Introduction to LaTeX for Statistics 2007

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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, plots and pictures 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 and equation numbering. Mathematical formulae are simple to typeset and reference. There are also standard dissertation title pages available. This document was edited using TeXnicCenterand typeset in LaTeX.

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   TeXnicCenter

We will be using TeXnicCenter to create, edit, compile and view LaTeX files. To start TeXnicCenter go to Start ▶ All Programs ▶ TeXnicCenter. A window like this should appear:
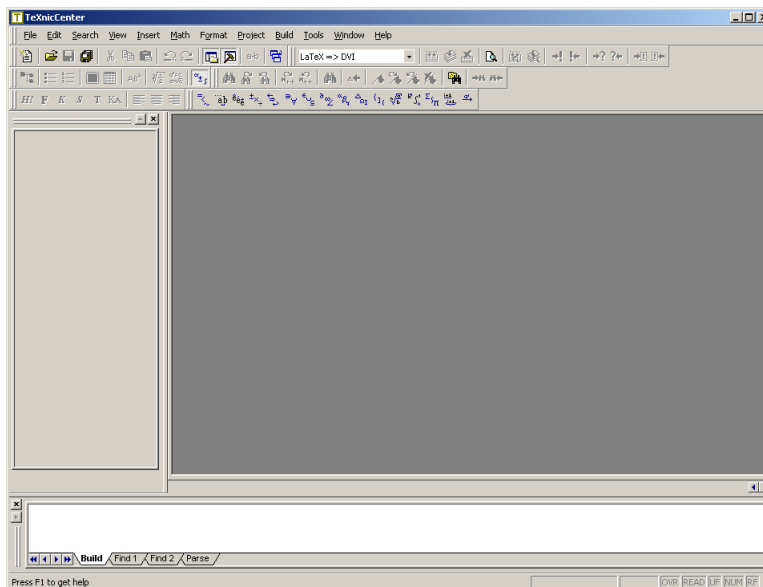

Figure 1: TeXnicCenter: Start–up screen

The first time you run TEXnicCenter you will need to do a little setting up.
See `www.stats.ox.ac.uk/about_us/it_information/restrictedaccess/using_latex/` and click on the link in the ''Configuring TeXnicCenter' section for details.

Take a little time to explore TEXnicCenter. There are three large windows. The one on the left can be closed as we won't be needing it today. Click on the X. Your screen should now look like this.
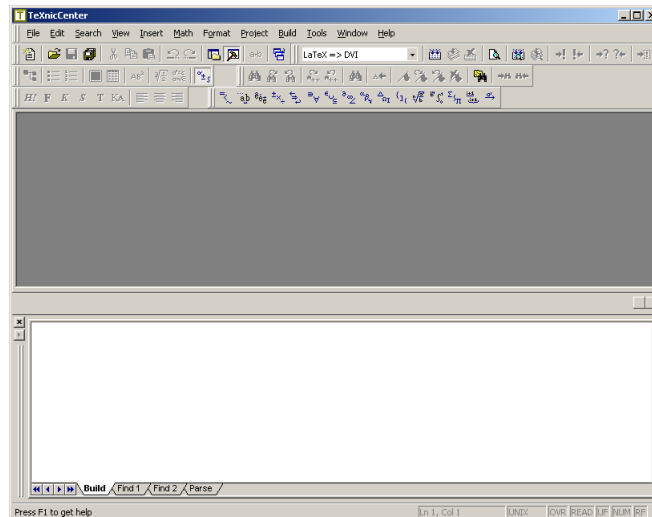
Figure 2: TEXnicCenter: editing and error screen

Find the Output Profile drop down menu box. See what options there are.

Find the following buttons:

- Build and view current file (Ctrl+Shift+F5)
- Build Output (F7)
- Build current file (Ctrl+F7)
- View Output (F5)
- Find (Ctrl+F)
- Replace (Ctrl+H)

These buttons are used for creating and viewing LATEX files. Most of the other buttons are used for typesetting. See if you can find some of these:

- **Bold**
- *Slanted*
- Align left
- Itemization

- Equation array

- Footnote

Now you have explored the TEXnicCenter it is time to start using LATEX.

Please download these three files for use during this practical. Browse to http://www.stats.ox.ac.uk/people/support_staff/srh/latex/ and save the three files small.tex, plot.eps and test.bib in your home folder. To be really organised you could create a new folder to keep them in.

