Partha's First LaTeX Lesson

Charly Bank & David McMillan

2nd Edition: October 11, 2004

Abstract

This document is a starting point for LaTeX beginners. As well, it may give some new ideas to veterans or intermediate users. This 'lesson' is really a collection of practical examples with minimal explanation. We have tried to include whatever might be required to get started with LaTeX and produce decent looking reports with cool equations and data presentation. The required files are located in the directory **/home/mcmillan/latex**. You can copy the files **ex.tex**, **hobbes.ps**, **gnufig.tex** and **Make**. Type `Make` and your LaTeX file will be compiled twice, converted to a postscript file and viewed with 'Ghostview'.

Contents

1 Hello

More and more grad students are getting involved with LaTeX. This text is to show some of the possibilities this document preparation system offers. It is not intended to be a LaTeX manual. Instead, it is intended as an example document and will be best used by comparing the source file with the final product. Some explanations are incorporated in the text and others are contained in the source code.

2 Beginning of a LaTeX File

Leslie Lamport developed LaTeX by writing TeX macros. As such it is a program for preparing documents. Before LaTeX can set the text you have written, you need to make some declarations. The text itself, enclosed by `\begin{document}` and `\end{document}`, follows these declarations.

2.1 Declarations

Please see the source file for details on `\documentstyle` and declarations of format. The declarations before the beginning of the document are often referred to as the *preamble*.

2.2 Titlepage

Between `\begin{titlepage}` and `\end{titlepage}` you can create the first page of your document, usually showing the title and author in large, bold letters. This page will not be numbered.

2.3 Table of Contents

Every section and subsection in your document will automatically appear in the table of contents (toc). If you want to suppress the entry, insert an asterisk like so `\subsection*{Heading}`.
If you want the contents entry to be different from the heading, the command is `\subsection[toc Entry`
See § 2.1 for some information about section numbering and limiting table of contents entries in general. Your table of contents will appear wherever you put the command `\tableofcontents`. The next section is an example of `\subsubsection`.

2.4 Text

For the text part of your document, just type it in the way you normally would, separating your paragraphs with blank lines. LaTeX regards blank spaces and carriage returns

equivalently. You can put in a 'hard' space with the tilde character.

Subsubsection Heading

Note that there is no number for this section according to our preamble and the toc entry is different from the heading. We even added some garbage to the toc.

2.5 Numbering of Sections, Pages, Equations

Sections, pages and equations are numbered automatically, although you have control over some aspects of the numbering. Details about page numbering can be found in the source code. Equations which are specified by the `\begin{equation}` and `\end{equation}` commands will be given numbers according to what you have specified in the preamble.

3 Math Mode in LaTeX

3.1 Equation and Displaymath Commands

Some examples from Linear Inverse Theory:

The inverse problem can be written:

$$\begin{array}{ll} \text{minimize} & \phi = \|\mathbf{s}\|^2 \\ \text{subject to} & \mathbf{A}\cdot\mathbf{s} = \mathbf{t} \end{array} \tag{3.1}$$

Often, new equations are added or really hard ones are eliminated to give the reader a break. It is very tedious to change all equation reference numbers in the text, so we let LaTeX take care of that by referencing the equation label as we see in Equation 3.1. You can do the same with figures, bibliography entries and sections as seen in the source for § 2.5. Also, it's a good idea to include some reminder of what the reference is referring to!

To put equations or symbols in your text enclose your math expression with the symbol $.

To get the minimum structure solution using an augmented matrix, we consider the derivative and minimize

$$\phi_m = \alpha_x \int w_x(x,z)\Big(\partial_x \mathbf{s}(x,z)\Big)^2\, dx\, dz \;+\; \alpha_z \int w_z(x,z)\Big(\partial_z \mathbf{s}(x,z)\Big)^2\, dx\, dz$$

where w_x and w_z are weight functions. α_x and α_z balance derivatives in x and z directions against one another. The large parentheses were generated with the `\Bigl(` and `\Bigr)`

commands. In general, LaTeX will size your brackets, braces and parentheses according to what's inside them if you use `\left(` and `\right)`.

