

# L<sup>A</sup>T<sub>E</sub>X practical, CDT 2016

Susan Hutchinson  
Department of Statistics,  
University of Oxford

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# 1 Introduction

This is a short introduction to  $\text{\LaTeX}$  using Texmaker.

This file available at [http://www.stats.ox.ac.uk/pub/susan/cdt/LaTeX\\_exercises.pdf](http://www.stats.ox.ac.uk/pub/susan/cdt/LaTeX_exercises.pdf). I recommend that you open a copy on the desktop as many of the links are clickable and it will be easy to copy  $\text{\LaTeX}$  text in the later exercises.

## 2 $\text{\LaTeX}$

If you are new to  $\text{\LaTeX}$  then have a look at section 2.3 on page 14 which contains further exercises and their answers. These can be done independently and should provide a useful resource when you come to write more complex documents.

Finally, Section 2.5, 'Helpful Hints', contains several pages of characters and their markup.

There is also have a copy of 'The Not So Short Introduction to  $\text{\LaTeX}2\epsilon$ ' in each office which will be a useful reference for the independent exercises.

### 2.1 Texmaker

We will be using Texmaker to create, edit, typeset and view  $\text{\LaTeX}$  documents. To start Texmaker enter `texmaker` in the Type to search box. A window like Figure 1 should appear:

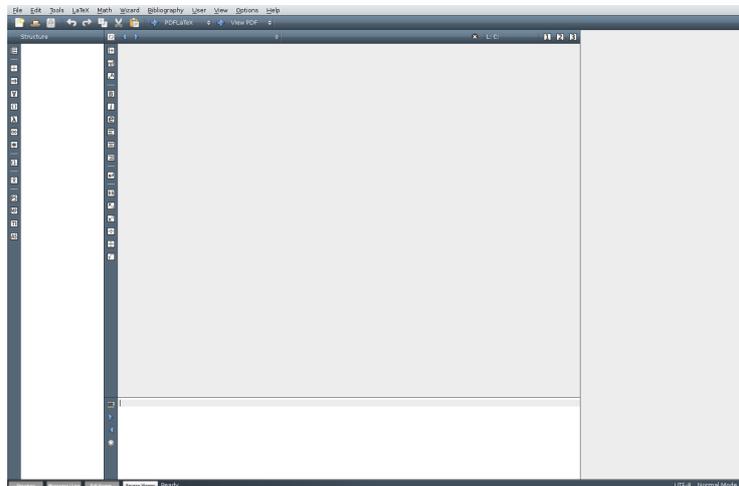


Figure 1: Texmaker: Start-up screen

Find the Run drop-down menu box to the right of PDF $\text{\LaTeX}$ . See what other options there are.

Find the following buttons:

- View (F7)
- Find (Ctrl+F)
- Replace (Ctrl+R)

- Save (Ctrl+S)

The keyboard shortcuts are included after each command.

These buttons are used for compiling and viewing L<sup>A</sup>T<sub>E</sub>X documents. Most of the other buttons are used for typesetting. See if you can find some of these:

- **Bold**
- *Italic*
- **Left**
- **Part/Chapter/Section**
- **Relation symbols**
- **Greek Letters**

## 2.2 Building a L<sup>A</sup>T<sub>E</sub>X document

### 2.2.1 Before you start

You will need to download some files before starting.

1. Create a new directory called LaTeX for this work.
2. Download the files `template.tex` and `test.bib` from <http://www.stats.ox.ac.uk/pub/susan/cdt> for use during this practical.
3. Find an R plot you have created or download `Hills.pdf` from the above location.

You can download fresh copies of the files whenever you want. Other files here include `Exercises.pdf` This file.

`final_template.tex` For downloading at the end of the practical session. This file can be used as a template for your practicals.

`small.tex` For the independent exercises.

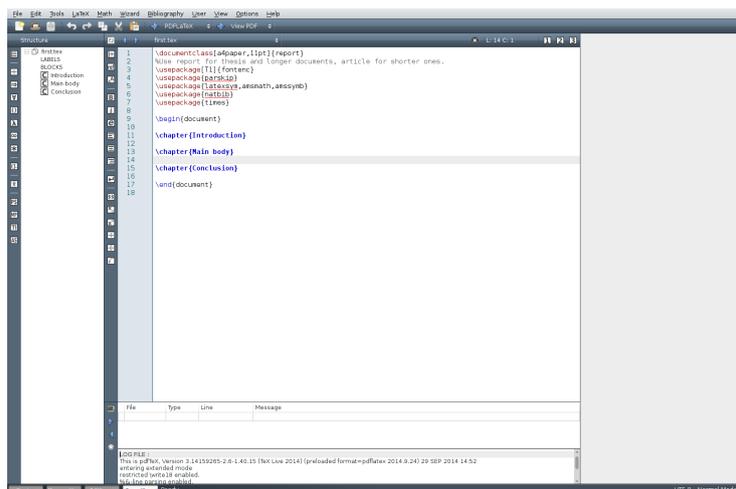
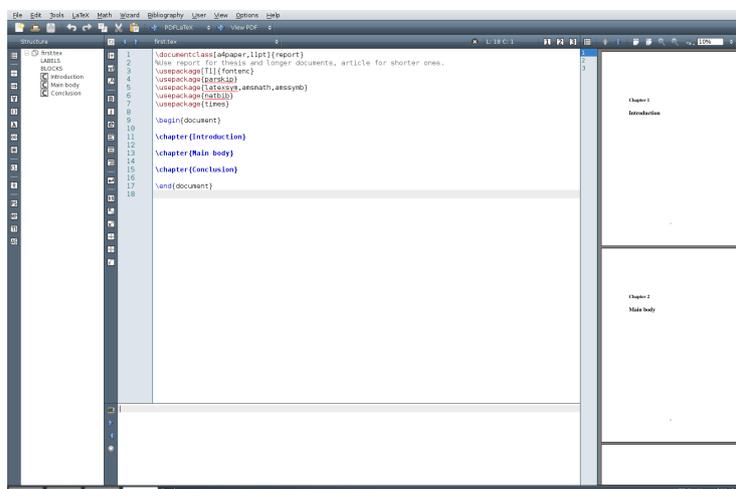
Open the file `template.tex` from Texmaker and save it as `first.tex`. L<sup>A</sup>T<sub>E</sub>X documents must *always* end with `.tex`. Click on the arrow to the left of **PDFLaTeX** to build the document.

Each time you finish making changes to `first.tex`, it must be built as in Figure 2.

The large centre screen is the editor window where you add to and change your document. Notice the small window below this. Information about the build will appear here. If there are errors then they will be shown here.

If the build has completed without errors, then click on the arrow to the left of the **View PDF** to preview your document. The preview window on the right shows you how the document will look when it's printed as in Figure 3.

Note that some of the text in the editing screen (not on this printed page!) is highlighted in different colours. This shows us which are typesetting commands and which is text; it also makes finding errors much easier.

Figure 2: Building `first.tex`Figure 3: Previewing `first.tex`

Now change the text `Main body` to `Research`, build the document again and click on the **View PDF** arrow. Do you notice how Chapter 2 is now ‘Research’? as in Figure 4.

## 2.2.2 How does it work?

Let’s look at the significant lines in `first.tex`.

```
\documentclass[a4paper,11pt]{article}
```

All  $\text{\LaTeX}$  documents begin with a `\documentclass` declaration. The two options between `[...]` specify the default font size (`11pt`) and paper size (`a4paper`). The final statement `{article}` describes the document’s class. Conventionally the `article` class is used for shorter documents and the `report` class 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  $\text{\LaTeX}$  commands is consistent — a command begins with a `\` (a backslash), is altered by options contained in `[...]` (square brackets) and is defined by what is between `{...}` (curly brackets). See for example the first line of the `first.tex` document:

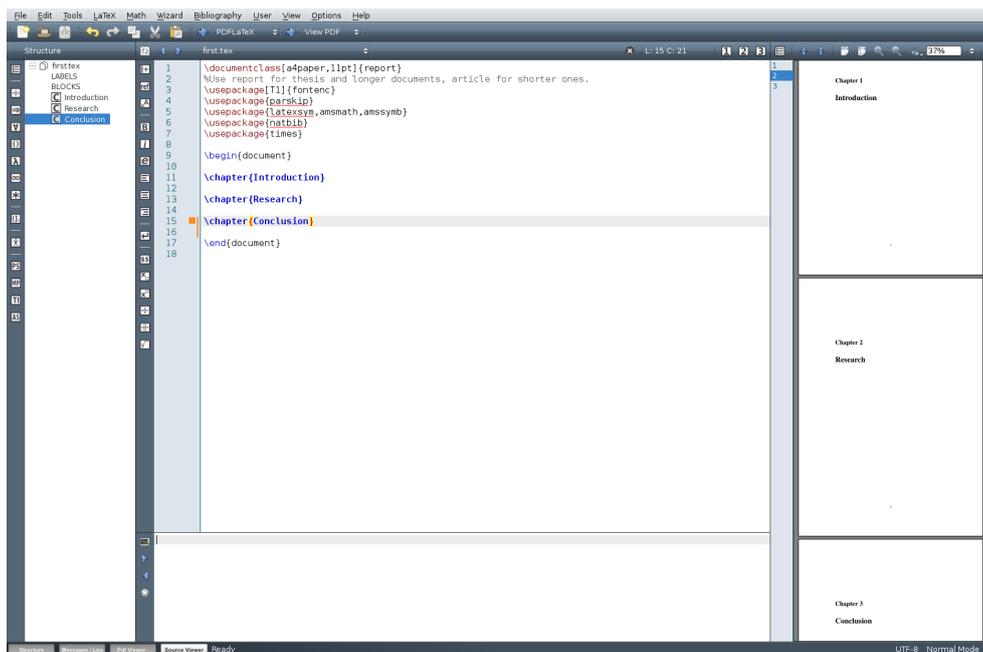


Figure 4: Typesetting with a new chapter heading

```
\documentclass[a4paper,11pt]{article}
```

The next line

```
%Use article for short documents
```

is a comment. It is ignored when the document is typeset. The following lines beginning

```
\usepackage{...}
```

add extra features such as additional symbols for maths — `amsmath`, `amssymb` — or change the default behaviour — `times` which changes the font to Times. You will be adding more packages in later exercises.

This part of the document is known as the preamble.

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 within the main document has been divided into sections with the commands

```
\chapter{Introduction}
```

and

```
\chapter{Research}
```

and so on. As this is part of the main document — the part people will read — the text appears in the preview window, after the document has been built. The chapters, sections and subsections are numbered automatically.

### 2.2.3 Adding some text

Now add some text after `\Chapter{Introduction}` and build the document again. Perhaps you could write a little about yourself.

In these exercises, all text to be typed in will appear in a font like `this` with a line above and below. Here's the text I typed into `first.tex`.

---

```
\section{Who am I?}
```

```
My name is Susan Hutchinson. I work in the Department of Statistics and I
particularly enjoy teaching LaTeX.
```

---

Some characters need to be typeset carefully, for example `\%`, `\#` and `\$`.

---

When you've built your document again and clicked on the **View PDF**, the text you entered should appear in the right hand preview window as in Figure 5.

