# LaTeX

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# Chapter 1

# Introduction

## What is TeX

**TeX** (pronounced "Tech", with "ch" like in the Scottish "Loch"; see below for details on pronunciation) is a markup language created by Donald Knuth to typeset documents attractively and consistently. It's also a Turing-complete programming language, in the sense that it supports the if-else construct, it can calculate (the calculations are performed while compiling the document), etc., but you would find it very hard to make anything else but typesetting with it. The fine control TeX offers makes it very powerful, but also difficult and time-consuming to use. Knuth started writing the TeX typesetting engine in 1977 to explore the potential of the digital printing equipment that was beginning to infiltrate the publishing industry at that time, especially in the hope that he could reverse the trend of deteriorating typographical quality that he saw affecting his own books and articles. TeX as we use it today was released in 1982, with some slight enhancements added in 1989 to better support 8-bit characters and multiple languages. TeX is renowned for being extremely stable, for running on many different kinds of computers, and for being virtually bug free.

The version number of TeX is converging to $\pi$ and is now at 3.1415926.

Its name originates from the Greek word $\tau\epsilon\chi\nu o\lambda o\gamma\iota\alpha$ (*technologìa*, in English technology); its first syllable is $\tau\epsilon\chi$, similar to *TeX* in the Latin alphabet.[1] The name of the language is thus upper-case $\tau\epsilon\chi$: TEX, and the convention has arisen that the name is also its own pronunciation when written in the International Phonetic Alphabet. Unfortunately, there is ambiguity among authors as to whether this transcription is **/tex/** or **/tɛx/**: the vowel is thus pronounced either as the "ay" of words such as "way, hay, bay" (former case) or as the "e" of words such as "bet, met, let" (latter and more frequent case).

## What is LaTeX

**LaTeX** (pronounced either "Lah-tech" /la.tɛx/ or, less often, "Lay-tech" /le.tɛx/) is a macro package based on TeX created by Leslie Lamport. Its purpose is to simplify

[1] http://tex.loria.fr/general/texbook.tex

TeX typesetting, especially for documents containing mathematical formulae. It is currently maintained by the LaTeX3 project. Many later authors have contributed extensions, called *packages* or *styles*, to LaTeX. Some of these are bundled with most TeX/LaTeX software distributions; more can be found in the Comprehensive TeX Archive Network (CTAN).

Since LaTeX comprises a group of TeX commands, LaTeX document processing is essentially programming. You create a text file in LaTeX markup. The LaTeX macro reads this to produce the final document.

Clearly this has disadvantages in comparison with a WYSIWYG (What You See Is What You Get) program such as Openoffice.org Writer or Microsoft Word:

- You can't see the final result straight away.
- You need to know the necessary commands for LaTeX markup.
- It can sometimes be difficult to obtain a certain 'look'.

On the other hand, there are certain advantages to the markup language approach:

- The layout, fonts, tables and so on are consistent throughout.
- Mathematical formulae can be easily typeset.
- Indices, footnotes and references are generated easily.
- Your documents will be correctly structured.

The LaTeX-like approach can be called WYSIWYM, i.e. What You See Is What You Mean: you can't see how the final version will look like while typing. Instead you see the logical structure of the document. LaTeX takes care of the formatting for you.

The LaTeX document is a plain text file containing the content of the document, with additional markup. When the source file is processed by the macro package, it can produce documents in several formats. LaTeX supports natively DVI and PDF, but using other software you can easily create PostScript, PNG, JPG, etc.

## Skills needed

LaTeX is a very easy system to learn, and requires no specialist knowledge, although literacy and some familiarity with the publishing process is useful. It is, however, assumed that you are completely fluent and familiar with using your computer before you start. Specifically, effective use of this document requires that you already know and understand the following very thoroughly:

- how to use a good plain-text editor (not a wordprocessor like OpenOffice, WordPerfect, or Microsoft Word).
- where to find all 95 of the printable ASCII characters on your keyboard and what they mean, and how to type accents and symbols, if you use them.

- how to create, open, save, close, rename, move, and delete files and folders (directories).
- how to use a Web browser and/or File Transfer Protocol (FTP) program to download and save files from the Internet.
- how to uncompress and unwrap (unzip or detar) downloaded files.

If you don't know how to do these things yet, it's important to go and learn them first. Trying to become familiar with the fundamentals of using a computer at the same time as learning LaTeX is not likely to be as effective as doing them in order. These are not specialist skills, they are all included in the European Computer Driving Licence (ECDL) and the relevant sections of the ECDL syllabus are noted in the square brackets above, so they are well within the capability of anyone who uses a computer.

## Prerequisites

At a minimum, you'll need the following programs to edit LaTeX:

- An editor (You can use a basic text editor like notepad, but a dedicated LaTeX editor will be more useful).
  - On Windows, TeXnicCenter(http://www.texniccenter.org/) is a popular free and open source LaTeX editor.
  - On Unix-like (including Mac OS X) systems, Emacsen and gvim provide powerful TeX enviroments for the tech-savvy, while Texmaker http://www.xm1math.net/texmaker/index.html and Kile http://kile.sf.net provide more user-friendly development environments.
- The LaTeX binaries and style sheets — e.g. MiKTeX http://www.miktex.org/ for Windows, teTeX http://www.tug.org/teTeX/ for Unix/Linux and teTeX for Mac OS X http://www.rna.nl/tex.html.
- A DVI viewer to view and print the final result. Usually, a DVI viewer is included in the editor or is available with the binary distribution.

A distribution of LaTeX, with many packages, add-ins, editors and viewers for Unix, Linux, Mac and Windows can be obtained from the TeX users group at http://www.tug.org/texlive/.

## Applications within a distribution

Here are the main programs you expect to find in any (La)TeX distribution:

- **tex**: the simplest compiler: generates DVI from TeX source
- **pdftex**: generates PDF from TeX source
- **latex**: generates DVI from LaTeX source (the most used one)
- **pdflatex**: generates PDF from LaTeX source

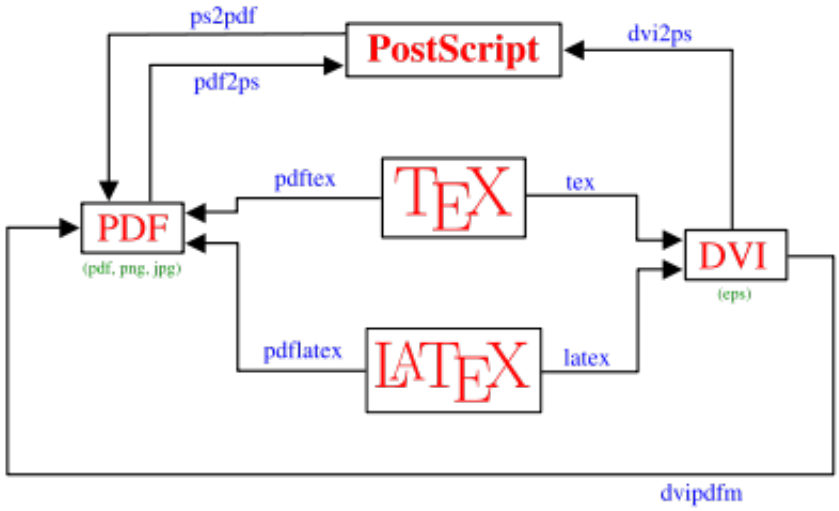
- **dvi2ps**: converts DVI to PostScript
- **dvipdf**: converts DVI to PDF
- **dvipdfm**: an improved version of **dvipdf**

When LaTeX was created, the only format it could create was DVI; then the PDF support was added by *pdflatex*, even if several people still don't use it. As it is clear from this short list, PDF files can be created with both *pdflatex* and *dvipdfm*; some think that the output of *pdflatex* is better than the output of *dvipdfm*. DVI is an old format, and it does not support hyperlinks for example, while PDF does, so passing through DVI you will bring all the bad points of that format to PDF.

Strictly speaking, you would write your document slightly differently depending on the compiler you are using (*latex* or *pdflatex*). But as we will see later, it is possible to add a sort of abstraction layer, to hide the details of which compiler you're using, and the compiler will handle the translation itself.

Note that, since LaTeX is just a collection of macros for TeX, if you compile a plain TeX document with a LaTeX compiler (such as *pdflatex*) it will work, while the opposite is not true: if you try to compile a LaTeX source with a TeX compiler you will get only a lot of errors.

The following diagram shows the relationships between the (La)TeX source code and all the formats you can create from it:




The boxed red text represents the file formats, the blue text on the arrows represents the commands you have to use, the small dark green text under the boxes represents the image formats that are supported. Any time you pass through an arrow you lose some information, which might decrease the quality of your document. Therefore, in order to achieve the highest quality in your output file, you should choose the

shortest route to reach your target format. This is probably the most convenient way to obtain an output in your desired format anyway. Starting from a LaTeX source, the best way is to use only *latex* for a DVI output or *pdflatex* for a PDF output, converting to PostScript only when it is necessary to print the document.

Most of the programs should be already within your LaTeX distribution; the others come with Ghostscript, which is a free and multi-platform software as well.

# Chapter 2

# Absolute Beginners

This tutorial is aimed at getting familiar with the bare bones of LaTeX. First, ensure that you have LaTeX installed on your computer (see Installation for instructions of what you will need). We will begin with creating the actual source LaTeX file, and then take you through how to feed this through the LaTeX system to produce quality output, such as postscript or PDF.

## The LaTeX source

The first thing you need to be aware of is that LaTeX uses a markup language in order to describe document structure and presentation. What LaTeX does is to convert your source text, combined with the markup, into a high quality document. For the purpose of analogy, web pages work in a similar way: the HTML is used to describe the document, but it is your browser that presents it in its full glory — with different colours, fonts, sizes, etc.

The input for LaTeX is a plain ASCII text file. You can create it with any text editor. It contains the text of the document, as well as the commands that tell LaTeX how to typeset the text.

For the truly impatient, a minimal example looks something like the following (the commands will be explained later):

```
\documentclass{article}

\begin{document}
Hello world!
\end{document}
```

### Spaces

"Whitespace" characters, such as blank or tab, are treated uniformly as "space" by LaTeX. Several consecutive whitespace characters are treated as one "space". Whitespace at the start of a line is generally ignored, and a single line break is treated as

"whitespace." An empty line between two lines of text defines the end of a paragraph. Several empty lines are treated the same as one empty line. The text below is an example. On the left hand side is the text from the input file, and on the right hand side is the formatted output.

```
It does not matter whether you
enter one or several
after a word.

An empty line starts a new
paragraph.
```

spaces

It does not matter whether you enter one or several spaces after a word.
An empty line starts a new paragraph.

## Special Characters

The following symbols are reserved characters that either have a special meaning under LaTeX or are unavailable in all the fonts. If you enter them directly in your text, they will normally not print, but rather make LaTeX 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:

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

The other symbols and many more can be printed with special commands in mathematical formulae or as accents. The backslash character \ can *not* be entered by adding another backslash in front of it (\\); this sequence is used for line breaking. For introducing a backslash in math mode, you can use `\backslash` instead.

If you want to insert text that might contain several particular symbols (such as URIs), you can consider using the `\verb` command, that will be discussed later in this book.

## LaTeX Commands

LaTeX commands are case sensitive, and take one of the following two formats:

- They start with a backslash \ and then have a name consisting of letters only. Command names are terminated by a space, a number or any other "non-letter".
- They consist of a backslash \ and exactly one non-letter.

Some commands need a parameter, which has to be given between curly braces { } after the command name. Some commands support optional parameters, which are added after the command name in square brackets `[ ]`. The general syntax is: `\commandname[option1,option2,...]{argument1}{argument2}...`

## LaTeX environments

*Environments* in LaTeX have a role that is quite similar to commands, but they usually have effect on a wider part of the document. Their syntax is:

```
\begin{environmentname}
text to be influenced
\end{environmentname}
```

between the `\begin` and the `\end` you can put other commands and nested environments. In general, environments can accept arguments as well, but this feature is not commonly used and so it will be discussed in more advanced parts of the document.

Anything in LaTeX can be expressed in terms of commands and environments.

## Comments

When LaTeX encounters a % character while processing an input file, it ignores the rest of the present line, the line break, and all whitespace at the beginning of the next line.

This can be used to write notes into the input file, which will not show up in the printed version.

```
This is an % stupid
% Better: instructive <----
example: Supercal%
            ifragilist%
icexpialidocious
```

This is an example: Supercalifragilisticexpialidocious

The `%` character can also be used to split long input lines where no whitespace or line breaks are allowed.

## Input File Structure

When LaTeX processes an input file, it expects it to follow a certain structure. Thus every input file must start with the command

`\documentclass{...}`

This specifies what sort of document you intend to write. After that, you can include commands that influence the style of the whole document, or you can load packages that add new features to the LaTeX system. To load such a package you use the command

`\usepackage{...}`

When all the setup work is done, you start the body of the text with the command

`\begin{document}`

Now you enter the text mixed with some useful LaTeX commands. At the end of the document you add the

`\end{document}`
command, which tells LaTeX to call it a day. Anything that follows this command will be ignored by LaTeX. The area between `\documentclass` and `\begin{document}` is called the *preamble*.

### A Typical Command Line Session

LaTeX itself does not have a GUI (graphical user interface), since it is just a program that crunches away at your input files, and produces either a DVI or PDF file. Some LaTeX installations feature a graphical front-end where you can click LaTeX into compiling your input file. On other systems there might be some typing involved, so here is how to coax LaTeX into compiling your input file on a text based system. Please note: this description assumes that a working LaTeX installation already sits on your computer.

1. Edit/Create your LaTeX input file. This file must be plain ASCII text. On Unix all the editors will create just that. On Windows you might want to make sure that you save the file in ASCII or Plain Text format. When picking a name for your file, make sure it bears a `.tex` extension.

2. Run LaTeX on your input file. If successful you will end up with a `.dvi` file. It may be necessary to run LaTeX several times to get the table of contents and all internal references right. When your input file has a bug LaTeX will tell you about it and stop processing your input file.

Type ctrl-D to get back to the command line.

```
latex foo.tex
```

Now you may view the DVI file. On Unix with X11 you can type `xdvi foo.dvi`, on Windows you can use a program called *yap* (yet another previewer).
You can run a similar procedure with `pdflatex` to produce a PDF document from the original `tex` source. Similar to above, type the commands:

```
pdflatex foo.tex
```

Now you may view the PDF file, `foo.pdf`.

## Our first document

Now we can create our first document. We will produce the absolute bare minimum that is needed in order to get some output, the well known **Hello World!** approach will be suitable here.

- Open your favourite text-editor. If you use vim or emacs, they also have syntax highlighting that will help to write your files.

- Reproduce the following text in your editor. This is the LaTeX source.

```
% hello.tex - Our first LaTeX example!
\documentclass{article}
\begin{document}
Hello World!
\end{document}
```

- Save your file as `hello.tex`.

## What does it all mean?

| | |
|---|---|
| `% hello.tex - Our first LaTeX example!` | The first line is a *comment*. This is because it begins with the percent symbol (%); when LaTeX sees this, it simply ignores the rest of the line. Comments are useful for humans to annotate parts of the source file. For example, you could put information about the author and the date, or whatever you wish. |
| `\documentclass{article}` | This line is a command and tells LaTeX to use the `article` document class. A document class file defines the formatting, which in this case is a generic article format. The handy thing is that if you want to change the appearance of your document, substitute article for another class file that exists. |
| `\begin{document}` | This line is the beginning of the environment called `document`; it alerts LaTeX that content of the document is about to commence. Anything above this command is known generally to belong in the *preamble*. |
| `Hello World!` | This was the only actual line containing real content — the text that we wanted displayed on the page. |
| `\end{document}` | The `document` environment ends here. It tells LaTeX that the document source is complete, anything after this line will be ignored. |

As we have said before, each of the LaTeX commands begin with a backslash (\). This is LaTeX's way of knowing that whenever it sees a backslash, to expect some commands. Comments are not classed as a command, since all they tell LaTeX is to ignore the line. Comments never affect the output of the document.

## Generating the document

It is clearly not going to be the most exciting document you have ever seen, but we want to see it nonetheless. I am assuming that you are at a command prompt, already in the directory where `hello.tex` is stored.

1. Type the command: `latex hello` (the `.tex` extension is not required, although you can include it if you wish)
2. Various bits of info about LaTeX and its progress will be displayed. If all went well, the last two lines displayed in the console will be:

```
Output written on hello.dvi (1 page, 232 bytes).
Transcript written on hello.log.
```

This means that your source file has been processed and the resulting document is called *hello.dvi*, which takes up 1 page and 232 bytes of space. This way you created the DVI file, but with the same source file you can create a PDF document. The steps are exactly the same as before, but you have to replace the command `latex` with `pdflatex`:

1. Type the command: `pdflatex hello` (as before, the `.tex` extension is not required)
2. Various bits of info about LaTeX and its progress will be displayed. If all went well, the last two lines displayed in the console will be:

```
Output written on hello.pdf (1 page, 5548 bytes).
Transcript written on hello.log.
```

you can notice that the PDF document is bigger than the DVI, even if it contains exactly the same information. The main differences between the DVI and PDF formats are:

- **DVI** needs less disk space and it is faster to create. It does not include the fonts within the document, so if you want the document to be viewed properly on another computer, there must be all the necessary fonts installed. It does not support any interactivity such as hyperlinks or animated images. DVI viewers are not very common, so you can consider using it for previewing your document while typesetting.
- **PDF** needs more disk space and it is slower to create, but it includes all the necessary fonts within the document, so you will not have any problem of portability. It supports internal and external hyperlinks. Nowadays it is the *de facto* standard for sharing and publishing documents, so you can consider using it for the final version of your document.

About now, you saw you can create both DVI and PDF document from the same source. This is true, but it gets a bit more complicated if you want to introduce images or links. This will be explained in detail in the next chapters, about now assume you can compile in both DVI and PDF without any problem.

Note, in this instance, due to the simplicity of the file, you only need to run the LaTeX command once. However, if you begin to create complex documents, including bibliographies and cross-references, etc, LaTeX needs to be executed multiple times to resolve the references. But this will be discussed in the future when it comes up.

# Chapter 3

# Basics

## Document Classes

The first information LaTeX needs to know when processing an input file is the type of document the author wants to create. This is specified with the `\documentclass` command.

`\documentclass[options]{class}`

Here class specifies the type of document to be created. The LaTeX distribution provides additional classes for other documents, including letters and slides. The options parameter customizes the behavior of the document class. The options have to be separated by commas.

Example: an input file for a LaTeX document could start with the line

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

which instructs LaTeX to typeset the document as an article with a base font size of eleven points, and to produce a layout suitable for double sided printing on A4 paper.

Here are some document classes that can be used with LaTeX:

| | |
|---|---|
| `article` | for articles in scientific journals, presentations, short reports, program documentation, invitations, ... |
| `proc` | a class for proceedings based on the article class. |
| `minimal` | is as small as it can get. It only sets a page size and a base font. It is mainly used for debugging purposes. |
| `report` | for longer reports containing several chapters, small books, thesis, ... |
| `book` | for real books |
| `slides` | for slides. The class uses big sans serif letters. |
| `memoir` | for changing sensibly the output of the document. It is based on the `book` class, but you can create any kind of document with it http://www.ctan.org/tex-archive/macros/latex/contrib/memoir/memman.pdf |
| `letter` | for writing letters. |

Table 3.1: Document Classes

The most common options for the standard document classes are listed in following table:

| | |
|---|---|
| `10pt, 11pt, 12pt` | Sets the size of the main font in the document. If no option is specified, 10pt is assumed. |
| `a4paper, letterpaper,...` | Defines the paper size. The default size is `letterpaper`; However, many European distributions of TeX now come pre-set for A4, not Letter, and this is also true of all distributions of pdfLaTeX. Besides that, `a5paper, b5paper, executivepaper`, and `legalpaper` can be specified. |
| `fleqn` | Typesets displayed formulas left-aligned instead of centered. |
| `leqno` | Places the numbering of formulae on the left hand side instead of the right. |
| `titlepage, notitlepage` | Specifies whether a new page should be started after the document title or not. The article class does not start a new page by default, while report and book do. |
| `onecolumn, twocolumn` | Instructs LaTeX to typeset the document in one column or two columns. |
| `twoside, oneside` | Specifies whether double or single sided output should be generated. The classes `article` and `report` are single sided and the `book` class is double sided by default. Note that this option concerns the style of the document only. The option `twoside` does not tell the printer you use that it should actually make a two-sided printout. |
| `landscape` | Changes the layout of the document to print in landscape mode. |
| `openright, openany` | Makes chapters begin either only on right hand pages or on the next page available. This does not work with the `article` class, as it does not know about chapters. The `report` class by default starts chapters on the next page available and the `book` class starts them on right hand pages. |
| `draft` | makes LaTeX indicate hyphenation and justification problems with a small square in the right-hand margin of the problem line so they can be located quickly by a human. |

Table 3.2: Document Class Options

For example, if you want a report to be in 12pt type on A4, but printed one-sided in draft mode, you would use:

```
\documentclass[12pt,a4paper,oneside,draft]{report}
```

## Packages

While writing your document, you will probably find that there are some areas where basic LaTeX cannot solve your problem. If you want to include graphics, colored text or source code from a file into your document, you need to enhance the capabilities of LaTeX. Such enhancements are called packages. Packages are activated with the

`\usepackage[options]{package}`

command, where package is the name of the package and options is a list of keywords that trigger special features in the package. Some packages come with the LaTeX base distribution. Others are provided separately.

Modern TeX distributions come with a large number of packages pre-installed. If you are working on a Unix system, use the command `texdoc` for accessing package documentation. For more information, see the Packages section.

## Files You Might Encounter

When you work with LaTeX you will soon find yourself in a maze of files with various extensions and probably no clue. The following list explains the most common file types you might encounter when working with TeX:

## Big Projects

When working on big documents, you might want to split the input file into several parts. LaTeX has three commands to insert a file into another when building the document.

The simplest is the \input command:

`\input{filename}`

\input inserts the contents of another file, named *filename.tex*; note that the .tex extension is omitted. For all practical purposes, \input is no more than a simple, automated cut-and-paste of the source code in *filename.tex*.

The other main inclusion command is \include:

`\include{filename}`

The `\include` command is different from </code>\input</code> in that it starts a new page just before inclusion. Since a new page is started at every `\include` command, it is appropriate to use it for large entities such as book chapters.

Very large documents (that usually include many files) take a very long time to compile, and most users find it convenient to test their last changes by including only the files they have been working on. One option is to hunt down all `\include` commands in the inclusion hierarchy and to comment them out:

```
%\include{filename1}
\include{filename2}
\include{filename3}
%\include{filename4}
```

In this case, the user wants to include only *filename2.tex* and *filename3.tex*. If the inclusion hierarchy is intricate, commenting can become error-prone: it is then convenient to use the `\includeonly` command *in the preamble*:

```
\includeonly{filename2,filename3}
```

This way, only `\include` commands for the specified files will be executed, and inclusion will be handled in only one place. Note that there must be no spaces between the filenames and the commas.

## Picking suitable filenames

Never, ever use directories (folders) or file names that contain spaces. Although your operating system probably supports them, some don't, and they will only cause grief and tears with TeX. Make filenames as short or as long as you wish, but strictly avoid spaces. Stick to upper- and lower-case letters without accents (A-Z and a-z), the digits 0-9, the hyphen (-), and the full point or period (.), (similar to the conventions for a Web URL): it will let you refer to TeX files over the Web more easily and make your files more portable.

| | |
|---|---|
| `.tex` | LaTeX or TeX input file. It can be compiled with latex. |
| `.sty` | LaTeX Macro package. This is a file you can load into your LaTeX document using the \usepackage command. |
| `.dtx` | Documented TeX. This is the main distribution format for LaTeX style files. If you process a `.dtx` file you get documented macro code of the LaTeX package contained in the `.dtx` file. |
| `.ins` | The installer for the files contained in the matching `.dtx` file. If you download a LaTeX package from the net, you will normally get a `.dtx` and a `.ins` file. Run LaTeX on the `.ins` file to unpack the `.dtx` file. |
| `.cls` | Class files define what your document looks like. They are selected with the `\documentclass` command. |
| `.fd` | Font description file telling LaTeX about new fonts. |
| `.dvi` | Device Independent File. This is the main result of a LaTeX compile run with *latex*. You can look at its content with a DVI previewer program or you can send it to a printer with dvips or a similar application. |
| `.pdf` | Portable Document Format. This is the main result of a LaTeX compile run with *pdflatex*. You can look at its content or print it with any PDF viewer. |
| `.log` | Gives a detailed account of what happened during the last compiler run. |
| `.toc` | Stores all your section headers. It gets read in for the next compiler run and is used to produce the table of content. |
| `.lof` | This is like `.toc` but for the list of figures. |
| `.lot` | And again the same for the list of tables. |
| `.aux` | Another file that transports information from one compiler run to the next. Among other things, the `.aux` file is used to store information associated with cross-references. |
| `.idx` | If your document contains an index. LaTeX stores all the words that go into the index in this file. Process this file with makeindex. |
| `.ind` | The processed .idx file, ready for inclusion into your document on the next compile cycle. |
| `.ilg` | Logfile telling what makeindex did. |

Table 3.4: Common file extensions in LaTeX

# Chapter 4

# Document Structure

The main point of writing a text is to convey ideas, information, or knowledge to the reader. The reader will understand the text better if these ideas are well-structured, and will see and feel this structure much better if the typographical form reflects the logical and semantical structure of the content.

LaTeX is different from other typesetting systems in that you just have to tell it the logical and semantical structure of a text. It then derives the typographical form of the text according to the "rules" given in the document class file and in various style files. LaTeX allows users to structure their documents with a variety of hierarchal constructs, including chapters, sections, subsections and paragraphs.

## The `document` environment

After the Document Class Declaration, the text of your document is enclosed between two commands which identify the beginning and end of the actual document:

```
\documentclass[11pt,a4paper,oneside]{report}

\begin{document}
...
\end{document}
```

You would put your text where the dots are. The reason for marking off the beginning of your text is that LaTeX allows you to insert extra setup specifications before it (where the blank line is in the example above: we'll be using this soon). The reason for marking off the end of your text is to provide a place for LaTeX to be programmed to do extra stuff automatically at the end of the document, like making an index.

A useful side-effect of marking the end of the document text is that you can store comments or temporary text underneath the `\end{document}` in the knowledge that LaTeX will never try to typeset them:

```
...
\end{document}
Don't forget to get the extra chapter from Jim!
```

## Preamble

The *preamble* is everything from the start of the Latex source file until the \begin{document} command. It normally contains commands that affect the entire document.

```
% simple.tex - A simple article to illustrate document structure.

\documentclass{article}
\usepackage{mathptmx}

\begin{document}
```

The first line is a comment (as denoted by the % sign). The \documentclass command takes an argument, which in this case is article, because that's the type of document we want to produce. It is also possible to create your own, as is often done by journal publishers, who simply provide you with their own class file, which tells Latex how to format your content. But we'll be happy with the standard article class for now! \usepackage is an important command that tells Latex to utilize some external macros. In this instance, I specified mathptmx which means Latex will use the Postscript Times type 1 font instead of the default ComputerModern font. And finally, the \begin{document}. This strictly isn't part of the preamble, but I'll put it here anyway, as it implies the end of the preamble by nature of stating that the document is now starting.

## Top Matter

At the beginning of most documents there will be information about the document itself, such as the title and date, and also information about the authors, such as name, address, email etc. All of this type of information within Latex is collectively referred to as *top matter*. Although never explicitly specified (there is no \topmatter command) you are likely to encounter the term within Latex documentation.

A simple example:

```
\documentclass[11pt,a4paper,oneside]{report}

\begin{document}
\title{How to Structure a LaTeX Document}
\author{Andrew Roberts}
\date{December 2004}
\maketitle
\end{document}
```

The \title, \author, and \date commands are self-explanatory. You put the title, author name, and date in curly braces after the relevant command. The title and author are usually compulsory (at least if you want LaTeX to write the title automatically); if you omit the \date command, LaTeX uses today's date by default. You always finish the top matter with the \maketitle command, which tells LATEX that it's complete and it can typeset the title according to the information you have provided and the class (style) you are using. If you omit \maketitle, the titling will never be typeset (unless you write your own).

Here is a more complicated example:

```
\title{How to Structure a \LaTeX{} Document}
\author{Andrew Roberts\\
  School of Computing,\\
  University of Leeds,\\
  Leeds,\\
  United Kingdom,\\
  LS2 1HE\\
  \texttt{andyr@comp.leeds.ac.uk}}
\date{\today}
\maketitle
```

as you can see, you can use commands as arguments of \title and the others. The double backslash (\\) is the LaTeX command for forced linebreak. LaTeX normally decides by itself where to break lines, and it's usually right, but sometimes you need to cut a line short, like here, and start a new one.

If there are two authors separate them with the \and command.

```
\title{Our Fun Document}
\author{John Doe \and Jane Doe}
\date{\today}
\maketitle
```

If you are provided with a class file from a publisher, or if you use the AMS article class (amsart), then you can use several different commands to enter author information. The email address is at the end, and the \texttt commands formats the email address using a mono-spaced font. The built-in command called \today will be replaced with the current date when processed by LaTeX. But you are free to put whatever you want as a date, in no set order. If braces are left empty, then the date is omitted.

Using this approach, you can create only basic output whose layout is very hard to change. If you want to create your title freely, see the Title Creation section.

## Abstract

As most research papers have an abstract, there are predefined commands for telling LaTeX which part of the content makes up the abstract. This should appear in its logical order, therefore, after the top matter, but before the main sections of the body. This command is available for the document class *article* and *report*, but not *book*.

```
\documentclass{article}

\begin{document}

\begin{abstract}
Your abstract goes here...
...
\end{abstract}
...
\end{document}
```

By default, LaTeX will use the word "Abstract" as a title for your abstract, if you want to change it into anything else, e.g. "Executive Summary", add the following line in the preamble:

```
\renewcommand{\abstractname}{Executive Summary}
```

## Sectioning Commands

The commands for inserting sections are fairly intuitive. Of course, certain commands are appropriate to different document classes. For example, a book has chapters but an article doesn't. Here is an edited version of some of the structure commands in use from *simple.tex*.

```
\section{Introduction}
This section's content...

\section{Structure}
This section's content...

\subsection{Top Matter}
This subsection's content...

\subsubsection{Article Information}
This subsubsection's content...
```

As you can see, the commands are fairly intuitive. Notice that you do not need to specify section numbers. LaTeX will sort that out for you! Also, for sections, you do not need to markup which content belongs to a given block, using `\begin` and `\end` commands, for example. LaTeX provides 7 levels of depth for defining sections:

All the titles of the sections are added automatically to the table of contents (if you decide to insert one). But if you make manual styling changes to your heading, for example a very long title, or some special line-breaks or unusual font-play, this would appear in the Table of Contents as well, which you almost certainly don't want. LATEX allows you to give an optional extra version of the heading text which only gets used in the Table of Contents and any running heads, if they are in effect. This optional alternative heading goes in [square brackets] before the curly braces:

| Command | Level | comment |
|---|---|---|
| \part{''part''} | -1 | not in letters |
| \chapter{''chapter''} | 0 | only books and reports |
| \section{''section''} | 1 | not in letters |
| \subsection{''subsection''} | 2 | not in letters |
| \subsubsection{''subsubsection''} | 3 | not in letters |
| \paragraph{''paragraph''} | 4 | not in letters |
| \subparagraph{''subparagraph''} | 5 | not in letters |

```
\section[Effect on staff turnover]{An analysis of the
effect of the revised recruitment policies on staff
turnover at divisional headquarters}
```

### Section numbering

Numbering of the sections is performed automatically by LaTeX, so don't bother adding them explicitly, just insert the heading you want between the curly braces. Parts get roman numerals (Part I, Part II, etc.); chapters and sections get decimal numbering like this document, and appendices (which are just a special case of chapters, and share the same structure) are lettered (A, B, C, etc.). You can change the depth to which section numbering occurs, so you can turn it off selectively. By default it is set to 2. If you only want parts, chapters, and sections numbered, not subsections or subsubsections etc., you can change the value of the `secnumdepth` counter using the `\setcounter` command, giving the depth level from the previous table. For example, if you want to change it to "1":

```
\setcounter{secnumdepth}{1}
```

A related counter is `tocdepth`, which specifies what depth to take the Table of Contents to. It can be reset in exactly the same way as `secnumdepth`. For example:

```
\setcounter{tocdepth}{3}
```

To get an unnumbered section heading which does not go into the Table of Contents, follow the command name with an asterisk before the opening curly brace:

```
\subsection*{Introduction}
```

All the divisional commands from \part* to \subparagraph* have this "starred" version which can be used on special occasions for an unnumbered heading when the setting of `secnumdepth` would normally mean it would be numbered.

If you want the unnumbered section to be in the table of contents anyway, use the `\addcontentsline` command like this:

```
\section*{Introduction}
\addcontentsline{toc}{section}{Introduction}
```

## Appendices

The separate numbering of appendices is also supported by LaTeX. The `\appendix` macro can be used to indicate that following sections or chapters are to be numbered as appendices.