$$\begin{array}{ll} \text{minimize} & \phi_m = \alpha_x \parallel \mathbf{W}_x \mathbf{s} \parallel^2 = \alpha_z \parallel \mathbf{W}_z \mathbf{s} \parallel^2 \\ \text{subject to} & \phi_d = \parallel \mathbf{A} \cdot \mathbf{s} - \mathbf{t}^{obs} \parallel^2 = \phi_d^* \end{array} \tag{3.2}$$

where $\mathbf{W}_x$ and $\mathbf{W}_z$ are the forward difference matrices and ϕ_d^* is the target misfit. We form the augmented system of equations

$$\mathbf{G} \cdot \mathbf{s} = \tilde{\mathbf{t}}$$
$$\text{where} \quad \mathbf{G} = \begin{pmatrix} \mathbf{A} \\ \sqrt{\alpha_x}\,\mathbf{W}_x \\ \sqrt{\alpha_z}\,\mathbf{W}_z \end{pmatrix} \quad \text{and} \quad \tilde{\mathbf{t}} = \begin{pmatrix} \mathbf{t}^{obs} \\ 0 \\ 0 \end{pmatrix}$$

3.2 Arrays

Here are a couple of all purpose examples using the array environment in math mode.

$$\begin{aligned} C^+(z) &= e^{-kz}\cos kz - e^{k(z-2H)}\cos k(z-2H), \\ S^+(z) &= e^{-kz}\sin kz + e^{k(z-2H)}\sin k(z-2H), \\ C^-(z) &= e^{kz}\cos kz + e^{k(z-2H)}\cos k(z-2H), \\ S^-(z) &= e^{kz}\sin kz + e^{k(z-2H)}\sin k(z-2H). \end{aligned}$$

$$\boldsymbol{R} = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \sigma_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_N \end{bmatrix},$$

$$\boldsymbol{U} = \begin{bmatrix} | & | & & | \\ \boldsymbol{u}_1 & \boldsymbol{u}_2 & \cdots & \boldsymbol{u}_P \\ | & | & & | \end{bmatrix}.$$

4 More Math Examples

In some ways the examples in this section are different from those in § 3.1. First, all subscripts and superscripts are included with braces, even if they are blank. If you have single character subscripts or superscripts (but not both), you don't need the braces. Blank ones are included because that pushes the supers up and the subs down, and it keeps them all at the same level. Second, you can make your bold vector symbols slanted by using `\mbox` and `\boldmath`. The basic spacing commands in LaTeX are `\,` for a thin space, `\:`

for a medium space, `\;` for a thick space and `\!` for a thin backspace. It's all a matter of preference and usually LaTeX is versatile enough to make it do what you want.

You can put limits on your integrals like so

$$\Phi_0 = \frac{4}{3}\pi G \int_0^{a_e} \rho(a)\, \frac{\partial}{\partial a} \left[\frac{3a^2 - r^2}{2a^3} + \sum_{l=1}^{\infty} \frac{3\epsilon_l}{2l+1} \frac{r^l}{a^{l-2}} Y_l^0 \right] da,$$

or, if you like them above and below,

$$\Phi_1 = \frac{4}{3}\pi G \int\limits_0^{a_1} \rho(a)\, \frac{\partial}{\partial a} \left[\frac{a^3}{r} + \sum_{l=1}^{\infty} \frac{3\epsilon_l}{2l+1} \frac{a^{l+3}}{r^{l+1}} Y_l^0 \right] da.$$

Taking the curl of the momentum equation and substituting the continuity equation and $\boldsymbol{\Omega} = \Omega\hat{\boldsymbol{z}}$ results in the vorticity equation

$$\boldsymbol{\zeta}_t - 2\Omega \boldsymbol{u}_z - \nu\nabla^2\boldsymbol{\zeta} = \mathbf{0} \tag{4.1}$$

where $\boldsymbol{\zeta} = \nabla \times \boldsymbol{u}$ is the vorticity. These two functions form the transform pair

$$T\,(t) \iff \frac{L}{2}\, sinc^2\left(\frac{\pi f L}{2}\right) \tag{4.2}$$

The eigendecomposition of $\boldsymbol{R}_p$ is then

$$\boldsymbol{R}_p = \sum_{j=1}^{2M} \left(\lambda_j + \sigma_w^2\right) \boldsymbol{v}_j \boldsymbol{v}_j^H + \sum_{j=2M+1}^{p+1} \sigma_w^2\, \boldsymbol{v}_j \boldsymbol{v}_j^H \tag{4.3}$$

where λ_j, $1 \le j \le 2M$, are the *positive* eigenvalues of $\boldsymbol{S}_p$ and $\boldsymbol{v}_j$, $1 \le j \le 2M$, are the corresponding eigenvectors. These *principle* eigenvectors span the signal subspace of $\boldsymbol{R}_p$ and are orthogonal to the remaining eigenvectors $\boldsymbol{v}_j$, $2M+1 \le j \le p+1$, which span the noise subspace of $\boldsymbol{R}_p$.

