An Introduction to LaTeX

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1 Introduction

LaTeX is a language for typesetting text and mathematics. Due to its flexibility, ease of use, and professional typographic quality, LaTeX is currently used in almost all areas of science and the humanities. LaTeX offers a high level of mathematical typesetting capabilities, so it is used by mathematicians and statisticians for word processing.

This document is illustrate how to do a few things with LaTeX. There are numerious instruction manuals on the Web and several books on LaTeX.

LaTeX on the web

Most things about LaTeX are found at the *TeX Users Group (TUG)* home page, http://www.tug.org. You should read about the history of TeX and LaTeX. Explore this site for free LaTeX systems, manuals, and add-ons.

Books on LaTeX

The original book on LaTeX is by Leslie Lamport [3]. A more modern and comprehensive book is Mittelbach and Goossens [4]. My recommended book for a rank beginner is Griffiths and Higham [1]. My favorite general book is Kopka and Daly, [2].

Basic structure of a tex file

A *tex file* is file with a file extension `.tex`. For our purposes, a tex file contains text and commands for the LaTeX system. A simple example of the contents of a tex file is

```
\documentclass{article}
\begin{document}
This is some text.
\end{document}
```

Everything you type in will be neatly formatted and typeset. Separate paragraphs by blank lines. Of course changing spacing, type styles, and using formulas requires additional commands.

2 Document classes

A document classes determines the layout, style for headings, and other elements of the document. Some classes are standard (built in) and others have been contributed by users.

The class is specified in the first line of a tex file as

`\documentclass{`*name*`}`

where *name* is the name of the style

Standard classes

There are five standard document classes, namely, *article*, *report*, *book*, *slides*, and *letter*. A specified class determines a special format. When you declare the class option, LaTeX will compile your tex source file by using your specified format.

Contributed classes

Users have developed many other classes and contributed them for all to use. Many of these are so popular that they are included with every LaTeX distribution. One might not be aware of whether a class is standard or contributed.

Ph.D.students will want to use a *thesis* class approved by their graduate school. This will guarantee that style will conform to the required format. For making slides, the *beamer* class has many more features than the standard document class *slides*.

See the TUG web site for more classes.

3 Typesetting Mathematics

The International Standards Organization (ISO) has established the recognized conventions for typesetting mathematics. See [2] for a brief synopsis of these conventions. For the most part, LaTeX is consistent with the conventions, however there is `DeclareMathOperator` command to define operators not built in.

Math modes

There are two math modes, *inline* and *display*. For the in line mode, a $ signals the start of math mode, and another $ signals the end. For the display mode, a \[signals the start of math mode and \] signals the end. In display mode, formulas are set apart on their own line, and larger symbols are used. The commands to produce a formula are placed between these delimiters.

Inline mode

The LaTeX code for the average of $X_1, \cdots, X_n$ is

```
\bar{X} = \frac{1}{n}\sum_{i=1}^n X_i
```

This formula is displayed in inline mode in the following sentence. The average of $X_1, \cdots, X_n$ is $\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$. $\bar{X}$ is the common estimator of the population mean.

Display mode

This formula is displayed in display mode in the following sentence. The average of $X_1, \cdots, X_n$ is

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} X_i.$$

$\bar{X}$ is the common estimator of the population mean.

Formulas

Here we illustrate a few of the commands that produce mathematical formulas. You can get a full list from a book or the Web. Most things are easy to remember. For example, to get β while in math mode you type `\beta`. To get $\hat{y}$ you type `\hat{y}`.

Continued fractions

The input

```
\[
a_0 + \frac{1}{a_1 + \frac{1}{a_2 +
\frac{1}{a_3 + \cdots}}}
\]
```

gives the continued fraction

$$a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \cdots}}}$$

Integrals

The input

```
\[
F(x) = \int_{-\infty}^x
\frac{1}{\sqrt{2\pi\sigma^2}}
 e^{-\frac{(t-\mu)^2}{2\sigma^2}} \dif t
\]
```

gives the integral

$$F(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(t-\mu)^2}{2\sigma^2}} \, \mathrm{d}t$$