3   LATEX

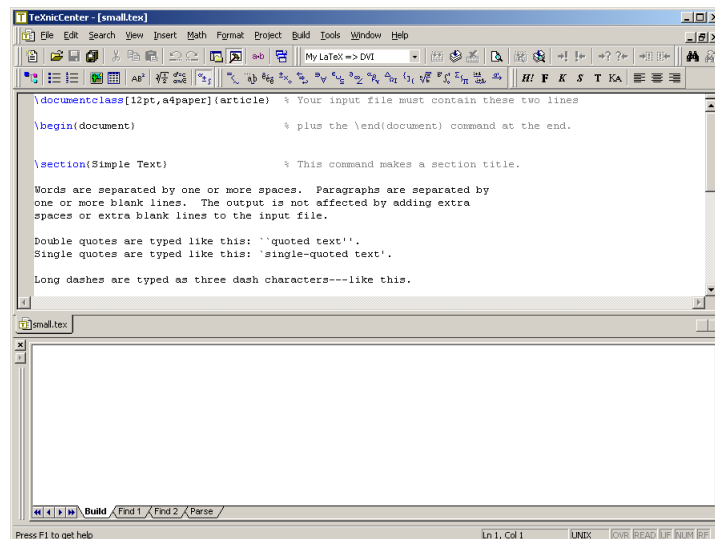Go to File − > Open. . . and open small.tex. You should see a screen like this: Note that some of the text

Figure 3: TEXnicCenter
: Opening an example file.

on the screen (not on this printed page!) is highlighted in different colours. This to help you find errors quickly.

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.

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 divided into sections with the commands

`\section{Simple Text}`

and

`\subsection{A Warning or Two}`

When the file is compiled these sections and subsections 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.

Compiling LaTeX files
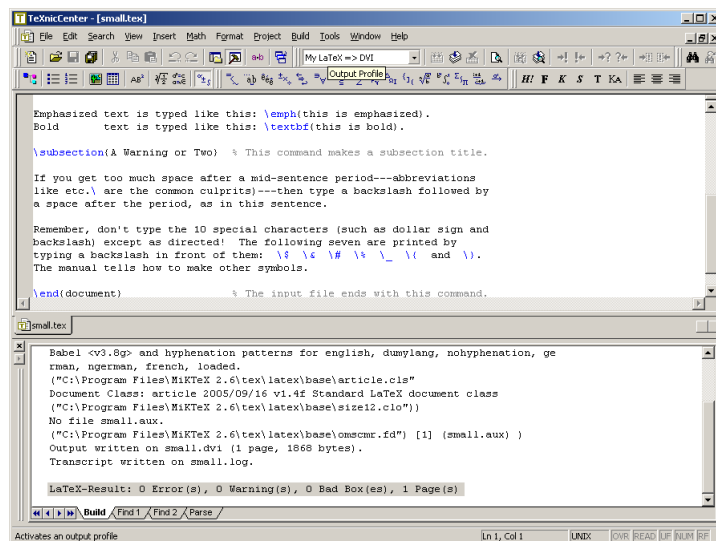

Figure 4: A successful LaTeX compilation

Once you have a file containing LaTeX commands it should be compiled. To compile your file click on the Build current file (F7) button. See Figure 4 for an example.

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 bottom of the TeXnicCenter screen 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.

4

To look at the compiled version of the file click on the View Output (F5). A new window should open which looks similar to Figure 5. It should show a formatted version of the file.
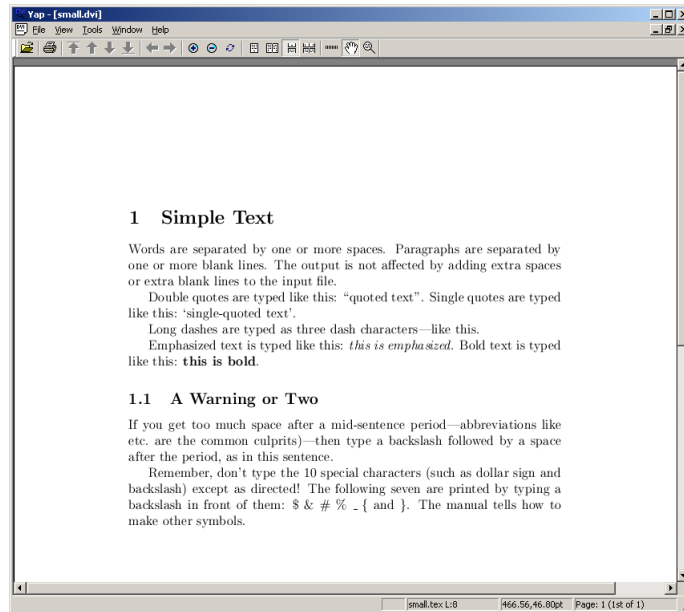

