Exercises for LaTeX
Statistics 2006

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Contents

1 Introduction

Today we will be looking at LaTeX, a typesetting system which is very suitable for producing scientific and mathematical documents of high typographic quality. LaTeX is based on TeX, a computer language designed for use in mathematical typesetting. It is a markup language, like HTML (the code used to produce web pages), rather than a WYSIWYG (**W**hat **Y**ou **S**ee **I**s **W**hat **Y**ou **G**et) wordprocessor like Microsoft Word.

It is straightforward to include graphs in these documents. It is also easy to produce a table of contents and list of figures at the beginning of a LaTeX document, relatively easy to create a bibliography and possible to create an index. Many aspects of document production are automated, such as section numbering. Mathematical formulae are simple to typeset and reference. There are also standard dissertation title pages available. This document was edited using `emacs` and typeset in LaTeX.

You should have copies of the following

- The Not So Short Introduction to LaTeX 2_ε. This is a fairly brief introduction to LaTeX and should cover all that you need.
- LaTeX Exercises. A selection of these exercises will be done during the class. [This document]
- Answers to LaTeX Exercises. These will be handed out at the end of the class.
- Special Characters. A comprehensive list of all special characters and how to typeset them.

As well as doing the exercises we will look at producing documents containing graphs, how to spell check your documents, and economical ways to print. If there is time we will look at creating bibliographies using BibTeX.

2 Emacs

[These instructions are for Windows users. Let me know if you are using Linux.]

We will be using the `emacs` editor for creating and editing files. There are other ways of using LaTeX and TeX but `emacs` is freely available and is commonly found on many different platforms. `emacs` is a powerful text editor with many configuration options.

To start `emacs` use Start → All Programs → GNU Emacs from N→ Emacs. A command prompt window will appear briefly and then disappear and then a window like Figure 1 should open.

Let's have a closer look at this window. There is a menu bar at the top of the window with options such as File, Edit and Help. The menus are context dependent and so will change depending on what you are using `emacs` for. The Help menu includes an `emacs` tutorial and FAQ. For the very keen, the Options menu allows you to customize `emacs`. For now, we will concentrate on loading and editing LaTeX files and then compiling, viewing and printing them.

You now need to download three files for use during this practical. Browse to `http://www.stats.ox.ac.uk/people/hutchins/latex/` and save the three files `small.tex`, `plot.ps` and `test.bib` on your P: drive. Make sure the test.bib file is really called `test.bib` and not `test_bib.txt`.

To be really organised you could create a new folder to keep them in.