4 Tabular displays and arrays

The *tabular* environment is good for making tables. The code

```
\begin{tabular}{|c|c|ccc|}
\multicolumn{2}{c}{}&\multicolumn{3}{c}{Drugs} \\ \cli
\multicolumn{1}{c}{Alcohol} &\multicolumn{1}{c|}{Subje
\multicolumn{1}{c}{A}       &\multicolumn{1}{c}{ B} &
\multicolumn{1}{c|}{C} \\
\hline
Yes & RST &  3.56 & 4.04 & 3.26 \\
Yes & JBM &  3.79 & 3.88 & 3.49 \\
Yes & DGH &  4.09 & 5.32 & 3.79 \\
Yes & WJT &  3.33 & 3.63 & 3.03 \\
Yes & EEA &  3.35 & 3.63 & 3.05 \\
\hline
```

```
No &  DCJ &  2.83 & 2.55 & 2.63 \\
No &  CJW &  2.93 & 2.42 & 2.73 \\
No &  RLA &  2.98 & 3.07 & 2.78 \\
No &  HEM &  2.32 & 2.15 & 2.12 \\
No &  AMR &  2.73 & 3.23 & 2.53 \\
\hline
\end{tabular}
```

gives

		Drugs		
Alcohol	Subject	A	B	C
Yes	RST	3.56	4.04	3.26
Yes	JBM	3.79	3.88	3.49
Yes	DGH	4.09	5.32	3.79
Yes	WJT	3.33	3.63	3.03
Yes	EEA	3.35	3.63	3.05
No	DCJ	2.83	2.55	2.63
No	CJW	2.93	2.42	2.73
No	RLA	2.98	3.07	2.78
No	HEM	2.32	2.15	2.12
No	AMR	2.73	3.23	2.53

The array environment

The array environment is just like the tabular environment except it is in math mode.

A numeric matrix

The input

```
\[ \left[ \begin{array}{rrr}
 12 & 13 &  24 \\
 14 & 27 &  39 \\
 20 & 29 & 11
\end{array} \right] \]
```

gives

$$\left[\begin{array}{rrr} 12 & 13 & 24 \\ 14 & 27 & 39 \\ 20 & 29 & 11 \end{array} \right]$$

A matrix of mathematics expressions

The input

```
\[  -A^{-1} =
\left[
\renewcommand{\arraystretch}{1.5}
\begin{array}{ccc}
  \frac{1}{\theta_1 }      & 0                          &
  \frac{1}{\theta_4 }      & \frac{1}{\theta_4 }   &
                                  \frac{1}{\theta_4 } \
  \frac{\theta_2}{\theta_4 \theta_3  } &
                \frac{\theta_2 }{\theta_4  \theta_3  }
  \frac{\theta_2 }{\theta_4  \theta_3  }+\frac{1}{\the
\end{array}
\right] . \]
```

gives

$$-A^{-1} = \begin{bmatrix} \frac{1}{\theta_1} & 0 & 0 \\ \frac{1}{\theta_4} & \frac{1}{\theta_4} & \frac{1}{\theta_4} \\ \frac{\theta_2}{\theta_4\theta_3} & \frac{\theta_2}{\theta_4\theta_3} & \frac{\theta_2}{\theta_4\theta_3} + \frac{1}{\theta_3} \end{bmatrix}.$$

The align environment

The align environment is a special array with three columns. The displays are aligned on a center symbol. The equation is automatically in math mode.

Binomial theorem

The input

```
\begin{align}
(a+b)^3 &= (a+b)(a+b)^2          \nonumber \\
        &= (a+b)(a^2+2ab+b^2) \nonumber \\
        &= a^3+3a^2b+3ab^2+b^3 \label{eqn}
\end{align}
```

gives

$$
\begin{aligned}
(a+b)^3 &= (a+b)(a+b)^2 \\
&= (a+b)(a^2+2ab+b^2) \\
&= a^3+3a^2b+3ab^2+b^3 \qquad (1)
\end{aligned}
$$

The equations without `\nonumber` are numbered.

5 Miscellaneous

In this section some slightly more advanced topics are presented:

1. Writing your own commands
2. Bibliographies
3. Cross referencing
4. The verbatim environment

Writing your own commands

If you have an expression that appears multiple times, you may make the expression into a new command with a construct like

\newcommand{*command name*}{*definition*}.