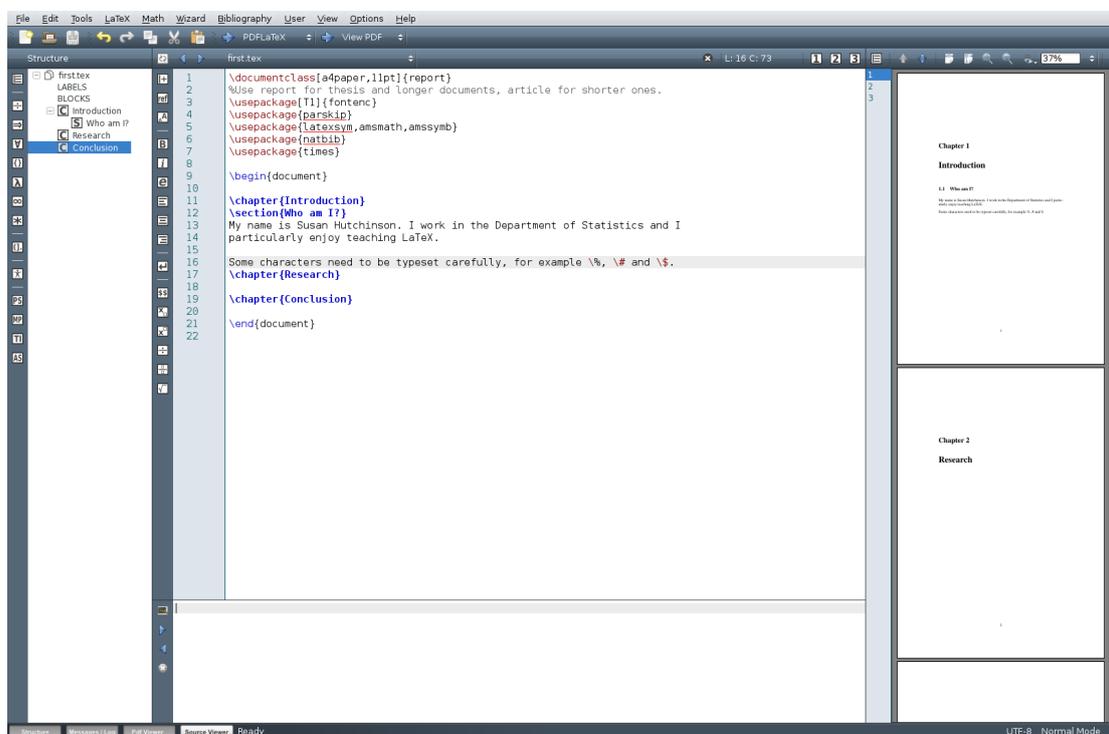


Figure 5: Adding some text

When writing text in a L<sup>A</sup>T<sub>E</sub>X document some characters have a special meaning. The following seven characters are printed by typing a backslash in front of them: `$` `&` `#` `%` `_` `{` and `}` so you need to type `\$`, `\&` and so on.

Most of the time you will be writing text for reports or dissertations as you have done here. For more about entering text see the first exercise in Section 2.3.1. The exercises in that section can be done independently later. Here you will find out to change the format of text using commands that are embedded within the text, for example `\emph` is used to *italicise* text and `\textbf` for **bold** text.

The exercises in this section demonstrate other skills that you will need when writing L<sup>A</sup>T<sub>E</sub>X documents. I have also suggested some further exercises for you to try on your own.

### 2.2.4 Fixing errors

It often happens that you make a mistake in your document. One important skill you will need is finding the error and fixing it.

Change the document so that it contains a mistake – perhaps by replacing ‘section’ by ‘sektion’ or leaving out the closing } after `\begin{document}`.

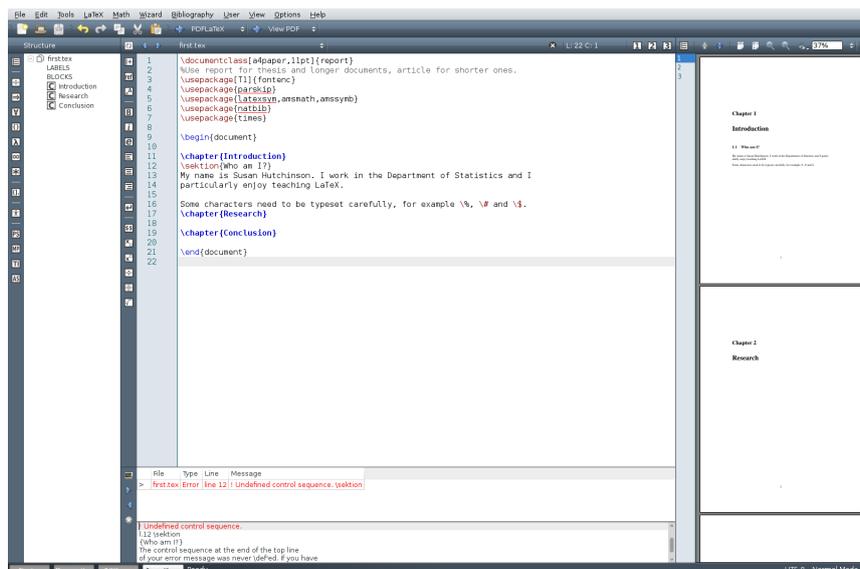


Figure 6: Texmaker: Locating errors

Now typeset the document again and see what happens. Depending on the error you have introduced you may see something like Figure 6 appear in a new screen at the bottom of your Texmaker editing window. The line number where the error appears is displayed here.

Now fix the error and typeset the document again.

### 2.2.5 Typesetting mathematics

There are several different ways of typesetting formulae and equations. They can appear ‘inline’ – within a paragraph – like this:  $C(n, r) = n!/(r!(n - r)!)$  or separately as follows so the paragraph is broken up. This is known as ‘display math’.

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

Now add a subsection `\section{Maths}` to the Research chapter of document and then enter the following to typeset two equations.

---

```
\section{Maths}
```

This equation is part of the sentence:

```
$x\wedge (y\vee z) = (x\wedge y) \vee (x\wedge z)$ but the next one is
```

displayed separately.

```


$$\nabla^2 f(x,y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$


```

Your editor and preview windows should look like Figure 7. Note how the \$ symbol is used

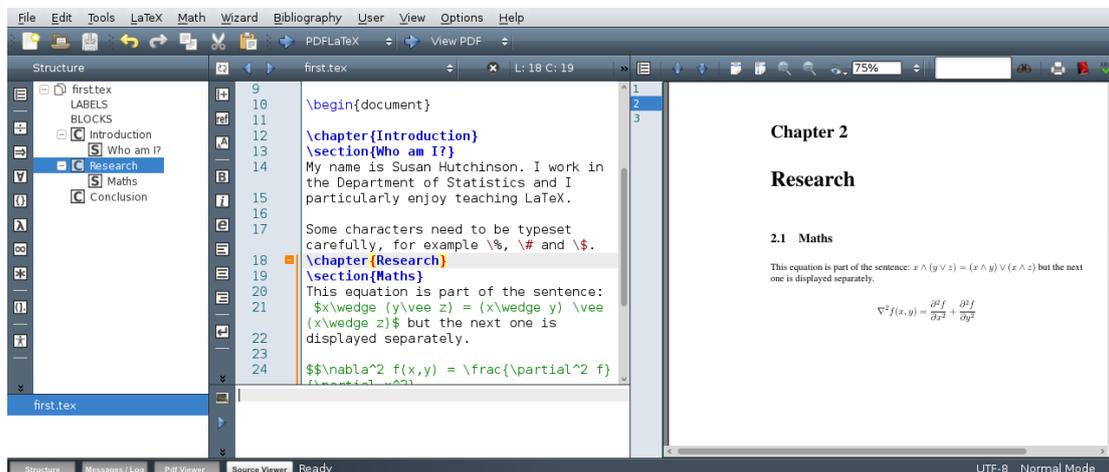


Figure 7: Some mathematics

at the start and end of each equation. To typeset the equation centred on a line on its own in display math mode use  $at the beginning and end of the equation.$

Many more maths exercises can be found in Section 2.3.2. Again, these can be done independently. Finally, Chapter 3 of *The Not So Short Introduction to L<sup>A</sup>T<sub>E</sub>X<sub>2</sub>ε* describes more ways displaying mathematics.

### 2.2.6 Plots

You will need to include plots from R in your document. Either create a plot from R in PDF format and save it in the same directory as your .tex document. Alternatively use the Hills.pdf file downloaded at the start of these exercises.

In the preamble (between `\documentclass...` and `\begin{document}`) add this before `\usepackage{times}`.

---

```
\usepackage{graphicx}
```

---

Add these lines immediately before `\section{Maths}`

---

```

\section{A plot}
\begin{figure}[htb]
\centering
\includegraphics[width=0.9\textwidth]{Hills.pdf}
\caption{The record times in 1984 for 35 Scottish hill races.}
\end{figure}

```

---

After typesetting the output should look like Figure 8.

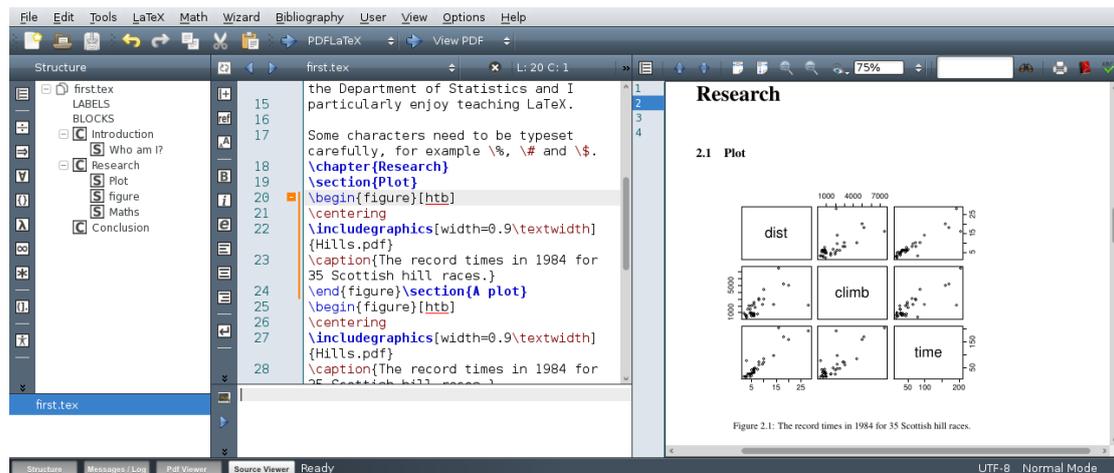


Figure 8: Adding a plot

Let's look more closely at the lines we added.

<code>\begin{figure} ... \end{figure}</code>	Starts and ends the figure environment.
<code>[htb]</code>	Where to place the plot (here, top, bottom) on the page.
<code>\centering</code>	Centre the plot on the page.
<code>\includegraphics{Hills.pdf}</code>	Include the plot file.
<code>[width=0.9\textwidth]</code>	Make the plot scale to .9 of the width of the page.