In the report or book classes this gives:

```
\appendix
\chapter{First Appendix}
```

For the article class use:

```
\appendix
\section{First Appendix}
```

## Ordinary paragraphs

After section headings comes your text. Just type it and leave a blank line between paragraphs. That's all LaTeX needs. The blank line means "start a new paragraph here": it does **not** mean you get a blank line in the typeset output. The spacing between paragraphs is a separately definable quantity, a dimension or length called `\parskip`. This is normally zero (no space between paragraphs, because that's how books are normally typeset), but you can easily set it to any size you want with the `\setlength` command in the Preamble:

```
\setlength{\parskip}{1cm}
```

This will set the space between paragraphs to 1cm. Leaving multiple blank lines between paragraphs in your source document achieves nothing: all extra blank lines get ignored by LaTeX because the space between paragraphs is controlled only by the value of `\parskip`.

White-space in LaTeX can also be made flexible (what Lamport calls "rubber" lengths). This means that values such as `\parskip` can have a default dimension plus an amount of expansion minus an amount of contraction. This is useful on pages in complex documents where not every page may be an exact number of fixed-height lines long, so some give-and-take in vertical space is useful. You specify this in a `\setlength` command like this:

```
\setlength{\parskip}{1cm plus4mm minus3mm}
```

Paragraph indentation can also be set with the `\setlength` command, although you would always make it a fixed size, never a flexible one, otherwise you would have very ragged-looking paragraphs.

```
\setlength{\parindent}{6mm}
```

By default, the first paragraph after a heading follows the standard Anglo-American publishers' practice of no indentation. Subsequent paragraphs are indented by the value of `\parindent` (default 18pt). You can change this in the same way as any other length.

To turn off indentation completely, set it to zero (but you still have to provide units: it's still a measure!).

```
\setlength{\parindent}{0in}
```

If you do this, though, and leave `\parskip` set to zero, your readers won't be able to tell easily where each paragraph begins! If you want to use the style of having no indentation with a space between paragraphs, use the `parskip` package, which does it for you (and makes adjustments to the spacing of lists and other structures which use paragraph spacing, so they don't get too far apart).

## Table of contents

All auto-numbered headings get entered in the Table of Contents (ToC) automatically. You don't have to print a ToC, but if you want to, just add the command `\tableofcontents` at the point where you want it printed (usually after the Abstract or Summary).

Entries for the ToC are recorded each time you process your document, and reproduced the next time you process it, so you need to re-run LATEX one extra time to ensure that all ToC pagenumber references are correctly calculated. We've already seen how to use the optional argument to the sectioning commands to add text to the ToC which is slightly different from the one printed in the body of the document. It is also possible to add extra lines to the ToC, to force extra or unnumbered section headings to be included.

The commands `\listoffigures` and `\listoftables` work in exactly the same way as `\tableofcontents` to automatically list all your tables and figures. If you use them, they normally go after the `\tableofcontents` command. The `\tableofcontents` command normally shows only numbered section headings, and only down to the level defined by the `tocdepth` counter, but you can add extra entries with the `\addcontentsline` command. For example if you use an unnumbered section heading command to start a preliminary piece of text like a Foreword or Preface, you can write:

```
\subsection*{Preface}
\addcontentsline{toc}{subsection}{Preface}
```

This will format an unnumbered ToC entry for "Preface" in the "subsection" style. You can use the same mechanism to add lines to the List of Figures or List of Tables by substituting `lof` or `lot` for `toc`.

### Depth

The default ToC will list headings of level 3 and above. To change how deep the table of contents displays automatically the following command can be used in the preamble: `\setcounter{tocdepth}{4}`

This will make the table of contents include everything down to paragraphs. The levels are defined above on this page.

## The Bibliography

Any good research paper will have a whole list of references. Fortunately, LaTeX has a slightly more intelligent approach to managing your references than the average word processor where everything has to be input manually (unless you purchase a 3rd party add-on). There are two ways to insert your references into LaTeX:

- you can embed them within the document itself. It's simpler, but it can be time-consuming if you are writing several papers about similar subjects so that you often have to cite the same books.

- you can store them in an external BibTeX file and then link them via a command to your current document and use a Bibtex style to define how they appear. This way you can create a small database of the references you might use and simply link them, letting LaTeX work for you.

In order to know how to add the bibliography to your document, see the Bibliography Management section.

# Chapter 5

# Errors and Warnings

LaTeX describes what it's typesetting while it does it, and if it encounters something it doesn't understand or can't do, it will display a message saying what's wrong. It may also display warnings for less serious conditions.

*Don't panic if you see error messages*: it's very common for beginners to mistype or mis-spell commands, forget curly braces, type a forward slash instead of a backslash, or use a special character by mistake. Errors are easily spotted and easily corrected in your editor, and you can then run LaTeX again to check you have fixed everything. Some of the most common errors are described in next sections.

## Error messages

The format of an error message is always the same. Error messages begin with an exclamation mark at the start of the line, and give a description of the error, followed by another line starting with the number, which refers to the line-number in your document file which LaTeX was processing when the error was spotted. Here's an example, showing that the user mistyped the `\tableofcontents` command:

```
! Undefined control sequence.
l.6 \tableofcotnetns
```

When LaTeX finds an error like this, it displays the error message and pauses. You must type one of the following letters to continue:

Some systems (Emacs is one example) run LaTeX with a "nonstop" switch turned on, so it will always process through to the end of the file, regardless of errors, or until a limit is reached.

## Warnings

Warnings don't begin with an exclamation mark: they are just comments by LaTeX about things you might want to look into, such as overlong or underrun lines (often

| Key | Meaning |
|---|---|
| x | Stop immediately and e**x**it the program. |
| q | Carry on **q**uietly as best you can and don't bother me with any more error messages. |
| e | Stop the program but re-position the text in my **e**ditor at the point where you found the error (This only works if you're using an editor which LaTeX can communicate with). |
| h | Try to give me more **h**elp. |
| i | (followed by a correction) means **i**nput the correction in place of the error and carry on (This is only a temporary fix to get the file processed. You still have to make that correction in the editor). |

caused by unusual hyphenations, for example), pages running short or long, and other typographical niceties (most of which you can ignore until later). Unlike other systems, which try to hide unevennesses in the text (usually unsuccessfully) by interfering with the letterspacing, LaTeX takes the view that the author or editor should be able to contribute. While it is certainly possible to set LaTeX's parameters so that the spacing is sufficiently sloppy that you will almost never get a warning about badly-fitting lines or pages, you will almost certainly just be delaying matters until you start to get complaints from your readers or publishers.

## Examples

Only a few common error messages are given here: those most likely to be encountered by beginners. If you find another error message not shown here, and it's not clear what you should do, ask for help.

Most error messages are self-explanatory, but be aware that the place where LaTeX spots and reports an error may be later in the file than the place where it actually occurred. For example if you forget to close a curly brace which encloses, say, italics, LaTeX won't report this until something else occurs which can't happen until the curly brace is encountered (e.g. the end of the document!) Some errors can only be righted by humans who can read and understand what the document is supposed to mean or look like.

Newcomers should remember to check the list of special characters: a very large number of errors when you are learning LaTeX are due to accidentally typing a special character when you didn't mean to. This disappears after a few days as you get used to them.

### Too many }'s

```
! Too many }'s.
l.6 \date December 2004}
```

The reason LaTeX thinks there are too many }'s here is that the opening curly brace is missing after the `\date` control sequence and before the word December, so

the closing curly brace is seen as one too many (which it is!). In fact, there are other things which can follow the \date command apart from a date in curly braces, so LaTeX cannot possibly guess that you've missed out the opening curly brace until it finds a closing one!

## Undefined control sequence

```
! Undefined control sequence.
l.6 \dtae
{December 2004}
```

In this example, LaTeX is complaining that it has no such command ("control sequence") as \dtae. Obviously it's been mistyped, but only a human can detect that fact: all LaTeX knows is that \dtae is not a command it knows about: it's undefined. Mistypings are the most common source of errors. If your editor has drop-down menus to insert common commands and environments, use them!

## Runaway argument

```
Runaway argument?
{December 2004 \maketitle
! Paragraph ended before \date was complete.
<to be read again>
\par
l.8
```

In this error, the closing curly brace has been omitted from the date. It's the opposite of the error of too many }'s, and it results in \maketitle trying to format the title page while LaTeX is still expecting more text for the date! As \maketitle creates new paragraphs on the title page, this is detected and LaTeX complains that the previous paragraph has ended but \date is not yet finished.

## Underfull hbox

```
Underfull \hbox (badness 1394) in paragraph
at lines 28--30
[][]\LY1/brm/b/n/10 Bull, RJ: \LY1/brm/m/n/10
Ac-count-ing in Busi-
[94]
```

This is a warning that LaTeX cannot stretch the line wide enough to fit, without making the spacing bigger than its currently permitted maximum. The badness (0-10,000) indicates how severe this is (here you can probably ignore a badness of 1394). It says what lines of your file it was typesetting when it found this, and the number in square brackets is the number of the page onto which the offending line was printed. The codes separated by slashes are the typeface and font style and size used in the line. Ignore them for the moment.

### Overfull hbox

```
[101]
Overfull \hbox (9.11617pt too wide) in paragraph
at lines 860--861
[]\LY1/brm/m/n/10 Windows, \LY1/brm/m/it/10 see
\LY1/brm/m/n/10 X Win
```

And the opposite warning: this line is too long by a shade over 9pt. The chosen hyphenation point which minimizes the error is shown at the end of the line (Win-). Line numbers and page numbers are given as before. In this case, 9pt is too much to ignore (over 3mm), and a manual correction needs making (such as a change to the hyphenation), or the flexibility settings need changing.

If the "overfull" word includes a forward slash, such as "`input/output`", this should be properly typeset as "`input\slash output`". The use of `\slash` has the same effect as using the "`/`" character, except that it can form the end of a line (with the following words appearing at the start of the next line). The "`/`" character is typically used in units, such as "`mm/year`" character, which should not be broken over multiple lines.

### Missing package

```
! LaTeX Error: File 'paralisy.sty' not found.
Type X to quit or <RETURN> to proceed,
or enter new name. (Default extension: sty)
Enter file name:
```

When you use the `\usepackage` command to request LaTeX to use a certain package, it will look for a file with the specified name and the filetype `.sty`. In this case the user has mistyped the name of the paralist package, so it's easy to fix. However, if you get the name right, but the package is not installed on your machine, you will need to download and install it before continuing. If you don't want to affect the global installation of the machine, you can simply download from Internet the necessary `.sty` file and put it in the same folder of the document you are compiling.

# Chapter 6

# Title Creation

There are several situations where you might want to vary the title from its default format. For shorter documents such as basic articles, the output of `\maketitle` is often adequate, but longer documents (such as books and reports) often require more involved formatting. While it is possible to change the output of `\maketitle`, it can be complicated even with minor changes to the title. In such cases it is often better to create the title from scratch.

## Create the title

Normally, the benefit of using LaTeX instead of traditional word processing programs is that LaTeX frees you to concentrate on content by handling margins, justification, and other typesetting concerns. On the other hand, if you want to write your own title format, it is exactly the opposite: you have to take care of everything–this time LaTeX will do nothing to help you. It can be challenging to create your own title format since LaTeX was not designed to be graphically interactive in the adjustment of layout. The process is similar to working with raw HTML with the added step that each time you want to see how your changes look, you have to re-compile the source. While this may seem like a major inconvenience, the benefit is that once the customized title format has been written, it serves as a template for all other documents that would use the title format you have just made. In other words, once you have a layout you like, you can use it for any other documents where you would like the same layout without any additional fiddling with layout.

First step: since you'll be working only on the first page of your document and you'll have to compile very often, you don't have to compile the whole document each time, you only need to take a look at the first page. That is why we'll first create a dummy document for preparing the title and then we'll simply include it within the existing big document we are writing. Call the dummy document `test_title.tex` and put the following code in it:

```
\documentclass[pdftex,12pt,a4paper]{report}
```

```
\usepackage[pdftex]{graphicx}

\newcommand{\HRule}{\rule{\linewidth}{0.5mm}}

\begin{document}

\input{./title.tex}
\end{document}
```

It is meant to be compiled with `pdflatex` to create a PDF in output. It is a very basic document, but take care that it has the same settings of the document you are writing, so the output won't change when you include the title in your document. In this case (see the first line) the font size is set to 12pt and the paper size is an A4. The package `graphicx` is included to insert an image in the title. Then a command is defined called `\HRule`; it will just insert a horizontal line whose length is like the size of the paper and whose thickness is 0.5 mm. If you want you can change its settings in the definition. Finally the document starts and it simply includes the `title.tex` file, that must be placed in the same directory of our dummy file `test_title.tex`.

Now create the `title.tex` and write in it:

```
\begin{titlepage}


\end{titlepage}
```

all the things you want to put in the title must be inside the `titlepage` environment. Now if you compile `test_title.tex` you will see a preview of your title in the `test_title.pdf` file. Here is what you need to know to write your title:

- **Alignment**: if you want to center some text just use `\begin{center} ... \end{center}`. If you want to align it differently you can use the environment `flushright` for right-alignment and `flushleft` for left alignment.
- **Images**: the command for including images is the following (the example is for a small logo, but you can introduce any image of any size): `\includegraphics[width=0.15\textwidth]{./logo}`. There is no `\begin{figure}` as you usually do because you don't want it to be floating, you just want it there where you placed it. When handling it, remember that it is considered like a big box by the TeX engine.
- **Text size**: If you want to change the size of some text just place it within brackets, {*like this*}, and you can use the following commands (in order of size): `\HUGE`, `\Huge`, `\LARGE`, `\Large`, `\large`, `\small`, `\tiny`. So for example: `{\large this text is slightly bigger than normal}, this one is not`
- **New lines**: you can force the start of a new line by `\\`. If you want to add more vertical space you don't need to use several new-line commands, just insert some vertical space. For example, this way `\\[1cm]` you start a new line after having left 1 cm of empty space.

- **Date**: you can insert the date of the current day with the command `\today`.
- **Filling the page**: the command `\vfill` keeps on adding empty spaces until the page is full. If you put it in the page, you are sure that all the following text will be placed at the bottom of the page.

## A practical example

All these tips might have made you confused. Then, here is a practical example. Get the `test_title.tex` described above and here is an example of a `title.tex`. On the right you can see the output after you compile `test_title.tex` in PDF:

```
\begin{titlepage}

\begin{center}


% Upper part of the page
\includegraphics[width=0.15\textwidth]{./logo}\\[1cm]

\textsc{\LARGE University of Beer}\\[1.5cm]

\textsc{\Large Final year project}\\[0.5cm]


% Title
\HRule \\[0.4cm]
{ \huge \bfseries Lager brewing techniques}\\[0.4cm]

\HRule \\[1.5cm]

% Author and supervisor
\begin{minipage}{0.4\textwidth}
\begin{flushleft} \large
\emph{Author:}\\
John \textsc{Smith}
\end{flushleft}
\end{minipage}
\begin{minipage}{0.4\textwidth}
\begin{flushright} \large
\emph{Supervisor:} \\
Dr. Mark \textsc{Brown}
\end{flushright}
\end{minipage}

\vfill
```

```
% Bottom of the page
{\large \today}

\end{center}

\end{titlepage}
```

UNIVERSITY OF BEER

FINAL YEAR PROJECT

# Lager brewing techniques

*Author:*
John SMITH

*Supervisor:*
Dr. Mark BROWN

September 12, 2006

The picture is from a file called `logo.png` that is in the same directory of both `title.tex` and `test_title.tex`. Since I wanted to insert both the author and supervisor names properly aligned I used a trick: I created two small minipages, one on left and one on the right. Their width is a bit less than half of page width (as you can see, they are exactly 40% of the text width). Within the minipages I have used different alignments. Using `\vfill` I could write the date exactly at the bottom of the page.

As you can see, the code looks "dirtier" than standard LaTeX source because you have to take care of the output as well. If you start changing font's output it will get more confused, but you can do it: it's only for the title and your complicated code will be isolated from all the rest within its own file `title.tex`.

## Insert it in your document

Once you have your `title.tex` ready, simply place it in the folder of your document and insert it with `\input{./title.tex}`. Don't forget to add the commands `\usepackage[pdftex]{graphicx}` and `\newcommand{\HRule}{\rule{\linewidth}{0.5mm}}`, otherwise you might get an error. So the beginning of your document should look like:

```
...
\usepackage[pdftex]{graphicx}

\newcommand{\HRule}{\rule{\linewidth}{0.5mm}}

\begin{document}

\input{./title.tex}
\tableofcontents
...
```

# Chapter 7

# Bibliography Management

For any academic/research writing, incorporating your references into your document is an important task. Fortunately, as LaTeX was aimed for this sort of work, it has a variety of features that make dealing with your references much simpler. LaTeX has built in support for citing references. However, a much more powerful and flexible solution is achieved thanks to an auxiliary tool called BibTeX (which comes bundled as standard with LaTeX.)

BibTeX allows you to store all your references in an external, flat-file database. You can then easily link this database to any LaTeX document, and cite any reference that is contained within the file. This is often more convenient than embedding them at the end of every document you write. You can have a centralized store of your bibliography, that can be linked to as many documents as you wish (write once, read many!). Of course, you can split your bibliographies over as many files as you wish, so you could have a file of references concerning *General Relativity*, and another about *Quantum Mechanics*. And if you were writing about *Quantum Gravity* (QG), which tries to bridge the gap between the inconsistencies of these two theories, then you can easily link both to your current document, as well another file of references about QG, for example. It's up to you how you store your references, of course.

## Embed system

If you are writing only one or two documents and aren't planning on writing more on the same subject for a long time, maybe you don't want to waste time creating a database of references you are never going to use. In this case you should consider using the basic and simple bibliography support that is embedded within LaTeX.

LaTeX provides an environment called `thebibliography` that you have to use where you want the bibliography, that usually means at the very end of your document, just before the `\end{document}` command. Here is a practical example:

```
\begin{thebibliography}{9}
```

```
\bibitem{lamport94}
  Leslie Lamport,
  \emph{\LaTeX: A Document Preparation System}.
  Addison Wesley, Massachusetts,
  2nd Edition,
  1994.

\end{thebibliography}
```

OK, so what is going on here? The first thing to notice is the establishment of the environment. `thebibliography` is a keyword that LaTeX recognizes as everything between the begin and end tags as being data for the bibliography. The optional argument which I supplied after the begin statement is telling LaTeX how wide the item label will be when printed. Note however, that it is not a literal parameter, i.e the number 9 in this case, but a text width. Therefore, I am effectively telling LaTeX that I will only need reference labels of one character in width, which means no more than nine references in total. If you want more than ten, then input a two-digit number, such as '99' which permits less than 100 references.

Next is the actual reference entry itself. This is prefixed with the `\bibitem{cite_key}` command. The *cite_key* should be a unique identifier for that particular reference, and is often some sort of mnemonic consisting of any sequence of letters, numbers and punctuation symbols (although not a comma). I often use the surname of the first author, followed by the last two digits of the year (hence *lamport94*). If that author has produced more than one reference for a given year, then I add letters after, 'a', 'b', etc. But, you should do whatever works for you. Everything after the key is the reference itself. You need to type it as you want it to be presented. I have put the different parts of the reference, such as author, title, etc., on different lines for readability. These linebreaks are ignored by LaTeX. I wanted the title to be in italics, so I used the `\emph{}` command to achieve this.

## Citations

To actually cite a given document is very easy. Go to the point where you want the citation to appear, and use the following: `\cite{cite_key}`, where the *cite_key* is that of the bibitem you wish to cite. When LaTeX processes the document, the citation will be cross-referenced with the bibitems and replaced with the appropriate number citation. The advantage here, once again, is that LaTeX looks after the numbering for you. If it was totally manual, then adding or removing a reference can be a real chore, as you would have to re-number all the citations by hand.

```
Instead of WYSIWYG editors, typesetting systems like
TeX or LaTeX \cite{lamport94} can be used.
```

### Multiple citations

When a sequence of multiple citations are needed, you should use a single `\cite{}` command. The citations are then separated by commas. Here's an example:

```
\cite{citation01,citation02,citation03}
```

The result will then be shown as citations inside the same brackets.

### No Cite

If you only want a reference to appear in the bibliography, but not where it is referenced in the main text, then the `\nocite{}` command can be used, for example:

```
Lamport showed in 1995 something...  \nocite{lamport95}.
```

## BibTeX

I have previously introduced the idea of embedding references at the end of the document, and then using the `\cite` command to cite them within the text. In this tutorial, I want to do a little better than this method, as it's not as flexible as it could be. Which is why I wish to concentrate on using BibTeX.

A BibTeX database is stored as a *.bib* file. It is a plain text file, and so can be viewed and edited easily. The structure of the file is also quite simple. An example of a BibTeX entry:

```
@article{greenwade93,
    author  = "George D. Greenwade",
    title   = "The {C}omprehensive {T}ex {A}rchive {N}etwork ({CTAN})",
    year    = "1993",
    journal = "TUGBoat",
    volume  = "14",
    number  = "3",
    pages   = "342--351"
}
```

Each entry begins with the declaration of the reference type, in the form of `@''type''`. BibTeX knows of practically all types you can think of, common ones such as *book*, *article*, and for papers presented at conferences, there is *inproceedings*, etc. In this example, I have referred to an article within a journal.

After the type, you must have a left curly brace '{' to signify the beginning of the reference attributes. The first one follows immediately after the brace, which is the citation key. This key must be unique for all entries in your bibliography. It is with this identifier that you will use within your document to cross-reference it to this entry. It is up to you as to how you wish to label each reference, but there is a loose standard in which you use the author's surname, followed by the year of publication. This is the scheme that I use in this tutorial.

Next, it should be clear that what follows are the relevant fields and data for that particular reference. The field names on the left are BibTeX keywords. They are

followed by an equals sign (=) where the value for that field is then placed. BibTeX expects you to explicitly label the beginning and end of each value. I personally use quotation marks (“), however, you also have the option of using curly braces ('{', '}'). But as you will soon see, curly braces have other roles, within attributes, so I prefer not to use them for this job as they can get more confusing.

Remember that each attribute must be followed by a comma to delimit one from another. You do not need to add a comma to the last attribute, since the closing brace will tell BibTeX that there are no more attributes for this entry, although you won't get an error if you do.

It can take a while to learn what the reference types are, and what fields each type has available (and which ones are required or optional, etc). So, look at this entry type reference and also this field reference for descriptions of all the fields. It may be worth bookmarking or printing these pages so that they are easily at hand when you need them.

## Authors

BibTeX can be quite clever with names of authors. It can accept names in *forename surname* or *surname, forename*. I personally use the former, but remember that the order you input them (or any data within an entry for that matter) is customizable and so you can get BibTeX to manipulate the input and then output it however you like. If you use the *forename surname* method, then you must be careful with a few special names, where there are compound surnames, for example "John von Neumann“. In this form, BibTeX assumes that the last word is the surname, and everything before is the forename, plus any middle names. You must therefore manually tell BibTeX to keep the 'von' and 'Neumann' together. This is achieved easily using curly braces. So the final result would be "John {von Neumann}“. This is easily avoided with the *surname, forename*, since you have a comma to separate the surname from the forename.

Secondly, there is the issue of how to tell BibTeX when a reference has more than one author. This is very simply done by putting the keyword *and* in between every author. As we can see from another example:

```
@book{goossens93,
    author    = "Michel Goossens and Frank Mittlebach and Alexander Samarin",
    title     = "The LaTeX Companion",
    year      = "1993",
    publisher = "Addison-Wesley",
    address   = "Reading, Massachusetts"
}
```

This book has three authors, and each is separated as described. Of course, when BibTeX processes and outputs this, there will only be an 'and' between the penultimate and last authors, but within the .bib file, it needs the *and*'s so that it can keep track of the individual authors.

## Standard templates

**@article** An article from a magazine or a journal.

**@book** A published book

**@booklet** A bound work without a named publisher or sponsor.

**@conference** Equal to inproceedings

**@inbook** A section of a book

**@incollection** A section of a book having its own title.

**@inproceedings** An article in a conference proceedings.

**@manual** Technical manual

**@mastersthesis** Master thesis

**@misc** Template useful for other kinds of publication

**@phdthesis** Ph.D. thesis

**@proceedings** The proceedings of a conference.

**@techreport** Technical report from educational, commercial or standardization institution.

**@unpublished** An unpublished article, book, thesis, etc.

## Preserving capital letters

In the event that BibTeX has been set to not preserve all capitalization within titles, problems can occur, especially if you are referring to proper nouns, or acronyms. To tell BibTeX to keep them, use the good ol' curly braces around the letter in question, (or letters, if its an acronym) and all will be well! Or you can put the whole title in curly braces:

```
title     = "{The LaTeX Companion}",
```

## A few additional examples

Below you will find a few additional examples of bibliography entries. The first one covers the case of multiple authors in the Surname, Firstname format, and the second one deals with the incollection case.

```
@article{AbedonHymanThomas2003,
  author = "Abedon, S. T. and Hyman, P. and Thomas, C.",
  year = "2003",
  title = "Experimental examination of bacteriophage latent-period evolution
  as a response to bacterial availability",
  journal = "Applied and Environmental Microbiology",
  volume = "69",
  pages = "7499--7506"
}

@incollection{Abedon1994,
  author = "Abedon, S. T.",
  title = "Lysis and the interaction between free phages and infected cells",
  pages = "397--405",
  booktitle = "Molecular biology of bacteriophage T4",
  editor = "Karam, Jim D. Karam and Drake, John W. and Kreuzer, Kenneth N.
     and Mosig, Gisela and Hall, Dwight and Eiserling, Frederick A.
     and Black, Lindsay W. and Kutter, Elizabeth and Carlson, Karin
     and Miller, Eric S. and Spicer, Eleanor",
  publisher = "ASM Press, Washington DC",
  year = "1994"
}
```

## Getting current LaTeX document to use your .bib file

Actually this is not very difficult. At the end of your LaTeX file (that is, after the content, but before `\end{document}`, you need to place the following commands:

```
\bibliographystyle{plain}
\bibliography{sample}
```

Bibliography styles are files recognized by BibTeX that tell it how to format the information stored in the `.bib` file when processed for output. And so the first command listed above is declaring which style file to use. The style file in this instance is `plain.bst` (which comes as standard with BibTeX). You do not need to add the .bst extension when using this command, as it is assumed. Despite its name, the plain style does a pretty good job (look at the output of this tutorial to see what I mean).

The second command is the one that actually specifies the `.bib` file you wish to use. The one I created for this tutorial was called `sample.bib`, but once again, you don't include the file extension. At the moment, the `.bib` file is in the same directory as the LaTeX document too. However, if your .bib file was elsewhere (which makes sense if you intend to maintain a centralized database of references for all your research), you need to specify the path as well, e.g `\bibliography{$HOME/some/where/sample.bib}`.

Now that LaTeX and BibTeX know where to look for the appropriate files, actually citing the references is fairly trivial. The `\cite{ref_key}` is the command you need, making sure that the *ref_key* corresponds exactly to one of the entries in the .bib

file. If you wish to cite more that one reference at the same time, do the following: `\cite{ref_key1, ref_key2, ..., ref_keyN}`.

## Why won't LaTeX generate any output?

The addition of BibTeX adds extra complexity for the processing of the source to the desired output. This is largely hidden to the user, but because of all the complexity of the referencing of citations from your source LaTeX file to the database entries in another file, you actually need multiple passes to accomplish the task. This means you have to run LaTeX a number of times, where each pass, it will perform a particular task until it has managed to resolve all the citation references. Here's what you need to type:

1. `latex latex_source_code` (doesn't require `.tex` extension)
2. `bibtex latex_source_code` (Do NOT use `.tex` extension)
3. `latex latex_source_code` (doesn't require `.tex` extension)
4. `latex latex_source_code` (doesn't require `.tex` extension)

After the first LaTeX run, you will see errors such as:

```
LaTeX Warning: Citation 'lamport94' on page 1 undefined on input line 21.
...
LaTeX Warning: There were undefined references.
```

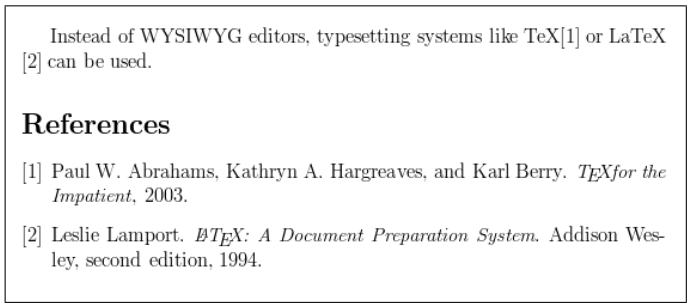
The next step is to run bibtex on that same LaTeX source (and not on the actual .bib file) to then define all the references within that document. You should see output like the following:

```
This is BibTeX, Version 0.99c (Web2C 7.3.1)
The top-level auxiliary file: latex_source_code.aux
The style file: plain.bst
Database file #1: sample.bib
```

The third step, which is invoking LaTeX for the second time will see more errors like "`LaTeX Warning: Label(s) may have changed. Rerun to get cross-references right.`". Don't be alarmed, it's almost complete. As you can guess, all you have to do is follow its instructions, and run LaTeX for the third time, and the document will be output as expected, without further problems.

## Biography styles

Below you can see three styles from available with LaTeX:



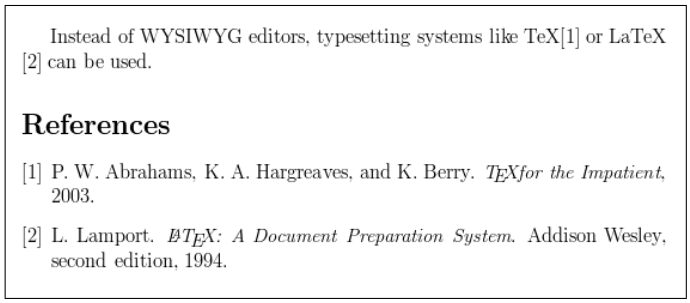
Instead of WYSIWYG editors, typesetting systems like TeX[1] or LaTeX [2] can be used.

## References

[1] Paul W. Abrahams, Kathryn A. Hargreaves, and Karl Berry. *TEXfor the Impatient*, 2003.

[2] Leslie Lamport. *LATEX: A Document Preparation System*. Addison Wesley, second edition, 1994.

Figure 7.1: plain



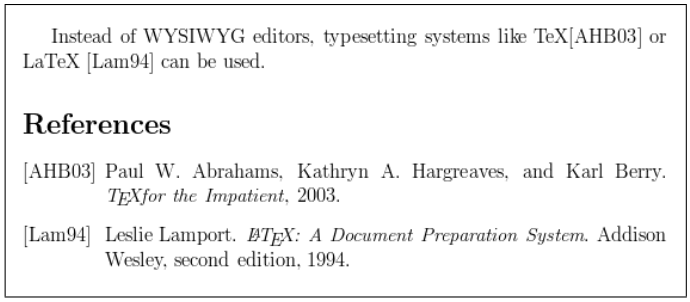
Instead of WYSIWYG editors, typesetting systems like TeX[1] or LaTeX [2] can be used.

## References

[1] P. W. Abrahams, K. A. Hargreaves, and K. Berry. *TEXfor the Impatient*, 2003.

[2] L. Lamport. *LATEX: A Document Preparation System*. Addison Wesley, second edition, 1994.

Figure 7.2: abbrv



Instead of WYSIWYG editors, typesetting systems like TeX[AHB03] or LaTeX [Lam94] can be used.

## References

[AHB03] Paul W. Abrahams, Kathryn A. Hargreaves, and Karl Berry. *TEXfor the Impatient*, 2003.

[Lam94] Leslie Lamport. *LATEX: A Document Preparation System*. Addison Wesley, second edition, 1994.

Figure 7.3: alpha

Web page http://www.cs.stir.ac.uk/~kjt/software/latex/showbst.html contains more examples.

## Including URLs in bibliography

As you can see, there is no field for URLs. One possibility is to include Internet addresses in `howpublished` or `note` fields:

```
howpublished = "\url{http://www.example.com}"
```

Note the usage of `\url` command to ensure proper appearance of URLs.

Another way is to use special field `url` and make bibliography style recognise it.

```
url = "http://www.example.com"
```

Styles provided by Natbib (see below) handle this field, other styles can be modified using urlbst program. Modifications of three standard styles (plain, abbrv and alpha) are provided with urlbst.

If you need more help about URLs in bibliography, visit FAQ of UK List of TeX.

## Customizing bibliography appearance

In my mind, one of the main advantages of BibTeX, especially for people who write many research papers, is the ability to customize your bibliography to suit the requirements of a given publication. You will notice how different publications tend to have their own style of formatting references, which authors must adhere to if they want their manuscript published. In fact, established journals and conference organizers often will have created their own bibliography style (.bst file) for those users of BibTeX, to do all the hard work for you.

It can achieve this because of the nature of the .bib database, where all the information about your references is stored in a structured format, but nothing about style. This is a common theme in LaTeX in general, where it tries as much as possible to keep content and presentation separate — as it should be!

A bibliography style file (`.bst`) will tell LaTeX how to format each attribute, what order to put them in, what punctuation to use in between particular attributes etc. Unfortunately, creating such a style by hand is not a trivial task. Which is why `Makebst` (also known as *custom-bib*) is the tool we need.

`Makebst` can be used to automatically generate a .bst file based on your needs. It is very simple, and actually asks you a series of questions about your preferences. Once complete, it will then output the appropriate style file for you to use.