Figure 5: The preview window

4   Exercises

4.1   A simple example

▷ Exercise 1   We are now going to input, compile and view a simple file. Use File − > New. . . and enter these lines

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

Goodbye now.
\end{document}
```

in the editing window. Use the File − > Save As. . . menu to save the file as `new.tex`. It is *very* important that the file has a `.tex` suffix.

Click on the Build and view current file button. You should see a compiled version of the file.

Now change the file so that it contains a mistake – perhaps by replacing 'section' by 'sektion' or 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:

```
! Undefined control sequence.
l.3 \sektion
           {Introduction}
```

or like this:

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

Can you see the red button in the lower window? This indicates that there is an error. Find the Next Error button and click on that. A red arrow should now point to the place where the error occured.
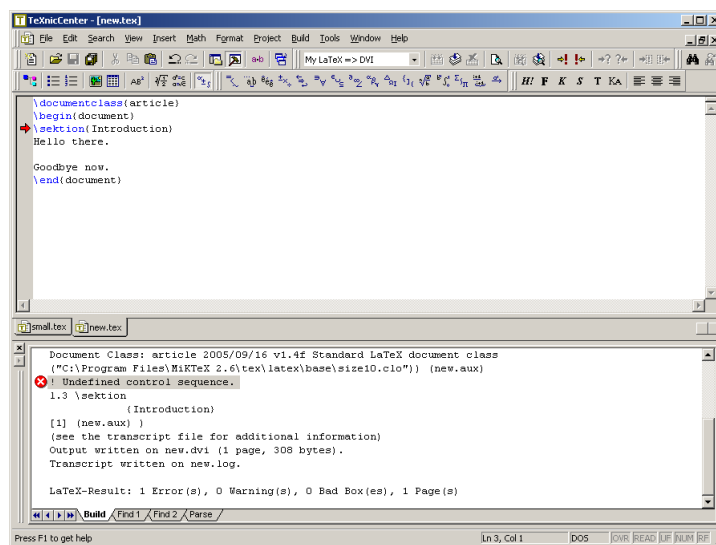

Figure 6: T_EXnicCenter: Locating errors

4.2 A longer document

▷ Exercise 2   Now load `small.tex` into T_EXnicCenter 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: $\underline{x}$ $\overline{y}$ $\overline{x + y}$.

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

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

▷ 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:

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

▷ 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:

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

4.5   Cross references

▷ 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 2ε" 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.

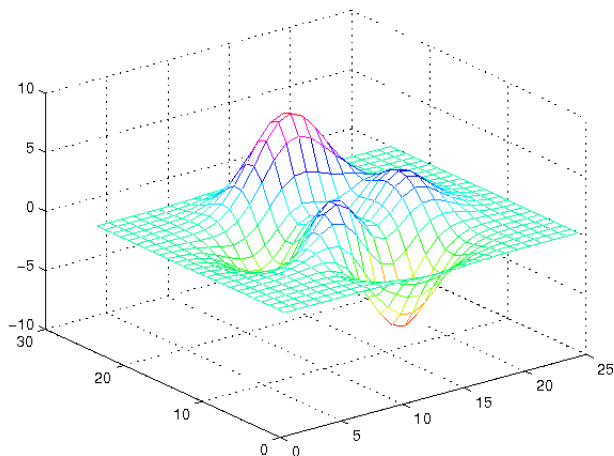**postscript** Use latex and dvips to compile and print files.

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.png` 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.png` insert the line

`{\includegraphics[scale=.4,angle=270]{plot.png}}` where in the text you would like the
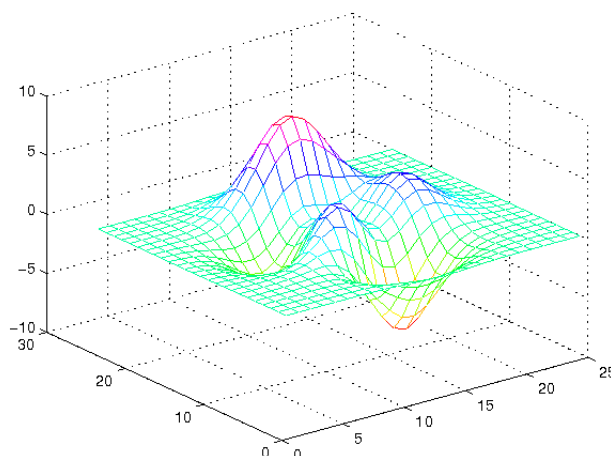

graph to appear.

Note that I have included `[scale=.4]` which scales the graph by 80%. 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=.4,angle=270]{plot.png}}
\end{figure}
```



```
\begin{figure}[ht]
\centering
{\includegraphics[scale=.4,angle=270]{plot.png}}
\caption{A centred graph with a caption.}
\end{figure}
```