There is a summary of some math symbols and things in Appendix A.

5 Floating Bodies

Floating bodies are figures and tables. Their placement is one of the weaker points of LaTeX. It may happen — especially if you have large figures — that upon viewing the document you'll find this figure and all subsequent ones at the end of the document. Then, use the commands `\newpage` and `\clearpage`. The latter must place all floating objects that have not yet been included before going on.

5.1 Tables

Table 1 on page 6 shows an example. Please refer to the source file for explanations.

Table 1: Water conductivity results from well samples.

Well Point	σ	k
7	447	.7
11	86	4.31
30	1735	48.9
82	773	4.53
234	1850	2.031

5.2 Figures

You may just leave an empty space to tape in a figure (e.g. figure 1).

Figure 1: You see nothing but a blank space.

We've included an encapsulated postscript file (i.e. the postscript file must be surrounded by a 'bounding box') into this document (see Figure 2).

And in Figure 3 you have it twice with 2 cm horizontal distance between the figures (note the distortion). We left the space at the bottom of this page empty on purpose so that the following list would not be split onto two different pages.

Figure 2: You see an encapsulated postscript file.

Figure 3: Same postscript file after a few jugs of beer.

6 Lists

Here are some examples of numbering and listing things. The following is a proposed surveying timetable using a three person survey team:

- Day 1 (Baldwin Patrol Yard)
  1. Morning:
     - Set up survey grid (all available personnel).
  2. Afternoon:
     - EM (2 person team).
     - VLF (1 person).
- Day 2 (Baldwin Patrol Yard)
  - EM (2 person team).
  - VLF (1 person).
- Day 3 (Baldwin Patrol Yard)
  - EM (2 person team).
  - Magnetics (1 person).
- Day 4 (Gormley Sand and Gravel Pit)
  1. Morning:
     - Set up survey line (all available personnel).
     - VLF (1 person).
     - Magnetics (1 person).
     - Magnetics (1 person).
  2. Afternoon:
     - EM (1 person).
     - Gravity (1 person).
     - 3rd team member to assist where necessary.

Nested enumerations will give you numbers, lower case letters then lowercase roman numerals (good for making up tests and assignments!).

7 Listing References

Arfken, G., 1985. *Mathematical Methods for Physicists,* Academic Press Inc., San Diego.

Courtillot, V., J. Besse, 1987. Magnetic field reversals, polar wander, and core-mantle coupling, *Science,* **237**, 1140-1147.

Jeffreys, H., 1976. *The Earth,* Cambridge University Press, Cambridge.

Jones, G.M., 1977. Thermal interaction of the core and the mantle and long-term behaviour of the geomagnetic field, *J. Geophys. Res.,* **82**, 1703-1709.

8 Comments and Useful Commands

Comments in your file are marked by '%' at the beginning of the line. When compiling, LaTeX will skip these lines.

If you want to make a **footnote**[1]...

Often it is necessary to use the `\mbox` command. For one, it is necessary in Math mode to include text into the equation. In normal text it tells LaTeX not to divide the contents of the 'mbox'. E.g. this long german word ,,Donaudampfschiffahrtskapitänswhisyfaß" cannot be split because it is in an `\mbox{...}`.

The `\begin{minipage}[pos]{width}` lets you position figures or tables. Position is relative to the present line:

this text is sitting on the line and these words are hanging from the line but this 'minipage' is centered around the present line.

See also section § 5.2 where this command is used to allow centering of the figures.

To compile, type `latex` *filename* (commonly the file will have the extension tex). LaTeX now prepares several files:

- ♣ *file*.toc contains the section headings that are to appear in the table of contents
- ♢ *file*.aux contains labels and numbers of equations, figures etc.
- ♡ *file*.log contains all the error messages
- ♠ *file*.dvi is the print file

It is important to realize that LaTeX uses *file*.toc and *file*.aux created during the last run to develop the table of contents and the numbering of equations and figures during the present run. You have to run LaTeX twice to get the table of contents and references right. So, don't worry about some of the error messages you get on the first try.