It should be installed with the LaTeX distribution (otherwise, you can download it) and it's very simple to initiate. At the command line, type:

```
latex makebst
```

LaTeX will find the relevant file and the questioning process will begin. You will have to answer quite a few (although, note that the default answers are pretty sensible), which means it would be impractical to go through an example in this tutorial. However, it is fairly straight-forward. And if you require further guidance, then there is a comprehensive manual available. I'd recommend experimenting with it and seeing what the results are when applied to a LaTeX document.

If you are using a custom built .bst file, it is important that LaTeX can find it! So, make sure it's in the same directory as the LaTeX source file, *unless* you are using one of the standard style files (such as *plain* or *plainnat*, that come bundled with LaTeX — these will be automatically found in the directories that they are installed. Also, make sure the name of the `.bst` file you want to use is reflected in the `\bibliographystyle{style}` command (but don't include the `.bst` extension!).

## Localizing bibliography appearance

When writing documents in languages other than English, you may find it desirable to adapt the appearance of your bibliography to the document language. This concerns words such as *editors*, *and*, or *in* as well as a proper typographic layout. The `babelbib` package can be used here. For example, to layout the bibliography in German, add the following to the header:

```
\usepackage[fixlanguage]{babelbib}
\selectbiblanguage{german}
```

Alternatively, you can layout each bibliography entry according to the language of the cited document:

`\usepackage{babelbib}`

The language of an entry is specified as an additional field in the BibTeX entry:

```
@article{mueller08,
  % ...
  language = {german}
}
```

For `babelbib` to take effect, a bibliography style supported by it — one of `babplain`, `babplai3`, `babalpha`, `babunsrt`, `bababbrv`, and `bababbr3` — must be used:

```
\bibliographystyle{babplain}
\bibliography{sample}
```

## Getting Bibliographic data

Many online databases provide bibliograhic data in BibTeX-Format, making it easy to build your own database. For example, Google Scholar offers the option to return properly formatted output, but you must turn it on in the Preferences. Here is an example of such a BibTeX entry: `http://scholar.google.com/scholar.bib?hl=en&lr=&output=search&q=info:iOXAsGZMSHsJ:scholar.google.com/&output=citation&oe=ASCII&oi=citation`

## Helpful Tools

- Referencer Referencer is a Gnome application to organise documents or references, and ultimately generate a BibTeX bibliography file.

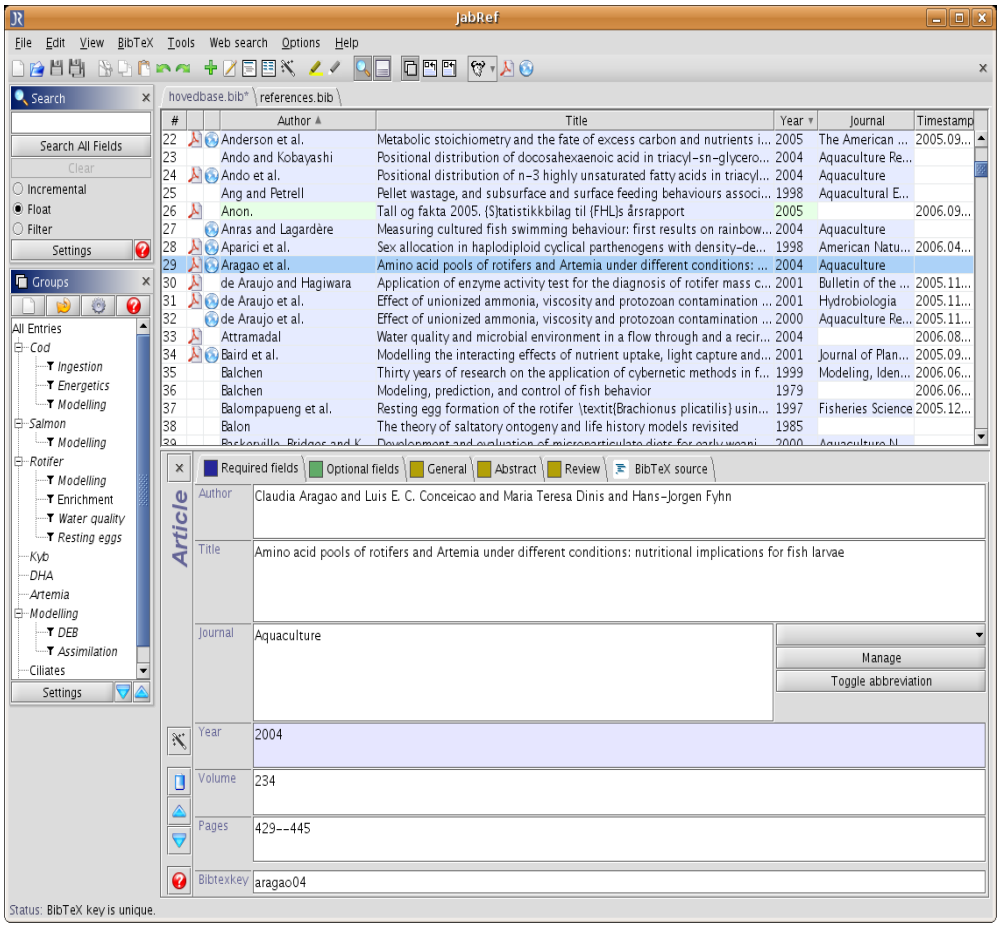



Figure 7.4: JabRef

- Citavi A free software which even searches libraries for citations and keeps all your knowledge in a database. Export of the database to all kinds of formats is possible. Works together with MS Word and Open Office Writer. Moreover plug ins for browsers and Arcobat Reader exist to automatically include references to your project.

- JabRef is a small Java program which lets you edit your BibTeX and other bibliographic databases easily, letting you (mostly) forget about the details.

- bibliographer Bibliographer is a BibTeX bibliography database editor which aims to be easy to use. Its features include linking files to your records with indexing and searching support. The interface is designed for the easy navigation of your bibliography, and double clicking a record will open the linked file.

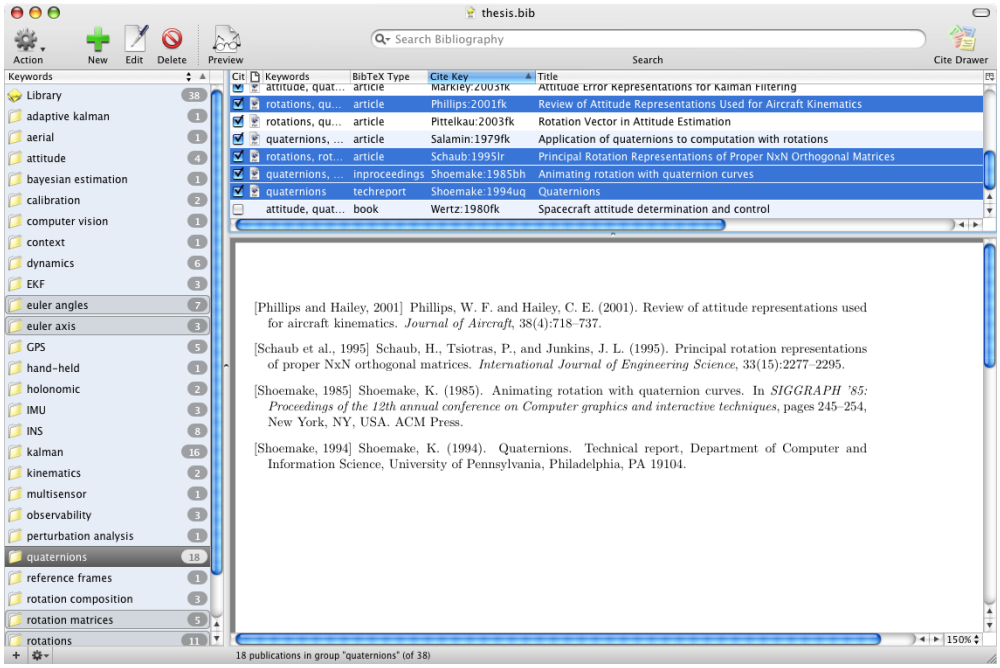



Figure 7.5: BibDesk

- cb2Bib The cb2Bib is a tool for rapidly extracting unformatted, or unstandardized biblographic references from email alerts, journal Web pages, and PDF files.
- KBibTeX KBibTeX is a BibTeX editor for KDE to edit bibliographies used with LaTeX. Features include comfortable input masks, starting web queries (e. g. Google or PubMed) and exporting to PDF, PostScript, RTF and XML/HTML. As KBibTeX is using KDE's KParts technology, KBibTeX can be embedded into Kile or Konqueror.
- Bibwiki Bibwiki is a Specialpage for MediaWiki to manage BibTeX bibliographies. It offers a straightforward way to import and export bibliographic records.
- BibDesk BibDesk is a bibliographic reference manager for Mac OS X. It features a very usable user interface and provides a number of features like smart folders based on keywords and live tex display.
- CiteULike CiteULike is a free online service to organise academic papers. It can export citations in BibTeX format, and can "scrape" BibTeX data from many popular websites.
- Bibtex Bibtex is a DokuWiki plugin that allows for the inclusion of bibtex formatted citations in DokuWiki pages and displays them in APA format.

- BibSonomy — A free social bookmark and publication management system based on BibTeX.

### Summary

Although it can take a little time to get to grips with BibTeX, in the long term, it's an efficient way to handle your references. It's not uncommon to find .bib files on websites that people compile as a list of their own publications, or a survey of relevant works within a given topic, etc. Or in those huge, online bibliography databases, you often find BibTeX versions of publications, so it's a quick cut-and-paste into your own .bib file, and then no more hassle!

Having all your references in one place can be a big advantage. And having them in a structured form, that allows customizable output is another one. There are a variety of free utilities that can load your .bib files, and allow you to view them in a more efficient manner, as well as sort them and check for errors.

## Natbib

Using the standard LaTeX bibliography support, you will see that each reference is numbered and each citation corresponds to the numbers. The numeric style of citation is quite common in scientific writing. In other disciplines, the author-year style, e.g., (Roberts, 2003), such as *Harvard* is preferred, and is in fact becoming increasingly common within scientific publications. A discussion about which is best will not occur here, but a possible way to get such an output is by the `natbib` package. In fact, it can supersede LaTeX's own citation commands, as Natbib allows the user to easily switch between Harvard or numeric.

The first job is to add the following to your preamble in order to get LaTeX to use the Natbib package:

```
\usepackage{natbib}
```

| | |
|---|---|
| **Citation command** | **Output** |
| `\citet{goossens93}` | Goossens et al. (1993) |
| `\citep{goossens93}` | (Goossens et al., 1993) |
| `\citet*{goossens93}` | Goossens, Mittlebach, and Samarin (1993) |
| `\citep*{goossens93}` | (Goossens, Mittlebach, and Samarin, 1993) |
| `\citeauthor{goossens93}` | Goossens et al. |
| `\citeauthor*{goossens93}` | Goossens, Mittlebach, and Samarin |
| `\citeyear{goossens93}` | 1993 |
| `\citeyearpar{goossens93}` | (1993) |

Table 7.1: **Natbib commands**

Also, you need to change the bibliography style file to be used, so edit the appropriate line at the bottom of the file so that it reads: `\bibliographystyle{plainnat}`.

Once done, it is basically a matter of altering the existing `\cite` commands to display the type of citation you want.

The main commands simply add a *t* for 'textual' or *p* for 'parenthesized', to the basic `\cite` command. You will also notice how Natbib by default will compress references with three or more authors to the more concise *1st surname et al* version. By adding an asterisk (*), you can override this default and list all authors associated with that citation. There are some other less common commands that Natbib supports, listed in the table here.

The final area that I wish to cover about Natbib is customizing its citation style. There is a command called `\bibpunct` that can be used to override the defaults and change certain settings. For example, I have put the following in the preamble:

```
\bibpunct{(}{)}{;}{a}{,}{,}
```

The command requires six mandatory parameters.

1. The symbol for the opening bracket.
2. The symbol for the closing bracket.
3. The symbol that appears between multiple citations.
4. This argument takes a letter:
   - *n* — numerical style.
   - *s* — numerical superscript style.
   - *any other letter* — author-year style.
5. The punctuation to appear between the author and the year (in parenthetical case only).
6. The punctuation used between years, in multiple citations when there is a common author. e.g., (Chomsky 1956, 1957). If you want an extra space, then you need `{,~}`.

So as you can see, this package is quite flexible, especially as you can easily switch between different citation styles by changing a single parameter. Do have a look at the Natbib manual, it's a short document and you can learn even more about how to use it.

# Chapter 8

# Tables

In academic writing, tables are a common feature, often for summarising results from research. It is therefore a skill that needs mastering in order to produce good quality papers.

However, if there is one area about LaTeX that I feel is the least intuitive, then I am afraid that this is it. Basic tables are not too taxing, but you will quickly notice that anything more advanced can take a fair bit of construction. So, we will start slowly and build up from there.

## The `tabular` environment

The `tabular` environment can be used to typeset beautiful tables with optional horizontal and vertical lines. LaTeX determines the width of the columns automatically.

The first line of the environment has the form: `\begin{tabular}[pos]{table spec}`

the *table spec* argument tells LaTeX the alignment to be used in each column and the vertical lines to insert.

The number of columns does not need to be specified as it is inferred by looking at the number of arguments provided. It is also possible to add vertical lines between the columns here. The following symbols are available to describe the table columns (some of them require that the package *array* has been loaded):

| | |
|---|---|
| `l` | left-justified column |
| `c` | centered column |
| `r` | right-justified column |
| `p{width}` | paragraph column with text vertically aligned at the top |
| `m{width}` | paragraph column with text vertically aligned in the middle (requires array package) |
| `b{width}` | paragraph column with text vertically aligned at the bottom (requires array package) |
| \| | vertical line |
| \|\| | double vertical line |

By default, if the text in a column is too wide for the page, LaTeX won't automatically wrap it. Using `p{width}` you can define a special type of column which will wrap-around the text as in a normal paragraph. You can pass the width using any unit supported by LaTeX, such as pt and cm, or *command lengths*, such as `\textwidth`.You can find a complete list in appendix Useful Measurement Macros.

The optional parameter *pos* can be used to specify the vertical position of the table relative to the baseline of the surrounding text. You can use the following letters:

| | |
|---|---|
| `b` | bottom |
| `c` | center |
| `t` | top |

In the first line you have pointed out how many columns you want, their alignment and the vertical lines to separate them. Once in the environment, you have to introduce the text you want, separating between cells and introducing new lines. The commands you have to use are the following:

| | |
|---|---|
| `&` | column separator |
| `\\` | start new row (additional space may be specified after `\\` using square brackets, such as `\\[6pt]`) |
| `\hline` | horizontal line |
| `\cline{i-j}` | partial horizontal line beginning in column $i$ and ending in column $j$ |

Note, any white space inserted between these commands is purely down to ones' preferences. I personally add spaces between to make it easier to read.

## Basic examples

This example shows how to create a simple table in LaTeX. It is a three-by-three table, but without any lines.

```
\begin{tabular}{ l c r }
  1 & 2 & 3 \\
  4 & 5 & 6 \\
  7 & 8 & 9 \\
\end{tabular}
```

1 2 3
4 5 6
7 8 9

Expanding upon that by including some vertical lines:

```
\begin{tabular}{ l | c || r | }
  1 & 2 & 3 \\
  4 & 5 & 6 \\
  7 & 8 & 9 \\
\end{tabular}
```

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |

To add horizontal lines to the very top and bottom edges of the table:

```
\begin{tabular}{ l | c || r | }
  \hline
  1 & 2 & 3 \\
  4 & 5 & 6 \\
  7 & 8 & 9 \\
  \hline
\end{tabular}
```

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |

And finally, to add lines between all rows, as well as centering (notice the use of the center environment — of course, the result of this is not obvious from the preview on this web page):

```
\begin{center}
  \begin{tabular}{ l | c || r | }
    \hline
    1 & 2 & 3 \\ \hline
    4 & 5 & 6 \\ \hline
    7 & 8 & 9 \\
    \hline
  \end{tabular}
\end{center}
```

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |

```
\begin{tabular}{|r|l|}
  \hline
  7C0 & hexadecimal \\
  3700 & octal \\ \cline{2-2}
  11111000000 & binary \\
  \hline \hline
  1984 & decimal \\
  \hline
\end{tabular}
```

| | |
|---|---|
| 7C0 | hexadecimal |
| 3700 | octal |
| 11111000000 | binary |
| 1984 | decimal |

## Column specification using >{\cmd} and <{\cmd}

Using the array package, one is able to alter the column specification. This is done in the argument of the tabular environment using >{\command} for commands executed right *before* each column element. The code <{\command} for commands to be executed right *after* each column element. As an example: to get a column in math mode enter: \begin{tabular}{|>{$}c<{$}}. Another example is changing the font: \begin{tabular}{|>{\small}c} to print the column in a small font.

The argument of the > and < specifications must be correctly balanced when it comes to { and } characters. This means that >{\bfseries} is valid, while >{\textbf} will not work and >{\textbf{} is not valid. If there is the need to use the text of the table as an argument (for instance, using the \underline to produce a line below the text), one should use the \bgroup and \egroup commands: >{\underline\bgroup}c<{\egroup} produces the intended effect.

## Text wrapping in tables

LaTeX's algorithms for formatting tables have a few shortcomings. One is that it will not automatically wrap text in cells, even if it has overrun the width of the page. For columns that you know will contain a certain amount of text, then it is recommended that you use the *p* attribute and specify the desired width of the column (although it may take some trial-and-error to get the result you want). Use the *m* attribute to have the lines aligned toward the middle of the box and the *b* attribute to align along the bottom of the box.

Here is a practical example. The following code creates two tables with the same code; the only difference is that the last column of the second one has a defined width of 5 centimeters, while in the first one we didn't specify any width. Compiling this code:

```
\documentclass{article}

\usepackage[english]{babel}

\begin{document}
```

```
Without specifying width for last column:

\begin{center}
    \begin{tabular}{ | l | l | l | l |}
    \hline
    Day & Min Temp & Max Temp & Summary \\ \hline
    Monday & 11C & 22C & A clear day with lots of sunshine.
    However, the strong breeze will bring down the temperatures. \\ \hline
    Tuesday & 9C & 19C & Cloudy with rain, across many northern regions. Clear spells
    across most of Scotland and Northern Ireland,
    but rain reaching the far northwest. \\ \hline
    Wednesday & 10C & 21C & Rain will still linger for the morning.
    Conditions will improve by early afternoon and continue
    throughout the evening. \\
    \hline
    \end{tabular}
\end{center}

With width specified:

\begin{center}
    \begin{tabular}{ | l | l | l | p{5cm} |}
    \hline
    Day & Min Temp & Max Temp & Summary \\ \hline
    Monday & 11C & 22C & A clear day with lots of sunshine.
    However, the strong breeze will bring down the temperatures. \\ \hline
    Tuesday & 9C & 19C & Cloudy with rain, across many northern regions. Clear spells
    across most of Scotland and Northern Ireland,
    but rain reaching the far northwest. \\ \hline
    Wednesday & 10C & 21C & Rain will still linger for the morning.
    Conditions will improve by early afternoon and continue
    throughout the evening. \\
    \hline
    \end{tabular}
\end{center}

\end{document}
```

You get the following output:

Without specifying width for last column:

| Day | Min Temp | Max Temp | Summary |
|---|---|---|---|
| Monday | 11C | 22C | A clear day with lots of sunshine. However, the strong breeze w |
| Tuesday | 9C | 19C | Cloudy with rain, across many northern regions. Clear spells ac |
| Wednesday | 10C | 21C | Rain will still linger for the morning. Conditions will improve b |

With width specified:

| Day | Min Temp | Max Temp | Summary |
|---|---|---|---|
| Monday | 11C | 22C | A clear day with lots of sunshine. However, the strong breeze will bring down the temperatures. |
| Tuesday | 9C | 19C | Cloudy with rain, across many northern regions. Clear spells across most of Scotland and Northern Ireland, but rain reaching the far northwest. |
| Wednesday | 10C | 21C | Rain will still linger for the morning. Conditions will improve by early afternoon and continue throughout the evening. |

Note that the first table is cropped: The output is wider than the page width.

## Other environments inside tables

If you use some LaTeX enviroments inside table cells, like `verbatim` or `enumerate`

```
\begintabular| c | c |
    \hline
    \beginverbatim
    code
    \endverbatim
    & description
  \\ \hline
\endtabular
```

you might encounter errors similar to

```
! LaTeX Error: Something's wrong--perhaps a missing \item.
```

To solve this problem, change column specifier to "paragraph" (`p`, `m` or `b`).
`\begin{tabular}{| m{5cm} | c |}`

## Defining multiple columns

It is possible to define many identical columns at once using the `*{num}{str}` syntax.
This is particularly useful when your table has many columns.
Here is a table with six centered columns flanked by a single column on each side:

```
\begin{tabular}{l*{6}{c}r}
Team              & P & W & D & L & F  & A & Pts \\
\hline
Manchester United & 6 & 4 & 0 & 2 & 10 & 5 & 12  \\
Celtic            & 6 & 3 & 0 & 3 & 8  & 9 & 9   \\
Benfica           & 6 & 2 & 1 & 3 & 7  & 8 & 7   \\
FC Copenhagen    & 6 & 2 & 1 & 2 & 5  & 8 & 7   \\
\end{tabular}
```

| Team | P | W | D | L | F | A | Pts |
|---|---|---|---|---|---|---|---|
| Manchester United | 6 | 4 | 0 | 2 | 10 | 5 | 12 |
| Celtic | 6 | 3 | 0 | 3 | 8 | 9 | 9 |
| Benfica | 6 | 2 | 1 | 3 | 7 | 8 | 7 |
| FC Copenhagen | 6 | 2 | 1 | 2 | 5 | 8 | 7 |

## @-expressions

The column separator can be specified with the `@{...}` construct.

It typically takes some text as its argument, and when appended to a column, it will automatically insert that text into each cell in that column before the actual data for that cell. This command kills the inter-column space and replaces it with whatever is between the curly braces. To add space, use `@{\hspace{width}}`.

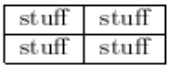
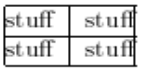
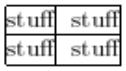
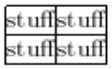
Admittedly, this is not that clear, and so will require a few examples to clarify. Sometimes, it is desirable in scientific tables to have the numbers aligned on the decimal point. This can be achieved by doing the following:

```
\begin{tabular}{r@{.}l}
  3   & 14159 \\
  16  & 2     \\
  123 & 456   \\
\end{tabular}
```

3.14159
16.2
123.456

Its space suppressing qualities actually make it quite useful for manipulating the horizontal spacing between columns. Given a basic table, and varying the column descriptions:

```
\begin{tabular}{|l|l|}
  \hline
  stuff & stuff \\ \hline
  stuff & stuff \\
  \hline
\end{tabular}
```

| | |
|---|---|
| {\|l\|l\|} |  |
| {\|@{}l\|l@{}\|} |  |
| {\|@{}l@{}\|l@{}\|} |  |
| {\|@{}l@{}\|@{}l@{}\|} |  |

## Spanning

To complete this tutorial, we take a quick look at how to generate slightly more complex tables. Unsurprisingly, the commands necessary have to be embedded within the table data itself.

### Rows spanning multiple columns

The command for this looks like this: \multicolumn{num_cols}{alignment}{contents}. *num_cols* is the number of subsequent columns to merge; *alignment* is pretty obvious, either l, c, or r. And *contents* is simply the actual data you want to be contained within that cell. A simple example:

```
\begin{tabular}{|l|l|}
  \hline
  \multicolumn{2}{|c|}{Team sheet} \\
  \hline
  GK & Paul Robinson \\
  LB & Lucus Radebe \\
  DC & Michael Duberry \\
  DC & Dominic Matteo \\
  RB & Didier Domi \\
  MC & David Batty \\
  MC & Eirik Bakke \\
  MC & Jody Morris \\
  FW & Jamie McMaster \\
  ST & Alan Smith \\
  ST & Mark Viduka \\
  \hline
\end{tabular}
```

| Team sheet | |
|---|---|
| GK | Paul Robinson |
| LB | Lucus Radebe |
| DC | Michael Duberry |
| DC | Dominic Matteo |
| RB | Didier Domi |
| MC | David Batty |
| MC | Eirik Bakke |
| MC | Jody Morris |
| FW | Jamie McMaster |
| ST | Alan Smith |
| ST | Mark Viduka |

### Columns spanning multiple rows

The first thing you need to do is add \usepackage{multirow} to the preamble. This then provides the command needed for spanning rows: \multirow{num_rows}{width}{contents}. The arguments are pretty simple to deduce (* for the *width* means the contents natural width).

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

\begin{tabular}{|l|l|l|}
\hline
\multicolumn{3}{|c|}{Team sheet} \\
\hline
Goalkeeper & GK & Paul Robinson \\ \hline
\multirow{4}{*}{Defenders} & LB & Lucus Radebe \\
 & DC & Michael Duberry \\
 & DC & Dominic Matteo \\
 & RB & Didier Domi \\ \hline
\multirow{3}{*}{Midfielders} & MC & David Batty \\
 & MC & Eirik Bakke \\
 & MC & Jody Morris \\ \hline
Forward & FW & Jamie McMaster \\ \hline
\multirow{2}{*}{Strikers} & ST & Alan Smith \\
 & ST & Mark Viduka \\
\hline
\end{tabular}
```

| Team sheet | | |
|---|---|---|
| Goalkeeper | GK | Paul Robinson |
| Defenders | LB | Lucus Radebe |
| | DC | Michael Duberry |
| | DC | Dominic Matteo |
| | RB | Didier Domi |
| Midfielders | MC | David Batty |
| | MC | Eirik Bakke |
| | MC | Jody Morris |
| Forward | FW | Jamie McMaster |
| Strikers | ST | Alan Smith |
| | ST | Mark Viduka |

The main thing to note when using `\multirow` is that a blank entry must be inserted for each appropriate cell in each subsequent row to be spanned.

If there is no data for a cell, just don't type anything, but you still need the "&" separating it from the next column's data. The astute reader will already have deduced that for a table of $n$ columns, there must always be $n - 1$ ampersands in each row. The exception to this is when `\multicolumn` and `\multirow` are used to create cells which span multiple columns or rows.

### Spanning in both directions simultaneously

Here is a nontrivial example how to use spanning in both directions simultaneously and have the borders of the cells drawn correctly:

```
\usepackage{multirow}

\begin{tabular}{cc|c|c|c|c|l}
\cline{3-6}
& & \multicolumn{4}{|c|}{Primes} \\ \cline{3-6}
& & 2 & 3 & 5 & 7 \\ \cline{1-6}
\multicolumn{1}{|c|}{\multirow{2}{*}{Powers}} &
\multicolumn{1}{|c|}{504} & 3 & 2 & 0 & 1 &     \\ \cline{2-6}
\multicolumn{1}{|c|}{}                          &
\multicolumn{1}{|c|}{540} & 2 & 3 & 1 & 0 &     \\ \cline{1-6}
\multicolumn{1}{|c|}{\multirow{2}{*}{Powers}} &
\multicolumn{1}{|c|}{gcd} & 2 & 2 & 0 & 0 & min \\ \cline{2-6}
\multicolumn{1}{|c|}{}                          &
\multicolumn{1}{|c|}{lcm} & 3 & 3 & 1 & 1 & max \\ \cline{1-6}
\end{tabular}
```

| | | Primes | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 3 | 5 | 7 | |
| Powers | 504 | 3 | 2 | 0 | 1 | |
| | 540 | 2 | 3 | 1 | 0 | |
| Powers | gcd | 2 | 2 | 0 | 0 | min |
| | lcm | 3 | 3 | 1 | 1 | max |

The dummy command `\multicolumn{1}{|c|}{...}` is just used to draw vertical borders both on the left and on the right of the cell. When combined with `\multirow{2}{*}{...}` it draws vertical borders that span two rows. Note that we cannot just use `\hline` to draw horizontal lines, since we do not want the line to be drawn over the text that spans several rows. Instead we use the command `\cline{2-6}` and opt out the first column that contains the text "Powers".

### Resize tables

The command `\resizebox{width}{height}{object}` can be used with `\tabular` to specify the height and width of a table. The following example shows how to resize a table to 8cm width while maintaining the original width/height ratio.

```
\resizebox{8cm}{!} {
  \begin{tabular}...
  \end{tabular}
}
```

### Sideways tables

Tables can also be put on their side within a document using the `rotating` package and the `sidewaystable` environments in place of the table environment. (NOTE: most DVI viewers do not support displaying rotated text. Convert your document to a PDF to see the result. Most, if not all, PDF viewers do support rotated text.)

```
\usepackage{rotating}

\begin{sidewaystable}
  \begin{tabular}...
  \end{tabular}
\end{sidewaystable}
```

## The `table` environment — captioning etc

Although the `tabular` environment typesets tables brilliantly, it doesn't cover all that you need to do with tables. For example, you might want a caption for your table. For this and other reasons, you should typically place your `tabular` environment inside a `table` environment:

```
\begin{table}[h]
  \caption{Performance at peak F-measure}
  \begin{tabular}{| r | r || c | c | c |}

      ...

  \end{tabular}
\end{table}
```

Why do the two different environments exist? Think of it this way: The `tabular` environment is concerned with arranging elements in a tabular grid, while the `table` environment represents the table more conceptually. This explains why it isn't `tabular` but `table` that provides for captioning (because the caption isn't displayed in the grid-like layout).

A `table` environment has a lot of similarities with a `figure` environment, in the way the "floating" is handled etc. For instance you can specify its placement in the page with the option `[placement]`, the valid values are:

| | |
|---|---|
| `h` | where the table is declared (**h**ere, like in the example above) |
| `t` | at the **t**op of the page (this is the default) |
| `b` | at the **b**ottom of the page |
| `p` | on a dedicated **p**age of floats |

The `table` environment is also useful when you want to have a list of tables at the beginning or end of your document with the command `\listoftables`; it enables making cross-references to the table with:

```
You may refer to table~\ref{my_table} for an example.

...

\begin{table}
  \begin{tabular}
     ...
  \end{tabular}
  \caption{An example of table}
  \label{my_table}
\end{table}
```

## The `tabular*` environment — controlling table width

This is basically a slight extension on the original tabular version, although it requires an extra argument (before the column descriptions) to specify the preferred width of the table.

```
\begin{tabular*}{0.75\textwidth}{ | c | c | c | r | }
  \hline
  label 1 & label 2 & label 3 & label 4 \\
  \hline
  item 1  & item 2  & item 3  & item 4  \\
  \hline
\end{tabular*}
```

| label 1 | label 2 | label 3 | label 4 | |
|---|---|---|---|---|
| item 1 | item 2 | item 3 | item 4 | |

However, that doesn't look quite as intended. The columns are still at their natural width (just wide enough to fit their contents) whilst the rows are as wide as the table width specified. This looks very ugly. The reason for the mess is that you must also explicitly insert extra column space. Fortunately, LaTeX has *rubber lengths*, which unlike others, are not fixed, and LaTeX can dynamically decide how long they should be. So, the solution to the current problem is:

```
\begin{tabular*}{0.75\textwidth}{@{\extracolsep{\fill}} | c | c | c | r | }
  \hline
  label 1 & label 2 & label 3 & label 4 \\
  \hline
  item 1  & item 2  & item 3  & item 4  \\
  \hline
\end{tabular*}
```

| label 1 | label 2 | label 3 | label 4 |
|---|---|---|---|
| item 1 | item 2 | item 3 | item 4 |

You will notice the `@{...}` construct added at the beginning of the column description. Within it is the `\extracolsep` command, which requires a width. A fixed width could have been used, however, by using a rubber length, such as `\fill`, the columns are automatically spaced evenly.

## The `tabularx` package — simple column stretching

This package provides a table environment called `tabularx` which is similar to the `tabular*` environment, except that it has a new column specifier `X`. The column(s) specified with this specifier will be stretched to make the table as wide as specified.

```
\usepackage{tabularx}

...

\begin{tabularx}{\textwidth}{ |l|X|l|X| }
  \hline
  label 1 & label 2 & label 3 & label 4 \\
  \hline
```

```
  item 1  & item 2  & item 3  & item 4  \\
  \hline
\end{tabularx}
```

The content provided for the boxes is treated as for a `p` column, except that the width is calculated automatically. If you use the package `array`, you may also apply any`textgreater`{\cmd} or`textless`{\cmd} command to achieve specific behavior (like \`centering`, or \`raggedright`\`arraybackslash`) as described previously.

## Vertically centered images

Inserting images into a table row will align it at the top of the cell. By using the `array` package this problem can be solved. Defining a new columntype will keep the image vertically centered.