In some cases you may want to give a plot an exact height and width in which case you would use

<code>[width=4.8in, height=3.2in]</code>	These options give the plot an exact height and width.
--	--

<code>\caption{The record ... races.}</code>	A caption for the plot.
--	-------------------------

See the exercises in Section 2.3.4 for ways of typesetting graphs.

### 2.2.7 Tables from R

Here is a simple table generated in R from the first 10 values in the `hills` data set. Start R, and then execute the following commands which are marked by a `>`:

---

```
> library(MASS)
> library(xtable)
> data(hills)
> hills.table <- xtable(hills[1:10,])
> x.ltx <- toLatex(hills.table)
> x.ltx
% latex table generated in R 3.1.1 by xtable 1.7-4 package
% Wed Oct  8 14:00:57 2014
\begin{table}[ht]
\centering
```

---

```

\begin{tabular}{rrrr}
\hline
& dist & climb & time \\
\hline
Greenmantle & 2.50 & 650 & 16.08 \\
Carnethy & 6.00 & 2500 & 48.35 \\
Craig Dunain & 6.00 & 900 & 33.65 \\
Ben Rha & 7.50 & 800 & 45.60 \\
Ben Lomond & 8.00 & 3070 & 62.27 \\
Goatfell & 8.00 & 2866 & 73.22 \\
Bens of Jura & 16.00 & 7500 & 204.62 \\
Cairnpapple & 6.00 & 800 & 36.37 \\
Scolty & 5.00 & 800 & 29.75 \\
Traprain & 6.00 & 650 & 39.75 \\
\hline
\end{tabular}
\end{table}

```

---

In a new section, copy the L<sup>A</sup>T<sub>E</sub>X table into `first.tex`. Once built, the table should look like Table 2.2.7.

	dist	climb	time
Greenmantle	2.50	650	16.08
Carnethy	6.00	2500	48.35
Craig Dunain	6.00	900	33.65
Ben Rha	7.50	800	45.60
Ben Lomond	8.00	3070	62.27
Goatfell	8.00	2866	73.22
Bens of Jura	16.00	7500	204.62
Cairnpapple	6.00	800	36.37
Scolty	5.00	800	29.75
Traprain	6.00	650	39.75

Let's look at the lines we've entered. There are some similarities with the mark-up for the plot we added earlier. This time we have used the `table` environment not the `figure` environment.

---

<code>\begin{table}[ht]</code>	Start the table environment.
<code>\centering</code>	Centre the table
<code>\begin{tabular}{rrrr}</code>	Begin the tabular environment
<code>{rrrr}</code>	Four right-aligned columns.
<code>\hline</code>	Draw a horizontal line.
<code>&amp; dist &amp; climb &amp; time \\</code>	Headers for columns 3, 4 and 5.
<code>\hline</code>	Draw a horizontal line.
<code>Greenmantle &amp; 2.50 &amp; 650 &amp; 16.08 \\</code>	The next 10 lines are the data.
<code>Carnethy &amp; 6.00 &amp; 2500 &amp; 48.35 \\</code>	
<code>Craig Dunain &amp; 6.00 &amp; 900 &amp; 33.65 \\</code>	
<code>Ben Rha &amp; 7.50 &amp; 800 &amp; 45.60 \\</code>	
<code>Ben Lomond &amp; 8.00 &amp; 3070 &amp; 62.27 \\</code>	
<code>Goatfell &amp; 8.00 &amp; 2866 &amp; 73.22 \\</code>	
<code>Bens of Jura &amp; 16.00 &amp; 7500 &amp; 204.62 \\</code>	
<code>Cairnpapple &amp; 6.00 &amp; 800 &amp; 36.37 \\</code>	
<code>Scolty &amp; 5.00 &amp; 800 &amp; 29.75 \\</code>	
<code>Traprain &amp; 6.00 &amp; 650 &amp; 39.75 \\</code>	
<code>\hline</code>	Draw a horizontal line
<code>\end{tabular}</code>	End the tabular environment
<code>\end{table}</code>	End the table environment.

Things to note:

`{rrrr}` defines the number and alignment of the columns.

`&` separates columns on each row.

`\\` Ends each row.

For further exercises on creating tables see Section 2.3.1.

### 2.2.8 Cross references

Cross references allow you to refer to other parts of your document. For example, you may want to refer to a plot you have included in another chapter.

We are going to set up a reference to the Hills plot which you added above.

Add these two lines to the plot immediately after the line

```
\includegraphics[width=.0\textwidth]{Hills.pdf}.
```

---

```
\caption{The record times in 1984 for 35 Scottish hill races.}
\label{fig:HillsPlot}
```

---

Now add the following lines after `\chapter{Conclusion}`.

---

```
Figure~\ref{fig:HillsPlot} on page~\pageref{fig:HillsPlot} illustrates
the relationship between the times, heights and distances covered by
fell-racers.
```

---

You will need to run **pdfLaTeX** twice for the references to be resolved. The first time you will see ?? in place of the numbers. See Figure 9 for a final version.

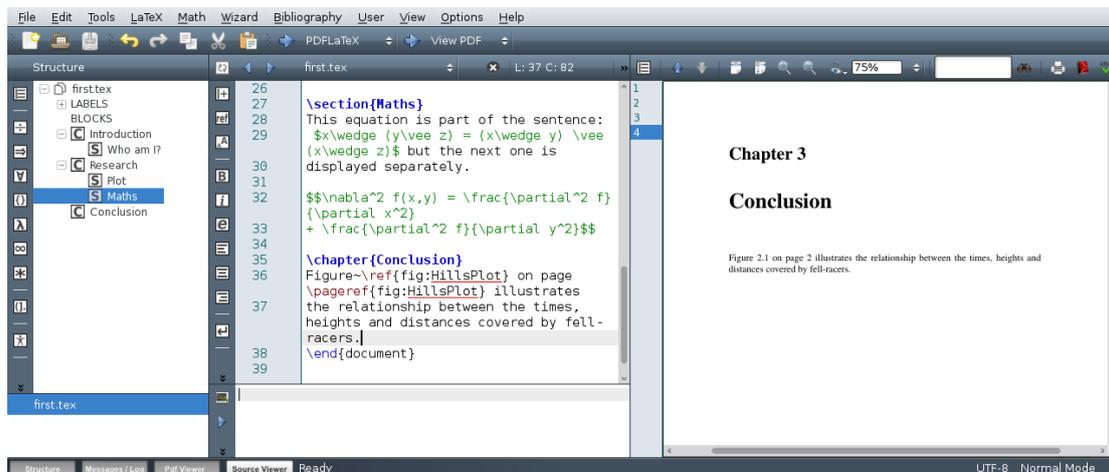


Figure 9: A complete cross-reference

You can use any text you like for your labels but it is recommended that you choose labels that are easy to remember. I use labels beginning `fig:` for figure references, `sec:` for section references and so on. This is not necessary but makes it easier to remember where a reference points. It does not affect the typesetting.

Cross references can be used to reference sections, tables, equations and much else too.

<code>\label{fig:HillsPlot}</code>	Defines the label.
Figure~ <code>\ref{fig:HillsPlot}</code> on	Refers to the figure number of the plot
page <code>\pageref{fig:HillsPlot}</code> illustrates	Refers to the page number of the plot

### 2.2.9 A simple bibliography

In the preamble include `\usepackage{natbib}` and `\usepackage{url}`. This command determines the style of the citations that will appear in your document. Both author–year and numerical citations can be used. At the end of the `.tex` document, just before `\end{document}` add

```
\bibliographystyle{apalike2}
\bibliography{test}
```

The command `\bibliographystyle{plainnat}` tells L<sup>A</sup>T<sub>E</sub>X how to format the bibliographical information stored in the file `test.bib`. Use `\bibliography{test}` to include the bibliography file in your document. The sample `test.bib` file you have looks like this:

```
@Book{Lamport,
  author = "Leslie Lamport",
  title = "\LaTeX{}: A Document Preparation System",
  publisher = "Addison Wesley",
  address = "Reading, Massachusetts",
  edition = "2nd",
  year = "1994",
```

```

}

@Book{Goossens,
  author =      "Michel Goossens and Frank Mittelbach and Alexander Samarin",
  title =       "{The \LaTeX{} Companions}",
  publisher =   "Addison Wesley",
  address =     "Reading, Massachusetts",
  edition =    "1st",
  year =        "1994",
}

@Article{Fenn,
  author =      "J{\u}rgen Fenn",
  title =       "{Managing Citations and Your Bibliography with BiB\TeX}",
  journal =     "{The Prac\TeX\ Journal}",
  year =        "2006",
  volume =     "4",
  note =       "{\url{http://www.tug.org/pracjournal/2006-4/fenn/fenn.pdf}}",
}

@Article{Mertz,
  author =      "Andrew Mertz and William Slough",
  title =       "Beamer by Example",
  journal =     "{The Prac\TeX\ Journal}",
  year =        "2005",
  volume =     "4",
  note =       "{\url{http://tug.org/pracjournal/2005-4/mertz/mertz.pdf}}",
}

```

You will need to add your own references to this file.

Here are a few example citations.

Using `\cite{Lamport}` produces Lamport (1994).

Using `\cite{Goossens}` produces Goossens et al. (1994).

To build a document containing citations you should use

- **PDFLaTeX**
- **BibTeX**
- **PDFLaTeX**

at least! 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 at the end of this document.

### 2.2.10 Printing your document

You cannot print from the preview window. Use the file browser to find the PDF file. Double click on it and it will open in **Adobe Reader**. You can then print.

### 2.2.11 Downloading the final version of the template

Finally download the final version of `final_template.tex` from the Skills section of Weblearn. This file can be used as a template for later practical sessions.

**This completes the practical session exercises.**

## 2.3 L<sup>A</sup>T<sub>E</sub>X exercises to try on your own

The answers to these exercises are in the next section.

Please download these two files for use in these exercises. Browse to <http://www.stats.ox.ac.uk/pub/susan/cdt> and save the two files

- `small.tex`
- `test.bib`

in your home directory. To be really organised you could create a new directory to keep them in.

The following exercises are designed to show many features of L<sup>A</sup>T<sub>E</sub>X. If possible try to do at least the following

- Exercises 1–6 on simple text typesetting.
- Some of the maths exercises.
- Exercise 41 on cross references
- Finally have a look at Section 2.3.4 on page 18 for how to include graphs and images in documents.

Load `small.tex` into Texmaker. Remember that you should save the document and click on the green typeset button after each change.

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{mathptmx}` to the preamble. The font should now look different as you are now using Times Roman.
5. Swap the emphasised and bold text.

### 2.3.1 Typesetting Text

▷ Exercise 1 We will now typeset some simple sentences. You should have a copy of *The Not So Short Introduction to L<sup>A</sup>T<sub>E</sub>X2<sub>ε</sub>* which we will be using for reference for the rest of these exercises. Chapter 2 *Typesetting Text* is particularly helpful and Section 2.5, ‘Helpful Hints’ of this document has instructions on how to typeset many characters.

Start a new section in the document. Typeset the following sentences – there are some helpful suggestions just below if you get stuck.

