental}
\begin{center}
\includegraphics[height=2.5in]{dental.ps}
\end{center}
\end{figure}
```

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



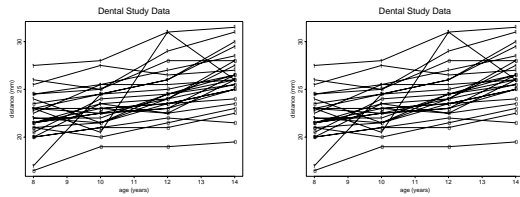
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Useful package: subfigure – \usepackage{subfigure}

- Create a “*multi-panel*” 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}
```

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(a)

(b)

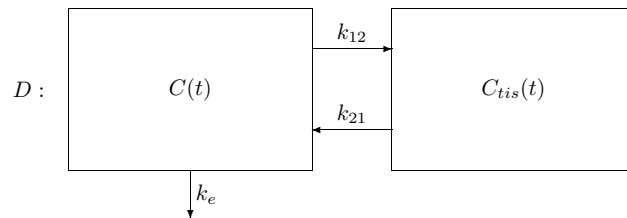
Figure 2: (a) The dental data of Pothoff and Roy. (b) The dental data of Pothoff and Roy, again.

PICTURES

L^AT_EX 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:



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

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

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`

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Resources online and on the Web:

- The *Comprehensive T_EX 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/

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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* (*Available on the class web page*)

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