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,angle=270,width=5cm]{plot.png}
```
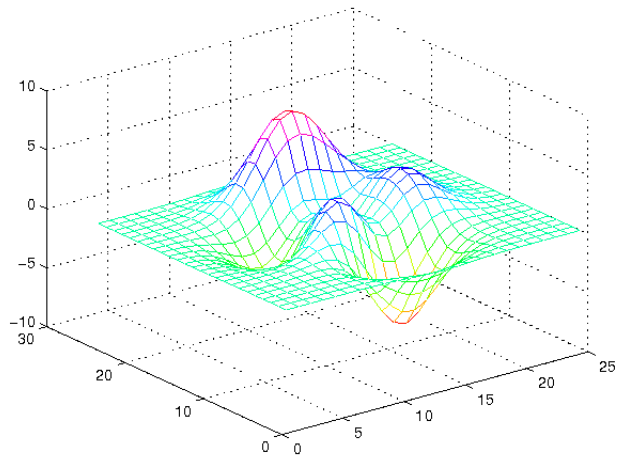
Figure 7: A centred graph with a caption.

```
\hspace{1cm}
\includegraphics[scale=.4,angle=270,width=5cm]{plot.png}
\caption{Two figures next to each other}
\end{center}
\end{figure}
```
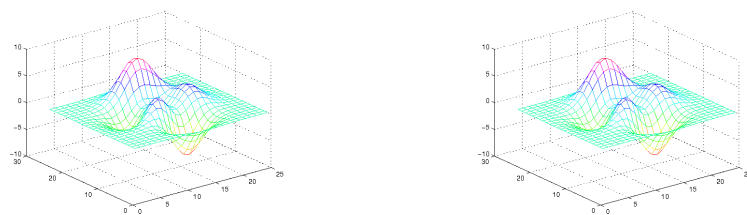
which produces the following output

Figure 8: Two figures next to each other

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

```
\begin{figure}[ht]
\begin{center}
\begin{minipage}[b]{.5\textwidth}
\centering
\includegraphics[scale=.4,angle=270,width=6.5cm]{plot.png}
\caption{Graph on the left}
\end{minipage}%
\begin{minipage}[b]{.5\textwidth}
\centering
\includegraphics[scale=.4,angle=270,width=6.5cm]{plot.png}
\caption{Graph on the right}
\end{minipage}%
\end{center}
\end{figure}
```
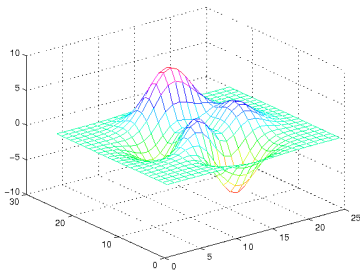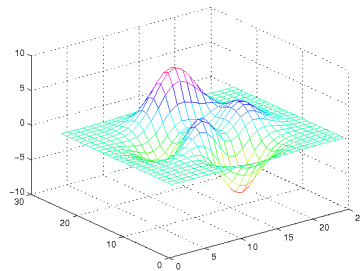
Figure 9: Graph on the left

Figure 10: 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{Lamport}` produces Lamport [1994].

Using `\citep{Lamport}` produces [Lamport, 1994].

Using `\cite{Goossens}` produces Goossens et al. [1994].

Using `\cite*{Goossens}` produces Goossens, Mittelbach, and Samarin [1994].

Using `\citep{Fenn}` produces [Fenn, 2006].

Using `\cite*{Mertz}` produces Mertz and Slough [2005].

Using `\citep*{Mertz}` produces [Mertz and Slough, 2005].

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

Interesting links:

- `http://www.ctan.org/what_is_tex.html`

References

Jürgen Fenn. Managing Citations and Your Bibliography with BiBT$_E$X. *The PracT$_E$X Journal*, 4, 2006. `http://www.tug.org/pracjourn/2006-4/fenn/fenn.pdf`.

Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The L^{A}T$_E$X Companions*. Addison Wesley, Reading, Massachusetts, 1st edition, 1994.

Leslie Lamport. *L^{A}T$_E$X: A Document Preparation System*. Addison Wesley, Reading, Massachusetts, 2nd edition, 1994.

Andrew Mertz and William Slough. Beamer by example. *The PracT$_E$X Journal*, 4, 2005. `http://tug.org/pracjourn/2005-4/mertz/mertz.pdf`.