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 L<sup>A</sup>T<sub>E</sub>X that are 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’ section should help with these.

**pounds** To typeset the £ symbol use \pounds.

Finally, it can seem difficult to decide whether to put a space after a L<sup>A</sup>T<sub>E</sub>X 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 typeset 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: 1.

▷ Exercise 2 Give your document a title. You will need to include

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

immediately after \begin{document}. To include a table of contents add \tableofcontents after the title. You must have at least one section, subsection or chapter for the table of contents to appear. Note that you must run pdfLaTeX twice in order for entries in the table of contents to be displayed.

▷ Exercise 3 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 L<sup>A</sup>T<sub>E</sub>X2e* for more information about lists.]

- ▷ Exercise 4 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 5 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.]

### 2.3.2 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 L<sup>A</sup>T<sub>E</sub>X<sub>2</sub> $\epsilon$*  describes the different ways displaying mathematics. The Helpful Hints document will also be useful for these exercises.

- ▷ Exercise 6 Typeset the following:  $C(n, r) = n!/(r!(n - r)!)$ . Note the spacing in the denominator.
- ▷ Exercise 7 Typeset the equation  $a + b = c - d = xy = w/z$  as in-line and displayed mathematical text.
- ▷ Exercise 8 Typeset the equation  $(fg)' = f'g + fg'$  as in-line and displayed mathematical text.
- ▷ Exercise 9 Typeset  $\alpha\beta = \gamma + \delta$  as in-line and displayed mathematical text.
- ▷ Exercise 10 Typeset  $\Gamma(n) = (n - 1)!$  as in-line and displayed mathematical text.
- ▷ Exercise 11 Typeset:  $x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$ .
- ▷ Exercise 12 Typeset:  $2 + 4 + 6 + \dots + 2n = n(n + 1)$ .
- ▷ Exercise 13 Typeset:  $\vec{x} \cdot \vec{y} = 0$  if and only if  $\vec{x} \perp \vec{y}$ .

- ▷ Exercise 14 Typeset:  $\vec{x} \cdot \vec{y} \neq 0$  if and only if  $\vec{x} \not\perp \vec{y}$ .
- ▷ Exercise 15 Typeset:  $(\forall x \in \mathbb{R})(\exists y \in \mathbb{R})$  such that  $y > x$ .
- ▷ Exercise 16 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 17 Typeset: What are the points where  $\frac{\partial}{\partial x} f(x, y) = \frac{\partial}{\partial y} f(x, y) = 0$ ?
- ▷ Exercise 18 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 19 Typeset:  $\nabla^2 f(x, y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$ .
- ▷ Exercise 20 Typeset the following expression:  $\lim_{x \rightarrow 0} (1+x)^{\frac{1}{x}} = e$ .
- ▷ Exercise 21 Typeset: The cardinality of  $(-\infty, \infty)$  is  $\aleph_1$ .
- ▷ Exercise 22 Typeset:  $\lim_{x \rightarrow 0^+} x^x = 1$ .

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

- ▷ Exercise 23 Typeset the following integral:  $\int_0^1 3x^2 dx = 1$ .
- ▷ Exercise 24 Typeset the following:  $\sqrt{2} - \sqrt{\frac{x+y}{x-y}} - \sqrt[3]{10} - e^{\sqrt{x}}$ .
- ▷ Exercise 25 Typeset:  $\|x\| = \sqrt{x \cdot x}$ .
- ▷ Exercise 26 Typeset:  $\phi(t) = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-x^2/2} dx$ .
- ▷ Exercise 27 Typeset the following:  $\underline{x} - \bar{y} - \overline{x+y}$ .
- ▷ Exercise 28 Typeset  $\lceil [x] \rceil \leq \lfloor [x] \rfloor$ .
- ▷ Exercise 29 Typeset:  $\sin(2\theta) = 2 \sin \theta \cos \theta$   $\cos(2\theta) = 2 \cos^2 \theta - 1$ .
- ▷ Exercise 30 Typeset:

$$\int \csc^2 x dx = -\cot x + C \quad \lim_{\alpha \rightarrow 0} \frac{\sin \alpha}{\alpha} = 1 \quad \lim_{\alpha \rightarrow \infty} \frac{\sin \alpha}{\alpha} = 0.$$

- ▷ Exercise 31 Typeset:

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

- ▷ Exercise 32 Typeset:

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

▷ Exercise 33 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  $M(t) = \exp[\{b(\theta + t a \phi) - b(\theta)\}/(a\phi)]$ .

▷ Exercise 34 Typeset: If  $Y_{rc}$ ,  $r = 1, \dots, R$ ,  $c = 1, \dots, C$  are random variables, show that

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

▷ Exercise 35 Typeset:

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

▷ Exercise 36 Typeset:

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

▷ Exercise 37 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 38 Typeset:

$$h_i(t) = \lim_{\epsilon \rightarrow 0} \frac{1}{\epsilon} \frac{\mathbf{P}(t < T_i \leq t + \epsilon)}{\mathbf{P}(T_i > t)}.$$

### 2.3.3 Cross references

▷ Exercise 39 Create a reference to your first section using `\ref` and `\label` commands. See section 2.8 of *The Not So Short Introduction to L<sup>A</sup>T<sub>E</sub>X2<sub>ε</sub>* for details.

### 2.3.4 Including graphs in L<sup>A</sup>T<sub>E</sub>X documents

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

**postscript** If your graphs or pictures are in postscript or encapsulated postscript format you must use `latex` and `dvips` to typeset and print documents.

**jpg, pdf or png** If your graphs or pictures are in JPG, PDF or PNG format then you must use `pdflatex` to typeset and print documents.

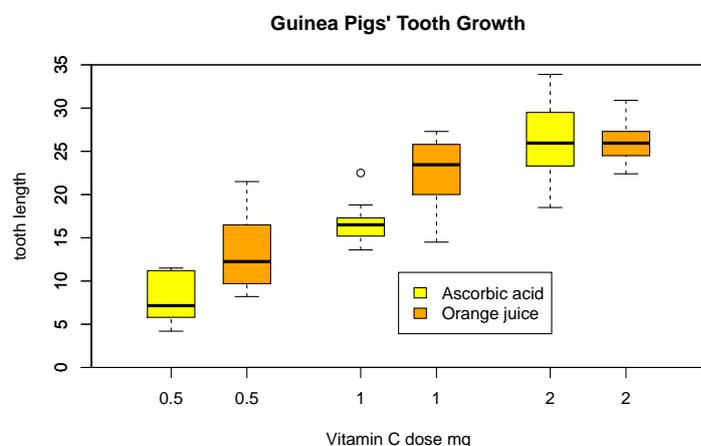
*You cannot mix postscript and encapsulated postscript graphs or pictures with any other format*

In the following example we will use a .png graph. Include the `GuineaPigPlot.pdf` file in your L<sup>A</sup>T<sub>E</sub>X document. To do this add the following line to the preamble of your L<sup>A</sup>T<sub>E</sub>X document, that is between the `\documentclass...` and the `\begin{document}`.

```
\usepackage{graphicx}
```

To include the graph found in the file, `GuineaPigPlot.pdf` insert the line

```
\includegraphics[width=0.6\textwidth]{GuineaPigPlot.pdf}
```



at the place in the text you would like the graph to appear.

Note that I have included `[width=0.6\textwidth]` which scales to 60% of the the page width. This is often useful because the standard size produced by some applications is rather large.

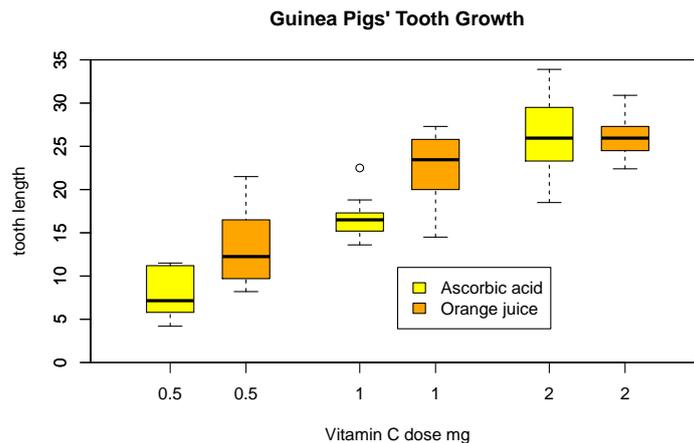
The basic method can be developed. You can centre the graph on the page with the following commands

```
\begin{figure}[ht]
\centering
\includegraphics[width=0.6\textwidth]{GuineaPigPlot.pdf}
\end{figure}
```

By enclosing the plot in a `figure` environment you are able to add extra features such as captions and labels for cross-references.

Including the command `\listoffigures` after `\tableofcontents` will produce a list of figures.

Figures are known as *floats* because they are floated to the nearest sensible position on a page when the .`tex` document is typeset. This means that placement of figures can cause problems; often they will appear at the end of a section of chapter particularly when there are a lot of figures and not much text. The option `[ht]` gives L<sup>A</sup>T<sub>E</sub>X the choice positioning



the figure either here or at the top of the page. The more choices you offer the less chance that all the pictures will end up on one page.

Here is an example of a centred graph with a caption. See Figure 10.

```
\begin{figure}[ht]
\centering
\includegraphics[width=0.6\textwidth]{GuineaPigPlot.pdf}
\caption{A centred graph with a caption.}
\end{figure}
```

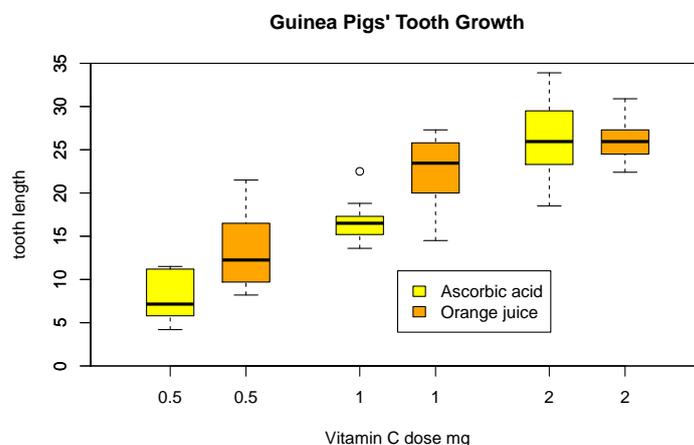


Figure 10: A centred graph with a caption.