As grad students we will have to write a thesis. To avoid LaTeX compiling the whole text every single time it is reasonable to split the text into smaller files (e.g. title.tex, chapter1.tex, chapter2.tex,...) and prepare a master file that looks like

[1] This is how you make a footnote!

declarations...

```
\includeonly{chapter2,chapter3}
\begin{document}
\include{title}
\include{chapter1}
\include{chapter2}
\include{chapter3}
\include{chapter4}
\end{document}
```

In the case shown only chapters 2 and 3 will be compiled. However, LaTeX will not restart numbering pages, sections, equations and is still able to refer to labels in other chapters. Note that the extension tex is omitted in the commands `include` and `includeonly` and that each `include` has LaTeX start a new page.

Fortunately, somebody (we're not sure who) decided that your thesis should have a certain title page and a certain line spacing and a certain list of figures and... Well, to make a long story short, lazy students and procrastinators take note, there is a command here on our Geophysics and Astronomy system that will basically do everything for you. Just type `get.thesis` and a new directory called *thesis* will be created and a bunch of files put in there. You'll get a couple of example chapter files, a title page file, bibliography file, etc. Just edit the text in these files and compile with `latex thesis`. All the gnitpicking details are taken care of for you!

9 Viewing and Printing a LaTeX File

Use 'xdvi *filename*.dvi' after running LaTeX to view the file. Use 'dvips *filename*.dvi' to print the document (for options of 'dvips' see appendix C).

A Miscellaneous Stuff

A.1 Special Characters

There are special characters which must be preceded by a backslash when you want them to appear in your text. They are:

{ } # $ % & ~ _

A.2 Style and Size

Styles:
\rm Roman, \it *Italic*, \sl *Slanted*, \bf **Bold Face**, \sf Sans Serif, \tt Typewriter, \sc Small Caps

Sizes:

tiny, scriptsize, footnotesize, small, normalsize, large, Large, LARGE, huge, Huge
To get this is scriptsize type {\scriptsize this is scriptsize}, etc.

Accents in text:
\'e = é , \`e = è , \^a = â , \c{c} = ç

A.3 Symbols in Math Mode

Greek letters:

α	\alpha	β	\beta	γ	\gamma	δ	\delta	ϵ	\epsilon
ε	\varepsilon	ζ	\zeta	η	\eta	θ	\theta	ϑ	\vartheta
ι	\iota	κ	\kappa	λ	\lambda	μ	\mu	ν	\nu
ξ	\xi	$\o$	o	π	\pi	ϖ	\varpi	ρ	\rho
ϱ	\varrho	σ	\sigma	ς	\varsigma	τ	\tau	υ	\upsilon
ϕ	\phi	φ	\varphi	χ	\chi	ψ	\psi	ω	\omega
Γ	\Gamma	Δ	\Delta	Θ	\Theta	Λ	\Lambda	Ξ	\Xi
Π	\Pi	Σ	\Sigma	Υ	\Upsilon	Φ	\Phi	Ψ	\Psi
Ω	\Omega								

A selection of math symbols:

$\perp$	\perp	$\|$	|	∇	\nabla	∂	\partial	∞	\infty
$\leq$	\le	$\ll$	\ll	$\geq$	\ge	$\gg$	\gg	$\approx$	\approx
$\pm$	\pm	$\times$	\times	$\odot$	\odot	$\oplus$	\oplus	$\otimes$	\otimes
$\angle$	\angle	$\triangle$	\triangle	$\Box$	\Box	$\circ$	\circ	$\bigcirc$	\bigcirc
$\Re$	\Re	$\Im$	\Im	$\mho$	\mho	$\leadsto$	\leadsto		
$\sum$	\sum	$\int$	\int	$\oint$	\oint	$\prod$	\prod		

$\rightarrow$	\rightarrow	$\longrightarrow$	\longrightarrow	$\Rightarrow$	\Rightarrow	$\Longrightarrow$	\Longrightarrow
$\leftarrow$	\leftarrow	$\leftrightarrow$	\leftrightarrow	etc.			