```
\newcolumntype{S}{>{\centering\arraybackslash} m{.4\linewidth} }
```

## Professional tables

Many tables in professionally typeset books and journals feature simple tables, which have appropriate spacing above and below lines, and almost *never* use vertical rules. Many examples of LaTeX tables (including this Wikibook) showcase the use of vertical rules (using "|"), and double-rules (using \`hline`\`hline`" or "||"), which are regarded as unnecessary and distracting in a professionally published form. The booktabs package is useful for easily providing this professionalism in LaTeX tables, and the documentation also provides guidelines on what constitutes a "good" table.

In brief, the package uses \`toprule` for the uppermost rule (or line), \`midrule` for the rules appearing in the middle of the table (such as under the header), and \`bottomrule` for the lowermost rule. This ensures that the rule weight and spacing are acceptable. In addition, \`cmidrule` can be used for mid-rules that span specified columns. The following example contrasts the use of booktabs and normal LaTeX implementations (the later example requires \`usepackage`{`booktabs`} in the preamble).

**Normal LaTeX**

```
\begin{tabular}{llr}
\hline
\multicolumn{2}{c}{Item} \\
\cline{1-2}
Animal & Description & Price (\$) \\
\hline
Gnat  & per gram & 13.65 \\
      & each     &  0.01 \\
Gnu   & stuffed  & 92.50 \\
Emu   & stuffed  & 33.33 \\
```

```
Armadillo & frozen & 8.99 \\
\hline
\end{tabular}
```

| Item | | |
|---|---|---|
| Animal | Description | Price ($) |
| Gnat | per gram | 13.65 |
| | each | 0.01 |
| Gnu | stuffed | 92.50 |
| Emu | stuffed | 33.33 |
| Armadillo | frozen | 8.99 |

**Using** `booktabs`

```
\begin{tabular}{llr}
\toprule
\multicolumn{2}{c}{Item} \\
\cmidrule(r){1-2}
Animal & Description & Price (\$) \\
\midrule
Gnat  & per gram & 13.65 \\
      & each     &  0.01 \\
Gnu   & stuffed  & 92.50 \\
Emu   & stuffed  & 33.33 \\
Armadillo & frozen & 8.99 \\
\bottomrule
\end{tabular}
```

| Item | | |
|---|---|---|
| Animal | Description | Price ($) |
| Gnat | per gram | 13.65 |
| | each | 0.01 |
| Gnu | stuffed | 92.50 |
| Emu | stuffed | 33.33 |
| Armadillo | frozen | 8.99 |

## Need more complicated features?

Have a look at one of the following packages:

- `hhline`: do whatever you want with horizontal lines
- `array`: gives you more freedom on how to define columns
- `colortbl`: make your table more colorful
- `supertab`: for tables that need to stretch over several pages

- `longtable`: same as above. Note: footnotes do not work properly in a normal tabular environment. If you replace it with a longtable environment, footnotes work properly
- `xtabular`: Yet another package for tables that need to span many pages
- `tabulary`: modified tabular* allowing width of columns set for equal heights

## Summary

This concludes discussion of basic tables. Experimentation quickly leads to mastery. While the table syntax in LaTeX can look rather messy, seeing new examples can look confusing. But hopefully, enough has been covered here so that a user can create any table needed for your papers. Unsurprisingly, LaTeX has plenty more up its sleeve, so expect a follow up tutorial covering more advanced features in the near future.

# Chapter 9

# Importing Graphics

Strictly speaking, LaTeX cannot manage pictures directly: in order to introduce graphics within documents, LaTeX just creates a box with the same size of the image you want to include and embeds the picture, without any other processing. This means you will have to take care that the images you want to include are in the right format to be included. This is not such a hard task because LaTeX supports the most common picture formats around.

## The `graphicx` package

As stated before, LaTeX can't manage pictures directly, so we will need some extra help: we have to load the `graphicx` package in the preamble of our document:

```
\usepackage{graphicx}
```

This package accepts as an argument the external driver to be used to manage pictures; luckily the recent version of this package takes care of everything by itself, changing the driver according to the compiler you are using, so you don't have to worry about anything. Just in case you want to understand better how it works, here are the possible options you can pass to the package:

- `dvips` (default if compiling with *latex*), if you are compiling with *latex* to get a DVI and you want to see your document with a DVI or PS viewer.
- `dvipdfm`, if you are compiling with *latex* to get a DVI that you want to convert to PDF using *dvipdfm*, to see your document with any PDF viewer.
- `pdftex` (default if compiling with *pdflatex*), if you are compiling with *pdftex* to get a PDF that you will see with any PDF viewer.

but, again, you don't need to pass any option to the package because the default settings are fine most of the cases.

In many respects, importing your images into your document using LaTeX is fairly simple... *once* you have your images in the right format that is! Therefore, I fear for many people the biggest effort will be the process of converting their graphics files. Now we will see which formats we can include and then we will see how to do it.

## Document Options

The graphics and graphicsx packages recognize the "draft" and "final" options given in the `\documentclass[...]{...}` command at the start of the file. Using "draft" as the option will suppress the inclusion of the image in the output file and will replace the contents with the name of the image file that would have been seen. Using "final" will result in the image being placed in the output file. The default is "draft".

## Supported image formats

As explained before, the image formats you can use depend on the driver that `graphicx` is using but, since the driver is automatically chosen according to the compiler, then the allowed image formats will depend on the compiler you are using.

### Compiling with *latex*

The only format you can include while compiling with *latex* is Encapsulated PostScript (EPS).

The EPS format was defined by Adobe Systems for making it easy for applications to import postscript-based graphics into documents. Because an EPS file declares the size of the image, it makes it easy for systems like LaTeX to arrange the text and the graphics in the best way. EPS is a vector format—this means that it can have very high quality if it is created properly, with programs that are able to manage vector graphics. It is also possible to store bit-map pictures within EPS, but they will need *a lot* of disk space.

Most decent graphics software has the ability to save images in the EPS format (extension is normally `.eps`). Here are some examples of software that can output EPS formats:

- Creating and converting vector graphics:
  - Commercial vector graphics software, such as Adobe Illustrator, CorelDRAW, and FreeHand are commonly used and can *read* and *write* EPS figues. However, these products are limited to Windows and Mac OS platforms.
  - Inkscape can save in vector EPS format, and it can run on multiple platforms. However, it cannot open EPS figures—only export.
- Creating and converting raster-only graphics to EPS:
  - GIMP, has a graphical user interface, and it is multi-platform.
  - For command-line:
    - ImageMagick (`convert`) or GraphicsMagick (`gm convert`). These two programs operate much the same way, and can convert between most graphics formats.
    - imgtops. A lightweight graphics utility.

- Creating publication-quality vector-based plots and charts:
  - Gnuplot, producing scientific graphics since 1986.
  - R, statistical and scientific figures.

There are some tricks to be able to import other formats than EPS into your DVI document, but they're very complicated. On the other hand, converting any image to EPS is very simple, so it's not worth considering them.

### Compiling with `pdflatex`

If you are compiling with `pdflatex` to get a PDF, you have a wider choice. You can insert

- **JPG**, widely used on Internet, digital cameras, etc. They are the best choice if you want to insert photos
- **PNG**, very common format (even if not as much as JPG), it's a lossless format and it's the best choice for diagrams (if you were not able to generate a vector version)
- **PDF**, it is widely used for documents but can be used to store images as well. It supports both vector and bit-map images, but if you want to store bit-maps you'd better use JPG or PNG, they need less disk space.

JPG and PNG are supported by any image processing program, so you just have to use the one you prefer. If you want to create high quality vector PDF to embed within your PDF document, you can use Inkscape: it supports many vector formats and so you can use it convert from one to other. You could also create your graphics directly with Inkscape. If you want to make mathematical plots, then Gnuplot can save in any format.

Note, that EPS files can not be used with pdflatex, however they can be converted to PDF using epstopdf, included in most LaTeX distributions. In Windows, multiple files can be converted by placing the following line in a batch file (a text file with a .BAT extension) in the same directory as the images: `for %%f in (*.eps) do epstopdf %%f` which can then be run from the command line.

Images can be saved in multiple formats for different purposes. For example, a directory can have "`diagram.pdf`" for high-resolution printing, while "`diagram.png`" can be used for previewing on the monitor. You can specify which image file is to be used by `pdflatex` through the preamble command:

```
\DeclareGraphicsExtensions{.pdf,.png,.jpg}
```

which specified the hierarchy of files to include in the document, if they exist and have the same prefix.

## Including graphics

After we have seen which formats we can include and how we could manage those formats, now it's time to learn how to include them in our document. After you have loaded the `graphicx` package in your preamble, you can include images with `\includegraphics`, whose syntax is the following:

```
\includegraphics[attr1=val1, attr2=val2, ..., attrn=valn]{imagename}
```

As you should hopefully be aware by now, arguments in square brackets are optional, whereas curly braces are compulsory. The argument of the curly braces is the name of the image, write it *without* the extension. This way the LaTeX compiler will look for any supported image format in that directory and will take the best one (EPS if the output is DVI; JPEG, PNG or PDF if the output is PDF). The variety of possible attributes that can be set is fairly large, and so I shall cover the most useful:

| | | |
|---|---|---|
| `width=xx` | Specify the preferred width of the imported image to *xx*. | *NB. Only specifying either width or height will scale the image whilst maintaining the aspect ratio.* |
| `height=xx` | Specify the preferred height of the imported image to *xx*. | |
| `keepaspectratio` | This can be set to either *true* or *false*. When true, it will scale the image according to both height and width, but will not distort the image, so that neither width or height are exceeded. | |
| `scale=xx` | Scales the image by the desired scale factor. e.g, 0.5 to reduce by half, or 2 to double. | |
| `angle=xx` | This option can rotate the image by *xx* degrees (anti-clockwise) | |
| `trim=l b r t` | This option will crop the imported image by *l* from the left, *b* from the bottom, *r* from the right, and *t* from the top. Where l, b, r and t are lengths. | |
| `clip` | For the `trim` option to work, you must set `clip=true`. | |

In order to use more than one option at a time, simply separate with a comma. Included graphics will be inserted just *there*, where you placed the code, and the compiler will handle them as "big boxes". As we will see in the next section, this may lead to a bad output so you'd better place graphics inside floating objects.

## Examples

OK, it's time to see graphicx in action. Here are some examples:

```
\includegraphics{chick}
```

This simply imports the image, without any other processing. However, it is very large (so I won't display it here!). So, let's scale it down:

This has now reduced by half. If you wish to be more specific and give actual lengths of the image dimensions, this is how to go about it:

One can also specify the scale with respect to the width of a line in the local environment (`\linewidth`), the width of the text on a page (`\textwidth`) or the

```
\includegraphics[scale=0.5]{chick}
```

```
\includegraphics[width=2.5cm]{chick}
```

height of the text on a page (`\textheight`) (pictures not shown):

```
\includegraphics[width=0.5\linewidth]{chick}

\includegraphics[width=0.75\textwidth]{chick}

\includegraphics[height=0.75\textheight]{chick}
```

To rotate (I also scaled the image down):

```
\includegraphics[scale=0.5, angle=180]{chick}
```

And finally, an example of how to crop an image should you wish to focus in one particular area of interest:

```
\includegraphics[trim = 10mm 80mm 20mm 5mm, clip,
  width=3cm]{chick}
```

Note the presence of `clip`, as the trim operation will not work without it.

As you may have noticed, the file name of the picture is always without the extensions: the format of the picture does not matter, LaTeX will take care of getting the right version for us. Consider the following situation: you have added some pictures to your document in JPG and you have successfully compiled it in PDF. Now you want to compile it in DVI, you run *latex* and you get a lot of errors... because you forgot to provide the EPS versions of the pictures you want to insert. At the beginning of this book, we have stated that the same LaTeX source can be compiled in both DVI and PDF without any change. This is true, as long as you don't use particular packages, and `graphicx` is one of those. In any case, you can still use both compilers with documents with pictures as well, as long as you always remember to provide the pictures in two formats (EPS and one of JPG, PNG and PDF).

## Borders

It is possible to have LaTeX create a border around your image by using `fbox`:

```
\setlength\fboxsep{0pt}
\setlength\fboxrule{0.5pt}
\fbox{\includegraphics{chick}}
```

You can control the border padding with the \setlength\fboxsep{0pt} command, in this case I set it to 0pt to avoid any padding, so the border will be placed tightly around the image. You can control the thickness of the border by adjusting the \setlength\fboxrule{0.5pt} command.

### Graphics storage

There is a way to tell LaTeX where to look for images: for example, it can be useful if you had stored images centrally for use in many different documents. The answer is in a command \graphicspath which you supply with an argument giving the name of an additional directory path you want searched when a file uses the \includegraphics command, here are some examples:

```
\graphicspath{{c:\mypict~1\camera}}
\graphicspath{{/var/lib/images/}}
\graphicspath{{./images/}}
\graphicspath{{images_folder/}{other_folder/}{third_folder/}}
```

please see http://www.ctan.org/tex-archive/macros/latex/required/graphics/grfguide.pdf

As you may have noticed, in the first example I've used the "safe" (MS-DOS) form of the Windows *MyPictures* folder because it's a bad idea to use directory names containing spaces. Using absolute paths, \graphicspath does make your file less portable, while using relative paths (like the last example), you shouldn't have any problem with portability, but remember not to use spaces in file-names.

### Images as figures

There is one major topic missing from this chapter that is relevant, and that is to do with making that image a *figure*. For this, you will want a caption, and maybe cross-reference. However, this was deliberate, as it is not only images that are figures. Therefore, this material is to be covered within its own tutorial (see Floats, Figures and Captions).

## Xfig

Vector graphics can be created using Xfig (see Installation), and exported for LaTeX. Once your graphic is saved as an test.fig file you need to export it using the FILE>EXPORT drop down menu from the main Xfig window and then selecting the "Combined PS/Latex (both parts)" in the language drop down list. If you don't change any other settings, two files will be created in the same directory as test.fig file, such as: test.pstex_t and test.pstex. The figure can then be placed in a LaTeX document:

```
\begin{figure}
  \begin{center}
    \input{./xfig/test.pstex_t}
```

```
    \caption{This is the caption of my figure}
    \label{fig:test}
  \end{center}
\end{figure}
```

# Chapter 10

# Floats, Figures and Captions

In the previous chapter, the importing of graphics was introduced. However, just having a picture stuck in-between paragraphs does not look professional. For starters, we want a way of adding captions, and to be able to cross-reference. What we need is a way of defining *figures*. It would also be good if Latex could apply similar principles to when it arranges text to look its best, to arranging pictures too. This is where *floats* come into play.

## Floats

Floats are containers for things in a document that cannot be broken over a page. LaTeX by default recognizes "table" and "figure" floats, but you can define new ones of your own (see below). Floats are there to deal with the problem of the object that won't fit on the present page, and to help when you really don't want the object here just now.

Floats are not part of the normal stream of text, but separate entities, positioned in a part of the page to themselves (top, middle, bottom, left, right, or wherever the designer specifies). They always have a caption describing them and they are always numbered so they can be referred to from elsewhere in the text. LaTeX automatically floats Tables and Figures, depending on how much space is left on the page at the point that they are processed. If there is not enough room on the current page, the float is moved to the top of the next page. This can be changed by moving the Table or Figure definition to an earlier or later point in the text, or by adjusting some of the parameters which control automatic floating.

Authors sometimes have many floats occurring in rapid succession, which raises the problem of how they are supposed to fit on the page and still leave room for text. In this case, LaTeX stacks them all up and prints them together if possible, or leaves them to the end of the chapter in protest. The skill is to space them out within your text so that they intrude neither on the thread of your argument or discussion, nor on the visual balance of the typeset pages.

## Figures

To create a figure that floats, use the `figure` environment.

```
\begin{figure}[placement specifier]
... figure contents ...
\end{figure}
```

In the previous section, I was saying how floats are used to allow Latex to handle figures, whilst maintaining the best possible presentation. However, there may be times when you disagree, and a typical example is with its positioning of figures. The *placement specifier* parameter exists as a compromise, and its purpose is to give the author a greater degree of control over where certain floats are placed.

| Specifier | Permission |
|---|---|
| `h` | Place the float *here*, i.e., *approximately* at the same point it occurs in the source text (however, not *exactly* at the spot) |
| `t` | Position at the *top* of the page. |
| `b` | Position at the *bottom* of the page. |
| `p` | Put on a special *page* for floats only. |
| `!` | Override internal parameters Latex uses for determining "good" float positions. |
| `H` | Places the float at precisely the location in the LaTeX code. Requires the `float` package,[1] e.g., `\usepackage{float}`. This is somewhat equivalent to `h!`. |

What you do with these *placement permissions* is to list which of the options that you wish to make available to Latex. These are simply possibilities, and Latex will decide when typesetting your document which of your supplied specifiers it thinks is best.

Use `\listoffigures` to add a list of the figures in the beginning of the document. To change the name used in the caption from **Figure** to **Example**, use `\renewcommand{\figurename}{Example}`.

## Tables

Although tables have already been covered, it was only the internal syntax that was discussed. The `tabular` environment that was used to construct the tables is not a float by default. Therefore, for tables you wish to float, wrap the `tabular` environment within a `table` environment, like this:

```
\begin{table}
  \begin{tabular}{...}
  ... table data ...
  \end{tabular}
\end{table}
```

[1] http://www.ctan.org/tex-archive/macros/latex/contrib/float/

You may feel that it is a bit long winded, but such distinctions are necessary, because you may not want all tables to be treated as a float.

Use `\listoftables` to add a list of the tables in the beginning of the document.

## Captions

It is always good practice to add a caption to any figure or table. Fortunately, this is very simple in Latex. All you need to do is use the `\caption{text}` command within the float environment. Because of how LaTeX deals sensibly with logical structure, it will automatically keep track of the numbering of figures, so you do not need to include this within the caption text.

The location of the caption is traditionally underneath the float. However, it is up to you to therefore insert the caption command after the actual contents of the float (but still within the environment). If you place it before, then the caption will appear above the float. Try out the following example to demonstrate this effect:

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

\usepackage[english]{babel}
\usepackage{graphicx}

\begin{document}

\begin{figure}[h!]
  \caption{A picture of a gull.}
  \centering
    \includegraphics[width=0.5\textwidth]{gull}
\end{figure}

\begin{figure}[h!]
  \centering
    \reflectbox{%
      \includegraphics[width=0.5\textwidth]{gull}}
  \caption{A picture of the same gull
           looking the other way!}
\end{figure}

\begin{table}[h!]
  \begin{center}
    \begin{tabular}{| l c r |}
    \hline
    1 & 2 & 3 \\
    4 & 5 & 6 \\
    7 & 8 & 9 \\
    \hline
```

```
    \end{tabular}
  \end{center}
  \caption{A simple table}
\end{table}

Notice how the tables and figures
have independent counters.

\end{document}
```

Figure 1: A picture of a gull.

Figure 2: A picture of the same gull looking the other way!

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |

Table 1: A simple table

Notice how the tables and figures have independent counters.

note that the command `\reflectbox{...}` flips horizontally its content.

## Lists of figures and tables

Captions can be listed at the beginning of a paper or report in a "List of Tables" or a "List of Figures" section by using the `\listoftables` or `\listoffigures` commands, respectively. The caption used for each figure will appear in these lists, along with the figure numbers, and page numbers that they appear on.

The `\caption` command also has an optional parameter, `\caption[short]{long}` which is used for the *List of Tables* or *List of Figures*. Typically the `short` description is for the caption listing, and the `long` description will be placed beside the figure or table. This is particularly useful if the caption is long, and only a "one-liner" is desired in the figure/table listing. Here is an example of this usage:

```
\documentclass[12pt]{article}
\usepackage{graphicx}

\begin{document}

\listoffigures

\section{Introduction}

\begin{figure}[hb]
  \centering
  \includegraphics[width=4in]{gecko}
  \caption[Close up of \textit{Hemidactylus} sp.]%
  {Close up of \textit{Hemidactylus} sp., which is
   part the genus of the gecko family. It is the
   second most speciose genus in the family.}
\end{figure}

\end{document}
```

## List of Figures

1 Close up of *Hemidactylus* sp. . . . . 1

# 1 Introduction

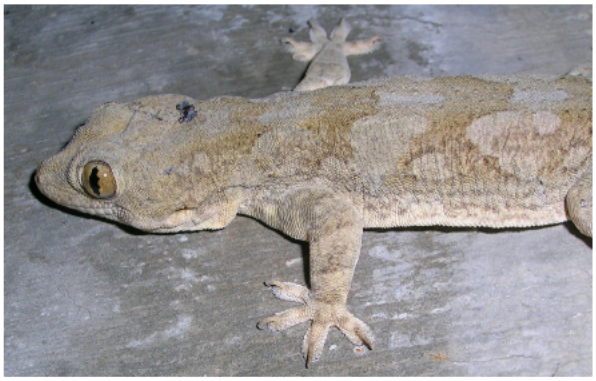


Figure 1: Close up of *Hemidactylus* sp., which is part the genus of the gecko family. It is the second most speciose genus in the family.

### Side captions

It is sometimes desirable to have a caption appear on the side of a float, rather than above or below. The `sidecap` package can be used to place a caption beside a figure or table. The following example demonstrates this for a figure by using a `SCfigure` environment in place of the `figure` environment. `SCfigure` does not accept the usual `figure` arguments.

```
\documentclass{article}

\usepackage[pdftex]{graphicx}
\usepackage{sidecap}

\begin{document}

\begin{SCfigure}
  \centering
  \includegraphics[width=0.55\textwidth]%
    {Giraff_picture}% picture filename
  \caption{ ... caption text ... }
\end{SCfigure}

\end{document}
```

Figure 1: The giraffe (*Giraffa camelopardalis*) is an African even-toed ungulate mammal, the tallest of all land-living animal species. Males can be 4.8 to 5.5 metres tall and weigh up to 1,360 kilograms. The record-sized bull was 5.87 m tall and weighed approximately 2,000 kg. Females are generally slightly shorter and weigh less than the males do.

## Labels and Cross-referencing

Labels and cross-references work fairly similarly to the general case — see the Labels and Cross-referencing section for more information.

*Warning:* If you want to label a figure so that you can reference it later, you have to add the label **after the caption** but **inside the floating environment**. If it is declared outside, it will give the section number. If the label picks up the section or list number instead of the figure number, put the label inside the caption to ensure correct numbering.

## Wrapping text around figures

Although not normally the case in academic writing, an author may prefer that some floats do not break the flow of text, but instead allow text to wrap around it. (Obviously, this effect only looks decent when the figure in question is significantly narrower than the text width.)

A word of warning: Wrapping figures in LaTex will require a lot of manual adjustment of your document. There are several packages available for the task, but none of them work perfectly. Before you make the choice of including figures with text wrapping in your document, make sure you have considered all the options. For example, you could use a layout with two columns for your documents and have no text-wrapping at all.

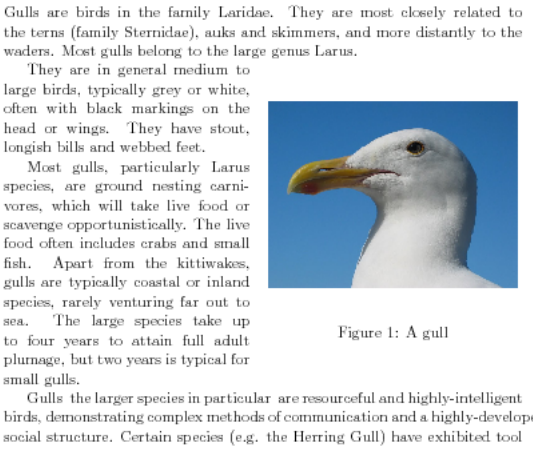
Anyway, we will look at the package `wrapfig`.

To use `wrapfig`, you must first add `\usepackage{wrapfig}` to the preamble. This then gives you access to:

`\begin{wrapfigure}[lineheight]{alignment}{width}`

*Alignment* can normally be either *l* for left, or *r* for right. Lowercase *l* or *r* forces the figure to start precisely where specified (and may cause it to run over page breaks), while capital *L* or *R* allows the figure to float. If you defined your document as twosided, the alignment can also be *i* for inside or *o* for outside, as well as *I* or *O*. The *width* is obviously the width of the figure. An example:

```
\begin{wrapfigure}{r}{0.5\textwidth}
  \begin{center}
    \includegraphics[width=0.48\textwidth]{gull}
  \end{center}
  \caption{A gull}
\end{wrapfigure}
```



Gulls are birds in the family Laridae. They are most closely related to the terns (family Sternidae), auks and skimmers, and more distantly to the waders. Most gulls belong to the large genus Larus.

They are in general medium to large birds, typically grey or white, often with black markings on the head or wings. They have stout, longish bills and webbed feet.

Most gulls, particularly Larus species, are ground nesting carnivores, which will take live food or scavenge opportunistically. The live food often includes crabs and small fish. Apart from the kittiwakes, gulls are typically coastal or inland species, rarely venturing far out to sea. The large species take up to four years to attain full adult plumage, but two years is typical for small gulls.

Figure 1: A gull

Gulls the larger species in particular are resourceful and highly-intelligent birds, demonstrating complex methods of communication and a highly-developed social structure. Certain species (e.g. the Herring Gull) have exhibited tool

Note that we have specified a size for both the `wrapfigure` environment and the image we have included. We did it in terms of the text width: it is always better to use relative sizes in LaTeX, let LaTeX do the work for you! The "wrap" is slightly bigger than the picture, so the compiler will not return any strange warning and you will have a small white frame between the image and the surrounding text. You can change it to get a better result, but if you don't keep the image smaller than the "wrap", you will see the image *over* the text, and this shouldn't be the effect you want to get!

## Tip for figures with too much white space

It happens that you'll generate figures with too much (or too little) white space on the top or bottom. In such a case, you can simply make use of the optional argument `[lineheight]`. It specifies the height of the figure in number of lines of text.

Another possibility is adding space within the float using the `\vspace{...}` command. The argument is the size of the space you want to add, you can use any unit you want, including pt, mm, in, etc. If you provide a negative argument, it will add a *negative* space, thus removing some white space. Here is an example, the code is exactly the one of the previous case, we just added some negative vertical spaces to shrink everything up:

```
\begin{wrapfigure}{r}{0.5\textwidth}
  \vspace{-20pt}
  \begin{center}
    \includegraphics[width=0.48\textwidth]{gull}
  \end{center}
```

```
  \vspace{-20pt}
  \caption{A gull}
  \vspace{-10pt}
\end{wrapfigure}
```

Gulls are birds in the family Laridae. They are most closely related to the terns (family Sternidae), auks and skimmers, and more distantly to the waders. Most gulls belong to the large genus Larus.

They are in general medium to large birds, typically grey or white, often with black markings on the head or wings. They have stout, longish bills and webbed feet.

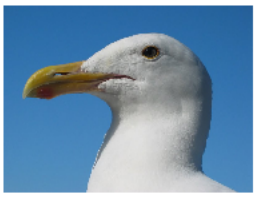


Figure 1: A gull

Most gulls, particularly Larus species, are ground nesting carnivores, which will take live food or scavenge opportunistically. The live food often includes crabs and small fish. Apart from the kittiwakes, gulls are typically coastal or inland species, rarely venturing far out to sea. The large species take up to four years to attain full adult plumage, but two years is typical for small gulls.

Gulls the larger species in particular are resourceful and highly-intelligent birds, demonstrating complex methods of communication and a highly-developed social structure. Certain species (e.g. the Herring Gull) have exhibited tool use behaviour. Many species of gull have learned to co-exist successfully with man and have thrived in human habitats. Others rely on kleptoparasitism to get their food.

In this case it may look too shrunk, but you can manage spaces the way you like. In general, you'd better not to add any space at all: let LaTeX do the formatting work! you shouldn't worry about appearance; moreover, if LaTeX decided to add some space, there will be a reason considering that LaTeX is such an old and stable program, right?

## Subfloats

A useful extension is the `subfig` package, which uses subfloats within a single float. This gives the author the ability to have subfigures within figures, or subtables within table floats. Subfloats have their own caption, and an optional global caption. An example will best illustrate the usage of this package:

```
\begin{figure}
  \centering
  \subfloat[A gull]{\label{fig:gull}\includegraphics[width=0.3\textwidth]{gull}}
  \subfloat[A tiger]{\label{fig:tiger}\includegraphics[width=0.3\textwidth]{tiger}}
  \subfloat[A mouse]{\label{fig:mouse}\includegraphics[width=0.3\textwidth]{mouse}}
  \caption{Pictures of animals}
  \label{fig:animals}
\end{figure}
```

(a) A gull (b) A tiger (c) A mouse

Figure 1: Pictures of animals

You will notice that the figure environment is set up as usual. You may also use a table environment for subtables. For each subfloat, you need to use:

`\subfloat[sub caption]{ ... figure or table ... }`

If you intend to cross-reference any of the subfloats, see where the label is inserted; `\caption` will provide the global caption. `subfig` will arrange the figures or tables side-by-side providing they can fit, otherwise, it will automatically shift subfloats below. This effect can be added manually, by putting the newline command (\\) before the figure you wish to move to a newline.

Horizontal spaces between figures is controlled by one of several commands, which are placed in between each `\subfloat{}` command:

- Any whitespace (such as spaces, returns, and tabs) will result in one regular space
- Math spaces: `\qquad`, `\quad`, `\;`, and `\,`
- Generic space: `\hspace{length}`

## Wide figures in two column documents

If you are writing a document using two columns (i.e. you started your document with something like `\documentclass[twocolumn]{article}`), you might have noticed that you can't use floating elements that are wider than the width of a column (using a LaTeX notation, wider than `0.5\textwidth`), otherwise you will see the image overlapping with text. If you really have to use such wide elements, the only solution is to use the "starred" variants of the floating environments, that are `{figure*}` and `{table*}`. Those "starred" versions work exactly like the standard ones, but they will be as wide as the page, so you will get no overlapping.

A bad point of those environments is that they can be placed only at the top of the page or on their own page. If you try to specify their position using modifiers like *b* or *h* they will be ignored.

To prevent the figures from being placed out-of-order with respect to their "non-starred" counterparts, the package `fixltx2e` [2] should be used (e.g. `\usepackage{fixltx2e}`).

[2] http://www.tex.ac.uk/cgi-bin/texfaq2html?label=2colfltorder

## Custom Floats

If tables and figures are not adequate for your needs, then you always have the option to create your own! Examples of such instances could be source code examples, or maps. For a program float example, one might therefore wish to create a float named `program`. The package `float` is your friend for this task. *All commands to set up the new float must be placed in the preamble, and not within the document.*

1. Add \usepackage{float} to the preamble of your document
2. Declare your new float using: \newfloat{type}{placement}{ext}[outer counter], where:
   - *type* — the new name you wish to call your float, in this instance, 'program'.
   - *placement* — t, b, p, or h (as previously described in Placement), where letters enumerate permitted placements.
   - *ext* — the file name extension of an auxiliary file for the list of figures (or whatever). Latex writes the captions to this file.
   - *outer counter* — the presence of this parameter indicates that the counter associated with this new float should depend on outer counter, for example 'chapter'.
3. The default name that appears at the start of the caption is the type. If you wish to alter this use, \floatname{type}{floatname}
4. Changing float style can be issued with \floatstyle{style} (Works on all subsequent \newfloat commands, therefore, must be inserted before \newfloat to be effective).
   - `plain` — the normal style for Latex floats, i.e., nothing!
   - `boxed` — a box is drawn that surrounds the float, and the caption is printed below.
   - `ruled` — the caption appears above the float, with rules immediately above and below. Then the float contents, followed by a final horizontal rule.

An example document using a new `program` float type:

```
\documentclassarticle

\usepackagefloat

\floatstyleruled
\newfloatprogramthplop
\floatnameprogramProgram

\begindocument
```

```
\beginprogram
  \beginverbatim

class HelloWorldApp
  public static void main(String[] args)
    //Display the string
    System.out.println("Hello World!");


\endverbatim
  \captionThe Hello World! program in Java.
\endprogram

\enddocument
```

**Program 1** The Hello World! program in Java.

```
class HelloWorldApp {
  public static void main(String[] args) {
    //Display the string
    System.out.println("Hello World!");
  }
}
```

The `verbatim` environment is an environment that is already part of Latex. Although not introduced so far, its name is fairly intuitive! Latex will reproduce everything you give it, including new lines, spaces, etc. It is good for source code, but if you want to introduce a lot of code you might consider using the `listings` package, that was made just for it.

## Summary

That concludes all the fundamentals of floats. You will hopefully see how much easier it is to let Latex do all the hard work and tweak the page layouts in order to get your figures in the best place. As always, the fact that Latex takes care of all caption and reference numbering is a great time saver.

# Chapter 11

# Formatting

The term formatting is rather broad, but in this case it needs to be as this section will guide you through the various text, paragraph and page formatting techniques. Formatting tends to refer to most things to do with appearance, it makes the list of possible topics quite eclectic: text style, font, size; paragraph alignment, interline spacing, indents; special paragraph types; list structures; footnotes, margin notes, etc.

A lot of the formatting techniques are required to differentiate certain elements from the rest of the text. It is often necessary to add emphasis to key words or phrases. A numbered or bulleted list is also commonly used as a clear and concise way of communicating an important issue. Footnotes are useful for providing extra information or clarification without interrupting the main flow of text. So, for these reasons, formatting is very important. However, it is also very easy to abuse, and a document that has been over-done can look and read worse than one with none at all.