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[width=5cm]{GuineaPigPlot.pdf}
\hspace{1cm}
\includegraphics[width=5cm]{GuineaPigPlot.pdf}
\caption{Two figures next to each other}
\end{center}
\end{figure}
```

```
\end{center}
\end{figure}
```

which produces the output in figure 11.

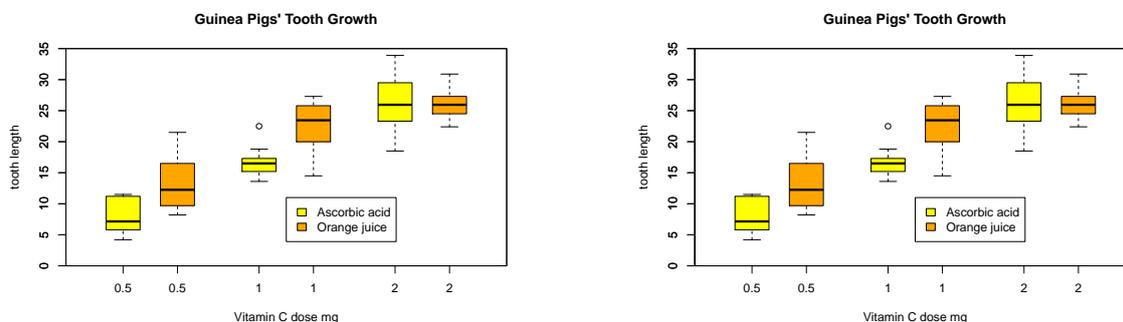


Figure 11: Two figures next to each other

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

```
\begin{figure}[ht]
\begin{center}
\begin{minipage}[b]{.5\textwidth}
\centering
\includegraphics[width=0.7\textwidth]{GuineaPigPlot.pdf}
\caption{Graph on the left}
\end{minipage}%
\begin{minipage}[b]{.5\textwidth}
\centering
\includegraphics[width=0.7\textwidth]{GuineaPigPlot.pdf}
\caption{Graph on the right}
\end{minipage}%
\end{center}
\end{figure}
```

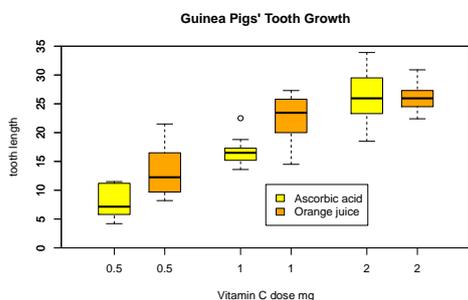


Figure 12: Graph on the left

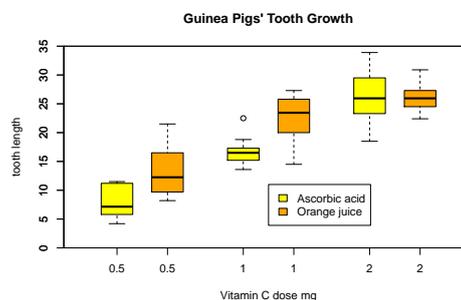


Figure 13: Graph on the right

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

### 2.3.5 Including R code

Sometimes tutors and supervisors will ask you to include your R code. This is a simple way to do it.

Add the following at the beginning of the file after `\usepackage{times}`.

---

```
\usepackage{zi4}
\usepackage[a4paper, left=3cm, right=3cm, top=3cm, bottom=3cm]{geometry}
```

---

These lines set the font for verbatim text, and change the dimensions of the page to make them large enough to hold standard length lines.

Then add this just before `\end{document}` at the end of the file.

---

```
\clearpage
\section*{Appendix}
\begin{verbatim}
Put your R code here.
\end{verbatim}
```

---

The Appendix should appear on a new page as in Figure 14.

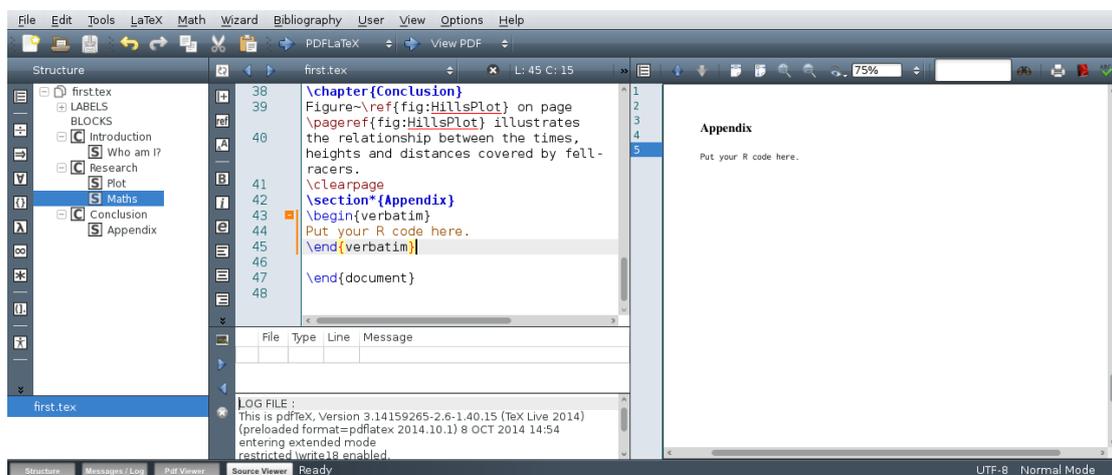


Figure 14: An Appendix with R code

What each line means.

<code>\clearpage</code>	Forces all figures, tables to be printed before beginning the next section and starts a new page.
<code>\section*{Appendix}</code>	Gives the section a title, but no number.
<code>\begin{verbatim} ... \end{verbatim}</code>	Typeset everything exactly as it appears.

## 2.4 Answers to L<sup>A</sup>T<sub>E</sub>X exercises

### 2.4.1 Typesetting Text

#### ▷ Answer 1

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?

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 \AE schylus understand \OE dipus?

They took some honey and plenty of money wrapped up in a \pounds 5 note.

\’El\’eves, refusez vos le\c cons! Jetez vos cha\^i nes!

Can you take a ferry from \”Oland to \AA land?

#### ▷ Answer 2

Don’t forget to run L<sup>A</sup>T<sub>E</sub>X twice to make sure the table of contents is up to date.

#### ▷ Answer 3

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.

```

\begin{enumerate}
\item You can mix list environments as much as you like
\begin{itemize}
\item But it might start to look silly
\item[-]With different symbols
\end{itemize}
\item So do remember
\begin{description}
\item[Stupid] things will not become smart because they are in a list.
\item[Smart] things, though, can be presented beautifully in a list.
\end{description}

```

▷ Answer 4

### Vegetable Production

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

```

\begin{center}
\medskip

{\large \bf Vegetable Production}

\begin{tabular}{|l|l|r|} \hline
{\textsf Vegetable } & {\textsf Comments} & {\textsf Weight}\\
\hline \hline
Carrots & Good early crop, then carrot fly. & 7kg \\
Lettuce & Slow to start, then bolted. & 1kg \\
French beans & Excellent. & 12kg \\
\hline
\end{tabular}
\end{center}

```

▷ Answer 5

### Currencies 1 Jan 1992

London:	New York:
£: \$ 1.8672	£: \$ 1.8655
£: DM 2.8369	\$: DM 1.5175
£: FFr 9.969080	\$: FFr 5.1845

```

\begin{center}
\medskip
{\Large \bfseries Currencies 1 Jan 1992}\\
\bigskip
\begin{tabular}{ll}
\sffamily \large London: & \sffamily\large New York:\\
\hline \hline

```

```

\pounds : \$ 1.8672 &\pounds : \$ 1.8655 \\
\pounds : DM 2.8369 &\$: DM 1.5175\\
\pounds : FFr 9.969080 &\$: FFr 5.1845
\end{tabular}
\end{center}

```

### 2.4.2 Mathematics

▷ Answer 6

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

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

▷ Answer 7

This equation is in-line  $a + b = c - d = xy = w/z$  and the following one is displayed.

$$a + b = c - d = xy = w/z$$

This equation is in-line  $\$a+b=c-d=xy=w/z\$$  and the following one is displayed.  $\$\$a+b=c-d=xy=w/z\$\$$

▷ Answer 8

An in-line example:  $(fg)' = f'g + fg'$  followed by one that is displayed:

$$(fg)' = f'g + fg'$$

An in-line example:  $\$(fg)' = f'g + fg'\$$  followed by one that is displayed:  $\$\$(fg)' = f'g + fg'\$\$$

▷ Answer 9

In-line the equation is  $\alpha\beta = \gamma + \delta$  and displayed

$$\alpha\beta = \gamma + \delta$$

In-line the equation is  $\$\alpha\beta = \gamma + \delta\$$  and displayed  $\$\$\alpha \beta = \gamma + \delta\$\$$

▷ Answer 10

In-line the equation is  $\Gamma(n) = (n - 1)!$  and displayed

$$\Gamma(n) = (n - 1)!$$

In-line the equation is  $\$\Gamma(n) = (n-1)\!\$$  and displayed  $\$\$\Gamma(n) = (n-1)\!\!\$$

▷ Answer 11

$x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$ .

$x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$ .

▷ Answer 12

$$2 + 4 + 6 + \cdots + 2n = n(n + 1).$$

$$2 + 4 + 6 + \cdots + 2n = n(n+1).$$

▷ Answer 13

$\vec{x} \cdot \vec{y} = 0$  if and only if  $\vec{x} \perp \vec{y}$ .

$\vec{x} \cdot \vec{y} = 0$  if and only if  $\vec{x} \perp \vec{y}$ .

▷ Answer 14

$\vec{x} \cdot \vec{y} \neq 0$  if and only if  $\vec{x} \not\perp \vec{y}$ .

$\vec{x} \cdot \vec{y} \neq 0$  if and only if  $\vec{x} \not\perp \vec{y}$ .

or use  $\vec{x} \cdot \vec{y} \neq 0$  which is  $\vec{x} \cdot \vec{y} \neq 0$

▷ Answer 15

$(\forall x \in \mathbb{R})(\exists y \in \mathbb{R})$  such that  $y > x$ .

$(\forall x \in \mathbb{R})(\exists y \in \mathbb{R})$  such that  $y > x$ .

Note that `amssymb` must be included in the `usepackage` declaration at the beginning of the file in order to use `\mathbb{R}`.

▷ Answer 16

$$\frac{a+b}{c} = \frac{a}{b+c} + \frac{1}{a+b+c} \neq \frac{1}{a} + \frac{1}{b} + \frac{1}{c}.$$

$\frac{a+b}{c} \neq \frac{a}{b+c} + \frac{1}{a+b+c}$   $\neq \frac{1}{a} + \frac{1}{b} + \frac{1}{c}$ .

`\ne` could be used instead of `\not=`

▷ Answer 17

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

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

▷ Answer 18

$$e^x - e^{-x} + 1 = 0 \quad x_0 \quad x_0^2 \quad 2^{x_0}.$$

$e^x - e^{-x} + 1 = 0$   $x_0$   $x_0^2$   $2^{x_0}$ .

▷ Answer 19

$$\nabla^2 f(x, y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}.$$

$\nabla^2 f(x,y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$ .

▷ Answer 20

$$\lim_{x \rightarrow 0} (1+x)^{\frac{1}{x}} = e.$$

$\lim_{x \rightarrow 0} (1+x)^{\frac{1}{x}} = e$ .

▷ Answer 21

The cardinality of  $(-\infty, \infty)$  is  $\aleph_1$ .

The cardinality of  $(-\infty, \infty)$  is  $\aleph_1$ .

▷ Answer 22

$$\lim_{x \rightarrow 0^+} x^x = 1.$$

$\lim_{x \rightarrow 0^+} x^x = 1$ .

▷ Answer 23

$$\int_0^1 3x^2 dx = 1.$$

$\int_0^1 3x^2 dx = 1$ .

▷ Answer 24

$$\sqrt{2} \quad \sqrt{\frac{x+y}{x-y}} \quad \sqrt[3]{10} \quad e^{\sqrt{x}}.$$

$\sqrt{2} \quad \sqrt{\frac{x+y}{x-y}} \quad \sqrt[3]{10} \quad e^{\sqrt{x}}$ .

▷ Answer 25

$$\|x\| = \sqrt{x \cdot x}.$$

$\|x\| = \sqrt{x \cdot x}$ .

▷ Answer 26

$$\phi(t) = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-x^2/2} dx.$$

$\phi(t) = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-x^2/2} dx$ .

▷ Answer 27

$$\underline{x} \quad \overline{y} \quad \overline{\underline{x+y}}.$$

$\underline{x} \quad \overline{y} \quad \overline{\underline{x+y}}$ .

▷ Answer 28

$$[x] \leq \lceil x \rceil.$$

$\lceil x \rceil \leq \lfloor x \rfloor$

▷ Answer 29

$$\sin(2\theta) = 2 \sin \theta \cos \theta \quad \cos(2\theta) = 2 \cos^2 \theta - 1.$$

$$\sin(2\theta) = 2 \sin \theta \cos \theta \quad \cos(2\theta) = 2 \cos^2 \theta - 1.$$

▷ Answer 30

$$\int \csc^2 x \, dx = -\cot x + C \quad \lim_{\alpha \rightarrow 0} \frac{\sin \alpha}{\alpha} = 1 \quad \lim_{\alpha \rightarrow \infty} \frac{\sin \alpha}{\alpha} = 0.$$

$\int \csc^2 x \, dx = -\cot x + C$   
 $\lim_{\alpha \rightarrow 0} \frac{\sin \alpha}{\alpha} = 1$   
 $\lim_{\alpha \rightarrow \infty} \frac{\sin \alpha}{\alpha} = 0.$

▷ Answer 31

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

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

▷ Answer 32

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

$\left[ \begin{array}{ccc} aa & \cdots & az \\ \vdots & \ddots & \vdots \\ za & \cdots & zz \end{array} \right]$

▷ Answer 33

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  $M(t) = \exp[\{b(\theta + t a \phi) - b(\theta)\}/(a\phi)].$

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  $M(t)$

$$M(t) = \exp\left[\frac{b(\theta + t\phi) - b(\theta)}{a(\phi)}\right].$$

▷ Answer 34

If  $Y_{rc}$ ,  $r = 1, \dots, R$ ,  $c = 1, \dots, C$  are random variables, show that

$$\sum_{r,c} (Y_{rc} - \bar{Y}_{..})^2 = \sum_{r,c} (\bar{Y}_r - \bar{Y}_{..})^2 + \sum_{r,c} (\bar{Y}_{.c} - \bar{Y}_{..})^2 + \sum_{r,c} (Y_{rc} - \bar{Y}_{.c} - \bar{e}Y_{..})^2. \quad (2)$$

If  $Y_{rc}$ ,  $r=1, \dots, R$ ,  $c=1, \dots, C$  are random variables, show that