To load a file

- click on the File menu

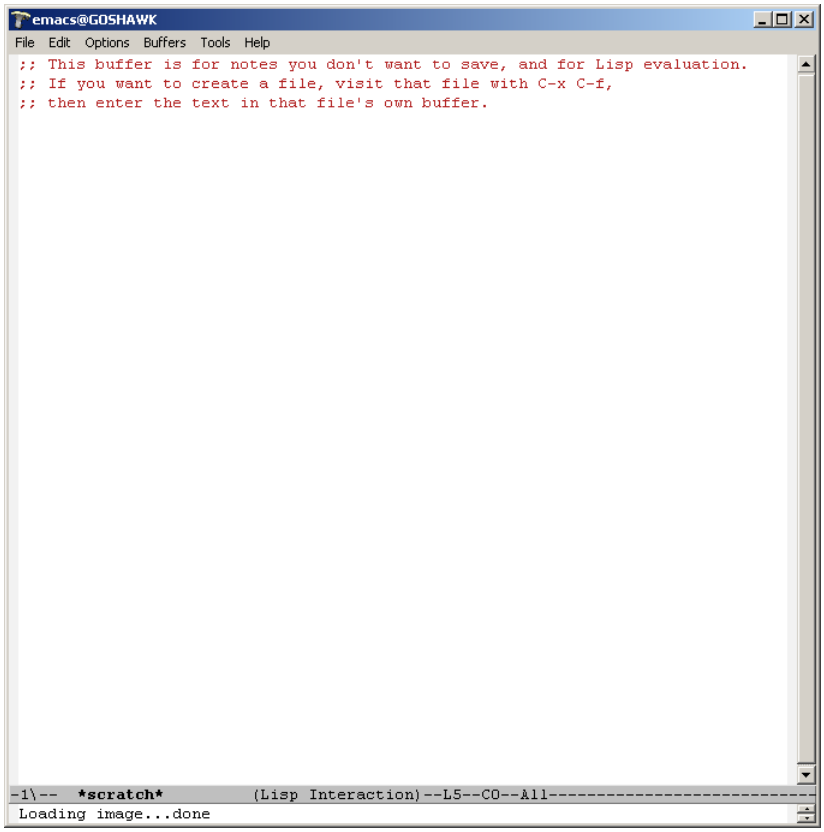


Figure 1: The emacs start up window

- select Open File... A list of files and folders on your `P:` drive should appear.
- Find the file `small.tex` which you should select and Open.

3 LaTeX

The `emacs` window should now look something like Figure 2. Note that some of the text on the screen (not on this printed page!) is highlighted in different colours. This is because `emacs` recognises the structure of different languages. It also makes finding syntax errors more straightforward.

Let's look at some of the significant lines in the file.

```
\documentclass[12pt,a4paper]{article}
```

All LaTeX files begin with a

```
\documentclass
```

declaration. The two options contained in [...] specify the default font size and paper size. The final statement

```
{article}
```

describes the document's class. Conventionally `article` is used for shorter documents, `report` for longer dissertations. Other options include `book` and `letter`. Note that everything that appears on a line after a % is a comment and is ignored.

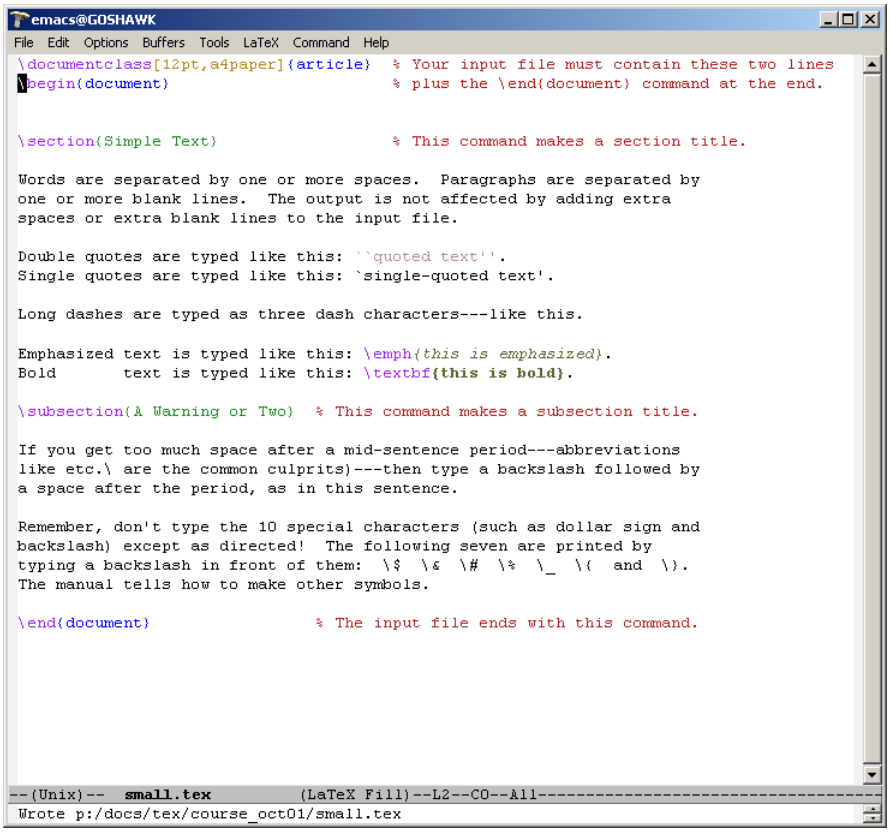


Figure 2: A small LaTeX file

The syntax of LaTeX commands is consistent — a command begins with a \, is altered by options contained in [...] and is defined by what's contained within {...}.

The main body of a document – that is the information that you want people to read – begins with

```
\begin{document}
```

and is always ended by

```
\end{document}
```

The information has been broken up into sections with the commands

```
\section{Simple Text}
```

and

```
\subsection{A Warning or Two}
```

When the file is compiled these will be numbered automatically. Various formatting commands are embedded within the text. For example `\emph` is used to *italicise* text and `\textbf` for **bold** text. Note that these formatting changes are also displayed in your `emacs` window.