## Text formatting

### Hyphenation

LaTeX hyphenates words whenever necessary. If the hyphenation algorithm does not find the correct hyphenation points, you can remedy the situation by using the following commands to tell TeX about the exception. The command

`\hyphenation{word list}`

causes the words listed in the argument to be hyphenated only at the points marked by "-". The argument of the command should only contain words built from normal letters, or rather signs that are considered to be normal letters by LaTeX. The hyphenation hints are stored for the language that is active when the hyphenation command occurs. This means that if you place a hyphenation command into the preamble of your document it will influence the English language hyphenation. If you place the command after the `\begin{document}` and you are using some package for national language support like babel, then the hyphenation hints will be active in the language activated through babel. The example below will allow "hyphenation" to be hyphenated as well as "Hyphenation", and it prevents "FORTRAN", "Fortran" and

"fortran" from being hyphenated at all. No special characters or symbols are allowed in the argument. Example:

```
\hyphenation{FORTRAN Hy-phen-a-tion}
```

The command \ inserts a discretionary hyphen into a word. This also becomes the only point hyphenation is allowed in this word. This command is especially useful for words containing special characters (e.g., accented characters), because LaTeX does not automatically hyphenate words containing special characters.

```
\begin{minipage}{2in}
I think this is: su\-per\-cal\-%
i\-frag\-i\-lis\-tic\-ex\-pi\-%
al\-i\-do\-cious
\end{minipage}
```

I think this is: supercalifragi-
listicexpialidocious

Several words can be kept together on one line with the command

```
\mbox{text}
```

It causes its argument to be kept together under all circumstances. Example:

```
My phone number will change soon. It will be \mbox{0116 291 2319}.
```

\fbox is similar to \mbox, but in addition there will be a visible box drawn around the content.

## Quotes

Latex treats left and right quotes as different entities. For single quotes, ‘ (on British and American keyboards, this symbol is found on the key adjacent to the number 1) gives a left quote mark, and ’ is the right. For double quotes, simply double the symbols, and Latex will interpret them accordingly. (Although, you can use the " for right double quotes if you wish).

| | |
|---|---|
| To ‘quote’ in Latex | To ‘quote’ in Latex. |
| To ‘‘quote’’ in Latex | To “quote” in Latex. |
| To ‘‘quote" in Latex | To “quote” in Latex. |
| ‘‘Please press the ‘x’ key.’’ | “Please press the ‘x’ key.” |

The right quote is also used for apostrophe in Latex without trouble.

| Command | Output | Command | Output |
|---|---|---|---|
| \`{o} | ò | \'{o} | ó |
| \"{o} | ö | \H{o} | ő |
| \^{o} | ô | \~{o} | õ |
| \v{o} | ǒ | \={o} | ō |
| \b{o} | o̲ | \.{o} | ȯ |
| \d{o} | ọ | \c{o} | o̧ |
| \r{o} | o̊ | \t{oo} | o͡o |
| \i | ı | | |

## Accents

It does not take long before you need to use an accented character within your document. Personally, I find it tends to be names of researchers whom I wish to cite which contain accents. It's easy to apply, although not all are easy to remember:

To place an accent on top of an i or a j, its dot has to be removed. This is accomplished by typing `\i` and `\j`. If you have to write all your document in a foreign language and you have to use particular accents several times, then using the right configuration you can write those characters directly in your document. For more information, see the Internationalization.

## The Space Between Words

To get a straight right margin in the output, LaTeX inserts varying amounts of space between the words. It inserts slightly more space at the end of a sentence, as this makes the text more readable. LaTeX assumes that sentences end with periods, question marks or exclamation marks. If a period follows an uppercase letter, this is not taken as a sentence ending, since periods after uppercase letters normally occur in abbreviations.

Any exception from these assumptions has to be specified by the author. A backslash in front of a space generates a space that will not be enlarged. A tilde '~' character generates a space that cannot be enlarged and additionally prohibits a line break. The command `\@` in front of a period specifies that this period terminates a sentence even when it follows an uppercase letter.

The additional space after periods can be disabled with the command

`\frenchspacing`

which tells LaTeX not to insert more space after a period than after ordinary character. This is very common in non-English languages, except bibliographies. If you use `\frenchspacing`, the command `\@` is not necessary.

Some very long words, numbers or URLs may not be hyphenated properly and move far beyond side margin. One solution for this problem is to use `sloppypar` environment, which tells LaTeX to adjust word spacing less strictly. As result, some

spaces between words may be a bit too large, but long words will be placed properly.

```
This is a paragraph with
a very long word ABCDEFGHIJKLMNOPRST;
then we have an another bad thing
--- a long number 1234567890123456789.

\begin{sloppypar}
This is a paragraph with
a very long word ABCDEFGHIJKLMNOPRST;
then we have an another bad thing
--- a long number 1234567890123456789.
\end{sloppypar}
```

This is a paragraph with a very long word ABCDEFGHIJKLMNOPRST; then we have an another bad thing — a long number 1234567890123456789.

This is a paragraph with a very long word ABCDEFGHIJKLMNOPRST; then we have an another bad thing — a long number 1234567890123456789.

## Ligatures

Some letter combinations are typeset not just by setting the different letters one after the other, but by actually using special symbols (like "ff"), called ligatures. Ligatures can be prohibited by inserting {} between the two letters in question. This might be necessary with words built from two words. Here is an example:

```
\Large Not shelfful\\
but shelf{}ful
```

Not shelfful
but shelfful

## Slash marks

The normal typesetting of the / character in LaTeX does not allow following characters to be "broken" on to new lines, which often create "overfull" errors in output (where letters push off the margin). Words that use slash marks, such as "input/output" should be typeset as "`input\slash output`", which allow the line to "break" after the slash mark (if needed). The use of the / character in LaTeX should be restricted to units, such as "`mm/year`", which should not be broken over multiple lines.

## Emphasizing Text

In order to add some emphasis to a word or phrase, the simplest way is to use the \emph{text} command. That's it! See, dead easy.

```
I want to \emph{emphasize} a word.
```

I want to *emphasize* a word.

## Font Styles and size

I will really only scratch the surface about this particular field. This section is not about how to get your text in Verdana size 12pt! There are three main font families: roman (such as Times), sans serif (eg Arial) and monospace (eg Courier). You can also specify styles such as italic and bold:

The following table lists the commands you will need to access the typical font styles:

| LaTeX command | Equivalent to | Output style | Remarks |
|---|---|---|---|
| \textnormal{...} | {\normalfont ...} | document font family | this is the default or normal font |
| \emph{...} | {\em ...} | *emphasis* | typically italics |
| \textrm{...} | {\rmfamily ...} | roman font family | |
| \textsf{...} | {\sffamily ...} | sans serif font family | |
| \texttt{...} | {\ttfamily ...} | `teletypefont family` | this is a fixed-width or monospace font |
| \textup{...} | {\upshape ...} | upright shape | the same as the normal typeface |
| \textit{...} | {\itshape ...} | *italic shape* | |
| \textsl{...} | {\slshape ...} | *slanted shape* | a skewed version of the normal typeface (similar, but slightly different than italics) |
| \textsc{...} | {\scshape ...} | SMALL CAPITALS | |
| \textbf{...} | {\bfseries ...} | **bold** | |
| \textmd{...} | {\mdseries ...} | medium weight | a font weight in between normal and bold |

You may have noticed the absence of underline. Although this is available via the \underline{...} command, text underlined in this way will not break properly. This functionality has to be added with the `ulem` package. Stick \usepackage{ulem} in your preamble. By default, this overrides the \emph command with the underline rather than the italic style. It is unlikely that you wish this to be the desired effect, so it is better to stop `ulem` taking over \emph and simply call the underline command as and when it is needed.

- To disable `ulem`, add \normalem straight after the document environment begins.

- To underline, use \uline{...}.
- To add a wavy underline, use \uwave{...}.
- And for a strike-out \sout{...}.

Finally, there is the issue of size. This too is very easy, simply follow the commands on this table:

| Command | Output |
|---|---|
| \tiny | sample text |
| \scriptsize | sample text |
| \footnotesize | sample text |
| \small | sample text |
| \normalsize | sample text |
| \large | sample text |
| \Large | sample text |
| \LARGE | sample text |
| \huge | sample text |
| \Huge | sample text |

| size | 10pt (default) | 11pt option | 12pt option |
|---|---|---|---|
| \tiny | 5pt | 6pt | 6pt |
| \scriptsize | 7pt | 8pt | 8pt |
| \footnotesize | 8pt | 9pt | 10pt |
| \small | 9pt | 10pt | 11pt |
| \normalsize | 10pt | 11pt | 12pt |
| \large | 12pt | 12pt | 14pt |
| \Large | 14pt | 14pt | 17pt |
| \LARGE | 17pt | 17pt | 20pt |
| \huge | 20pt | 20pt | 25pt |
| \Huge | 25pt | 25pt | 25pt |

Table 11.1: Absolute Point Sizes in Standard Classes

Note that the font size definitions are set by the document style. Depending on the document style the actual font size may differ from that listed above. And not every document style has unique sizes for all 10 size commands.

Even if you can easily change the output of your fonts using those commands, you're better off not using explicit commands like this, because they work in opposition to the basic idea of LaTeX, which is to separate the logical and visual markup of your document. This means that if you use the same font changing command in several places in order to typeset a special kind of information, you should use \newcommand to define a "logical wrapper command" for the font changing command.

```
\newcommand{\oops}[1]{\textbf{#1}}

Do not \oops{enter} this room,
it's occupied by \oops{machines}
of unknown origin and purpose.
```

Do not **enter** this room, it's occupied by **machines** of unknown origin and purpose.

This approach has the advantage that you can decide at some later stage that you want to use some visual representation of danger other than `\textbf`, without having to wade through your document, identifying all the occurrences of `\textbf` and then figuring out for each one whether it was used for pointing out danger or for some other reason.

### Text mode superscript and subscript

To superscript text in text-mode, you can use the `\textsuperscript{}` command. This allows you to, for instance, typeset 6th as $6^{th}$:

```
Michelangelo was born on March 6\textsuperscript{th}, 1475.
```

The primary use of subscripts within the text environment is to typeset chemical formulae. For this purposes, a highly recommend package is mhchem. This package is easy to use, and works with your text fonts (rather than math fonts). To insert a chemical forumula, use `\ce{}` with the text-equivalent formula, for example:

```
% In your preamble, add:
\usepackage[version=3]{mhchem}
...

% In your document:
Ammonium sulphate is \ce{(NH4)2SO4}.
```

Ammonium sulphate is $(NH_4)_2SO_4$.

Subscripting in text-mode is not supported by LaTeX alone, however, several packages allow the use of the `\textsubscript{}` command. For instance, bpchem, KOMA-Script2 and, perhaps the most universal option since it is distributed with LaTeX, fixltx2e all support this command.

```
% In your preamble, add:
\usepackage{fixltx2e}
...

% In your document:
It is found that height\textsubscript{apple tree} is
different than height\textsubscript{orange tree}.
```

It is found that $\text{height}_{\text{appletree}}$ is different than $\text{height}_{\text{orangetree}}$.

If you do not load a package that supports `\textsubscript{}`, the math mode must be used. This is easily accomplished in running text by bracketing your text with the $ symbol. In math mode subscripting is done using the underscore: _{}.

For example, the formula for water is written as:

```
H$_2$O is the formula for water
```

$H_2O$ is the formula for water

Note that in math mode text will appear in a font suitable for mathematical variables. In math mode, to generate roman text, for example, one would use the `\mathrm` command:

```
This is $\mathrm{normal\ roman\ and}_\mathrm{subscript\ roman}$ text
```

This is normal roman $\text{and}_{\text{subscript roman}}$ text

Note the use of \<space> to insert a space in math mode.

Similarly, you can superscript using:

```
This is $\mathrm{normal\ roman\ and}^\mathrm{superscript\ roman}$ text
```

This is normal roman $\text{and}^{\text{superscript roman}}$ text

## Symbols and special characters

### Dashes and Hyphens

LaTeX knows four kinds of dashes: a hyphen (-), en dash (–), em dash (—), or a minus sign (-). You can access three of them with different numbers of consecutive dashes. The fourth sign is actually not a dash at all—it is the mathematical minus sign:

```
Hyphen: daughter-in-law, X-rated\\
En dash: pages 13--67\\
Em dash: yes---or no? \\
Minus sign: $0$, $1$ and $-1$
```

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

The names for these dashes are: '-'(-) hyphen , '–'(–) en-dash , '—'(—) em-dash and ''(−) minus sign. They have different purposes:

| Input | Output | Purpose |
|---|---|---|
| - | - | inter-word |
| -- | – | page range, 1–10 |
| --- | — | punctuation dash — like this |

### Euro € currency symbol

When writing about money these days, you need the Euro symbol. You have several choices. If the fonts you are using have a euro symbol and you want to use that one, first you have to load the *textcomp* package in the preamble:

```
\usepackage{textcomp}
```

then you can insert the euro symbol with the command `\texteuro`. If you want to use the official version of the Euro symbol, then you have to use *eurosym*, load it with the *official* option in the preamble:

```
\usepackage[official]{eurosym}
```

then you can insert it with the `\euro` command. Finally, if you want a Euro symbol that's matching with the current font style (e.g., bold, italics, etc.) but your current font does not provide it, you can use the *eurosym* package again but with a different option:

```
\usepackage[gen]{eurosym}
```

again you can insert the euro symbol with `\euro`

### Ellipsis (...)

A sequence of three dots is known as an *ellipsis*, which is commonly used to indicate omitted text. On a typewriter, a comma or a period takes the same amount of space as any other letter. In book printing, these characters occupy only a little space and are set very close to the preceding letter. Therefore, you cannot enter 'ellipsis' by just typing three dots, as the spacing would be wrong. Instead, there is a special command for these dots. It is called `\ldots`:

```
Not like this ... but like this:\\
New York, Tokyo, Budapest, \ldots
```

Not like this ... but like this:
New York, Tokyo, Budapest, ...

### Ready-made strings

There are some very simple LaTeX commands for typesetting special text strings:

| Command | Example | Description |
|---|---|---|
| `\today` | May 31, 2006 | Current date |
| `\TeX` | TEX | Your favorite typesetter |
| `\LaTeX` | LATEX | The Name of the Game |
| `\LaTeXe` | LATEX $2_\varepsilon$ | The current incarnation |

### Other symbols

Latex has *lots* of symbols at its disposal. The majority of them are within the mathematical domain, and later chapters will cover how to get access to them. For the more common text symbols, use the following commands:

| Command | Symbol | Command | Symbol |
|---|---|---|---|
| \% | % | \# | # |
| \$ | $ | \& | & |
| \{ | { | \} | } |
| _ | _ | \S | § |
| \P | ¶ | \dag | † |
| \ddag | ‡ | \textbackslash | \ |
| \textbar | \| | \textless | < |
| \textgreater | > | \textemdash | — |
| \textendash | – | \textregistered | ® |
| \texttrademark | ™ | \textquestiondown | ¿ |
| \textexclamdown | ¡ | \textcircled{a} | ⓐ |
| \textsuperscript{a} | ª | \copyright | © |
| \pounds | £ | | |

Not mentioned in above table, tilde (~) is used in LaTeX code to produce non-breakable space. To get printed tilde sign, either make it verbatim text or write \~{}.

Of course, these are rather boring, and it just so happens that for some more interesting symbols, then the Postscript ZipfDingbats font is available thanks to the `pifont`. Hopefully, you are beginning to notice now that when you want to use a package, you need to add the declaration to your preamble, in this instance: `\usepackage{pifont}`. Next, the command `\ding{number}`, will print the specified symbol. Here is a table of the available symbols:

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | | 33 | ✁ | 34 | ✂ | 35 | ✃ | 36 | ✄ | 37 | ☎ | 38 | ✆ | 39 | ✇ |
| 40 | ✈ | 41 | ✉ | 42 | ☛ | 43 | ☞ | 44 | ✌ | 45 | ✍ | 46 | ✎ | 47 | ✏ |
| 48 | ✐ | 49 | ✑ | 50 | ✒ | 51 | ✓ | 52 | ✔ | 53 | ✕ | 54 | ✖ | 55 | ✗ |
| 56 | ✘ | 57 | ✙ | 58 | ✚ | 59 | ✛ | 60 | ✜ | 61 | ✝ | 62 | ✞ | 63 | ✝ |
| 64 | ✠ | 65 | ✡ | 66 | ✢ | 67 | ✣ | 68 | ✤ | 69 | ✥ | 70 | ✦ | 71 | ✧ |
| 72 | ★ | 73 | ☆ | 74 | ✪ | 75 | ✫ | 76 | ✬ | 77 | ✭ | 78 | ✮ | 79 | ✯ |
| 80 | ✰ | 81 | ✱ | 82 | ✲ | 83 | ✳ | 84 | ✴ | 85 | ✵ | 86 | ✶ | 87 | ✷ |
| 88 | ✸ | 89 | ✹ | 90 | ✺ | 91 | ✻ | 92 | ✼ | 93 | ✽ | 94 | ✾ | 95 | ✿ |
| 96 | ❀ | 97 | ❁ | 98 | ❂ | 99 | ❃ | 100 | ❄ | 101 | ❅ | 102 | ❆ | 103 | ❇ |
| 104 | ❈ | 105 | ❉ | 106 | ❊ | 107 | ❋ | 108 | ● | 109 | ❍ | 110 | ■ | 111 | ❑ |
| 112 | ❒ | 113 | ❑ | 114 | ❒ | 115 | ▲ | 116 | ▼ | 117 | ◆ | 118 | ❖ | 119 | ◗ |
| 120 | \| | 121 | ❙ | 122 | ❚ | 123 | ❛ | 124 | ❜ | 125 | ❝ | 126 | ❞ | | |
| | | 161 | ❡ | 162 | ❢ | 163 | ❣ | 164 | ❤ | 165 | ❥ | 166 | ❦ | 167 | ❧ |
| 168 | ♣ | 169 | ♦ | 170 | ♥ | 171 | ♠ | 172 | ① | 173 | ② | 174 | ③ | 175 | ④ |
| 176 | ⑤ | 177 | ⑥ | 178 | ⑦ | 179 | ⑧ | 180 | ⑨ | 181 | ⑩ | 182 | ❶ | 183 | ❷ |
| 184 | ❸ | 185 | ❹ | 186 | ❺ | 187 | ❻ | 188 | ❼ | 189 | ❽ | 190 | ❾ | 191 | ❿ |
| 192 | ① | 193 | ② | 194 | ③ | 195 | ④ | 196 | ⑤ | 197 | ⑥ | 198 | ⑦ | 199 | ⑧ |
| 200 | ⑨ | 201 | ⑩ | 202 | ❶ | 203 | ❷ | 204 | ❸ | 205 | ❹ | 206 | ❺ | 207 | ❻ |
| 208 | ❼ | 209 | ❽ | 210 | ❾ | 211 | ❿ | 212 | ➔ | 213 | → | 214 | ↔ | 215 | ↕ |
| 216 | ➘ | 217 | ➙ | 218 | ➚ | 219 | ➛ | 220 | ➜ | 221 | → | 222 | ⟶ | 223 | ➝ |
| 224 | ➞ | 225 | ➡ | 226 | ➢ | 227 | ➢ | 228 | ➤ | 229 | ➥ | 230 | ➦ | 231 | ➧ |
| 232 | ➨ | 233 | ➩ | 234 | ➪ | 235 | ➫ | 236 | ➬ | 237 | ➭ | 238 | ➮ | 239 | ➯ |
| | | 241 | ➱ | 242 | ➲ | 243 | ➳ | 244 | ➴ | 245 | ➵ | 246 | ➶ | 247 | ➷ |
| 248 | ➸ | 249 | ➹ | 250 | ➺ | 251 | ➻ | 252 | ➼ | 253 | ➽ | 254 | ➾ | | |

Figure 11.1: ZapfDingbats symbols

.

# Paragraph Formatting

Altering the paragraph formatting is not often required, especially in academic writing. However, it is useful to know, and applications tend to be for formatting text in floats, or other more exotic documents.

## Paragraph Alignment

Paragraphs in Latex are usually fully justified (i.e., flush with both the left and right margins). For whatever reason, should you wish to alter the justification of a paragraph, there are three environments at hand, and also Latex command equivalents.

All text between the `\begin` and `\end` of the specified environment will be justified appropriately. The commands listed are for use within other environments. For example, `p` (paragraph) columns in `tabular`.

| Alignment | Environment | Command |
|---|---|---|
| Left justified | `flushleft` | \raggedright |
| Right justified | `flushright` | \raggedleft |
| Center | `center` | \centering |

### Paragraph Indents

Paragraph indents are normally fine. The size of the indent is determined by a parameter called \parindent. The default length that this constant holds is set by the document class that you use. It is possible to override using the \setlength command. \setlength{\parindent}{length} will reset the indent to *length*.

Be careful, however, if you decide to set the indent to zero, then it means you will need a vertical space between paragraphs in order to make them clear. The space between paragraphs is held in \parskip, which could be altered in a similar fashion as above. However, this parameter is used elsewhere too, such as in lists, which means you run the risk of making various parts of your document look very untidy (that is, even more untidy than this type of paragraph style!) It may be better to use a document class typeset for this style of indentation, such as `artikel3.cls` (written by a dutch person, translates to article3).

To indent all the lines of a paragraph other than just the first line, use the TeX command \hangindent. An example follows.

```
\hangindent=0.7cm This paragraph has an extra indentation at the left.
```

### Line Spacing

To change line spacing in the whole document use the command \linespread covered in LaTeX/Customizing LaTeX#Spacing.

To change line spacing in specific environments do the following:

1. Add \usepackage{setspace} to the document preamble.
2. This then provides the following environments to use within your document:
   - `doublespace` — all lines are double spaced.
   - `onehalfspace` — line spacing set to one-and-half spacing.
   - `singlespace` — normal line spacing.

## Special Paragraphs

For those of you who have read most/all of the tutorials so far, you will have already come across some of the following paragraph formats. Although seen before, it makes sense to re-introduce here, for the sake of completeness.

## `Verbatim` Text

There are several ways to introduce text that won't be interpreted by the compiler. If you use the `verbatim` environment, everything input between the *begin* and *end* commands are processed as if by a typewriter. All spaces and new lines are reproduced as given, and the text is displayed in an appropriate fixed-width font. Any LaTeX command will be ignored and handled as plain text. Ideal for typesetting program source code. This environment was used in an example in the previous tutorial. Here is an example:

```
\beginverbatim
The verbatim environment
  simply reproduces every
 character you input,
including all  s p a c e s!
\endverbatim
```

```
The verbatim environment
  simply reproduces every
 character you input,
including all  s p a c e s!
```

Note: once in the `verbatim` environment, the only command that will be recognized is `\end{verbatim}`. Any others will be output, verbatim! If this is an issue, then you can use the `alltt` package instead, providing an environment with the same name:

```
\begin{alltt}
Verbatim extended with the ability
to use normal commands.  Therefore, it
is possible to \emph{emphasize} words in
this environment, for example.
\end{alltt}
```

```
Verbatim extended with the ability
to use normal commands.  Therefore, it
is possible to emphasize words in
this environment, for example.
```

Remember to add `\usepackage{alltt}` to your preamble to use it though! Within the `alltt` environment, you can use the command `\normalfont` to get back the normal font.

If you just want to introduce a short verbatim phrase, you don't need to use the whole environment, but you have the `\verb` command: `\verb+my text+`

The first character following `\verb` is the delimiter: here we have used "+", but you can use any character you like but * and space; `\verb` will print verbatim all the text after it until it finds the next delimiter. For example, the code: `\verb|\textbf{Hi mate!}|` will print `\textbf{Hi mate!}`, ignoring the effect `\textbf` should have on text.

For more control over formatting, however, you can try the `fancyvrb` package, which provides a `Verbatim` environment (note the capital letter) which lets you draw a rule round the verbatim text, change the font size, and even have typographic effects inside the `Verbatim` environment. It can also be used in conjunction with the

`fancybox` package and it can add reference line numbers (useful for chunks of data or programming), and it can even include entire external files.

### Typesetting URLs

One of either the `hyperref` or `url` packages provides the `\url` command, which properly typesets URLs, for example:

```
Go to \url{http://www.uni.edu/~myname/best-website-ever.html} for my website.
```

will show this URL exactly as typed (similar to the `\verb` command), but the `\url` command also performs a hyphenless break at punctuation characters. It was designed for Web URLs, so it understands their syntax and will never break mid-way through an unpunctuated word, only at slashes and full stops. Bear in mind, however, that spaces are forbidden in URLs, so using spaces in `\url` arguments will fail, as will using other non-URL-valid characters.

When using this command through the `hyperref` package, the URL is "clickable" in the PDF document, whereas it is not linked to the web when using only the `url` package.

### `Listing` Environment

This is also an extension of the verbatim environment provided by the `moreverb` package. The extra functionality it provides is that it can add line numbers along side the text. The command: `\begin{listing}[''step'']{''first line''}`. The mandatory *first line* argument is for specifying which line the numbering shall commence. The optional *step* is the step between numbered lines (the default is 1, which means every line will be numbered).

To use this environment, remember to add `\usepackage{moreverb}` to the document preamble.

## Multi-line comments

As we have seen, the only way LaTeX allows you to add comments is by using the special character %, that will comment out all the rest of the line after itself. This approach is really time-consuming if you want to insert long comments or just comment out a part of your document that you want to improve later. Using the `verbatim` package, to be loaded in the preamble as usual:

```
\usepackage{verbatim}
```

you can use an environment called `comment` that will comment out everything within itself. Here is an example:

Note that this won't work inside complex environments, like math for example. You may be wondering, why should I load a package called `verbatim` to have the possibility to add comments? The answer is straightforward: commented text is not interpreted by the compiler just like verbatim text, the only difference is that verbatim text is introduced within the document, while the comment is just dropped.

```
This is another
\begin{comment}
rather stupid,
but helpful
\end{comment}
example for embedding
comments in your document.
```

This is another example for embedding comments in your document.

### Quoting text

LaTeX provides several environments for quoting text, they have small differences and they are aimed for different types of quotations. All of them are indented on either margin, and you will need to add your own quotation marks if you want them. The provided environments are:

`quote` for a short quotation, or a series of small quotes, separated by blank lines.

`quotation` for use with longer quotes, of more than one paragraph, because it indents the first line of each paragraph.

`verse` is for quotations where line breaks are important, such as poetry. Once in, new stanzas are created with a blank line, and new lines within a stanza are indicated using the newline command, \\. If a line takes up more than one line on the page, then all subsequent lines are indented until explicitly separated with \\.

### Abstracts

In scientific publications it is customary to start with an abstract which gives the reader a quick overview of what to expect. LaTeX provides the `abstract` environment for this purpose. It is available in `article` and `report` document classes; it's not available in the `book`, but it's quite simple to create your own if you really need it.

## List Structures

Lists often appear in documents, especially academic, as their purpose is often to present information in a clear and concise fashion. List structures in Latex are simply environments which essentially come in three flavors: `itemize`, `enumerate` and `description`.

All lists follow the basic format:

```
\begin{list_type}

  \item The first item
  \item The second item
  \item The third etc \ldots
```

```
\end{list_type}
```

All three of these types of lists can have multiple paragraphs per item: just type the additional paragraphs in the normal way, with a blank line between each. So long as they are still contained within the enclosing environment, they will automatically be indented to follow underneath their item.

### `Itemize`

This environment is for your standard bulleted list of items.

```
\begin{itemize}
  \item The first item
  \item The second item
  \item The third etc \ldots
\end{itemize}
```

- The first item
- The second item
- The third etc ...

### `Enumerate`

The enumerate environment is for ordered lists, where by default, each item is numbered sequentially.

```
\begin{enumerate}
  \item The first item
  \item The second item
  \item The third etc \ldots
\end{enumerate}
```

1. The first item
2. The second item
3. The third etc ...

### `Description`

The description environment is slightly different. You can specify the item label by passing it as an optional argument (although optional, it would look odd if you didn't include it!). Ideal for a series of definitions, such as a glossary.

## Compacted lists using `mdwlist`

As you may have noticed, in standard LaTeX document classes, the vertical spacing between items, and above and below the lists as a whole, is more than between

```
\begin{description}
  \item[First] The first item
  \item[Second] The second it
  \item[Third] The third etc \ldots
\end{description}
```

**First** The first item

**Second** The second item

**Third** The third etc ...

paragraphs: it may look odd if the descriptions are too short. If you want tightly-packed lists, use the `mdwlist` package (included in the `mdwtools` bundle), which provides "starred" versions of the previous environments, i.e. `itemize*`, `enumerate*` and `description*`. They work exactly in the same way, but the output is different.

## Nested Lists

Latex will happily allow you to insert a list environment into an existing one (up to a depth of four). Simply begin the appropriate environment at the desired point within the current list. Latex will sort out the layout and any numbering for you.

```
\begin{enumerate}
  \item The first item
  \begin{enumerate}
    \item Nested item 1
    \item Nested item 2
  \end{enumerate}
  \item The second item
  \item The third etc \ldots
\end{enumerate}
```

1. The first item
   (a) Nested item 1
   (b) Nested item 2
2. The second item
3. The third etc ...

## Customizing Lists

Customizing many things in LaTeX is not really within the beginners domain. While not necessarily difficult in itself, because beginners are already overwhelmed with the array of commands and environments, moving on to more advanced topics runs the risk of confusion.

However, since the tutorial is on formatting, I shall still include a brief guide on customizing lists. Feel free to skip!

### Customizing Enumerated Lists

The thing people want to change most often with Enumerated lists are the counters. Therefore, to go any further, a brief introduction to LaTeX *counters* is required. Anything that LaTeX automatically numbers, such as section headers, figures, and itemized lists, there is a counter associated with it that controls the numbering. Each counter also has a default format that dictates how it is displayed whenever LaTeX needs to print it. Such formats are specified using internal LaTeX commands:

| Command | Example |
|---|---|
| \arabic | 1, 2, 3 ... |
| \alph | a, b, c ... |
| \Alph | A, B, C ... |
| \roman | i, ii, iii ... |
| \Roman | I, II, III ... |
| \fnsymbol | Aimed at footnotes (see below), but prints a sequence of symbols. |

There are four individual counters that are associated with itemized lists, each one represents the four possible levels of nesting, which are called: `enumi`, `enumii`, `enumiii`, `enumiv`. Each counter entity holds various bits of information about itself. To get to the numbered element, simply use `\the` followed immediately (i.e., no space) by the name of the counter, e.g., `\theenumi`. This is often referred to as the *representation* of a counter. Also, in order to reset any of these counters in the middle of an enumeration simply use `\setcounter`. For example to reset `enumi` use: `\setcounter{enumi}{0}`

Now, that's most of the technicalities out of the way. To make changes to the formatting of a given level: `\renewcommand{\representation}{\format_command{counter}}`

Admittedly, the generic version is not that clear, so a couple of examples will clarify:

```
%Redefine the first level
\renewcommand{\theenumi}{\Roman{enumi}}
\renewcommand{\labelenumi}{\theenumi}

%Redefine the second level
\renewcommand{\theenumii}{\Alph{enumii}}
\renewcommand{\labelenumii}{\theenumii}
```

The method used above first explicitly changes the format used by the counter. However, the element that controls the label needs to be updated to reflect the change, which is what the second line does. Another way to achieve this result is this:

```
\renewcommand{\labelenumi}{\Roman{enumi}}
```

This simply redefines the appearance of the label, which is fine, providing that you do not intend to cross-reference to a specific item within the list, in which case the reference will be printed in the previous format. This issue does not arise in the first example.

### Customizing Itemised Lists

Itemized lists are not as complex as they do not need to count. Therefore, to customize, you simply change the labels. The itemize labels are accessed via `\labelitemi`, `\labelitemii`, `\labelitemiii`, `\labelitemiv`, for the four respective levels.

```
\renewcommand{\labelitemi}{\textgreater}
```

The above example would set the labels for the first level to a greater than (>) symbol. Of course, the text symbols available in Latex are not very exciting. Why not use one of the ZapfDingbat symbols, as described in the Symbols section. Or use a mathematical symbol:

```
\renewcommand{\labelitemi}{$\star$}
```

Itemized list with tightly set items, that is with no vertical space between two consecutive items, can be created as follows.

```
\begin{itemize}
  \setlength{\itemsep}{0cm}%
  \setlength{\parskip}{0cm}%
  \item Item opening the list
  \item Item tightly following
\end{itemize}
```

### Details of Customizing Lists

Note that it is necessary that the `\renewcommand` appears after the `\begin{document}` instruction so the changes made are taken into account. This is needed for both enumerated and itemized lists.

## Inline lists

Inline lists are a special case as they require the use of the `paralist` package which provides the `inparaenum` environment (with an optional formatting specification in square brackets):

```
...
\usepackage{paralist}

\begin{document}

\textbf{\itshape Inline lists}, which are
sequential in nature, just like enumerated
lists, but are
\begin{inparaenum}[\itshape a\upshape)]
\item formatted within their paragraph;
\item usually labelled with letters; and
\item usually have the final item prefixed with
‘and’ or ‘or’,
\end{inparaenum} like this example.
...
```

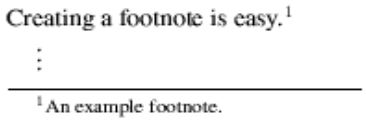
***Inline lists***, which are sequential in nature, just like enumerated lists, but are *a*) formatted within their paragraph; *b*) usually labelled with letters; and *c*) usually have the final item prefixed with 'and' or 'or', like this example.

## Footnotes

Footnotes are a very useful way of providing extra information to the reader. Usually, it is non-essential information which can be placed at the bottom of the page. This keeps the main body of text concise.

The footnote facility is easy to use. The command you need is: `\footnote{''text''}`. Do not leave a space between the command and the word where you wish the footnote marker to appear, otherwise Latex will process that space and will leave the output not looking as intended.

```
Creating a footnote is easy.\footnote{An example footnote.}
```




Latex will obviously take care of typesetting the footnote at the bottom of the page. Each footnote is numbered sequentially — a process that, as you should have guessed by now, is automatically done for you.