```
\begin{equation}
\label{linear.models.equation.1}
\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{e}Y_{..})^2.
\end{equation}
```

▷ Answer 35

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

$$f(x_i | \lambda_i) = \lambda_i e^{-\lambda_i x_i}, \quad f(y_i | \lambda_i, \psi) = \lambda_i \psi e^{-\lambda_i \psi y_i},$$

$$\quad x_i, y_i \geq 0.$$

You could use `\mid`, but the spacing would be larger.

▷ Answer 36

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

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

▷ Answer 37

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  $X$ .

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

The `amsmaths` `cases` environment was used here.

▷ Answer 38

$$h_i(t) = \lim_{\epsilon \rightarrow 0} \frac{1}{\epsilon} \frac{\Pr(t < T_i \leq t + \epsilon)}{\Pr(T_i > t)}.$$

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

### 2.4.3 Cross references

▷ Answer 39

To create a cross reference to a figure you need to set a label with an arbitrary name

```
\label{Plot1}
```

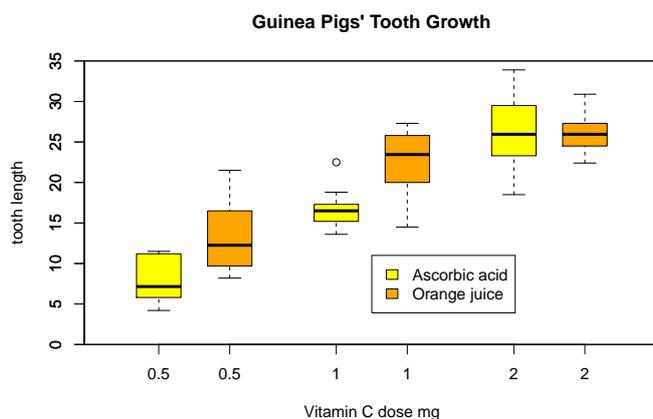


Figure 15: A plot with a reference

within the figure environment and then use