Compiling LaTeX files

Once you have a file containing LaTeX commands it should be compiled. Using the Command menu select LaTeX Interactive. The window should split in two, with the bottom half displaying the progress of the compilation. If you haven't altered the original file, it should compile without errors. See Figure 3 for an example.

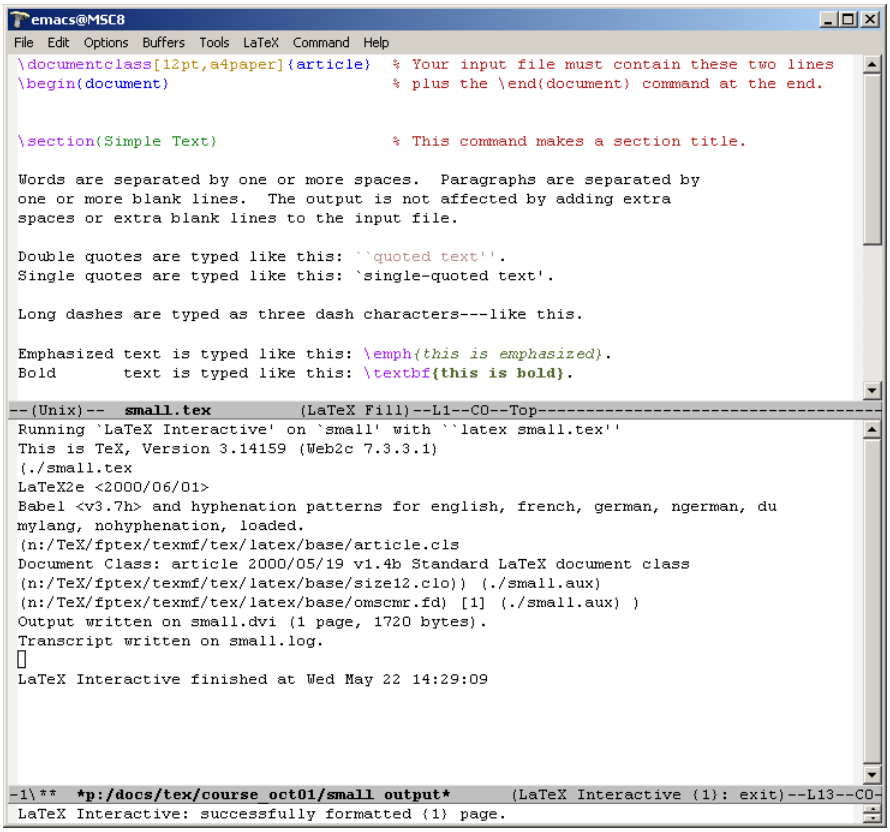


Figure 3: A successful LaTeX compilation

The bottom window can be closed by clicking in the top window, and selecting Unsplit Windows from the File menu. If you prefer not to see the progress of the LaTeX compilation, then use LaTeX from the Command menu instead of LaTeX Interactive.

A small digression on debugging. When LaTeX finds errors it shows a line number near where it thinks the error has occurred. If you look at the `emacs` window, the grey line which contains the name of the file you are editing also contains a line number and column position of the cursor. Move the cursor and left click to see the line and column numbers change. Use this information to help you find the error.

The compiled file can be displayed by selecting WinDvi on the Command menu. A new window should open which looks similar to Figure 4. It should show a formatted version of the file.

4 Exercises

4.1 A simple example

▷ Exercise 1 We are now going to input, compile and view a simple file. Open new emacs window and enter these lines into a file called `new.tex`. It is *very* important that the file has a `.tex` suffix.

```
\documentclass{article}
\begin{document}
\section{Introduction}
Hello there.

Goodbye now.
```