It is possible to customize the footnote marking. By default, they are numbered sequentially (Arabic). However, without going too much into the mechanics of Latex at this point, it is possible to change this using the following command (which needs to be placed at the beginning of the document, or at least before the first footnote command is issued).

## Margin Notes

I dare say that this is not a commonly used function, however, I thought I'd include it anyway, as it is simple to use command. `\marginpar{''margin text''}` will position the enclosed text on to the outside margin. To swap the default side, issue `\reversemarginpar` and that moves margin notes to the opposite side.

## Summary

Phew! What a busy tutorial! A lot of material was covered here, mainly because formatting is such a broad topic. Latex is so flexible that we actually only skimmed

| | |
|---|---|
| `\renewcommand{\thefootnote}{\arabic{footnote}}` | Arabic numerals, e.g., 1, 2, 3... |
| `\renewcommand{\thefootnote}{\roman{footnote}}` | Roman numerals (lowercase), e.g., i, ii, iii... |
| `\renewcommand{\thefootnote}{\Roman{footnote}}` | Roman numerals (uppercase), e.g., I, II, III... |
| `\renewcommand{\thefootnote}{\alph{footnote}}` | Alphabetic (lowercase), e.g., a, b, c... |
| `\renewcommand{\thefootnote}{\Alph{footnote}}` | Alphabetic (uppercase), e.g., A, B, C... |
| `\renewcommand{\thefootnote}{\fnsymbol{footnote}}` | A sequence of nine symbols (try it and see!) |

the surface, as you can have much more control over the presentation of your document if you wish. Having said that, one of the purposes of Latex is to take away the stress of having to deal with the physical presentation yourself, so you need not get too carried away!

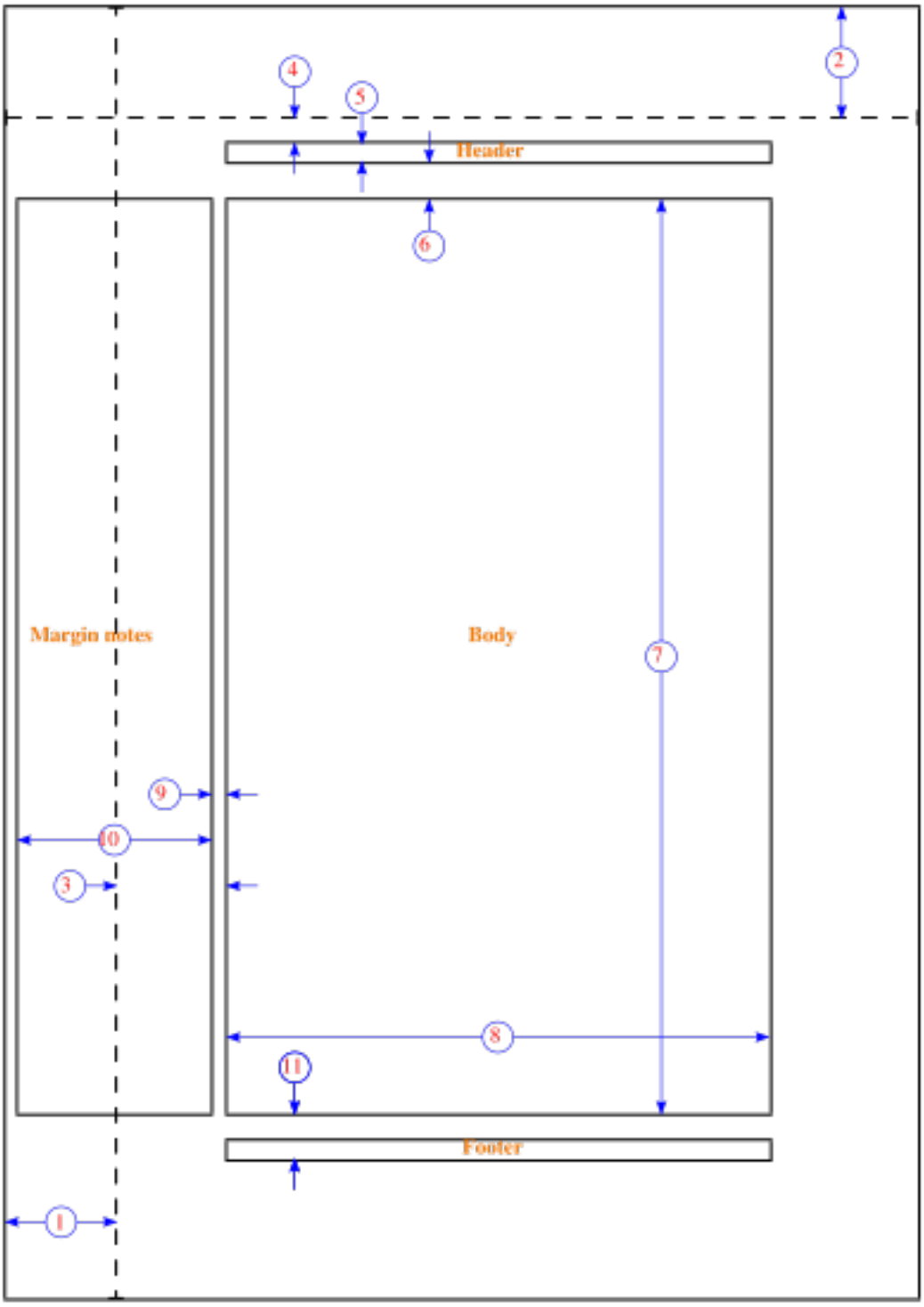
# Chapter 12

# Page Layout

Latex and the document class will normally take care of page layout issues for you. For submission to an academic publication, this entire topic will be out of your hands, as the publishers want to control the presentation. However, for your own documents, there are some obvious settings that you may wish to change: margins, page orientation and columns, to name but three. The purpose of this tutorial is to show you how to configure your pages.

## Page Dimensions

A page in Latex is defined by myriad internal parameters. Each parameter corresponds to the length of an element of the page, for example, `\paperheight` is the physical height of the page. Here you can see a diagram showing all the variables defining the page:


4
5
2
Header
6
Margin notes
Body
7
9
10
3
8
11
Footer
1

1. one inch + `\hoffset`
2. one inch + `\voffset`
3. `\oddsidemargin` = 31pt
4. `\topmargin` = 20pt
5. `\headheight` = 12pt
6. `\headsep` = 25pt
7. `\textheight` = 592pt
8. `\textwidth` = 390pt
9. `\marginparsep` = 10pt
10. `\marginparwidth` = 35pt
11. `\footskip` = 30pt

- `\marginparpush` = 7pt (not shown)
- `\hoffset` = 0pt
- `\voffset` = 0pt
- `\paperwidth` = 597pt
- `\paperheight` = 845pt

It will not have been immediately obvious — because it doesn't really cause any serious problems — that the default page size for all standard document classes is *US letter*. This is shorter by 18 mm (about 3/4 inch), and slightly wider by 8 mm (about 1/4 inch), compared to A4 (which is the standard in almost all the rest of the world). As I said, it's not a great problem, and most printers will print the page without a hiccup. However, it is possible to specify alternative sizes.

```
\documentclass[a4paper]{article}
```

The above example illustrates how to pass the optional argument to the `\documentclass`, which will then modify the page dimensions accordingly. The standard document classes that are a part of Latex are built to be fairly generic, which is why you have the flexibility of specifying the page size. Other classes may have different options (or none at all). Normally, 3rd party classes come with some documentation to let you know.

Readers from a word processing background are probably thinking why there is so much white space surrounding the text. There is a good reason, and it's all down to readability. Have a look in a few books, and pick a few lines at random. Count the number of characters per line. I bet the average is about 66. Studies have shown that it's easier to read text when there are 60-70 characters per line — and it would seem

that 66 is the optimal number. Therefore, the page margins are set to ensure that readability remains as good as possible. Also, white space is often left in the inner margin for the assumption that the document will be bound.

If you wish to change the margins of your document, there are many ways to do so:

- Simply use the `fullpage` package for somewhat standardized smaller margins:

  `\usepackage{fullpage}`

- Use the `a4wide` package for a page with A4 document size with smaller margins.

- Use the `geometry` package. This package allows you to specify the 4 margins without needing to remember the particular page dimensions commands. It may be implemented as follows:

  `\usepackage[top=tlength,bottom=blength,left=llength,right=rlength]{geometry}`

- Edit individual page dimension variables described above, using the `\addtolength` and `\setlength` commands. For instance,

```
\oddsidemargin=-1cm
\setlength{\textwidth}{6.5in}
\addtolength{\voffset}{-5pt}
```

Additionally, there are several packages designed to solve the problem of varying pages sizes, which override any defaults setup by the document class. One of the most versatile packages for page layout is the `geometry` package. For instance, to set the page size, add the following to your preamble:

`\usepackage[a4paper]{geometry}`

The `geometry` package has many pre-defined page sizes, like `a4paper`, built in. Others include: `a0paper`, `a1paper`, ..., `a6paper`, `b0paper`, `b1paper`, ..., `b6paper`, `letterpaper`, `legalpaper`, `executivepaper`.

## Page Orientation

When you talk about changing page orientation, it usually means changing to landscape mode, since portrait is the default. I shall introduce two slightly different styles of changing orientation.

The first is for when you want all of your document to be in landscape from the very beginning. There are various packages available to achieve this, but the one I prefer is the `geometry` package. All you need to do is call the package, with *landscape* as an option:

`\usepackage[landscape]{geometry}`

Although, if you intend to use `geometry` to set your paper size, don't add the `\usepackage` commands twice, simply string all the options together, separating with a comma:

```
\usepackage[a4paper,landscape]{geometry}
```

The second method is for when you are writing a document in portrait, but you have some contents, like a large diagram or table that would be displayed better on a landscape page. However, you still want the consistency of your headers and footers appearing the same place as the other pages.

The `lscape` package is for this very purpose. It supplies a `landscape` environment, and anything inside is basically rotated. No actual page dimensions are changed. This approach is more applicable to books or reports than to typical academic publications. Using `pdflscape` instead of `lscape` when generating a PDF document will make the page appear right side up when viewed: the single page that is in landscape format will be rotated, while the rest will be left in portrait orientation.

Also, to get a table to appear correctly on a landscaped page, one must place the `tabular` environment inside a `table` environment, which is itself inside the `landscape` environment. e.g., it should look like this:

```
\begin{landscape}
\begin{table}
\centering     % optional, probably makes it look better to
have it centered on the page
\begin{tabular}{....}
.......
\end{tabular}
\end{table}
\end{landscape}
```

## Page Styles

Page styles in Latex terms refers not to page dimensions, but to the running headers and footers of a document. You may have noticed that in every example document produced for these tutorials, each page has its respective number printed at the bottom, even though not a single command has been issued to tell Latex to do it! That is because the document class in use has already defined the page style for you. Of course, you don't need to stick with the defaults if you don't want to.

There are two commands at your disposal for changing the page style. `\pagestyle{style}` will apply the specified style to the current and all subsequent pages. `\thispagestyle{style}` will only affect the current page. The possible styles are:

| | |
|---|---|
| empty | Both header and footer are clear |
| plain | Header is clear, but the footer contains the page number. |
| headings | Header displays page number and other information which the document class deems important, e.g., section headers. |
| myheadings | Similar to above, however, is possible to control the information in the header. |

An issue to look out for is that the major sectioning commands (`\part`, `\chapter` or `\maketitle`) specify a `\thispagestyle{plain}`. So, if you wish to suppress all

styles by inserting a \pagestyle{empty} at the beginning of your document, then the style command at each section will override your initial rule, for those pages only. To achieve your intended result, you will have to follow the offending commands with \thispagestyle{empty}.

## Customising with fancyhdr

The fancyhdr package, written by Piet van Oostrum, provides a few simple commands that allow you to customize the header and footer lines of your document. For a more complete guide, the author of the package produced this documentation.

The tricky problem when customizing headers and footers is to get things like running section and chapter names in there. LaTeX accomplishes this with a two-stage approach. In the header and footer definition, you use the commands \rightmark and \leftmark to represent the current section and chapter heading, respectively. The values of these two commands are overwritten whenever a chapter or section command is processed. For ultimate flexibility, the \chapter command and its friends do not redefine \rightmark and \leftmark themselves. They call yet another command (\chaptermark, \sectionmark, or \subsectionmark) that is responsible for redefining \rightmark and \leftmark.

If you want to change the look of the chapter name in the header line, you need only "renew" the \chaptermark command.

To begin, add the following lines to your preamble:

```
\usepackage{fancyhdr}
\setlength{\headheight}{15.2pt}
\pagestyle{fancy}
```

The second line will prevent LaTeX from giving a warning. Both the header and footer comprise three elements each according to its horizontal position (left, centre or right). To set their values, the following commands are available:

| | |
|---|---|
| \lhead[*lh-even*]{*lh-odd*} | \lfoot[*lf-even*]{*lf-odd*} |
| \chead[*ch-even*]{*ch-odd*} | \cfoot[*cf-even*]{*cf-odd*} |
| \rhead[*rh-even*]{*rh-odd*} | \rfoot[*rf-even*]{*rf-odd*} |

Hopefully, the behaviour of the above commands is fairly intuitive: if it has *head* in it, it affects the head etc, and obviously, *l*, *c* and *r* means left, centre and right respectively. Documents can be either one- or two-sided. Articles are by default one-sided, books are two-sided. Two-sided documents differentiate the left (even) and right (odd) pages, whereas one-sided do not.

Watch out: if you give long text in two different "parts" only in the footer or only in the header, you might see overlapping text, be careful. There are special commands you can use as arguments:

| | |
|---|---|
| `\thepage` | number of the current page |
| `\leftmark` | current chapter name printed like "CHAPTER 3. THIS IS THE CHAPTER TITLE" |
| `\rightmark` | current section name printed like "1.6. THIS IS THE SECTION TITLE" |
| `\thesection` | current section number |

Note that `\leftmark` and `\rightmark` convert the names to uppercase, whichever was the formatting of the text. If you want them to print the actual name of the chapter without converting it to uppercase use the following command:

```
\renewcommand{\chaptermark}[1]{\markboth{#1}{}}
\renewcommand{\sectionmark}[1]{\markright{#1}{}}
```

now `\leftmark` and `\rightmark` will just print the name of the chapter and section, without number and without affecting the formatting. Moreover, with the following commands you can define the thickness of the decorative lines on both the header and the footer:

```
\renewcommand{\headrulewidth}{0.5pt}
\renewcommand{\footrulewidth}{0pt}
```

The first line for the header, the second for the footer. Setting it to zero means that there will be no line.

An example:

```
\fancyhf{}

\lhead{Andrew Roberts}
\rhead{\today}
\rfoot{\thepage}
```

It is often necessary to clear any defaults or a previous style definition, and the first line of the above example will do this. The commands are an alternative interface to customising the headers/footers that fancyhdr offers, and so by not passing anything to them, it assumes that you want it all blank.

The result of these commands will put my name at the top left, todays date at the top right, and the current page number at the bottom right of the page. Even if the document class was two-sided, because no optional text has been supplied for the even pages, the style will be used for all pages.

This approach a serious bad point: some pages like the title or the beginning of each chapter have no header or footer, but with the code we have shown *every* page will get the same output. There is a way to solve this problem: you can use the *fancyplain* style. If you do so, you can use the command `\fancyplain{...}{...}` inside `\lhead{...}` etc.

When LaTeX wants to create a page with an empty style, it will insert the first argument of `fancyplain`, in all the other cases it will use the second argument. So, an improved version of the previous code would be:

```
\pagestyle{fancyplain}

\fancyhf{}

\lhead{\fancyplain{}{Andrew Roberts}}
\rhead{\fancyplain{}{\today}}
\rfoot{\fancyplain{}{\thepage}}
```

It has the same behavior of the previous code, but you will get empty header and footer in the title and at the beginning of chapters.

For two-sided, it's common to mirror the style of opposite pages, you tend to think in terms of *inner* and *outer*. So, the same example as above for two-sided is:

```
\lhead[Andrew Roberts]{}
\rhead[]{Andrew Roberts}
\lhead[]{\today}
\rhead[\today]{}
\lfoot[\thepage]{}
\rfoot[]{\thepage}
```

This is effectively saying my name is top outer, todays date is top inner, and current page number is bottom outer. You can use the `fancyplain` command within them for two-sided documents, too.

As an example, here is the complete code of a basic configuration you could use for a real document:

```
\usepackage{fancyhdr}
\setlength{\headheight}{15pt}

\pagestyle{fancyplain}
\renewcommand{\chaptermark}[1]{\markboth{#1}{}}

\lhead{\fancyplain{}{\thepage}}
\chead{}
\rhead{\fancyplain{}{\textit{\leftmark}}}
\lfoot{}
\cfoot{}
\rfoot{}
```

*NB. If you want to make the* ***article class two-sided****, use* `\documentclass[twoside]{article}`.

## Another approach with `fancyhdr`

If you want to get different style for even and odd pages, there is another possible way, still using `fancyhdr`. Start again with: `\fancyhf{}` it will just delete the

current heading/footer configuration, so you can make your own. Now you can create what you want using the command `\fancyhead` for header and `\fancyfoot` for footer. They work in the same way, so we'll explain only the first one. The syntax is: `\fancyhead[selectors]{output you want}`

The selectors are the following:

| | |
|---|---|
| **E** | even page |
| **O** | odd page |
| **L** | left side |
| **C** | centered |
| **R** | right side |

so **CE** will refer to the center of the even pages and **RO** to the right side of the odd pages. Whether it is header or footer, depends if you are using `\fancyhead` or `\fancyfoot`. You can use multiple selectors separated by a comma. Here is an example:

```
\fancyhead[CE]{Author's Name}
\fancyhead[CO]{\today}
\fancyfoot[LE,RO]{\thepage}
```

it will print author's name on the center of the header of the even pages, the date of the current day on the center of the odd pages and the current page number on the left size of even pages *and* on the right size of the odd pages. Finally, in order to have the pages at the beginning of any chapter really plain, you could redefine the *plain* style, for example to have a really plain page when you want. The command to use is `\fancypagestyle{plain}{...}` and the argument can contain all the commands explained before. An example is the following:

```
\fancypagestyle{plain}{ %
\fancyhf{} % remove everything
\renewcommand{\headrulewidth}{0pt} % remove lines as well
\renewcommand{\footrulewidth}{0pt}}
```

Finally, here is the complete code of a possible style you could use for a two-sided document:

```
\usepackage{fancyhdr}
\setlength{\headheight}{15pt}

\pagestyle{fancy}
\renewcommand{\chaptermark}[1]{\markboth{#1}{}}
\renewcommand{\sectionmark}[1]{\markright{#1}{}}

\fancyhf{}
\fancyhead[LE,RO]{\thepage}
\fancyhead[RE]{\textit{\nouppercase{\leftmark}}}
```

```
\fancyhead[LO]{\textit{\nouppercase{\rightmark}}}

\fancypagestyle{plain}{ %
\fancyhf{} % remove everything
\renewcommand{\headrulewidth}{0pt} % remove lines as well
\renewcommand{\footrulewidth}{0pt}}
```

### Page *n* of *m*

Some people like to put the current page number in context with the whole document. LaTeX only provides access to the current page number. However, you can use the `lastpage` package to find the total number of pages, like this:

```
\usepackage{lastpage}
...
\cfoot{\thepage\ of \pageref{LastPage}}
```

*Note the capital letters.* Also, add a backslash after `\thepage` to ensure adequate space between the page number and 'of'. And recall, when using references, that you have to run LaTeX an extra time to resolve the cross-references.

## Multi-column Pages

It is common to see articles and conference proceedings formatted with two columns of text. However, such publishers will usually provide you with their own document class, which automatically implements this format, without you having to do anything. It is very easy to format your page in this way. If you are using a standard Latex document class, then you can simply pass the optional argument *twocolumn* to the document class: `\documentclass[twocolumn]{article}` which will give the desired effect.

While this simple addition will do the job 9 out of 10 times, it is widely acknowledged that there are many limitations of this approach, and that the `multicol` package is much more useful for handling multiple columns. It has several advantages:

- Can support up to ten columns.
- Implements a *multicol* environment, therefore, it is possible to mix the number of columns within a document.
- Additionally, the environment can be nested inside other environments, such as `figure`.
- `Multicol` outputs *balanced* columns, whereby the columns on the final page will be of roughly equal length.
- Vertical rules between columns can be customised.
- Column environments can be easily customised locally or globally.

Floats are not fully supported by this environment. It can only cope if you use the starred forms of the float commands (e.g., `\begin{figure*}` ) which makes the float span all columns. This is not hugely problematic, since floats of the same width as a column may be too small, and you would probably want to span them anyway.

To create a typical two-column layout:

```
\begin{multicols}{2}
  lots of text
  \ldots
\end{multicols}
```

The parameter `\columnseprule` holds the width of the vertical rules. By default, the lines are omitted as this parameter is set to a length of 0pt. Do the following before the beginning of the environment:

```
\setlength{\columnseprule}{1pt}
```

This will draw a thin line of 1pt in width. A thick line would not look very pleasing, however, you are free to put in any length of your choosing. Also, to change the horizontal space in between columns (the default is set at 10pt, which is quite narrow) then you need to change the `\columnsep` parameter:

```
\setlength{\columnsep}{20pt}
```

## Manual Page Formatting

There may be instances, especially in very long documents, such as books, that Latex will not get all page breaks looking as good as it could. It may, therefore, be necessary to manually tweak the page formatting. Of course, you should only do this at the very final stage of producing your document, once all the content is complete. Latex offers the following:

## Summary

This tutorial is relatively short, largely due to the fact that the whole Latex ethos is concentrate on the content, and let Latex (and/or other typographers who have developed suitable document classes) decide on the best presentation. The next step to achieve greater control of page layout is to set about designing your own class. Unfortunately, that is not a straightforward task, and is often best left to the professionals!

| | |
|---|---|
| `\newline` | Breaks the line at the point of the command. |
| `\\` | Breaks the line at the point of the command, it's a shorter version of the previous command but it does exactly the same |
| `\\*` | Breaks the line at the point of the command and additionally prohibits a page break after the forced line break |
| `\linebreak[number]` | Breaks the line at the point of the command. The *number* you provide as an argument represents the priority of the command in a range from 0 (it will be easily ignored) to 4 (do it anyway). LaTeX will try to produce the best line breaks possible, meeting its high standards. If it cannot, it will decide whether including the linebreak or not according to the priority you have provided. |
| `\newpage` | Ends the current page and starts a new one. |
| `\pagebreak[number]` | Breaks the current page at the point of the command. The optional *number* argument sets the priority in a scale from 0 to 4. |
| `\nopagebreak[number]` | Stops the page being broken at the point of the command. The optional *number* argument sets the priority in a scale from 0 to 4. |
| `\clearpage` | Ends the current page and causes any floats encountered in the input, but yet to appear, to be printed. |

# Chapter 13

# Mathematics

One of the greatest motivating forces for Donald Knuth when he began developing the original TeX system was to create something that allowed simple construction of mathematical formulas, whilst looking professional when printed. The fact that he succeeded was most probably why TeX (and later on, LaTeX) became so popular within the scientific community. Regardless of the history, typesetting mathematics is one of LaTeX's greatest strengths. However, it is also a large topic due to the existence of so much mathematical notation.

If you are writing a document that needs only a few simple mathematical formulas, then you can generally use plain LaTeX: it will give you all of the tools you need. However, if you are writing a scientific document that contains numerous complicated formulas, then you'll most likely need to use the `amsmath` package. It introduces several new commands that are more powerful and easy-to-use than the ones provided by plain LaTeX.

## Basic Mathematics: plain LaTeX

All the commands discussed in this section can be used in LaTeX without loading any external package. What is here is enough if you just want to write a few formulas, otherwise you'd better read the advanced section as well. In any case, this is a necessary introduction to how LaTeX can manage mathematics.

### Mathematics environments

LaTeX needs to know beforehand that the subsequent text does in fact contain mathematical elements. This is because LaTeX typesets maths notation differently than normal text. Therefore, special environments have been declared for this purpose. They can be distinguished into two categories depending on how they are presented:

- *text* — text formulas are displayed in-line, that is, within the body of text where it is declared. e.g., I can say that $a + a = 2a$ within this sentence.

- *displayed* — displayed formulas are separate from the main text.

As maths require special environments, there are naturally the appropriate environment names you can use in the standard way. Unlike most other environments, however, there are some handy shorthands to declaring your formulas. The following table summarizes them:

| Type | Environment | LaTeX shorthand | TeX shorthand |
|---|---|---|---|
| Text | `\begin{math}...\end{math}` | `\(...\)` | `$...$` |
| Displayed | `\begin{displaymath}...`<br>`\end{displaymath}` | `\[...\]` | `$$...$$` |

**Note:** Using the `$$...$$` should be avoided, as it may cause problems, particularly with the AMS-LaTeX macros. Furthermore, should a problem occur, the error messages may not be helpful.

Additionally, there is a second possible environment for the *displayed* type of formulas: `equation`. The difference between this and `displaymath` is that `equation` also adds sequential equation numbers by the side.

If you are typing text normally, you are said to be in *text mode*, while you are typing within one of those mathematical environments, you are said to be in *math mode*, that has some differences compared to the *text mode*:

1. Most spaces and line breaks do not have any significance, as all spaces are either derived logically from the mathematical expressions, or have to be specified with special commands such as `\quad`
2. Empty lines are not allowed. Only one paragraph per formula.
3. Each letter is considered to be the name of a variable and will be typeset as such. If you want to typeset normal text within a formula (normal upright font and normal spacing) then you have to enter the text using dedicated commands.

## Symbols

Mathematics has lots and lots of symbols! If there is one aspect of maths that is difficult in Latex it is trying to remember how to produce them. There are of course a set of symbols that can be accessed directly from the keyboard:

```
+ - = ! / ( ) [ ] < > | ’ :
```

Beyond those listed above, distinct commands must be issued in order to display the desired symbols. And there are *a lot!* Greek letters, set and relations symbols, arrows, binary operators, etc. Too many to remember, and in fact, they would overwhelm this tutorial if I tried to list them all. Therefore, for a complete reference document, see the external link at the bottom of the page.

### Greek letters

Greek letters are commonly used in mathematics, and they are very easy to type in *math mode*. You just have to type the name of the letter after a backslash: if the first letter is lowercase, you will get a lowercase Greek letter, if the first letter is uppercase (and only the first letter), then you will get an uppercase letter. Note that some uppercase Greek letters look like Latin ones, so they are not provided by LaTeX (e.g. uppercase *Alpha* and *Beta* are just "A" and "B" respectively). Theta and Phi are provided in two different versions:

```
\[
\alpha, \beta, \gamma, \mu,
\theta, \vartheta, \phi, \varphi, \omega,
\Gamma, \Theta, \Phi, \Omega
\]
```

$$\alpha, \beta, \gamma, \mu, \theta, \vartheta, \phi, \varphi, \omega, \Gamma, \Theta, \Phi, \Omega$$

### Set letters

Set letters are commonly used in Maths to name special sets like the set of natural numbers. To create one, just type `\mathbb{''letter''}` and put the letter in the brackets (using the `amssymb` package). It works only with capitals.

```
\[
\mathbb{N}, \mathbb{Z}, \mathbb{Q},
\mathbb{R}, \mathbb{C}
\]
```

$$\mathbb{N}, \mathbb{Z}, \mathbb{Q}, \mathbb{R}, \mathbb{C}$$

If you prefer bold letters, so choose `\mathbf{letter}`.

```
\[
\mathbf{N}, \mathbf{Z}, \mathbf{Q},
\mathbf{R}, \mathbf{C}
\]
```

$$\mathbf{N}, \mathbf{Z}, \mathbf{Q}, \mathbf{R}, \mathbf{C}$$

Note that you cannot bold greek letter using `\mathbf`. The `bm` package defines the `\bm` command which can do this.

## Fractions

To create a fraction, you must use the `\frac{numerator}{denominator}` command. (For those who need their memories refreshed, that's the *top* and *bottom* respectively!)

You can also embed fractions within fractions, as shown in the examples below:

```
\frac{x+y}{y-z}
\frac{\frac{1}{x}+\frac{1}{y}}{y-z}
```

$\frac{x+y}{y-z}$

$\frac{\frac{1}{x}+\frac{1}{y}}{y-z}$

It is also possible to produce a simple fraction of the form

$$x/y$$

using the command:

```
^x/_y
```

## Powers and indices

Powers and indices are mathematically equivalent to superscripts and subscripts in normal text mode. The carat (^) character is used to raise something, and the underscore (_) is for lowering. How to use them is best shown by example:

| Power | | Index | |
|---|---|---|---|
| `x^n` | $x^n$ | `n_i` | $n_i$ |
| `x^{2n}` | $x^{2n}$ | `n_{ij}` | $n_{ij}$ |

Note: if more than one character is to be raised (or lowered) then you must group them using the curly braces ({ and }).

Also, if you need to assign both a power and an index to the same entity, then that is achieved like this: `x^{2i}_{3j}` (or `x_{3j}^{2i}`, order is not significant).

$$x_{3j}^{2i}$$

## Roots

Typically, for the majority of times, you are after the square root, which is done easily using the following command: `\sqrt{x}`. However, this can be generalized to produce a root of any magnitude:

```
\sqrt[n]{x}
```

$\sqrt[n]{x}$

Latex will automatically ensure that the size of the root notation adjusts to the size of the contents.

The $n$ is optional, and without it will output a square root. Also, regardless of the size of root you're after, e.g., $n$=3, you still use the `\sqrt` command.

See also Tips and Tricks for another look of root.

## Brackets

The use of brackets soon becomes important when dealing with anything but the most trivial equations. Without them, formulas can become ambiguous. Also, special types of mathematical structures, such as matrices, typically rely on brackets to enclose them.

You may recall that you have the `( ) [ ] { } | |` symbols at your disposal, curly brackets requiring a prefixed backslash. Larger structures sometimes require a specified representation. This is shown by example:

```
      (\frac{x^2}{y^3})
\left(\frac{x^2}{y^3}\right)
```

$$(\frac{x^2}{y^3})$$
$$\left(\frac{x^2}{y^3}\right)$$

The first example shows what would happen if you used the standard bracket characters. As you can see, they would be fine for a simple equation that remained on a single line (e.g., (3 + 2) x (10-3) = 35) but not for equations that have greater vertical size, such as those using fractions. The second example illustrates the LaTeX way of coping with this problem.

The `\left#` and `\right#` commands provide the means for automatic sizing of brackets, curly braces or absolute value symbols. You must enclose the expression that you want in brackets (or absolute values) with these commands. The # after the command should be replaced with the style of bracket desired.

A problem happens if you want to split the equation across multiple lines, as the right bracket can only be used if there is a remaining open left bracket on the current line (though the types do not need to match). If you need to force a right bracket you can make an invisible left bracket and a full stop: `\left.`

Alternatively, check out the `nath` package, which provides auto-scaling delimiters.

## Arrays

Using the `array` environment you can create table-like structures in *math mode*. The `array` environment is basically equivalent to the `tabular` environment. For example, if you want to create a matrix, Latex, by default, doesn't have a specific command to use, but you can create a similar structure using `array`. You can use the array to arrange and align your data as you want, and then enclose it with appropriate left and right brackets, and this will give you your matrix. For a simple 2x2 matrix:

```
\[ \left[
  \begin{array}{ c c }
     1 & 2 \\
     3 & 4
  \end{array} \right]
\]
```

$$\left[\begin{array}{ c c }
1 & 2 \\
3 & 4
\end{array}\right]$$

Arrays are very flexible; here is an example of another matrix-like structure:

```
\[
\left( \begin{array}{c|c}
1 & 2 \\ \hline
3 & 4
\end{array} \right)
\]
```

$$\left( \begin{array}{c|c} 1 & 2 \\ \hline 3 & 4 \end{array} \right)$$

## Adding text to equations

The math environment differs from the text environment in the representation of text. Here is an example of trying to represent text within the math environment:

```
\[
  50 apples \times 100 apples = lots of apples^2
\]
```

$$50apples \times 100apples = lotsofapples^2$$

There are two noticeable problems. Firstly, there are no spaces between numbers and text, nor spaces between multiple words. Secondly, the words don't look quite right—the letters are more spaced out than normal. Both issues are simply artifacts of the maths mode, in that it doesn't expect to see words. Any spaces that you type in maths mode are ignored and Latex spaces elements according to its own rules. It is assumed that any characters represent variable names. To emphasize that each symbol is an individual, they are not positioned as closely together as with normal text.