```
\pageref{Plot1}
```

to refer to it. So use

this plot is on page `\pageref{Plot1}`

to see “ this plot is on page 30 ”.

See page 30 for example. Note that you will see

LaTeX Warning: There were undefined references.

so run  $\text{\LaTeX}$  twice to get the references resolved.

#### 2.4.4 A simple bibliography

▷ Answer 40

Remember that you need to run  $\text{\LaTeX}$  twice, then `bibtex` and then  $\text{\LaTeX}$  twice again to get all the references sorted out.

## 2.5 Helpful hints

### 2.5.1 Special Characters

The following symbols are reserved characters, that either have a special meaning under L<sup>A</sup>T<sub>E</sub>X or are not available in all the fonts. If you enter them in your text directly, they will normally not print, but rather coerce L<sup>A</sup>T<sub>E</sub>X to do things you did not intend.

`$ & % # _ { } ~ ^ \`

As you will see, these characters can be used in your documents all the same by adding a prefix backslash:

`\$ \& \% \# \_ \{ \}`

The other symbols and many more can be printed with special commands in mathematical formulae or as accents.

### 2.5.2 Dashes and Hyphens

L<sup>A</sup>T<sub>E</sub>X knows four kinds of dashes. You can access three of these with different numbers of consecutive dashes. The fourth sign is actually no dash at all: It is the mathematical minus sign:

daughter-in-law, X-rated	daughter-in-law, X-rated
pages 13-67	pages 13--67
yes—or no?	yes---or no?
0, 1 and -1	\$0\$, \$1\$ and \$-1\$

The names for these dashes are: - hyphen, - en-dash, -- em-dash and \$-\$ minus sign.

### 2.5.3 Quotation Marks

For quotation marks you should *not* use the " as on a typewriter. In publishing there are special opening and closing quotation marks. In L<sup>A</sup>T<sub>E</sub>X, use two ‘s on for opening quotation marks and two ’s for closing quotation marks.

“Please press the ‘x’ key.”                      ‘‘Please press the ‘x’ key.’’

### 2.5.4 Accents and Special Characters

L<sup>A</sup>T<sub>E</sub>X supports the use of accents and special characters from many languages. Table 1 shows all sorts of accents being applied to the letter o. Naturally other letters work too.

To place an accent on top of an i or a j, their dots have to be removed. This is accomplished by typing \i and \j. Here are some more examples.

Hôtel, naïve, élève,	H\^otel, na\\"\i ve, \\'el\‘eve,
smørrebrød, ¡Señorita!,	sm\o rrebr\o d, !‘Se\~norita!,
Schönbrunner Schloß Straße	Sch\\"onbrunner Schlo\ss\} Stra\ss e

### 2.5.5 List of Mathematical Symbols

In the following tables you find all the symbols normally accessible from *math mode*.

Table 1: Accents and Special Characters

ò	\‘o	ó	\’o	ô	\~o	õ	\~o
ō	\=o	ô	\.o	ö	\"o		
ö	\u o	ő	\v o	ő	\H o	ø	\c o
ø	\d o	ø	\b o	öo	\t oo		
œ	\oe	Œ	\OE	æ	\ae	Æ	\AE
å	\aa	Å	\AA				
ø	\o	Ø	\O	ı	\l	Ł	\L
ı	\i	Ј	\j	ı	!‘	ı	?‘

Table 2: Math Mode Accents

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

Table 3: Lowercase Greek Letters

$\alpha$	\alpha	$\theta$	\theta	$\upsilon$	\upsilon	$\upsilon$	\upsilon
$\beta$	\beta	$\vartheta$	\vartheta	$\pi$	\pi	$\phi$	\phi
$\gamma$	\gamma	$\iota$	\iota	$\varpi$	\varpi	$\varphi$	\varphi
$\delta$	\delta	$\kappa$	\kappa	$\rho$	\rho	$\chi$	\chi
$\epsilon$	\epsilon	$\lambda$	\lambda	$\varrho$	\varrho	$\psi$	\psi
$\varepsilon$	\varepsilon	$\mu$	\mu	$\sigma$	\sigma	$\omega$	\omega
$\zeta$	\zeta	$\nu$	\nu	$\varsigma$	\varsigma		
$\eta$	\eta	$\xi$	\xi	$\tau$	\tau		

Table 4: Uppercase Greek Letters

$\Gamma$	\Gamma	$\Lambda$	\Lambda	$\Sigma$	\Sigma	$\Psi$	\Psi
$\Delta$	\Delta	$\Xi$	\Xi	$\Upsilon$	\Upsilon	$\Omega$	\Omega
$\Theta$	\Theta	$\Pi$	\Pi	$\Phi$	\Phi		

Table 5: **Binary Relations**

You can produce corresponding negations by adding a `\not` command as prefix to the following symbols.

$<$	<code>&lt;</code>	$>$	<code>&gt;</code>	$=$	<code>=</code>
$\leq$	<code>\leq</code> or <code>\le</code>	$\geq$	<code>\geq</code> or <code>\ge</code>	$\equiv$	<code>\equiv</code>
$\ll$	<code>\ll</code>	$\gg$	<code>\gg</code>	$\doteq$	<code>\doteq</code>
$\prec$	<code>\prec</code>	$\succ$	<code>\succ</code>	$\sim$	<code>\sim</code>
$\preceq$	<code>\preceq</code>	$\succeq$	<code>\succeq</code>	$\simeq$	<code>\simeq</code>
$\subset$	<code>\subset</code>	$\supset$	<code>\supset</code>	$\approx$	<code>\approx</code>
$\subseteq$	<code>\subseteq</code>	$\supseteq$	<code>\supseteq</code>	$\cong$	<code>\cong</code>
$\sqsubset$ <sup>a</sup>	<code>\sqsubset</code>	$\sqsupset$ <sup>a</sup>	<code>\sqsupset</code>	$\Join$ <sup>a</sup>	<code>\Join</code>
$\sqsubseteq$	<code>\sqsubseteq</code>	$\sqsupseteq$	<code>\sqsupseteq</code>	$\bowtie$	<code>\bowtie</code>
$\in$	<code>\in</code>	$\ni$ , $\owns$	<code>\ni</code> , <code>\owns</code>	$\propto$	<code>\propto</code>
$\vdash$	<code>\vdash</code>	$\dashv$	<code>\dashv</code>	$\models$	<code>\models</code>
$ $	<code>\mid</code>	$\parallel$	<code>\parallel</code>	$\perp$	<code>\perp</code>
$\smile$	<code>\smile</code>	$\frown$	<code>\frown</code>	$\asymp$	<code>\asymp</code>
$:$	<code>:</code>	$\notin$	<code>\notin</code>	$\neq$ or $\ne$	<code>\neq</code> or <code>\ne</code>

<sup>a</sup>Use the `latexsym` package to access this symbol

Table 6: **Binary Operators**

$+$	<code>+</code>	$-$	<code>-</code>	$\triangleleft$	<code>\triangleleft</code>
$\pm$	<code>\pm</code>	$\mp$	<code>\mp</code>	$\triangleright$	<code>\triangleright</code>
$\cdot$	<code>\cdot</code>	$\div$	<code>\div</code>	$\star$	<code>\star</code>
$\times$	<code>\times</code>	$\setminus$	<code>\setminus</code>	$\ast$	<code>\ast</code>
$\cup$	<code>\cup</code>	$\cap$	<code>\cap</code>	$\circ$	<code>\circ</code>
$\sqcup$	<code>\sqcup</code>	$\sqcap$	<code>\sqcap</code>	$\bullet$	<code>\bullet</code>
$\vee$ , $\lor$	<code>\vee</code> , <code>\lor</code>	$\wedge$ , $\land$	<code>\wedge</code> , <code>\land</code>	$\diamond$	<code>\diamond</code>
$\oplus$	<code>\oplus</code>	$\ominus$	<code>\ominus</code>	$\uplus$	<code>\uplus</code>
$\odot$	<code>\odot</code>	$\oslash$	<code>\oslash</code>	$\amalg$	<code>\amalg</code>
$\otimes$	<code>\otimes</code>	$\bigcirc$	<code>\bigcirc</code>	$\dagger$	<code>\dagger</code>
$\triangleleft$	<code>\triangleleft</code>	$\bigtriangledown$	<code>\bigtriangledown</code>	$\ddagger$	<code>\ddagger</code>
$\lhd$ <sup>a</sup>	<code>\lhd</code>	$\rhd$ <sup>a</sup>	<code>\rhd</code>	$\wr$	<code>\wr</code>
$\unlhd$ <sup>a</sup>	<code>\unlhd</code>	$\unrhd$ <sup>a</sup>	<code>\unrhd</code>		

Table 7: **BIG Operators**

$\sum$	<code>\sum</code>	$\bigcup$	<code>\bigcup</code>	$\bigvee$	<code>\bigvee</code>	$\bigoplus$	<code>\bigoplus</code>
$\prod$	<code>\prod</code>	$\bigcap$	<code>\bigcap</code>	$\bigwedge$	<code>\bigwedge</code>	$\bigotimes$	<code>\bigotimes</code>
$\coprod$	<code>\coprod</code>	$\bigsqcup$	<code>\bigsqcup</code>			$\bigodot$	<code>\bigodot</code>
$\int$	<code>\int</code>	$\oint$	<code>\oint</code>			$\biguplus$	<code>\biguplus</code>

Table 8: Arrows

$\leftarrow$	<code>\leftarrow</code> or <code>\gets</code>	$\longleftarrow$	<code>\longleftarrow</code>	$\uparrow$	<code>\uparrow</code>
$\rightarrow$	<code>\rightarrow</code> or <code>\to</code>	$\longrightarrow$	<code>\longrightarrow</code>	$\downarrow$	<code>\downarrow</code>
$\leftrightarrow$	<code>\leftrightarrow</code>	$\longleftrightarrow$	<code>\longleftrightarrow</code>	$\updownarrow$	<code>\updownarrow</code>
$\Leftarrow$	<code>\Leftarrow</code>	$\Lleftarrow$	<code>\Lleftarrow</code>	$\Uparrow$	<code>\Uparrow</code>
$\Rightarrow$	<code>\Rightarrow</code>	$\Rrightarrow$	<code>\Rrightarrow</code>	$\Downarrow$	<code>\Downarrow</code>
$\Leftrightarrow$	<code>\Leftrightarrow</code>	$\Leftrightarrow$	<code>\Leftrightarrow</code>	$\Updownarrow$	<code>\Updownarrow</code>
$\mapsto$	<code>\mapsto</code>	$\longmapsto$	<code>\longmapsto</code>	$\nearrow$	<code>\nearrow</code>
$\hookrightarrow$	<code>\hookrightarrow</code>	$\hookrightarrow$	<code>\hookrightarrow</code>	$\searrow$	<code>\searrow</code>
$\leftharpoonup$	<code>\leftharpoonup</code>	$\rightharpoonup$	<code>\rightharpoonup</code>	$\swarrow$	<code>\swarrow</code>
$\leftharpoondown$	<code>\leftharpoondown</code>	$\rightharpoondown$	<code>\rightharpoondown</code>	$\nwarrow$	<code>\nwarrow</code>
$\rightleftharpoons$	<code>\rightleftharpoons</code>	$\iff$ (bigger spaces)	<code>\iff</code> (bigger spaces)	$\leadsto$	<code>\leadsto</code> <sup>a</sup>

<sup>a</sup>Use the `latexsym` package to access this symbol

Table 9: Delimiters

(	(	)	)	$\uparrow$	<code>\uparrow</code>	$\Uparrow$	<code>\Uparrow</code>
[	[ or <code>\lbrack</code>	]	] or <code>\rbrack</code>	$\downarrow$	<code>\downarrow</code>	$\Downarrow$	<code>\Downarrow</code>
{	<code>\{</code> or <code>\lbrace</code>	}	<code>\}</code> or <code>\rbrace</code>	$\updownarrow$	<code>\updownarrow</code>	$\Updownarrow$	<code>\Updownarrow</code>
$\langle$	<code>\langle</code>	$\rangle$	<code>\rangle</code>		or <code>\vert</code>		<code>\ </code> or <code>\Vert</code>
$\lfloor$	<code>\lfloor</code>	$\rfloor$	<code>\rfloor</code>	$\lceil$	<code>\lceil</code>	$\rceil$	<code>\rceil</code>
/	/	$\backslash$	<code>\backslash</code>	.	(dual. empty)		

Table 10: Large Delimiters

$\left($	<code>\lgroup</code>	$\right)$	<code>\rgroup</code>	$\left\{$	<code>\lmoustache</code>	$\right\}$	<code>\rmoustache</code>
$\uparrow$	<code>\arrowvert</code>	$\uparrow$	<code>\Arrowvert</code>	$\uparrow$	<code>\bracevert</code>		

Table 11: Miscellaneous Symbols

$\dots$	<code>\dots</code>	$\cdots$	<code>\cdots</code>	$\vdots$	<code>\vdots</code>	$\ddots$	<code>\ddots</code>
$\hbar$	<code>\hbar</code>	$\imath$	<code>\imath</code>	$\jmath$	<code>\jmath</code>	$\ell$	<code>\ell</code>
$\Re$	<code>\Re</code>	$\Im$	<code>\Im</code>	$\aleph$	<code>\aleph</code>	$\wp$	<code>\wp</code>
$\forall$	<code>\forall</code>	$\exists$	<code>\exists</code>	$\mho$ <sup>a</sup>	<code>\mho</code> <sup>a</sup>	$\partial$	<code>\partial</code>
'	'	'	<code>\prime</code>	$\emptyset$	<code>\emptyset</code>	$\infty$	<code>\infty</code>
$\nabla$	<code>\nabla</code>	$\triangle$	<code>\triangle</code>	$\Box$ <sup>a</sup>	<code>\Box</code> <sup>a</sup>	$\diamond$	<code>\Diamond</code> <sup>a</sup>
$\perp$	<code>\perp</code>	$\top$	<code>\top</code>	$\angle$	<code>\angle</code>	$\surd$	<code>\surd</code>