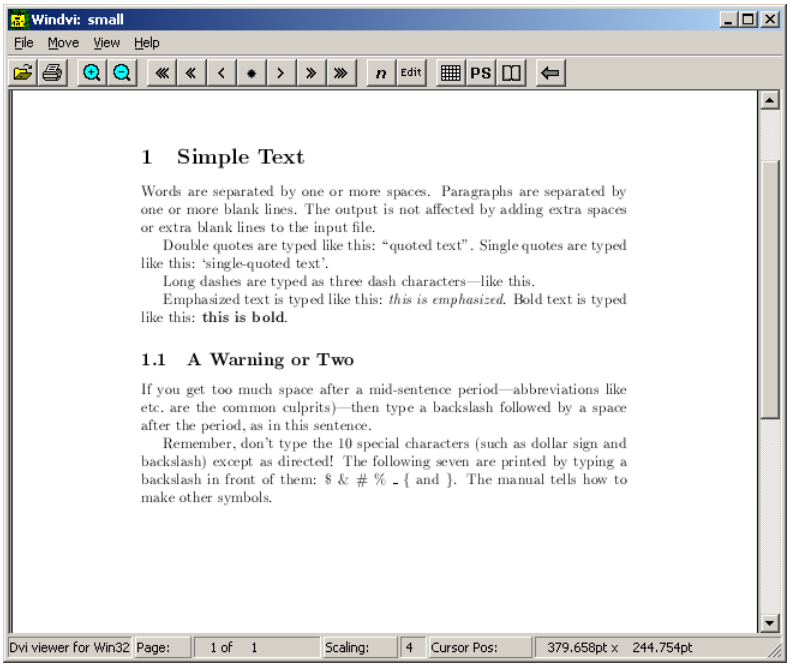


Figure 4: The preview window

```
\end{document}
```

Save the file. Then run Command -> LaTeX Interactive and Command -> WinDvi to compile and view the file.

Now change the file so that it contains a mistake – perhaps by leaving out a closing }. Now compile the file again and see what happens. Depending on the error you have introduced you may see something like this:

```
Runaway argument?
{document Hello there.
! Paragraph ended before \begin was complete.
<to be read again>
                                \par
l.4
```

Type X to quit. In general if a your latex compilation is stuck typing X or Control-C will force it to quit.

4.2 A longer document

▷ Exercise 2 Now load `small.tex` into `emacs` again. We are going to make some changes this file.

1. Change documentclass from article to report and then to book. You might want to include `\chapter{Introduction}` immediately after `\begin{document}`
2. Change the documentclass option `12pt` to `11pt`
3. Add `\usepackage{parskip}` to the preamble. How does the paragraph formatting change?
4. Add `\usepackage{times}` to the preamble. The font should now look different.
5. Add `\usepackage{color}`, then make some of the text red using `\textcolor{red}{some text}`. Change the color from red to green.

6. Swap the emphasised and bold text.

IMPORTANT The WinDvi window automatically refreshes whenever your `.tex` file is recompiled. You do not need to open a new one each time.

4.3 Typesetting Text

▷ Exercise 3 We will now typeset some simple sentences. You should have a copy of "The Not So Short Introduction to LaTeX2e" in the room which we will be using for reference for the rest of these exercises. See chapter 2 "Typesetting Text". You should also have a short document called "Helpful Hints" which contains instructions on how to typeset many characaters.

Start a new section in the document. Typeset the following:

> I entered the room and—horrors—I saw both my father-in-law and my mother-in-law.
>
> The winter of 1484–1485 was one of discontent.
>
> Frank wondered, "Is this a girl that can't say 'No!'?"
>
> Does Æschylus understand Œdipus?
>
> They took some honey and plenty of money wrapped up in a £5 note.
>
> Élèves, refusez vos leçons! Jetez vos chaînes!
>
> Can you take a ferry from Öland to Åland?

There are several features of LaTeX that evident here.

hyphens Have you noticed that there are different lengths of hyphen? For example in the first sentence both — and - are used. These are typeset using `---` and `-` respectively.

quotes When typesetting speech make sure that you use `''` and `''` to produce open and close quotation marks. The `'` character is usually found at the top lefthand side of the keyboard.

accents The Helpful Hints document should help with these.

pounds To typset the £ symbol use `\pounds`.

Finally, it can seem difficult to decide whether to put a space after a LaTeX command or not. A general rule is that if the command is a single non-alphanumeric then a space is not needed otherwise it is. For example to typset naïve you need `na\"\i ve`. In this case `\"` puts a double dot (or diaeresis) over the letter "i" and `\i` prints an "i" without a dot like this: ı.