Accents in mathmode:

$\hat{a}$	\hat{a}	$\breve{a}$	\breve{a}	$\grave{a}$	\grave{a}	$\bar{a}$	\bar{a}	$\dot{a}$	\dot{a}
$\vec{a}$	\vec{a}	$\check{a}$	\check{a}	$\acute{a}$	\acute{a}	$\tilde{a}$	\tilde{a}	$\ddot{a}$	\ddot{a}

Function names which are to be printed normally:
\cos gives cos and similarly arccos, arcsin, arctan, arg, cos, cosh, cot, coth, deg, det, exp, lim, ln, log, max, min, sec, sin, sinh, tan, tanh.

B Including Figures from GNUPLOT

For those familiar with `gnuplot`, you can include your plots in a LaTeX document quickly and easily. Plus you can use the usual math mode commands and symbols in your axis labels. An advantage of this choice is that these plots will be included in the `dvi` file. Figure 4 shows an example.

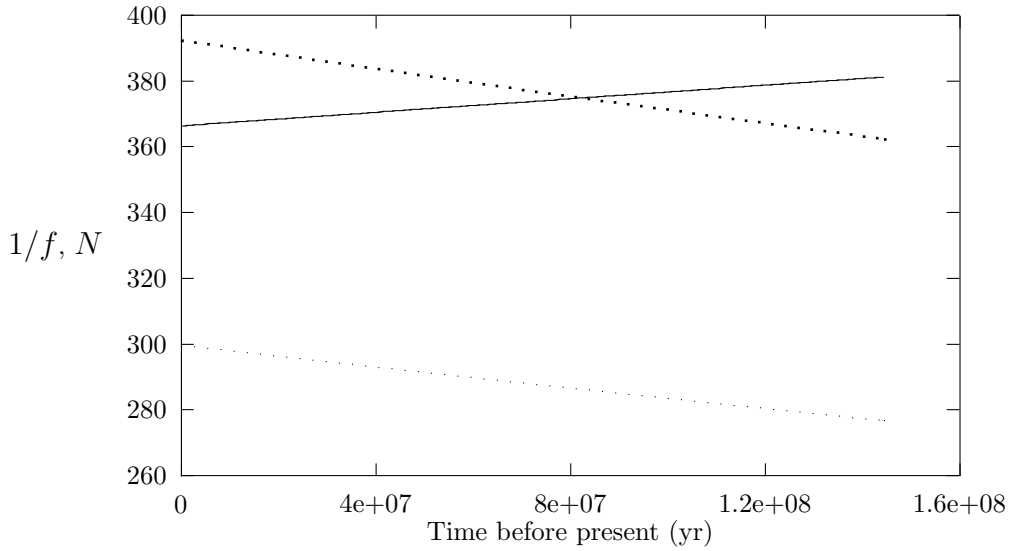

Figure 4: Example from GNUPLOT. Include some explanation of the different lines, since the GNUPLOT key is kind of ugly.

Here is the `gnuplot` script that generated the figure:

```
set term latex
set output 'gnufig.tex'
set nokey
set xlabel 'Time before present (yr)'
set xrange [0:1.6e+08]
set xtics 0,4e+07,1.6e+08
set ylabel '$1/f$, $N \;\;\;$'
plot 'prog.out' using 1:3 w lines 4
replot 'prog.out' using 1:5 w lines 2
replot 'prog.out' using 1:7 w lines 1
```

C Calling dvips

To print a dvi-file use '`dvips` *filename*`.dvi` *options*'. Some options that may be used are:

command	purpose	default
`-p`*n*	start printout with page *n* *	first page
`-n`*n*	print *n* number of pages	100.000 pages
`-l`*n*	end printout with page *n* *	last page
`-c`*n*	prints *n* copies of each page	1 copy per page
`-C`*n*	prints *n* copies of the entire document	1 copy
`-o`	produces a postscript file	output is *filename*`.ps`

Note *: Beware that the pagenumber is the one given by LaTeX. This number may not coincide with the number printed on the page.

To print the entire document '`hello`' on 'mort' (300 dpi laserprinter in room 223) simply use the command '`dvips hello.dvi`'.

'`dvips hello.dvi -p16 -n4 -c2`' prints four pages of the document `hello` starting on page sixteen and hands out two copies per page.

If you have incorporated encapsulated postscript files and want to preview the document with the figures you need to convert to postscript by typing

`dvips` *filename*`.dvi -o`

The command `xdvi` will only show blank spaces where the figures are to be set. Use 'Ghostview' to view text and figures as they would occur on the printed pages.