$\diamondsuit$	<code>\diamondsuit</code>	$\heartsuit$	<code>\heartsuit</code>	$\clubsuit$	<code>\clubsuit</code>	$\spadesuit$	<code>\spadesuit</code>
$\neg$ or <code>\not</code>	<code>\neg</code> or <code>\not</code>	$\flat$	<code>\flat</code>	$\natural$	<code>\natural</code>	$\sharp$	<code>\sharp</code>

<sup>a</sup>Use the `latexsym` package to access this symbol

Table 12: Non-Mathematical Symbols

These symbols can also be used in text mode.

†	<code>\dag</code>	§	<code>\S</code>	©	<code>\copyright</code>
‡	<code>\ddag</code>	¶	<code>\P</code>	£	<code>\pounds</code>

The symbols in the following tables all require the `amssymb` package.

Table 13: AMS Delimiters

⌈	<code>\ulcorner</code>	⌊	<code>\urcorner</code>	⌌	<code>\llcorner</code>	⌋	<code>\lrcorner</code>
---	------------------------	---	------------------------	---	------------------------	---	------------------------

Table 14: AMS Greek and Hebrew

$\digamma$	<code>\digamma</code>	$\varkappa$	<code>\varkappa</code>	$\beth$	<code>\beth</code>	$\daleth$	<code>\daleth</code>	$\gimel$	<code>\gimel</code>
------------	-----------------------	-------------	------------------------	---------	--------------------	-----------	----------------------	----------	---------------------

Table 15: AMS Binary Relations

$\lessdot$	<code>\lessdot</code>	$\gtrdot$	<code>\gtrdot</code>	$\doteqdot$ or $\Doteq$	<code>\doteqdot</code> or <code>\Doteq</code>
$\leqslant$	<code>\leqslant</code>	$\geqslant$	<code>\geqslant</code>	$\risingdotseq$	<code>\risingdotseq</code>
$\eqslantless$	<code>\eqslantless</code>	$\eqslantgtr$	<code>\eqslantgtr</code>	$\fallingdotseq$	<code>\fallingdotseq</code>
$\leqq$	<code>\leqq</code>	$\geqq$	<code>\geqq</code>	$\eqcirc$	<code>\eqcirc</code>
$\lll$ or $\llless$	<code>\lll</code> or <code>\llless</code>	$\ggg$ or $\gggtr$	<code>\ggg</code> or <code>\gggtr</code>	$\circeq$	<code>\circeq</code>
$\lesssim$	<code>\lesssim</code>	$\gtrsim$	<code>\gtrsim</code>	$\triangleq$	<code>\triangleq</code>
$\lessapprox$	<code>\lessapprox</code>	$\gtrapprox$	<code>\gtrapprox</code>	$\bumpeq$	<code>\bumpeq</code>
$\lessgtr$	<code>\lessgtr</code>	$\gtrless$	<code>\gtrless</code>	$\Bumpeq$	<code>\Bumpeq</code>
$\lesseqgtr$	<code>\lesseqgtr</code>	$\gtreqless$	<code>\gtreqless</code>	$\thicksim$	<code>\thicksim</code>
$\lesseqqgtr$	<code>\lesseqqgtr</code>	$\gtreqqless$	<code>\gtreqqless</code>	$\thickapprox$	<code>\thickapprox</code>
$\preccurlyeq$	<code>\preccurlyeq</code>	$\succcurlyeq$	<code>\succcurlyeq</code>	$\approxeq$	<code>\approxeq</code>
$\curlyeqprec$	<code>\curlyeqprec</code>	$\curlyeqsucc$	<code>\curlyeqsucc</code>	$\backsim$	<code>\backsim</code>
$\precsim$	<code>\precsim</code>	$\succsim$	<code>\succsim</code>	$\backsimeq$	<code>\backsimeq</code>
$\precapprox$	<code>\precapprox</code>	$\succapprox$	<code>\succapprox</code>	$\vDash$	<code>\vDash</code>
$\subseteqq$	<code>\subseteqq</code>	$\supseteqq$	<code>\supseteqq</code>	$\Vdash$	<code>\Vdash</code>
$\Subset$	<code>\Subset</code>	$\Supset$	<code>\Supset</code>	$\Vvdash$	<code>\Vvdash</code>
$\sqsubset$	<code>\sqsubset</code>	$\sqsupset$	<code>\sqsupset</code>	$\backepsilon$	<code>\backepsilon</code>
$\therefore$	<code>\therefore</code>	$\because$	<code>\because</code>	$\varpropto$	<code>\varpropto</code>
$\shortmid$	<code>\shortmid</code>	$\shortparallel$	<code>\shortparallel</code>	$\between$	<code>\between</code>
$\smallsmile$	<code>\smallsmile</code>	$\smallfrown$	<code>\smallfrown</code>	$\pitchfork$	<code>\pitchfork</code>
$\vartriangleleft$	<code>\vartriangleleft</code>	$\vartriangleright$	<code>\vartriangleright</code>	$\blacktriangleleft$	<code>\blacktriangleleft</code>
$\trianglelefteq$	<code>\trianglelefteq</code>	$\trianglerighteq$	<code>\trianglerighteq</code>	$\blacktriangleright$	<code>\blacktriangleright</code>

Table 16: AMS Arrows

$\dashleftarrow$	<code>\dashleftarrow</code>	$\dashrightarrow$	<code>\dashrightarrow</code>	$\multimap$	<code>\multimap</code>
$\leftleftarrows$	<code>\leftleftarrows</code>	$\rightrightarrows$	<code>\rightrightarrows</code>	$\Uparrow$	<code>\upuparrows</code>
$\leftrightarrows$	<code>\leftrightarrows</code>	$\rightleftarrows$	<code>\rightleftarrows</code>	$\Downarrow$	<code>\downdownarrows</code>
$\Lleftarrow$	<code>\Lleftarrow</code>	$\Rrightarrow$	<code>\Rrightarrow</code>	$\Uparrow$	<code>\upharpoonleft</code>
$\twoheadleftarrow$	<code>\twoheadleftarrow</code>	$\twoheadrightarrow$	<code>\twoheadrightarrow</code>	$\Uparrow$	<code>\upharpoonright</code>
$\leftarrowtail$	<code>\leftarrowtail</code>	$\rightarrowtail$	<code>\rightarrowtail</code>	$\Downarrow$	<code>\downharpoonleft</code>
$\leftrightharpoons$	<code>\leftrightharpoons</code>	$\rightleftharpoons$	<code>\rightleftharpoons</code>	$\Downarrow$	<code>\downharpoonright</code>
$\Lsh$	<code>\Lsh</code>	$\Rsh$	<code>\Rsh</code>	$\rightsquigarrow$	<code>\rightsquigarrow</code>
$\looparrowleft$	<code>\looparrowleft</code>	$\looparrowright$	<code>\looparrowright</code>	$\leftrightsquigarrow$	<code>\leftrightsquigarrow</code>
$\curvearrowleft$	<code>\curvearrowleft</code>	$\curvearrowright$	<code>\curvearrowright</code>		
$\circlearrowleft$	<code>\circlearrowleft</code>	$\circlearrowright$	<code>\circlearrowright</code>		

Table 17: AMS Negated Binary Relations and Arrows

$\nless$	<code>\nless</code>	$\ngtr$	<code>\ngtr</code>	$\varsubsetneqq$	<code>\varsubsetneqq</code>
$\lneq$	<code>\lneq</code>	$\gneq$	<code>\gneq</code>	$\varsupsetneqq$	<code>\varsupsetneqq</code>
$\nleq$	<code>\nleq</code>	$\ngeq$	<code>\ngeq</code>	$\nsubseteqeq$	<code>\nsubseteqeq</code>
$\nleqslant$	<code>\nleqslant</code>	$\ngeqslant$	<code>\ngeqslant</code>	$\nsupseteqeq$	<code>\nsupseteqeq</code>
$\lneqq$	<code>\lneqq</code>	$\gneqq$	<code>\gneqq</code>	$\nmid$	<code>\nmid</code>
$\lvertneqq$	<code>\lvertneqq</code>	$\gvertneqq$	<code>\gvertneqq</code>	$\nparallel$	<code>\nparallel</code>
$\nleqq$	<code>\nleqq</code>	$\ngeqq$	<code>\ngeqq</code>	$\nshortmid$	<code>\nshortmid</code>
$\lnsim$	<code>\lnsim</code>	$\gnsim$	<code>\gnsim</code>	$\nshortparallel$	<code>\nshortparallel</code>
$\lnapprox$	<code>\lnapprox</code>	$\gnapprox$	<code>\gnapprox</code>	$\nsim$	<code>\nsim</code>
$\nprec$	<code>\nprec</code>	$\nsucc$	<code>\nsucc</code>	$\ncong$	<code>\ncong</code>
$\npreceq$	<code>\npreceq</code>	$\nsucceq$	<code>\nsucceq</code>	$\nvdash$	<code>\nvdash</code>
$\nprecneqq$	<code>\nprecneqq</code>	$\nsuccneqq$	<code>\nsuccneqq</code>	$\nvDash$	<code>\nvDash</code>
$\nprecnsim$	<code>\nprecnsim</code>	$\nsuccnsim$	<code>\nsuccnsim</code>	$\nVdash$	<code>\nVdash</code>
$\nprecnapprox$	<code>\nprecnapprox</code>	$\nsuccnapprox$	<code>\nsuccnapprox</code>	$\nVDash$	<code>\nVDash</code>
$\subsetneq$	<code>\subsetneq</code>	$\supsetneq$	<code>\supsetneq</code>	$\ntriangleleft$	<code>\ntriangleleft</code>
$\varsubsetneq$	<code>\varsubsetneq</code>	$\varsupsetneq$	<code>\varsupsetneq</code>	$\ntriangleright$	<code>\ntriangleright</code>
$\nsubseteq$	<code>\nsubseteq</code>	$\nsupseteq$	<code>\nsupseteq</code>	$\ntrianglelefteq$	<code>\ntrianglelefteq</code>
$\subsetneqq$	<code>\subsetneqq</code>	$\supsetneqq$	<code>\supsetneqq</code>	$\ntrianglerighteq$	<code>\ntrianglerighteq</code>
$\nleftarrow$	<code>\nleftarrow</code>	$\nrightarrow$	<code>\nrightarrow</code>	$\nleftrightarrow$	<code>\nleftrightarrow</code>
$\nLeftarrow$	<code>\nLeftarrow</code>	$\nRightarrow$	<code>\nRightarrow</code>	$\nLeftrightarrow$	<code>\nLeftrightarrow</code>

Table 18: AMS Binary Operators

$\dot{+}$	<code>\dotplus</code>	$\cdot$	<code>\centerdot</code>	$\top$	<code>\intercal</code>
$\ltimes$	<code>\ltimes</code>	$\rtimes$	<code>\rtimes</code>	$\ast$	<code>\divideontimes</code>
$\Cup$	<code>\Cup</code> or <code>\doublecup</code>	$\Cap$	<code>\Cap</code> or <code>\doublecap</code>	$\smallsetminus$	<code>\smallsetminus</code>
$\veebar$	<code>\veebar</code>	$\bar{\wedge}$	<code>\barwedge</code>	$\bar{\bar{\wedge}}$	<code>\doublebarwedge</code>
$\boxplus$	<code>\boxplus</code>	$\boxminus$	<code>\boxminus</code>	$\ominus$	<code>\circleddash</code>
$\boxtimes$	<code>\boxtimes</code>	$\boxdot$	<code>\boxdot</code>	$\odot$	<code>\circledcirc</code>
$\leftthreetimes$	<code>\leftthreetimes</code>	$\rightthreetimes$	<code>\rightthreetimes</code>	$\circledast$	<code>\circledast</code>
$\curlyvee$	<code>\curlyvee</code>	$\curlywedge$	<code>\curlywedge</code>		

Table 19: AMS Miscellaneous

$\hbar$	<code>\hbar</code>	$\hslash$	<code>\hslash</code>	$\Bbbk$	<code>\Bbbk</code>
$\square$	<code>\square</code>	$\blacksquare$	<code>\blacksquare</code>	$\textcircled{S}$	<code>\circledS</code>
$\vartriangle$	<code>\vartriangle</code>	$\blacktriangle$	<code>\blacktriangle</code>	$\complement$	<code>\complement</code>
$\triangledown$	<code>\triangledown</code>	$\blacktriangledown$	<code>\blacktriangledown</code>	$\Game$	<code>\Game</code>
$\lozenge$	<code>\lozenge</code>	$\blacklozenge$	<code>\blacklozenge</code>	$\bigstar$	<code>\bigstar</code>
$\sphericalangle$	<code>\sphericalangle</code>	$\measuredangle$	<code>\measuredangle</code>	$\sphericalangle$	<code>\sphericalangle</code>
$\diagup$	<code>\diagup</code>	$\diagdown$	<code>\diagdown</code>	$\backprime$	<code>\backprime</code>
$\nexists$	<code>\nexists</code>	$\Finv$	<code>\Finv</code>	$\varnothing$	<code>\varnothing</code>
$\eth$	<code>\eth</code>	$\mho$	<code>\mho</code>		

## 2.6 Going Further

Useful links:

- [http://www.ctan.org/what\\_is\\_tex.html](http://www.ctan.org/what_is_tex.html)
- <http://theoval.cmp.uea.ac.uk/~nlct/latex/> This link is particularly useful for beginners and DPhil students as it contains a tutorial for beginners and a guide to writing a thesis using L<sup>A</sup>T<sub>E</sub>X.
- <http://detexify.kirelabs.org/classify.html#new> Find the markup for symbols.

Table 20: Math Alphabets

Example	Command	Required package
$ABCdef$	<code>\mathrm{ABCdef}</code>	
$ABCdef$	<code>\mathit{ABCdef}</code>	
$ABCdef$	<code>\mathnormal{ABCdef}</code>	
$ABC$	<code>\mathcal{ABC}</code>	
$\mathbb{ABC}$	<code>\mathbb{ABC}</code>	amsfonts or amssymb

### 3 Acknowledgements

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### References

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- Lamport, L. (1994).  *$\text{\LaTeX}$ : A Document Preparation System*. Reading, Massachusetts: Addison Wesley, 2nd edition.