▷ Exercise 4 Give your document a title. You will need to include

```
\title{Your title}
\author{Your name}
\date{A date}
\maketitle
```

immediately after the `\begin{document}`. To add a table of contents use `\tableofcontents` after the title. Note that you will need to rerun `latex` twice in order for entries in the table of contents to be displayed.

▷ Exercise 5 Lists. Using the `itemize`, `enumerate` and `description` environments typeset the following

1. You can mix list environments as much as you like
   - But it might start to look silly
   - With different symbols
2. So do remember

   Stupid things will not become smart because they are in a list.

   Smart things, though, can be presented beautifully in a list.

[See section 2.11.1 of "The Not So Short Introduction to LaTeX2e" for more information about lists.]

▷ Exercise 6 Typeset the following table

Vegetable Production

Vegetable	Comments	Weight
Carrots	Good early crop, then carrot fly.	7kg
Lettuce	Slow to start, then bolted.	1kg
French beans	Excellent.	12kg

▷ Exercise 7 If you have time, try this more complicated table.

Currencies 1 Jan 2001

London:	New York:
£: $ 1.8672	£: $ 1.8655
£: DM 2.8369	$: DM 1.5175
£: FFr 9.69080	$: FFr 5.1845

[See section 2.11.6 for information about tables.]

4.4 Mathematics

If you will be needing to typeset mathematical formulae then try as many of these exercises as possible. I will be handing out answers at the end of the class.

There are several different ways of typesetting formulae. They can appear "inline" – that is within a paragraph – like this: $C(n,r) = n!/(r!\,(n-r)$ or separately like this:

$$C(n,r) = n!/(r!\,(n-r)!)$$

so the paragraph is broken up. Chapter 3 of "The Not So Short Introduction to LaTeX2e" describes the different ways displaying mathematics. The Helpful Hints document will also be useful for these exercises.

▷ Exercise 8 Typeset the following: $C(n,r) = n!/(r!\,(n-r)!)$. Note the spacing in the denominator.

▷ Exercise 9 Typeset the equation $a + b = c - d = xy = w/z$ as in-line and displayed mathematical text.

▷ Exercise 10 Typeset the equation $(fg)' = f'g + fg'$ as in-line and displayed mathematical text.

▷ Exercise 11 Typeset $\alpha\beta = \gamma + \delta$ as in-line and displayed mathematical text.

▷ Exercise 12 Typeset $\Gamma(n) = (n-1)!$ as in-line and displayed mathematical text.

▷ Exercise 13 Typeset: $x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$.

▷ Exercise 14 Typeset: $2 + 4 + 6 + \cdots + 2n = n(n+1)$.

▷ Exercise 15 Typeset: $\vec{x} \cdot \vec{y} = 0$ if and only if $\vec{x} \perp \vec{y}$.

▷ Exercise 16 Typeset: $\vec{x} \cdot \vec{y} \neq 0$ if and only if $\vec{x} \not\perp \vec{y}$.

▷ Exercise 17 Typeset: $(\forall x \in \mathbb{R})(\exists y \in \mathbb{R})$ such that $y > x$.

▷ Exercise 18 Typeset the following: $\frac{a+b}{c}$ $\frac{a}{b+c}$ $\frac{1}{a+b+c} \neq \frac{1}{a} + \frac{1}{b} + \frac{1}{c}$.

▷ Exercise 19 Typeset: What are the points where $\frac{\partial}{\partial x} f(x,y) = \frac{\partial}{\partial y} f(x,y) = 0$?

▷ Exercise 20 Typeset each of the following: e^x e^{-x} $e^{i\pi} + 1 = 0$ x_0 x_0^2 ${x_0}^2$ 2^{x^x}.

▷ Exercise 21 Typeset: $\nabla^2 f(x,y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$.

▷ Exercise 22 Typeset the following expression: $\lim_{x \to 0}(1+x)^{\frac{1}{x}} = e$.

▷ Exercise 23 Typeset: The cardinality of $(-\infty, \infty)$ is $\aleph_1$.

▷ Exercise 24 Typeset: $\lim_{x \to 0^+} x^x = 1$.