An example

An example is

```
\newcommand{\polar}{\ensuremath{\left[
\begin{array}{l}
\cos(\beta t)\\ \sin(\beta t)
\end{array}
\right] \exp (\alpha t) }}
```

defines a command such that `\polar` produces

$$\left[\begin{array}{l} \cos(\beta t) \\ \sin(\beta t) \end{array}\right] \exp(\alpha t).$$

New commands with arguments

If you have an expression that appears multiple times but differs somewhat each time, you may make the expression into a new command with a construct like

\newcommand{*command name*}[*no. args*]{*definition*}.

For example

```
\newcommand{\polarn}[2]{\ensuremath{\left[
\begin{array}{l}
 \cos(#1 t) \\ \sin(#1 t)
\end{array}
\right] \exp (#2 t) }}
```

defines a command such that `\polarn{4.2}{3.6}` produces

$$\left[\begin{array}{l} \cos(4.2t) \\ \sin(4.2t) \end{array}\right] \exp(3.6t).$$

Bibliographies

LaTeX makes bibliographies a snap. Prepare a data base along the lines of

```
@book
  {
  griffiths.higham,
  author    = "David F. Griffiths and Desmond J. Higham",
  title     = "Learning \LaTeX ",
  publisher = "SIAM",
  year      = "1997"
  }
@book
  {
  lamport,
  author    = "Leslie Lamport",
  title     = "\LaTeX: A Document Preparation System",
  publisher = "Addison-Wesley Publishing Company",
  address   = "Reading, Massachusetts",
  year      = "1994"
  }
@book
```

```
  {
  mittelbach.goossens,
  author    = "Frank Mittelbach and Michel Goossens",
  title     = "The \LaTeX\ Companion",
  publisher = "Addison-Wesley Publishing Company",
  address   = "Reading, Massachusetts",
  edition   = "Second",
  year      = "2004"
  }
@book
  {
  kopka.daly,
  author    = "Helmut Kopka and Patrick W. Daly",
  title     = "A Guide to \LaTeX",
  edition   = "Fourth",
  publisher = "Addison-Wesley Publishing Company",
  address   = "Reading, Massachusetts",
  year      = "2004"
  }
```

With appropriate commands placed in the tex file and bibTEX program, you get an automatic bibliography with all the works you have cited. At the point of each citation you get the number of the reference automatically. In section 1, I cited some books. The first citation was obtained by the command `\cite{lamport}`.

Cross referencing

Back on slide 24 we put a label on equation 1. The reference to the slide number is by the command `\pageref{eqn}`. The reference to the equation number is by the command `\ref{eqn}`.

We can add and delete equations, and page numbers change with new material. But through the use of symbolic labels, the proper referencing is automatic.

Verbatim environment

Sometimes you may want to include program source code or output or something else that must be kept in its original form. You can do this by using verbatim environment.

`\verbatiminput{`*file name*`}`.

For example,

```
\verbatiminput{master.tex}
```

displays the source file of this document.

Here it is:

```
\documentclass[12pt]{article}
\synctex=1
\usepackage{screen}
\usepackage[latin1]{inputenc}
\usepackage{hyperref}
\usepackage{alltt}
%\usepackage{upright}
\usepackage{verbatim}
\setlength{\parskip}{0.5ex}
\bibliographystyle{plain}
\begin{document}
\title{\color{TitleColor}An Introduction to \LaTeX}
\author{David Allen}
\maketitle
\thispagestyle{empty}
\newscreen
\input{introduction}
\input{classes}
\input{mathematics}
\input{arrays}
\input{miscellaneous}
```

```
\newpage
\bibliography{latex}
\end{document}
```

References

[1] David F. Griffiths and Desmond J. Higham. *Learning LaTeX*. SIAM, 1997.

[2] Helmut Kopka and Patrick W. Daly. *A Guide to LaTeX*. Addison-Wesley Publishing Company, Reading, Massachusetts, fourth edition, 2004.

[3] Leslie Lamport. *LaTeX: A Document Preparation System*. Addison-Wesley Publishing Company, Reading, Massachusetts, 1994.

[4] Frank Mittelbach and Michel Goossens. *The LaTeX Companion*. Addison-Wesley Publishing Company, Reading, Massachusetts, second edition, 2004.