There are a number of ways that text can be added properly. The typical way is to wrap the text with the `\mbox{...}` command. This command hasn't been introduced before, however, its job is basically to create a text box just wide enough to contain the supplied text. Text within this box cannot be broken across lines. Let's see what happens when the above equation code is adapted:

$$50\text{apples} \times 100\text{apples} = \text{lots of apples}^2$$

The text looks better. However, there are no gaps between the numbers and the words. Unfortunately, you are required to explicitly add these. There are many ways to add spaces between maths elements, however, for the sake of simplicity, I find it easier, in this instance at least, just to literally add the space character in the affected `\mbox`(s) itself (just before the text.)

```
\[
  50 \mbox{ apples} \times 100 \mbox{ apples} =
  \mbox{lots of apples}^2
\]
```

$$50\ \text{apples} \times 100\ \text{apples} = \text{lots of apples}^2$$

## Formatted text

Using the \mbox is fine and gets the basic result. Yet, there is an alternative that offers a little more flexibility. You may recall the introduction of font formatting commands, such as \textrm, \textit, \textbf, etc. These commands format the argument accordingly, e.g., \textbf{bold text} gives **bold text**. These commands are equally valid within a maths environment to include text. The added benefit here is that you can have better control over the font formatting, rather than the standard text achieved with \mbox.

```
\begin{equation}
  50 \textrm{ apples} \times 100 \textbf{ apples} =
  \textit{lots of apples}^2
\end{equation}
```

$$50 \text{ apples} \times 100 \textbf{ apples} = \textit{lots of apples}^2$$

However, as is the case with Latex, there is more than one way to skin a cat! There are a set of formatting commands very similar to the font formatting ones just used, except they are aimed specifically for text in maths mode. So why bother showing you \textrm and co if there are equivalents for maths? Well, that's because they are subtly different. The maths formatting commands are:

| LaTeX command | Sample | Description | Common use |
|---|---|---|---|
| \mathnormal{...} | $ABCDEFabcdef123456$ | the default math font | most mathematical notation |
| \mathrm{...} | ABCDEFabcdef123456 | this is the default or normal font, unitalicised | units of measurement, one word functions |
| \mathit{...} | $ABCDEFabcdef123456$ | italicised font | |
| \mathbf{...} | $\mathbf{ABCDEFabcdef123456}$ | bold font | vectors |
| \mathsf{...} | $\mathsf{ABCDEFabcdef123456}$ | Sans-serif | |
| \mathtt{...} | $\mathtt{ABCDEFabcdef123456}$ | Monospace (fixed-width) font | |
| \mathcal{...} | $\mathcal{ABCDEF}\dashv\lfloor\rfloor\lceil\rceil\{\infty\in\ni\triangle\triangledown/$ | calligraphy | often used for sheaves/schemes and categories |
| \mathfrak{...}[1] | $\mathfrak{ABCDEFabcdef123456}$ | Fraktur | Almost canonical font for Lie algebras |
| \mathbb{...}[1] | $\mathbb{ABCDEF}\supset\cup\nVdash\nvDash\nvdash\nsubseteq\nsupseteq\ntriangleleft$ | Blackboard bold | Used to denote special sets (e.g. real numbers) |
| \mathscr{...}[2] | | Script | |

The maths formatting commands can be wrapped around the entire equation, and not just on the textual elements: they only format letters, numbers, and uppercase

[1] requires amsfonts or amssymb packages
[2] require mathrsfs package

Greek, and the rest of the maths syntax is ignored. So, generally, it is better to use the specific maths commands if required. Note that the calligraphy example gives rather strange output. This is because for letters, it requires upper case characters. The remaining letters are mapped to special symbols.

## Changing text size of equations

Probably a rare event, but there may be a time when you would prefer to have some control of the size. For example, using text-mode maths, by default a simple fraction will look like this: $\frac{a}{b}$ where as you may prefer to have it displayed larger, like when in display mode, but still keeping it in-line, like this

$$\frac{a}{b}$$

.

A simple approach is to utilize the predefined sizes for maths elements:

| | |
|---|---|
| `\displaystyle` | Size for equations in display mode |
| `\textstyle` | Size for equations in text mode |
| `\scriptstyle` | Size for first sub/superscripts |
| `\scriptscriptstyle` | Size for subsequent sub/superscripts |

A classic example to see this in use is typesetting continued fractions. The following code provides an example.

```
\begin{equation}
  x = a_0 + \frac{1}{a_1 + \frac{1}{a_2 + \frac{1}{a_3 + a_4}}}
\end{equation}
```

$$x = a_0 + \frac{1}{a_1 + \frac{1}{a_2 + \frac{1}{a_3 + a_4}}}$$

As you can see, as the fractions continue, they get smaller (although they will not get any smaller as in this example, they have reached the `\scriptstyle` limit. If you wanted to keep the size consistent, you could declare each fraction to use the display style instead, e.g.:

```
\begin{equation}
  x = a_0 + \frac{1}{\displaystyle a_1
          + \frac{1}{\displaystyle a_2
          + \frac{1}{\displaystyle a_3 + a_4}}}
\end{equation}
```

$$x = a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + a_4}}}$$

Another approach is to use the `\DeclareMathSizes` command to select your preferred sizes. You can only define sizes for `\displaystyle`, `\textstyle`, etc. One potential downside is that this command sets the global maths sizes, as it can only be used in the document preamble.

However, it's fairly easy to use: `\DeclareMathSizes{ds}{ts}{ss}{sss}`, where *ds* is the *display size*, *ts* is the *text size*, etc. The values you input are assumed to be point (pt) size.

NB the changes only take place if the value in the first argument matches the current document text size. It is therefore common to see a set of declarations in the preamble, in the event of the main font being changed. E.g.,

```
\DeclareMathSizes{10}{18}{12}{8}   % For size 10 text
\DeclareMathSizes{11}{19}{13}{9}   % For size 11 text
\DeclareMathSizes{12}{20}{14}{10}  % For size 12 text
```

## Plus and minus signs

Latex deals with the + and - signs in two possible ways. The most common is as a binary operator. When two maths elements appear either side of the sign, it is assumed to be a binary operator, and as such, allocates some space either side of the sign. The alternative way is a sign designation. This is when you state whether a mathematical quantity is either positive or negative. This is common for the latter, as in maths, such elements are assumed to be positive unless a — is prefixed to it. In this instance, you want the sign to appear close to the appropriate element to show their association. If you put a + or a — with nothing before it but you want it to be handled like a binary operator you can add an *invisible* character before the operator using {}. This can be useful if you are writing multiple-line formulas, and a new line could start with a = or a +, for example, then you can fix some strange alignments adding the invisible character where necessary.

## Controlling horizontal spacing

Latex is obviously pretty good at typesetting maths—it was one of the chief aims of the core Tex system that Latex extends. However, it can't always be relied upon to accurately interpret formulas in the way you did. It has to make certain assumptions when there are ambiguous expressions. The result tends to be slightly incorrect horizontal spacing. In these events, the output is still satisfactory, yet, any perfectionists will no doubt wish to *fine-tune* their formulas to ensure spacing is correct. These are generally very subtle adjustments.

There are other occasions where Latex has done its job correctly, but you just want to add some space, maybe to add a comment of some kind. For example, in the following equation, it is preferable to ensure there is a decent amount of space between the maths and the text.

```
\[f(n) = \left\{
\begin{array}{l l}
  n/2 & \quad \mbox{if $n$ is even}\\
  -(n+1)/2 & \quad \mbox{if $n$ is odd}\\
\end{array} \right. \]
```

$$f(n) = \begin{cases} n/2 & \text{if } n \text{ is even} \\ -(n+1)/2 & \text{if } n \text{ is odd} \end{cases}$$

Latex has defined two commands that can be used anywhere in documents (not just maths) to insert some horizontal space. They are `\quad` and `\qquad`

A `\quad` is a space equal to the current font size. So, if you are using an 11pt font, then the space provided by `\quad` will also be 11pt (horizontally, of course.) The `\qquad` gives twice that amount. As you can see from the code from the above example, `\quad`s were used to add some separation between the maths and the text.

OK, so back to the fine tuning as mentioned at the beginning of the document. A good example would be displaying the simple equation for the indefinite integral of $y$ with respect to $x$:

$$\int y \, \mathrm{d}x$$

If you were to try this, you may write:

```
\[ \int y \mathrm{d}x \]
```

$$\int y \mathrm{d}x$$

However, this doesn't give the correct result. Latex doesn't respect the white-space left in the code to signify that the $y$ and the $\mathrm{d}x$ are independent entities. Instead, it lumps them altogether. A `\quad` would clearly be overkill is this situation—what is needed are some small spaces to be utilized in this type of instance, and that's what Latex provides:

| Command | Description | Size |
|---|---|---|
| `\,` | small space | 3/18 of a quad |
| `\:` | medium space | 4/18 of a quad |
| `\;` | large space | 5/18 of a quad |
| `\!` | negative space | -3/18 of a quad |

NB you can use more than one command in a sequence to achieve a greater space if necessary.

So, to rectify the current problem:

```
\int y\, \mathrm{d}x
```
$$\int y\, \mathrm{d}x$$

```
\int y\:  \mathrm{d}x
```
$$\int y\: \mathrm{d}x$$

```
\int y\; \mathrm{d}x
```
$$\int y\; \mathrm{d}x$$

The negative space may seem like an odd thing to use, however, it wouldn't be there if it didn't have *some* use! Take the following example:

```
\[\left(
  \begin{array}{c}
    n \\
    r
  \end{array}
  \right) = \frac{n!}{r!(n-r)!}
\]
```
$$\left(\begin{array}{c} n \\ r \end{array}\right) = \frac{n!}{r!(n-r)!}$$

The matrix-like expression for representing binomial coefficients is too padded. There is too much space between the brackets and the actual contents within. This can easily be corrected by adding a few negative spaces after the left bracket and before the right bracket.

```
\[\left(\!
  \begin{array}{c}
    n \\
    r
  \end{array}
  \!\right) = \frac{n!}{r!(n-r)!}
\]
```
$$\left(\!\begin{array}{c} n \\ r \end{array}\!\right) = \frac{n!}{r!(n-r)!}$$

In any case, adding some spaces manually should be avoided whenever possible: it makes the source code more complex and it's against the basic principles of a What

You See is What You Mean approach. The best thing to do is to define some commands using all the spaces you want and then, when you use your command, you don't have to add any other space. Later, if you change your mind about the length of the horizontal space, you can easily change it modifying only the command you defined before. Let us use an example: you want the $d$ of a $dx$ in an integral to be in roman font and a small space away from the rest. If you want to type an integral like `\int x \; \mathrm{d} x`, you can define a command like this: `\newcommand{\dd}{\; \mathrm{d}}` in the preamble of your document. We have chosen `\dd` just because it reminds the "d" it replaces and it is fast to type. Doing so, the code for your integral becomes `\int x \dd x`. Now, whenever you write an integral, you just have to use the `\dd` instead of the "d", and all your integrals will have the same style. If you change your mind, you just have to change the definition in the preamble, and all your integrals will be changed accordingly.

### Argmax and argmin

LaTeX has no built-in "\argmax" command to typeset argmax. Some people get around this by using **\arg\max**. This could be undesirable, because a subscripted variable will appear centered beneath the word "max", instead of centered beneath the whole word.

The following command can be used to correctly display the argmax operator:

$$\underset{x}{\operatorname{arg\,max}}$$

```
\underset{x}{\operatorname{arg\,max}}
```

Another way is to define the command:

$$\underset{x}{\operatorname{arg\,max}}$$

```
\newcommand{\argmax}{\operatorname*{arg\,max}}
```

## Advanced Mathematics: AMS Math package

The AMS (American Mathematical Society) mathematics package is a powerful package that creates an higher layer of abstraction over mathematical LaTeX language; if you use it it will make your life easier. Some commands amsmath introduces will make other plain LaTeX commands obsolete: in order to keep consistency in the final output you'd better use `amsmath` commands whenever possible. If you do so, you will get an elegant output without worrying about alignment and other details, keeping your source code readable. If you want to use it, you have to add this in the preamble: `\usepackage{amsmath}`

## Introducing text and dots in formulas

You have been told to use `\mbox{...}` to insert text within formulas. Amsmath provides another command for it, that is `\text{...}`. It works like `\mbox`, but it's better because it will adjust the size of the text according to the context. For example, if you want to write text in a subscript, if you use `\mbox` the text will remain big, if you use `\text` the text will look smaller, as you would expect.

Amsmath defines also the `\dots` command, that is a generalization of the existing `\ldots`. You can use `\dots` in both text and math mode and LaTeX will replace it with three dots "..." but it will decide according to the context whether to put it on the bottom (like `\ldots`) or centered (like `\cdots`).

| | |
|---|---|
| `\dot{x}` | $\dot{x}$ |
| `\ddot{x}` | $\ddot{x}$ |
| `\hat{x}` | $\hat{x}$ |
| `\widehat{x}` | $\widehat{x}$ |

## Showing formulas

If you want to write a formula within the text, you still have to use `$ ... $` but, if you want to write a big formula on its own line, then amsmath introduces lots of changes. In the following sections there are all the possible ways to insert an in-line formula, with a description on how to do it. Any possible output can be expressed in terms of the following structures. Do not use the environments introduced in the plain LaTeX section: they have a different management of spaces before and after the formula, so you'd better use only amsmath environments for consistency. Moreover, amsmath prevents overlapping of the equation numbers with wide formula, while plain LaTeX does not.

### One centered formula, without any label

When you just want to show a formula without referencing it later, use the `equation*` environment. Here is an example:

```
\begin{equation*}
a x^2 + b x + c = 0
\end{equation*}
```

$$ax^2 + bx + c = 0$$

### One centered formula, with label

When you just want to show a formula and you want to reference it later, use the `equation` environment. Here is an example

```
\begin{equation}
a x^2 + b x + c = 0
\end{equation}
```

$$ax^2 + bx + c = 0 \tag{1}$$

**Several centered formulas, without label**

When you want to show several centered formulas without referencing them later use `gather*`. It can be useful if you want to show the steps leading to a conclusion:

```
\begin{gather*}
a x + b = 0 \\
a x^2 + b x + c = 0 \\
a x^3 + b x^2 + c x + d = 0
\end{gather*}
```

$$ax + b = 0$$
$$ax^2 + bx + c = 0$$
$$ax^3 + bx^2 + cx + d = 0$$

**Several centered formulas, one label for all of them**

When you want to show several formulas on different lines, but you want to reference all of them just with one number, then you have to use the `gathered` environment within `equation`. Here is an example:

```
\begin{equation}
\begin{gathered}
a x + b = 0 \\
a x^2 + b x + c = 0 \\
a x^3 + b x^2 + c x + d = 0
\end{gathered}
\end{equation}
```

$$\begin{gathered} ax + b = 0 \\ ax^2 + bx + c = 0 \\ ax^3 + bx^2 + cx + d = 0 \end{gathered} \tag{2}$$

**Several centered formulas, each with its own label**

When you want to show several formulas on different lines, but you want to be able to reference each of them by a different number, you have to use `gather`. Here is an example:

```
\begin{gather}
a x + b = 0 \\
a x^2 + b x + c = 0 \\
a x^3 + b x^2 + c x + d = 0
\end{gather}
```

$$ax + b = 0 \tag{3}$$
$$ax^2 + bx + c = 0 \tag{4}$$
$$ax^3 + bx^2 + cx + d = 0 \tag{5}$$

If you want to number all the lines but one or two, you can add the command `\notag` on the line you want not to be numbered.

**Several formulas, any alignment, without label**

When you want to show one or several formulas with a particular alignment you want to define, you have to use `flalign*`. Adding a \\ you start a new line, using & you can manage the alignment. On each line you can add as many `&` as you want, but there must be the same number of any line, otherwise LaTeX returns an error. On each line, the alignment is managed as following:

```
\begin{flalign*}
right & left & right & left & right & left \\
right & left & right & left & right & left
\end{flalign*}
```

you can add multiple & without anything between them, for example:

```
\begin{flalign*}
& left & & left & & left \\
& left & & left & & left
\end{flalign*}
```

it's quite hard to center a formula using `flalign*`, but it doesn't matter since you can use all the other environments defined above if you want to. Here is a practical example:

```
\begin{flalign*}
10xy^2+15x^2y-5xy &=  5\left(2xy^2+3x^2y-xy\right) = \\
   & = 5x\left(2y^2+3xy-y\right) = \\
   & = 5xy\left(2y+3x-1\right)
\end{flalign*}
```

$$\begin{aligned} 10xy^2+15x^2y-5xy &= 5\left(2xy^2+3x^2y-xy\right) = \\ &= 5x\left(2y^2+3xy-y\right) = \\ &= 5xy\left(2y+3x-1\right) \end{aligned}$$

**Several formulas, any alignment, each with its own label**

If you want to align your formulas as you want, but you want each line to be numbered, just use `flalign`. It works exactly like the starred version. Here is an example:

```
\begin{flalign}
10xy^2+15x^2y-5xy &=  5\left(2xy^2+3x^2y-xy\right) = \\
   & = 5x\left(2y^2+3xy-y\right) = \\
   & = 5xy\left(2y+3x-1\right)
\end{flalign}
```

$$\begin{aligned} 10xy^2+15x^2y-5xy &= 5\left(2xy^2+3x^2y-xy\right) = && (6)\\ &= 5x\left(2y^2+3xy-y\right) = && (7)\\ &= 5xy\left(2y+3x-1\right) && (8) \end{aligned}$$

**Several formulas, any alignment, one label for all of them**

If you want to manage the alignment as you like, but you want to be able to reference all the lines just with one number, then you have to use `split` within `equation`. Here is an example:

```
\begin{equation}
\begin{split}
10xy^2+15x^2y-5xy &=  5\left(2xy^2+3x^2y-xy\right) = \\
   & = 5x\left(2y^2+3xy-y\right) = \\
   & = 5xy\left(2y+3x-1\right)
\end{split}
\end{equation}
```

$$\begin{aligned} 10xy^2+15x^2y-5xy &= 5\left(2xy^2+3x^2y-xy\right) = \\ &= 5x\left(2y^2+3xy-y\right) = && (9)\\ &= 5xy\left(2y+3x-1\right) \end{aligned}$$

**Splitting long formulas**

LaTeX does not take care of splitting long formulas in several lines, you have to do it by yourself. One possible approach is to separate the long formula into smaller parts and align it manually; this way you will get the best approach according to your needs. Anyway, if you want LaTeX to work for you, you'd better use the `multline`

environment. If you use it, all you have to do is to add \\ where you want to start a new line. LaTeX will set the alignment automatically: the first line will be left-aligned, the last line right-aligned, all the lines in the middle will be centered. Here is an example:

```
\begin{multline}
\left(1+x\right)^n  = 1 + nx + \frac{n\left(n-1\right)}{2!}x^2 +\\
+ \frac{n\left(n-1\right)\left(n-2\right)}{3!}x^3 +\\
+ \frac{n\left(n-1\right)\left(n-2\right)\left(n-3\right)}{4!}x^4 + \dots
\end{multline}
```

$$(1+x)^n = 1 + nx + \frac{n\,(n-1)}{2!}x^2 + \\ + \frac{n\,(n-1)\,(n-2)}{3!}x^3 + \\ + \frac{n\,(n-1)\,(n-2)\,(n-3)}{4!}x^4 + \dots \quad (10)$$

There is a starred version `multline*` if you don't want to label it.

Remember that, if you are using adapting brackets such as `\left[ ... \right]` you cannot start a new line until all those brackets have been closed. The way to fix this is to put a period (the invisible delimiter) to match – using e.g. `\left( ... \right.`. To get the heights right, add an invisible object with height, using e.g. `\vphantom{\frac{1}{2}}`. Another way to take care of this is to set the size yourself with, for instance, one of `\big( \Big( \bigg( \Bigg(`.

### Other options

If you want several formulas to be labeled with the same number, but you still want to identify them with different letters, then you can use the `subequations` environments. You put `\begin{subequations}` outside any mathematical environment; until LaTeX finds `\end{subequations}`, all the labels for equations will have the same number with a letter next to it. For example, they'll be labeled 11a, 11b, 11c, etc. Here is an example:

```
\begin{subequations}
\begin{gather}
a x + b = 0 \\
a x^2 + b x + c = 0 \\
a x^3 + b x^2 + c x + d = 0
\end{gather}
\end{subequations}
```

$$ax + b = 0 \quad (11a)$$
$$ax^2 + bx + c = 0 \quad (11b)$$
$$ax^3 + bx^2 + cx + d = 0 \quad (11c)$$

you can use any mathematical environment within `subequations`.

If you want to underline the importance of a formula, you can put it inside a box. To do so, choose the mathematical environment you prefer and type your formula as an argument of `\boxed{...}`. Here is an example:

```
\begin{equation*}
\boxed{a x^2 + b x + c = 0}
\end{equation*}
```

$$\boxed{ax^2 + bx + c = 0}$$

## Matrix-like environments

Amsmath introduces several commands that will help you typing matrices. In plain TeX, the only way is to use the `array` environment, but you have to define how many columns you want and how you want them aligned, just like a table. If you use the environments amsmath introduces, you don't have to worry about it anymore, LaTeX will take care of it. Those environments are:

```
\begin{environment}
  a & b \\
  c & d
\end{environment}
```

| **environment** | output |
|---|---|
| `matrix` | $\begin{matrix} a & b \\ c & d \end{matrix}$ |
| `pmatrix` | $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$ |
| `bmatrix` | $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$ |
| `Bmatrix` | $\begin{Bmatrix} a & b \\ c & d \end{Bmatrix}$ |
| `vmatrix` | $\begin{vmatrix} a & b \\ c & d \end{vmatrix}$ |
| `Vmatrix` | $\begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$ |

As you can see, the syntax within the environment is just like `array`. Another environment introduced by amsmath that is based on `array` is the `cases` environment, that you can use to write "cases":

```
u(x) =
\begin{cases}
1 & \text{if } x \geq 0 \\
0 & \text{if } x < 0
\end{cases}
```

$$u(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{if } x < 0 \end{cases}$$

Just like before, you don't have to take care of definition or alignment of columns, LaTeX will do it for you.

## Dots

LaTeX gives you several commands to insert dots in your formulas. This can be particularly useful if you have to type big matrices omitting elements. First of all, here are the main dots-related commands LaTeX provides:

| Code | Output | Comment |
|---|---|---|
| \dots | $\dots$ | generic dots, to be used in text (outside formulas as well). It automatically manages whitespaces before and after itself according to the context, it's a higher level command. |
| \ldots | $\ldots$ | the output is similar to the previous one, but there is no automatic whitespace management; it works at a lower level. |
| \cdots | $\cdots$ | those dots are centered relative to the height of a letter |
| \vdots | $\vdots$ | vertical dots |
| \ddots | $\ddots$ | diagonal dots |
| \hdotsfor{''n''} | ..... | to be used in matrices, it creates a row of dots spanning $n$ columns. |

Using those commands it is possible to create any complicated output with a simple and elegant code. Here is a practical example:

```
\begin{equation}
A_{m,n} =
\begin{pmatrix}
a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\
a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\
\vdots  & \vdots  & \ddots & \vdots  \\
a_{m,1} & a_{m,2} & \cdots & a_{m,n} \\
\end{pmatrix}
\end{equation}
```

$$A_{m,n} = \begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m,1} & a_{m,2} & \cdots & a_{m,n} \end{pmatrix}$$

## Integrals and sums

Amsmath introduces more symbols for integrals:

| | |
|---|---|
| `\int` | $\int$ |
| `\iint` | $\iint$ |
| `\iiint` | $\iiint$ |
| `\iiiint` | $\iiiint$ |
| `\idotsint` | $\int \cdots \int$ |

this way the multiple integrals will look closer than simply using `\int` several times. Moreover, if you add subscripts to an integral, in standard LaTeX they will look like $\int_a^b$ (`\int_{a}^{b}`). If you want $a$ and $b$ to be placed on the bottom and top of those symbols (this is the behavior you would expect using limits), you have to load the package with `intlimits`: `\usepackage[intlimits]{amsmath}` this way, the integral symbols will be handled like limits and they will look like $\int\limits_a^b$.

If you want to write multiple-line subscripts you have to use `\substack{...}`. This is particularly useful for sums, but you could need it for integrals as well. Just place `\substack` as subscript and put in the argument the output you want. Within the argument of `\substack` you are allowed to use `\\` to start a new line. All the lines you introduce will be centered. Here is an example:

```
\sum_{\substack{
0<i<m \\
0<j<n
}} P(i,j)
```

$$\sum_{\substack{0<i<m \\ 0<j<n}} P(i,j)$$

## Math operators

There are operators such as `\sin`, `\cos`, `\log` that LaTeX handles in a special way: it prints them in roman instead of italics and leaves the right space before and after them. There are lot but you might want to make your own. With amsmath it is very easy, just use the following command (it is explained with an example):

`\DeclareMathOperator{\ustep}{ustep}` the first argument is the command you define, the second one is the text it will print. LaTeX will take care of font-formatting and spacing. There is also a starred version `\DeclareMathOperator*{...}{...}`, it works the same but the operator you define will be handled like `\lim`, so the subscripts will be placed under the operator instead of the bottom right like all the others.

### Fractions and binomials

Besides the standard `\frac` command to add fractions, amsmath adds two new commands. They use the same syntax but they have a sightly different meaning:

| | | | |
|---|---|---|---|
| `\dfrac` | forces the fraction to be in display style | equivalent to `\displaystyle \frac` | $\dfrac{x+1}{y^2}$ |
| `\tfrac` | forces the fraction to be in text style | equivalent to `\textstyle \frac` | $\tfrac{x+1}{y^2}$ |

for example, you could force the display style of a fraction within a matrix environment; using the amsmath shorter versions will keep your source code more readable. For `\binom` the dual commands are defined: `\dbinom` and `\tbinom`.

### Text over symbols

If you want to write something over a symbol you can easily do it with the following command: `\overset{top}{symbol}` it will take *top*, resize it and put it over *symbol*. With this command you can easily create new symbols like , that are given by

$\underset{=}{\overset{!}{=}}$ $\underset{\leq}{\overset{?}{\leq}}$

`\overset{!}{=}` and `\overset{?}{\leq}`. If you want to write under a symbol, the dual command is `\underset`, that works with the same syntax.

Anyway, if you want to write some text over an arrow, amsmath provides its own command:

`\xleftarrow{up}` $\xleftarrow{up}$

`\xleftarrow[down]{up}` $\xleftarrow[down]{up}$

it will create a left-pointing arrow of the right length and will write *up* over it and optionally *down* under it. For right-pointing arrows use `\xrightarrow` with the same syntax.

## List of Mathematical Symbols

All the pre-defined mathematical symbols from the \TeX\ package are listed below. More symbols are available from extra packages.

| Symbol | Script | Symbol | Script | Symbol | Script |
|---|---|---|---|---|---|
| $\leq$ | \leq | $\geq$ | \geq | $\equiv$ | \equiv |
| $\models$ | \models | $\prec$ | \prec | $\succ$ | \succ |
| $\sim$ | \sim | $\perp$ | \perp | $\preceq$ | \preceq |
| $\succeq$ | \succeq | $\simeq$ | \simeq | $\mid$ | \mid |
| $\ll$ | \ll | $\gg$ | \gg | $\asymp$ | \asymp |
| $\parallel$ | \parallel | $\subset$ | \subset | $\supset$ | \supset |
| $\approx$ | \approx | $\bowtie$ | \bowtie | $\subseteq$ | \subseteq |
| $\supseteq$ | \supseteq | $\cong$ | \cong | $\sqsubset$ | \sqsubset |
| $\sqsupset$ | \sqsupset | $\neq$ | \neq | $\smile$ | \smile |
| $\sqsubseteq$ | \sqsubseteq | $\sqsupseteq$ | \sqsupseteq | $\doteq$ | \doteq |
| $\frown$ | \frown | $\in$ | \in | $\ni$ | \ni |
| $\propto$ | \propto | $=$ | = | $\vdash$ | \vdash |
| $\dashv$ | \dashv | $<$ | < | $>$ | > |

Table 13.1: Relation Symbols

| Symbol | Script | Symbol | Script | Symbol | Script |
|---|---|---|---|---|---|
| $\pm$ | \pm | $\cap$ | \cap | $\diamond$ | \diamond |
| $\oplus$ | \oplus | $\mp$ | \mp | $\cup$ | \cup |
| $\triangle$ | \bigtriangleup | $\ominus$ | \ominus | $\times$ | \times |
| $\uplus$ | \uplus | $\bigtriangledown$ | \bigtriangledown | $\otimes$ | \otimes |
| $\div$ | \div | $\sqcap$ | \sqcap | $\triangleleft$ | \triangleleft |
| $\oslash$ | \oslash | $\ast$ | \ast | $\sqcup$ | \sqcup |
| $\triangleright$ | \triangleright | $\odot$ | \odot | $\star$ | \star |
| $\vee$ | \vee | $\bigcirc$ | \bigcirc | $\circ$ | \circ |
| $\wedge$ | \wedge | $\dagger$ | \dagger | $\bullet$ | \bullet |
| $\setminus$ | \setminus | $\ddagger$ | \ddagger | $\cdot$ | \cdot |
| $\wr$ | \wr | $\amalg$ | \amalg | | |

Table 13.2: Binary Operations

## Summary

As you can begin to see, typesetting maths can be tricky at times. However, because Latex provides so much control, you can get professional quality mathematics typesetting for relatively little effort (once you've had a bit of practice, of course!). It would be possible to keep going and going with maths topics because it seems potentially limitless. However, with this tutorial, you should be able to get along sufficiently.

## Notes

## Further reading

- meta:Help:Displaying a formula: Wikimedia uses a subset of LaTeX commands.

## External links

- Latex maths symbols
- `amsmath` documentation

# Chapter 14

# Theorems

With "theorem" we can mean any kind of labelled enunciation that we want to look separated from the rest of the text and with sequential numbers next to it. This approach is commonly used for theorems in mathematics, but can be used for anything. LaTeX provides a command that will let you easily define any theorem-like enunciation.

## Basic theorems

The easiest is the following: `\newtheorem{name}{Printed output}` put it in the preamble. The first argument is the name you will use to reference it, the second argument is the output LaTeX will print whenever you use it. For example: `\newtheorem{mydef}{Definition}`

will define the `mydef` environment; if you use it like this:

```
\begin{mydef}
Here is a new definition
\end{mydef}
```

It will look like this: **Definition 3** *Here is a new definition*
with line breaks separating it from the rest of the text.

## Theorem counters

Often the counters are determined by section, for example "Theorem 2.3" refers to the 3rd theorem in the 2nd section of a document. In this case, specify the theorem as follows: `\newtheorem{name}{Printed output}[numberby]`

where *numberby* specifies the section level at which the numbering is to take place.

By default, each theorem uses its own counter. However it is common for similar types of theorems (e.g. Theorems, Lemmas and Corollaries) to share a counter. In this case, define subsequent theorems as: `\newtheorem{name}[counter]{Printed output}`

where *counter* is the name of the counter to be used. Usually this will be the name of the master theorem.

You can also create a theorem environment that is not numbered by using the `newtheorem*` command[1]. For instance, `\newtheorem*{mydef}{Definition}` defines the `mydef` environment, which will generate definitions without numbering. This requires `amsthm` package.

## Proofs

The `proof` environment[1] can be used for adding the proof of a theorem. The basic usage is:

```
\begin{proof}
Here is my proof
\end{proof}
```

It just adds *Proof* in italics at the beginning of the text given as argument and a white square (Q.E.D Symbol) at the end of it. If you are writing in another language than English, just use babel with the right argument and the word *Proof* printed in the output will be translated accordingly; anyway, in the source the name of the environment remains `proof`.

If you would like to manually name the proof, include the name in square brackets:

```
\begin{proof}[Proof of important theorem]
Here is my important proof
\end{proof}
```

If the last line of the proof is displayed math then the Q.E.D. symbol will appear on a subsequent empty line. To put the Q.E.D. symbol at the end of the last line, use the `\qedhere` command:

```
\begin{proof}
Here is my proof:
\[
a^2 + b^2 = c^2 \qedhere
\]
\end{proof}
```

To use a custom Q.E.D. symbol, redefine the `\qedsymbol` command. To hide the Q.E.D. symbol altogether, redefine it to be blank: `\renewcommand{\qedsymbol}{}`

## Theorem styles

It adds the possibility to change the output of the environments defined by `\newtheorem` using the `\theoremstyle` command[1] command in the header: `\theoremstyle{stylename}` the argument is the style you want to use. All subsequently defined theorems will use this style. Here is a list of the possible pre-defined styles:

[1] Requires the `amsthm` package

| stylename | Description |
|---|---|
| plain | Used for theorems, lemmas, propositions, etc. (default) |
| definition | Used for definitions and examples |
| remark | Used for remarks and notes |

### Custom styles

To define your own style, the use the \newtheoremstyle command[1]:

```
\newtheoremstyle{stylename}% name of the style to be used
  {spaceabove}% measure of space to leave above the theorem. E.g.: 3pt
  {spacebelow}% measure of space to leave below the theorem. E.g.: 3pt
  {bodyfont}% name of font to use in the body of the theorem
  {indent}% measure of space to indent
  {headfont}% name of head font
  {headpunctuation}% punctuation between head and body
  {headspace}% space after theorem head
  {headspec}% Manually specify head
```

(Any arguments that are left blank will assume their default value). Here is an example *headspec*: `\thmname{#1}\thmnumber{ #2}:\thmnote{ #3}` which would look something like:
**Definition 2**: Topology
for the following: `\begin{definition}{Topology}...` (The note argument, which in this case is Topology, is always optional, but will not appear by default unless you specify it as above in the head spec).

## External links

- amsthm documentation

# Chapter 15

# Labels and Cross-referencing

Another good point of LaTeX is that you can easily reference almost anything that is numbered (sections, figures, formulas), and LaTeX will take care of numbering, updating it whenever necessary. The commands to be used do not depend on what you are referencing, and they are:

`\label{marker}` you give the object you want to reference a *marker*, you can see it like a name.