Here is a hint to make integrals look a little nicer: look at the difference between $\int_0^x f(t)\mathrm{d}t$ and $\int_0^x f(t)\,\mathrm{d}t$. In the second case there is a little extra space after $f(t)$, and it looks nicer; `\,` was used to add the additional space.

▷ Exercise 25 Typeset the following integral: $\int_0^1 3x^2\,\mathrm{d}x = 1$.

▷ Exercise 26 Typeset the following: $\sqrt{2}$ $\sqrt{\frac{x+y}{x-y}}$ $\sqrt[3]{10}$ $e^{\sqrt{x}}$.

▷ Exercise 27 Typeset: $\|x\| = \sqrt{x \cdot x}$.

▷ Exercise 28 Typeset: $\phi(t) = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-x^2/2}\,\mathrm{d}x$.

▷ Exercise 29 Typeset the following: $\underline{x}$ $\overline{y}$ $\overline{\underline{x+y}}$.

▷ Exercise 30 Typeset $\lceil \lfloor x \rfloor \rceil \leq \lfloor \lceil x \rceil \rfloor$.

▷ Exercise 31 Typeset: $\sin(2\theta) = 2\sin\theta\cos\theta \quad \cos(2\theta) = 2\cos^2\theta - 1$.

▷ Exercise 32 Typeset:

$$\int \csc^2 x \, \mathrm{d}x = -\cot x + C \qquad \lim_{\alpha \to 0} \frac{\sin\alpha}{\alpha} = 1 \qquad \lim_{\alpha \to \infty} \frac{\sin\alpha}{\alpha} = 0.$$

▷ Exercise 33 Typeset:

$$\tan(2\theta) = \frac{2\tan\theta}{1 - \tan^2\theta}.$$

▷ Exercise 34 Typeset:

$$\begin{bmatrix} aa & \cdots & az \\ \vdots & \ddots & \vdots \\ za & \cdots & zz \end{bmatrix}$$

▷ Exercise 35 Typeset:
A random variable Y has density

$$f(y;\theta,\phi) = \exp\left\{\frac{y\theta - b(\theta)}{a\phi} + c(y;\phi)\right\}$$

and its moment-generating function is $M(t) = \exp[\{b(\theta + ta\phi) - b(\theta)\}/(a\phi)]$.

▷ Exercise 36 Typeset: If Y_{rc}, $r = 1, \ldots, R$, $c = 1, \ldots, C$ are random variables, show that

$$\sum_{r,c}(Y_{rc} - \overline{Y}_{..})^2 = \sum_{r,c}(\overline{Y}_{r.} - \overline{Y}_{..})^2 + \sum_{r,c}(\overline{Y}_{.c} - \overline{Y}_{..})^2 + \sum_{r,c}(Y_{rc} - \overline{Y}_{.c} - \overline{Y}_{r.} + \overline{Y}_{..})^2. \qquad (1)$$

▷ Exercise 37 Typeset:

$$f(x_i \,|\, \lambda_i) = \lambda_i e^{-\lambda_i x_i}, \qquad f(y_i \,|\, \lambda_i, \psi) = \lambda_i \psi e^{-\lambda_i \psi y_i}, \qquad x_i, y_i \geq 0.$$

▷ Exercise 38 Typeset:

$$\frac{\partial G}{\partial t} = \lambda s(s-1)\frac{\partial G}{\partial s}.$$

▷ Exercise 39 Typeset:

1. Generate independent uniforms U and U_1.
2. Set $\begin{cases} X = 1/(4U-1), V = U_1/X^2 & \text{if } U < 0.5, \\ X = 4U - 3, V = U_1 & \text{otherwise.} \end{cases}$
3. If $V < 1 - 0.5|X|$ go to 5.
4. If $V \geq (1 + X^2/\nu)^{-(\nu+1)/2}$ go to 1.
5. Return X.

▷ Exercise 40 Typeset:

$$h_i(t) = \lim_{\epsilon \to 0} \frac{1}{\epsilon} \frac{\mathsf{P}(t < T_i \leqslant t + \epsilon)}{\mathsf{P}(T_i > t)}.$$

▷ Exercise 41 Cross references. Create a reference to your first section using `\ref` and `\label` commands. See section 2.8 of "The Not So Short Introduction to LaTeX 2_ε" for details.

5 Including graphs in LaTeX documents

First a graph needs to be saved in the correct format. There are two different conventions for graphics files.

postscript Use latex and dvips to compile and print files.

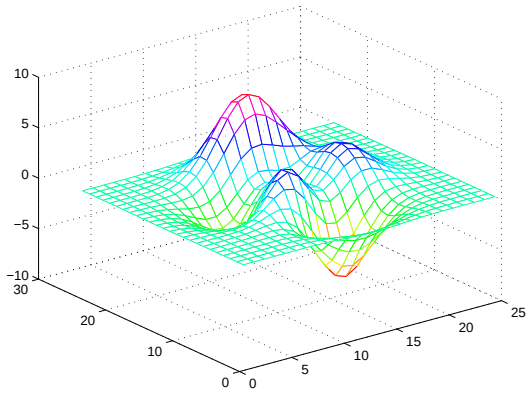
jpg, pdf or png Use pdflatex to compile and print files.

In the following example we will use a postscript graph. Now you need to include the `plot.ps` file in your LaTeX document. Add the following line to the preamble of your LaTeX file, that is between the `\documentclass...` and the `\begin{document}`.

```
\usepackage{graphicx}
```

To include the graph found in the file, `plot.ps` insert the line

```
{\includegraphics[scale=.5]{plot.ps}}
```



where in the text you would like the graph to appear.

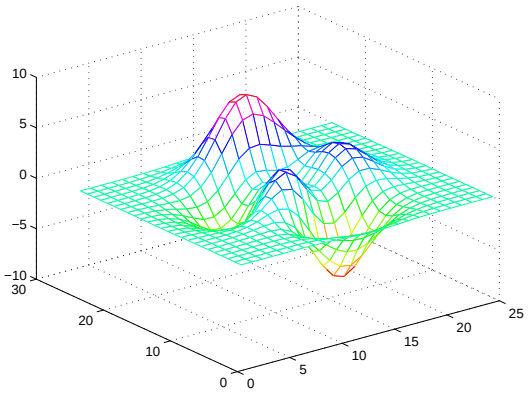
Note that I have included `[scale=.5]` which scales the graph by 50%. This is often useful because the standard size produced by some applications is rather large.

If when you use WinDvi to view a file, you only see an outline of the graph then try clicking on PS on the line just below the menus. If this doesn't solve the problem then run Dvips and GSview and the graphs should appear in the PostScript version of the file. This will need to be opened separately.

The basic method can be developed. You can centre the graph on the page with the following commands

```
\begin{figure}[ht]
\centering
{\includegraphics[scale=.5]{plot.ps}}
\end{figure}
```

```
\begin{figure}[ht]
\centering
{\includegraphics[scale=.4]{plot.ps}}
```




```
\caption{A centred graph with a caption.}
\end{figure}
```

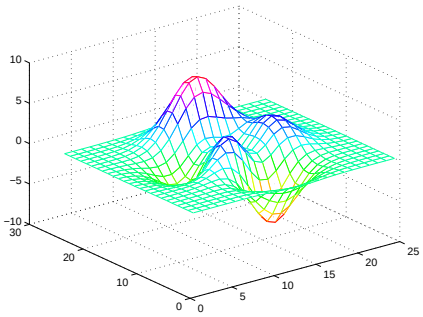


Figure 5: A centred graph with a caption.

There are many more options. Graphs can be rotated using `[angle=n]` where `n` is the angle of rotation. To include two graphs next to each other you need

```
\begin{figure}[ht]
\begin{center}
\includegraphics[scale=.4,width=5cm]{plot.ps}
\hspace{1cm}
\includegraphics[scale=.4,width=5cm]{plot.ps}
\caption{Two figures next to each other}
\end{center}
\end{figure}
```

which produces the following output

To produce two figures next to each other with separate captions use

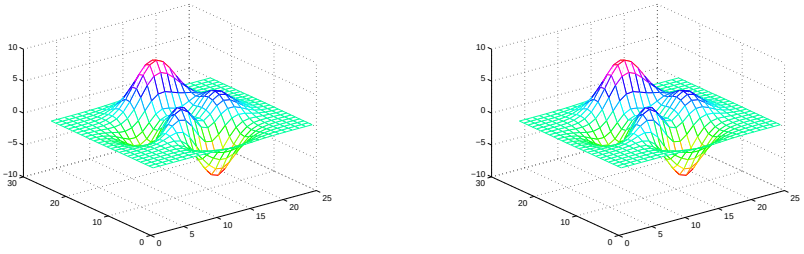


Figure 6: Two figures next to each other

```
\begin{figure}[ht]
\begin{center}
\begin{minipage}[b]{.5\textwidth}
\centering
\includegraphics[scale=.4,width=6.5cm]{plot.ps}
\caption{Graph on the left}
\end{minipage}%
\begin{minipage}[b]{.5\textwidth}
\centering
\includegraphics[scale=.4,width=6.5cm]{plot.ps}
\caption{Graph on the right}
\end{minipage}%
\end{center}
\end{figure}
```

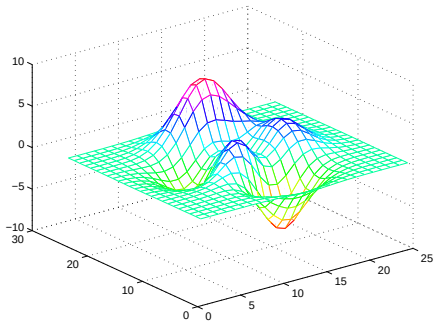


Figure 7: Graph on the left

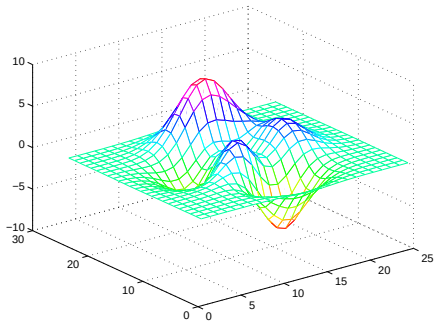


Figure 8: Graph on the right

You may have to experiment with the various `scale` and `width` options. Using `minipage` gives you much more flexibility.

▷ Exercise 42 A simple bibliography.

In the preamble include `\usepackage{natbib}`. This uses both author–year and numerical citations. At the end of the `.tex` file, just before `\end{document}` add

```
\bibliographystyle{plainnat}
\bibliography{test}
```

Here are a few example citations.

Using `\cite{Austen.09}` produces Austen [1809].

Using `\citep{Austen.09}` produces [Austen, 1809].

Using `\cite{Rumel.ZZ.86}` produces Rummelhart et al. [1986].

Using `\citep{Rumel.ZZ.86}` produces [Rummelhart et al., 1986].

Using`\citet*{Rumel.ZZ.86}` produces Rummelhart, Hinton, and Williams [1986].

Using `\citep*{Rumel.ZZ.86}` produces [Rummelhart, Hinton, and Williams, 1986].

Note that the variations of `\cite` produce slightly different versions of a reference.

To process a document containing citations you should run

```
latex
bibtex
latex
latex
```

at least! If a `.bib` file has citations in the citations, then a further run of `bibtex` and two more of `latex` are needed.

Finally adding `\addcontentsline{toc}{section}{\numberline{}\refname}` to the end of the file will ensure that "References" or "Bibliography" appears in the table of contents as it does in this document.

6 Acknowledgements

I would like to thank Professor Brian Ripley for permission to use material from exercises he devised for the Department of Statistics as part of an introductory LaTeX course.

7 Going Further

Some books that may be useful are

- Leslie Lamport: LaTeX, *A document preparation system*, 2nd edition, Addison-Wesley, (Reading, Massachusetts, 1994)
- Michel Goossens, Frank Mittelbach and Alexander Samarin: *The LaTeX Companion*, Addison-Wesley, (Reading, Massachusetts, 1994)
- Michel Goossens, Frank Mittelbach and Sebastian Rahtz: *The LaTeX Graphics Companion*, Addison-Wesley, (Reading, Massachusetts, 1997)
- Helmut Kopka and Patrick Daly: *A Guide to LaTeX*, Addison Wesley, 3rd Edition 1999

References

J. Austen. *Pride and Prejudice.* William Collins, Edinburgh, 5 edition, 1809.

D. E. Rummelhart, G. E. Hinton, and R. J. Williams. Learning Representations by Backpropagating Errors. *Nature*, 323:533–536, 1986. [Reprinted in Anderson and Rosenfeld (1988)].