`\ref{marker}` you can reference the object you have *marked* before. This prints the number that was assigned to the object

`\pageref{marker}` It will print the number of the page where the object is.

LaTeX will calculate the right numbering for the objects in the document, the *marker* you have used to label the object will not be shown anywhere in the document. Then LaTeX will replace the string "`\ref{marker}`" with the right number that was assigned to the object. If you reference a *marker* that does not exist, the compilation of the document will be successful but LaTeX will return a warning:

```
LaTeX Warning: There were undefined references.
```

and it will replace "`\ref{unknown-marker}`" with "??" (so it will be easy to find in the document).

As you may have noticed reading how it works, it is a two-step process: first the compiler has to store the labels with the right number to be used for referencing, then it has to replace the `\ref` with the right number. That is why, when you use references, you have to compile your document twice to see the proper output. If you compile it only once, LaTeX will use the older information it collected in previous compilations (that might be outdated), but the compiler will inform you printing on the screen at the end of the compilation: `LaTeX Warning: Label(s) may have changed. Rerun to get cross-references right.`

Using the command `\pageref{}` you can help the reader to find the referenced object by providing also the page number where it can be found. You could write something like: `See figure~\ref{fig:test} on page~\pageref{fig:test}.`

Since you can use exactly the same commands to reference almost anything, you might get a bit confused after you have introduced a lot of references. It is common practice among LaTeX users to add a few letters to the label to describe *what* you are referencing. Here is an example:

| | |
|---|---|
| `chap:` | chapter |
| `sec:` | section |
| `fig:` | figure |
| `tab:` | table |
| `eq:` | equation |

Following this convention, the label of a figure will look like `\label{fig:my_figure}`, etc. You are not obliged to use these prefixes. You can use any string as argument of `\label{...}`, but these prefixes become increasingly useful as your document grows in size.

Another suggestion: try to avoid using numbers within labels. You are better off describing *what* the object is about. This way, if you change the order of the objects, you will not be obliged to reference random pointless numbers.

If you want to be able to see the markers you are using in the output document as well, you can use the `showkeys` package; this can be very useful while developing your document. For more information see the Packages section.

## Examples

Here are some practical examples, but you will notice that they are all the same because they all use the same commands.

### Sections

```
\section{Greetings}
\label{sec:greetings}

Hello!

\section{Referencing}

I greeted in section \ref{sec:greetings}.
```

# 1 Greetings

Hello!

# 2 Referencing

I greeted in section 1.

you could place the label anywhere in the section; anyway, in order to avoid confusion, it is better to place it immediately after the beginning of the section. Note how the marker starts with *sec:*, as suggested before. The label is then referenced in a different section.

## Pictures

You can reference a picture by inserting it in the `figure` floating environment.

```
\begin{figure}
  \centering
    \includegraphics[width=0.5\textwidth]{gull}
  \caption{Close-up of a gull}
  \label{gull}
\end{figure}
Figure \ref{gull} shows a photograph of a gull.
```

Figure 1: Close-up of a gull

Figure 1 shows a photograph of a gull.

When a label is declared within a float environment, the `\ref{...}` will return the respective fig/table number, but it must occur **after** the caption. When declared outside, it will give the section number.

See the Floats, Figures and Captions section for more about the `figure` and related environments.

### Fixing wrong labels

A label may sometimes pick up the section or list number instead of the figure number. In this case, put the label inside the caption to ensure correct numbering:

```
\begin{figure}
  \begin{center}
    \includegraphics[width=0.5\textwidth]{gull}
```

```
    \caption{Close-up of a gull \label{fig:gull} }
  \end{center}
\end{figure}
```

### Issues with links to tables and figures handled by hyperref

In case you use the package `hyperref` to create a PDF, the links to tables or figures will point to the caption of the table or figure, which is always below the table or figure itself[1]. Therefore the table or figure will not be visible, it is above the pointer and one has to scroll up in order to see it. If you want the link point to the top of the image you can use the package `hypcap` http://www.ctan.org/tex-archive/macros/latex/contrib/oberdiek/hypcap.pdf with: `\usepackage[all]{hypcap}` Be sure to call this package *after* the package `hyperref`, which should otherwise be loaded last.

## Formulas

Here is an example showing how to reference formulas:

```
\begin{equation} \label{eq:solve}
x^2 - 5 x + 6 = 0
\end{equation}

\begin{equation}
x_1 = \frac{5 + \sqrt{25 - 4 \times 6}}{2} = 3
\end{equation}

\begin{equation}
x_2 = \frac{5 - \sqrt{25 - 4 \times 6}}{2} = 2
\end{equation}

and so we have solved equation \ref{eq:solve}
```

$$x^2 - 5x + 6 = 0 \tag{1}$$

$$x_1 = \frac{5 + \sqrt{25 - 4 \times 6}}{2} = 3 \tag{2}$$

$$x_2 = \frac{5 - \sqrt{25 - 4 \times 6}}{2} = 2 \tag{3}$$

and so we have solve equation 1

[1] http://www.ctan.org/tex-archive/macros/latex/contrib/hyperref/README

as you can see, the label is placed soon after the beginning of the math mode. In order to reference a formula, you have to use an environment that adds numbers. Most of the times you will be using the `equation` environment, that is the best choice for one-line formulas, if you are using `amsmath` or not. Note also the *eq:* prefix in the label.

#### `eqref`

The `amsmath` package adds a new command for referencing formulas, it is `\eqref{}`. It works exactly like `\ref{}`, but it adds brackets so that, instead of printing a plain number as *5*, it will print *(5)*. This can be useful to help the reader distinguishing between formulas and other things, without the need to repeat the word "formula" before any reference. It's output can be changed as you wish, for more information see the `amsmath` documentation.

## The `varioref` package

The `varioref` package introduces a new command called `\vref{}`. This command is used exactly like the basic `\ref`, but it has a different output according to the context. If the object to be referenced is in the same page, it works just like `\ref`; if the object is far away it will print something like "5 on page 25", i.e. it adds the page number automatically. If the object is close, it can use more refined sentences like "on the next page" or "on the facing page" automatically, according to the context and the document class.

This command has to be used very carefully. It outputs more than one word, so it may happen its output to stay between two different pages. In this case, the algorithm can get confused and cause a loop. Let's make an example. You label an object on page 23 and the `\vref` output happens to stay between page 23 and 24. If it were on page 23, it would print like the basic `ref`, if it were on page 24, it would print "on the previous page", but it is on both, and this may cause some strange errors at compiling time that are very hard to be fixed. You could think that this happens very rarely; unfortunately, if you write a long document you often edit with more than 100 references, situations like these are likely to happen. A possible way to avoid problems is to use the standard `ref` all the time, and convert it to `vref` when you are close to the final version of your document.

## The `hyperref` package and `\autoref{}`

The `hyperref` package introduces another useful command; `\autoref{}`. This command creates a reference with additional text corresponding to the targets type, all of which will be a hyperlink. For example, the command `\autoref{sec:intro}` would create a hyperlink to the `\label{sec:intro}` command, wherever it is. Assuming that this label is pointing to a section, the hyperlink would contain the text "section 3.4", or similar (capitalization rules will be followed, which makes this very convenient).

You can customize the prefixed text by redefining `\(type)autorefname` to the prefix you want, as in:

```
\def\subsectionautorefname{section}
```

If you would like a hyperlink reference, but do not want the predefined text that `\autoref{}` provides, you can do this with a command such as `\hyperref[sec:intro]{Appendix~\ref*{sec:intro}}`. Note that you can disable the creation of hyperlinks in `hyperref`, and just use these commands for automatic text.

The `hyperref` package also automatically includes the `nameref` package, and similarly named command. It is similar to `\autoref{}`, but inserts text corresponding to the section name, for example.

## The `hyperref` package and `\phantomsection`

When you define a `\label` outside a figure, a table, or other floating objects, the label points to the current section. In some case, this behavior is not what you'd like and you'd prefer the generated link to point to the line where the `\label` is defined. This can be achieved with the command `\phantomsection` as in this example:

```
%The link location will be placed on the line below.
\phantomsection
\label{the_label}
```

# Chapter 16

# Indexing

A useful feature of many books, index is an alphabetical list of words and expressions with the pages of the book upon which they are to be found. LaTeX supports the creation of indices with its package `makeidx`, and its support program `makeindex`, called on some systems `makeidx`.

To enable the indexing feature of LaTeX, the `makeidx` package must be loaded in the preamble with: `\usepackage{makeidx}`

and the special indexing commands must be enabled by putting the `\makeindex`

command into the input file preamble. The content of the index is specified with `\index{key}`

where *key* is the index entry. You enter the index commands at the points in the text that you want the final index entries to point to.

Below are examples of `index` entries:

| Example | Index Entry | Comment |
|---|---|---|
| `\index{hello}` | hello, 1 | Plain entry |
| `\index{hello!Peter}` | Peter, 3 | Subentry under 'hello' |
| `\index{Sam@\textsl{Sam}}` | *Sam*, 2 | Formatted entry |
| `\index{Lin@\textbf{Lin}}` | **Lin**, 7 | Same as above |
| `\index{Jenny\|textbf}` | Jenny, **3** | Formatted page number |
| `\index{Joe\|textit}` | Joe, *5* | Same as above |
| `\index{ecole@\'ecole}` | école, 4 | Handling of accents |
| `\index{Peter\|see{hello}}` | Peter, *see* hello | Cross-references |

When the input file is processed with LaTeX, each `\index` command writes an appropriate index entry, together with the current page number, to a special file. The file has the same name as the LaTeX input file, but a different extension (`.idx`). This `.idx` file can then be processed with the `makeindex program`. Type in the command

line:

```
makeindex filename
```

Note that *filename* is without extension: the program will look for *filename.idx* and use that. You can optionally pass *filename.idx* directly to the program as an argument. The `makeindex` program generates a sorted index with the same base file name, but this time with the extension `.ind`. If now the LaTeX input file is processed again, this sorted index gets included into the document at the point where LaTeX finds

`\printindex`

It is common to place it at the end of the document. The default index format is two columns.

The `showidx` package that comes with LaTeX prints out all index entries in the left margin of the text. This is quite useful for proofreading a document and verifying the index.

Note that the `\index` command can affect your layout if not used carefully. Here is an example:

```
My Word \index{Word}. As opposed
to Word\index{Word}. Note the
position of the full stop.
```

My Word . As opposed to Word. Note the position of the full stop.

## Abbreviation list

You can make a list of abbreviations with the package nomencl http://www.ctan.org/tex-archive/macros/latex/contrib/nomencl/.

To enable the Nomenclature feature of LaTeX, the `nomencl` package must be loaded in the preamble with:

```
\usepackage[<options>]{nomencl}
\makenomenclature
```

Issue the `\nomenclature[<prefix>]{<symbol >}{<description>}` command for each symbol you want to have included in the nomenclature list. The best place for this command is immediately after you introduce the symbol for the first time. Put `\printnomenclature` at the place you want to have your nomenclature list.

Run LaTeX 2 times then

```
makeindex filename.nlo  -s nomencl.ist -o filename.nls
```

followed by running LaTeX once again.

## Multiple indexes

If you need multiple indexes you can use the package multind http://www.tex.ac.uk/cgi-bin/texfaq2html?label=multind.

This package provides the same commands as makeidx, but now you also have to pass a name as the first argument to every command.

```
\usepackage{multind}
\makeindex{books}
\makeindex{authors}
...
\index{books}{A book to index}
\index{authors}{Put this author in the index}
...
\printindex{books}{The Books index}
\printindex{authors}{The Authors index}
```

# Chapter 17

# Algorithms and Pseudocode

LaTeX has a variety of packages that can help to format algorithms and "pseudocode". (Pseudocode is a loose way of expressing an algorithm in a way which resembles typical computer programming languages. It doesn't have much of a formal standardisation but uses only very common programming structures such as "if-else" blocks and "for" loops.)

## Typesetting using the `algorithmic` package

The `algorithmic` environment provides a number of popular constructs for algorithm designs. The command `\begin{algorithmic}` can be given the optional argument of a positive integer, which if given will cause line numbering to occur at multiples of that integer. E.g. `\begin{algorithmic}[5]` will enter the algorithmic environment and number every fifth line.

Below is an example of typesetting a basic algorithm using the `algorithmic` package (remember to add the `\usepackage{algorithmic}` statement to your document preamble):

```
\begin{algorithmic}
\IF {$i\geq maxval$}
        \STATE $i\gets 0$
\ELSE
        \IF {$i+k\leq maxval$}
                \STATE $i\gets i+k$
        \ENDIF
\ENDIF
\end{algorithmic}
```

The LaTeX source can be written to a format familiar to programmers so that it is easy to read. This will not, however, affect the final layout in the document.

There are several constructs provided by `algorithmic` detailed below

### Single line statements

**\STATE <text>** A simple statement, e.g. for setting a variable

```
\begin{algorithmic}
\STATE i=0
\end{algorithmic}
```

would produce

```
i = 0
```

### If-statements

There are three forms of this construct

**\IF<condition> <text> \ENDIF**

**\IF<condition> <text> \ELSE <text> \ENDIF**

**\IF<condition> <text> \ELSIF<condition> <text> \ELSE <text> \ENDIF**
The third form accepts as many \ELSIF{} clauses as required.

### For-loops

There are two forms

**\FOR<condition> <text> \ENDFOR**

**\FORALL<condition> <text> \ENDFOR** A traditional "for" loop. The method of iteration is usually described in the first argument,

e.g.

```
\FOR{$i$ = 1 to 10}
\STATE $i \leftarrow i + 1$
\ENDFOR
```

### While-loops

**\WHILE<condition> <text> \ENDWHILE**

### Repeat until condition

**\REPEAT <text> \UNTIL<condition>**

### Infinite loops

**\LOOP <text> \ENDLOOP**

### Precondition

**\REQUIRE <text>**

### Postcondition

**\ENSURE <text>**

### Returning variables

**\RETURN <text>**

### Printing variables

**\PRINT <text>** This is included because it is used so frequently it is considered an operation in its own right.

### Comments

**\COMMENT<text>**

Note that you can not use \COMMENT as the first statement of any closed structure, such as \IF..\ENDIF, \FOR..\ENDFOR, \FORALL..\ENDFORALL, \WHILE..\ENDWHILE, and \begin{algorithmic}..\end{algorithmic}. An error "LaTeX Error: Something's wrong–perhaps a missing \item" will be reported (It does not make much sense). There are two workaounds:

1. `Use \STATE \COMMENT{<text>}.`
2. `Use the optional arguments in those closed structures. For example, \WHILE[<comment-text>]{<condition>}`

## The `algorithm` environment

It is often useful for the algorithm produced by `algorithmic` to be "floated" to the optimal point in the document to avoid it being split across pages. The `algorithm` environment provides this and a few other useful features. Include it by adding the \usepackage{`algorithm`} to your document's preamble. It is entered into by

```
\begin{algorithm}
\caption{<your caption for this algorithm>}
\label{<your label for references later in your document>}
\begin{algorithmic}
<algorithmic environment>
```

```
\end{algorithmic}
\end{algorithm}
```

### Algorithm numbering

The default numbering system for the `algorithm` package is to number algorithms sequentially. This is often not desirable, particularly in large documents where numbering according to chapter is more appropriate. The official documentation is not very clear on how to change this, but it can be done by inserting a \numberwithin{} into the preamble:

```
\usepackage{algorithmic}
\usepackage{algorithm}
\numberwithin{algorithm}{chapter}  % <--- chapter, section etc.
% depending on what is required
```

When using hyperref and referencing algorithms latex gives an error: `! Undefined control sequence. <argument> algorithm.\theHalgorithm` This can be solved adding at the preamble: `\newcommand{\theHalgorithm}{\arabic{algorithm}}`

### List of algorithms

When you use figures or tables, you can add a list of them close to the table of contents; the `algorithm` package provides a similar command. Just put `\listofalgorithms` anywhere in the document, and LaTeX will print a list of the "algorithm" environments in the document with the corresponding page and the caption.

## An example from the manual

This is an example taken from the manual (official manual, p.7)

```
\begin{algorithm}                    % enter the algorithm environment
\caption{Calculate $y = x^n$}        % give the algorithm a caption
\label{alg1}                         % and a label for \ref{}
                                     % commands later in the document
\begin{algorithmic}                  % enter the algorithmic environment
\REQUIRE $n \geq 0 \vee x \neq 0$
\ENSURE $y = x^n$
\STATE $y \Leftarrow 1$
\IF{$n < 0$}
\STATE $X \Leftarrow 1 / x$
\STATE $N \Leftarrow -n$
\ELSE
\STATE $X \Leftarrow x$
\STATE $N \Leftarrow n$
\ENDIF
```

```
\WHILE{$N \neq 0$}
\IF{$N$ is even}
\STATE $X \Leftarrow X \times X$
\STATE $N \Leftarrow N / 2$
\ELSE[$N$ is odd]
\STATE $y \Leftarrow y \times X$
\STATE $N \Leftarrow N - 1$
\ENDIF
\ENDWHILE
\end{algorithmic}
\end{algorithm}
```

More information about all possible commands available at the project page http://developer.berlios.de/docman/?group_id=3442

The official manual is located at http://developer.berlios.de/docman/display_doc.php?docid=800&group_id=3442

## Code formating using the Listings package

A complete reference manual can be found at http://tug.ctan.org/tex-archive/macros/latex/contrib/listings/listings.pdf

This is a basic example for some Pascal code:

```
\documentclass{article}
\usepackage{listings}             % Include the listings-package
\begin{document}
\lstset{language=Pascal}          % Set your language (you can change
% the language for each code-block optionally)

\begin{lstlisting}                % Start your code-block
for i:=maxint to 0 do
begin
{ do nothing }
end;
Write('Case insensitive ');
WritE('Pascal keywords.');
\end{lstlisting}

\end{document}
```

# Chapter 18

# Letters

Sometimes the mundane things are the most painful. However, it doesn't have to be that way because of evolved, user-friendly templates. Thankfully, LaTeX allows for very quick letter writing, with little hassle.

## The `letter` class

To write letters use the standard document class *letter*.

You can write multiple letters in one LaTeX file — start each one with `\begin{letter}{recipient}` and end with `\end{letter}`. You can leave *recipient* blank. Each letter consists of four parts:

1. opening (like `\opening{Dear Sir or Madam,}` or `\opening{Dear Kate,}`)
2. main body — written as usual in LaTeX
3. closing (like `\closing{Yours sincerely,}`)
4. LaTeX will leave some space after closing for your hand-written signature; then it will put your name and surname, if you have declared them.
5. additional elements: post scriptum (`\ps{}`), carbon copy (`\cc{}`) and list of enclosures (`\encl{}`)

If you want your name, address and telephone number to appear in the letter, you have to declare them first (with `\signature{}`, `\address{}` and `\telephone{}`).

The output letter will look like this:

21 Bridge Street
Smallville
Dunwich DU3 4WE

April 24, 2007

Director
Doe & Co
35 Anthony Road
Newport
Ipswich IP3 5RT

Dear Sir or Madam:

I am writing to you on behalf of the Wikipedia project (http://www.wikipedia.org/), an endeavour to build a fully-fledged multilingual encyclopaedia in an entirely open manner, to ask for permission to use your copyrighted material.

...

That said, allow me to reiterate that your material will be used to the noble end of providing a free collection of knowledge for everyone; naturally enough, only if you agree. If that is the case, could you kindly fill in the attached form and post it back to me? We shall greatly appreciate it.

Thank you for your time and consideration.

I look forward to your reply.

Yours Faithfully,

Joe Bloggs

P.S. You can find the full text of GFDL license at http://www.gnu.org/copyleft/fdl.html.

encl: Copyright permission form

Figure 18.1: A sample letter.

Here is the example's code:

```
\documentclass{letter}
\signature{Joe Bloggs}
\address{21 Bridge Street \\ Smallville \\ Dunwich DU3 4WE}
\begin{document}

\begin{letter}{Director \\ Doe \& Co \\ 35 Anthony Road
\\ Newport \\ Ipswich IP3 5RT}
```

```
\opening{Dear Sir or Madam:}

I am writing to you on behalf of the Wikipedia project
(http://www.wikipedia.org/), an endeavour to build a fully-fledged
multilingual encyclopaedia in an entirely open manner, to ask for
permission to use your copyrighted material.

\ldots % The \ldots command produces dots in a way that will not upset
% the typesetting of the document.
% Note that the % sign tells latex that whatever following it is
% a comment that should not be included  in the compiled document.

That said, allow me to reiterate that your material will be used to
the noble end of providing a free collection of knowledge for everyone;
naturally enough, only if you agree. If that is the case, could you
kindly fill in the attached form and post it back to me? We shall
greatly appreciate it.

Thank you for your time and consideration.

I look forward to your reply.

\closing{Yours Faithfully,}
\ps{P.S. You can find the full text of GFDL license at
http://www.gnu.org/copyleft/fdl.html.}
\encl{Copyright permission form}

\end{letter}

\end{document}
```

## Envelopes

Here is a relatively simple envelope which uses the `geometry` package which is used because it vastly simplifies the task of rearranging things on the page (and the page itself).

```
% envelope.tex
\documentclass{letter}
\usepackage[margin=0.15in,papersize={4.125in,9.5in},landscape,twoside=false]
{geometry}
\setlength\parskip{0pt}
\pagestyle{empty}

\begin{document}
```

```
FROM-NAME

FROM-STREET ADDRESS

FROM-CITY, STATE, \ ZIP

\vspace{1.0in}\large
\setlength\parindent{3.6in}

TO-NAME

TO-STREET ADDRESS

TO-CITY, STATE, \ ZIP

\end{document}
```

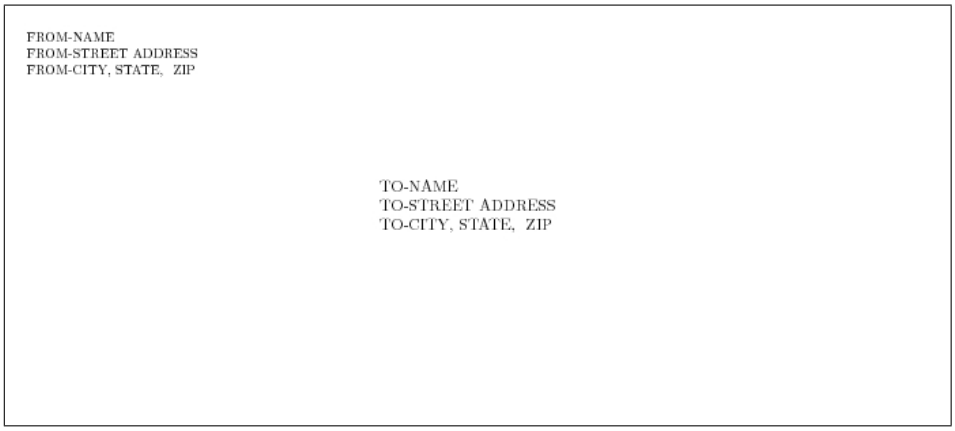



Figure 18.2: A sample envelope to be printed in landscape mode.

This will certainly take care of the spacing but the actual printing is between you and your printer. After all, different printers have different feeding mechanisms for envelopes. You may find the following commands useful for printing the envelope. In the first line, dvips command converts the .dvi file produced by latex into a .ps (PostScript) file. In the second line, pdflatex converts the source .tex file into a pdf file and xpdf opens that file (that is not necessary for the third line to work as expected). In the third line, the PostScript file is sent to the printer.

```
latex envelope.tex && dvips -t unknown -T 9.5in,4.125in envelope.dvi
&& gv envelope.ps
```

```
pdflatex envelope.tex && xpdf envelope.pdf
lpr -o landscape envelope.ps
```

I have found that `pdflatex` creates the right page size but not `dvips` despite what it says in the `geometry` manual. It will never work though unless your printer settings are adjusted to the correct page style. These settings depend on the printer filter you are using and in CUPS might be available on the `lpr` command line if you are masochistic.

## Sources

- Hypertext Help with LaTeX

# Chapter 19

# Packages

Add-on features for LaTeX are known as packages. Dozens of these are pre-installed with LaTeX and can be used in your documents immediately. They should all be stored in subdirectories of `texmf/tex/latex` named after each package. To find out what other packages are available and what they do, you should use the CTAN search page which includes a link to Graham Williams' comprehensive package catalogue. A package is a file or collection of files containing extra LaTeX commands and programming which add new styling features or modify those already existing. Installed package files all end with `.sty` (there may be ancillary files as well). When you try to typeset a document which requires a package which is not installed on your system, LaTeX will warn you with an error message that it is missing, and you can then download the package and install it using the instructions in the installing extra packages section. You can also download updates to packages you already have (both the ones that were installed along with your version of LaTeX as well as ones you added). There is no limit to the number of packages you can have installed on your computer (apart from disk space!), but there is probably a physical limit to the number that can be used inside any one LaTeX document at the same time, although it depends on how big each package is. In practice there is no problem in having even a couple of dozen packages active.

## Using an existing package

To use a package already installed on your system, insert a `\usepackage` command in your document preamble with the package name in curly braces: `\usepackage{package_name}`

For example, to use the `color` package, which lets you typeset in colors, you would type:

```
\documentclass[11pt,a4paper,oneside]{report}

\usepackage{color}

\begin{document}
```

```
...
\end{document}
```

You can include several package names in one \usepackage command by separating the names with commas, like this:

`\usepackage{package1,package2,package3}`

and you can have more than one \usepackage command. Some packages allow optional settings in square brackets. If you use these, you must give the package its own separate \usepackage command, like geometry shown below:

```
\documentclass[11pt,a4paper,oneside]{report}

\usepackage{pslatex,palatino,avant,graphicx,color}
\usepackage[margin=2cm]{geometry}

\begin{document}
\title{\color{red}Practical Typesetting}
\author{\color{blue}Peter Flynn\\ Silmaril Consultants}
\date{\color{green}December 2005}
\maketitle

\end{document}
```

Many packages can have additional formatting specifications in optional arguments in square brackets, in the same way as `geometry` does. Read the documentation for the package concerned to find out what can be done. You can pass several options together separated by a comma:

`\usepackage[option1,option2,option3]{package_name}`

## Package documentation

To find out what commands a package provides (and thus how to use it), you need to read the documentation. In the `texmf/doc` subdirectory of your installation there should be directories full of .dvi files, one for every package installed. This location is distribution-specific, but is *typically* found in:

| Distribution | Path |
|---|---|
| MiKTeX | `C:\Program Files\MiKTeX 2.7\doc\latex` |
| teTeX | `/usr/share/texmf-tetex/doc/latex` |

Generally, *most* of the packages are in the *latex* subdirectory, although other packages (such as BibTeX and font packages) are found in other subdirectories in `doc`. The documentation directories have the same name of the package (e.g. `amsmath`), which generally have one or more relevant documents in a variety of formats (`dvi`, `txt`, `pdf`, etc.). The documents generally have the same name as the package, but there are exceptions (for example, the documentation for `amsmath` is found at `latex/amsmath/amsdoc.dvi`).

If your installation procedure has not installed the documentation, the DVI files can all be downloaded from CTAN. Before using a package, you should read the documentation carefully, especially the subsection usually called "User Interface", which describes the commands the package makes available. You cannot just guess and hope it will work: you have to read it and find out.

## Packages list

Here is a (not complete) list of useful packages that can be used for a wide range of different kind of documents. Each package has a short description next to it and, when available, there is a link to a section describing such package in detail. All of them (unless stated) should be included in your LaTeX distribution as *package_name.sty*. For more information, refer to the documentation of the single packages, as described in the previous section. The list is in alphabetical order.

| | |
|---|---|
| **amsmath** | it contains the advanced math extensions for LaTeX. The complete documentation should be in your LaTeX distribution; the file is called *amsdoc*, and can be *dvi* or *pdf*. For more information, see the chapter about Mathematics |
| **amssymb** | it adds new symbols in to be used in math mode. |
| **amsthm** | it introduces the `proof` environment and the `theoremstyle` command. For more information see the Theorems section. |
| **array** | it extends the possibility of LaTeX to handle tables, fixing some bugs and adding new features. Using it, you can create very complicated and customized tables. For more information, see the Tables section. |
| **babel** | it provides the internationalization of LaTeX. It has to be loaded in any document, and you have to give as an option the main language you are going to use in the document. |
| **bm** | allows use of bold greek letters in math mode using the `\bm{...}` command. This supersedes the `amsbsy` package. |
| **boxedminipage** | it introduces the `boxedminipage` environment, that works exactly like `minipage` but adds a frame around it |
| **chngpage** | to easily change the margins of pages. The syntax is<br>`\changepage{textheight}{textwidth}%`<br>`  {evensidemargin}{oddsidemargin}%`<br>`  {columnsep}{topmargin}%`<br>`  {headheight}{headsep}%`<br>`  {footskip}`<br>All the arguments can be both positive and negative numbers; they will be added (keeping the sign) to the relative variable. |
| **cite** | assists in citation management |

| | |
|---|---|
| **color** | it adds support for colored text. For more information, see the relative section |
| **eucal** | other mathematical symbols |
| **fancyhdr** | to change header and footer of any page of the document. It is described in the Page Layout section |
| **fontenc** | to choose the font encoding of the output text. You might need it if you are writing documents in a language other than English. Check in the Internationalization section. |
| **geometry** | for easy management of document margins |
| **graphicx** | to manage external pictures |
| **hyperref** | it gives LaTeX the possibility to manage links within the document or to any URL when you compile in PDF. For more information, see the relative section |
| **indentfirst** | once loaded, the beginning of any chapter/section is indented by the usual paragraph indentation. |
| **inputenc** | to choose the encoding of the input text. You might need it if you are writing documents in a language other than English. Check in the Internationalization section. |
| **latexsym** | other mathematical symbols |
| **listings** | to insert programming code within the document. Many languages are supported and the output can be customized. For more information, see the relative section |
| **mathrsfs** | other mathematical symbols |
| **rotating** | It lets you rotate any kind of object. It is particularly useful for rotating tables. For more information, see the relative section |
| **setspace** | has the \doublespacing command for making double spaced documents |
| **showkeys** | it is very useful while writing any document. If you want to reference an image or a formula, you have to give it a name using `\label{...}` and then you can recall it using `\ref{...}`. When you compile the document these will be replaced only with numbers, and you can't know which label you had used unless you take a look at the source. If you have loaded the `showkeys` package, you will see the label just next or above the relative number in the compiled version. An example of a reference to a section is in section sec:mylabel 1.1. Moreover. This way you can easily keep track of the labels you add or use, simply looking at the preview (both *dvi* or *pdf*). Just before the final version, remove it |
| **showidx** | it prints out all index entries in the left margin of the text. This is quite useful for proofreading a document and verifying the index. For more information, see the Indexing section. |

| | |
|---|---|
| **syntonly** | if you add the following code in your preamble:<br><br>`\usepackage{syntonly}`<br>`\syntaxonly`<br><br>LaTeX skims through your document only checking for proper syntax and usage of the commands, but doesn't produce any (DVI or PDF) output. As LaTeX runs faster in this mode you may save yourself valuable time. If you want to get the output, you can simply comment out the second line. |
| **textcomp** | provides extra symbols, for example for different currencies (`\texteuro`,...), things like `\textcelsius` and many other |
| **theorem** | you can change the style of newly defined theorems. For more information see the Theorems section. |
| **units** | helps you typeset units correctly. For example `\unitfrac[1]{C}{s}=\unit[1]{A}`. Automatically handles the correct spacing between the number and the unit. Works in math mode as well. |
| **url** | it defines the `\url{...}` command. URLs often contain special character such as _ and &, in order to write them you should *escape* them inserting a backslash, but if you write them as an argument of `\url{...}`, you don't need to escape any special character and it will take care of proper formatting for you. If you are using the `hyperref`, you don't need to load `url` because it already provides the `\url{...}` command. |
| **verbatim** | it improves the `verbatim` environment, fixing some bugs. Moreover, it provides the `comment` environment, that lets you add multiple-line comments or comment out easily big parts of the code. |
| **wrapfig** | to insert images surrounded by text. It was discussed in section Floats, Figures and Captions |

# Chapter 20

# Installing Extra Packages

Most LaTeX installations come with a large set of pre-installed style packages, but many more are available on the net. The main place to look for style packages on the Internet is CTAN ( http://www.ctan.org/ ). Once you have identified a package you need and haven't already got (or you have got it and need to update it), use the indexes on any CTAN server to find the package you need and the directory where it can be downloaded from.

## Downloading packages

What you need to look for is always two files, one ending in `.dtx` and the other in `.ins`. The first is a DOCTeX file, which combines the package program and its documentation in a single file. The second is the installation routine (much smaller). You must always download both files. If the two files are not there, it means one of two things:

- *Either* the package is part of a much larger bundle which you shouldn't normally update unless you change version of LaTeX;
- *or* it's one of a few rare or unusual packages still supplied as a single `.sty` file intended for the now obsolete LaTeX 2.09

Download both files to a temporary directory. There will often be a `readme.txt` with a brief description of the package. You should of course read this file first.

## Installing a package

There are four steps to installing a LaTeX package:

1. **Extract the files** Run LaTeX on the `.ins` file. That is, open the file in your editor and process it as if it were a LaTeX document (which it is), or if you prefer, type latex followed by the `.ins` filename in a command window in your temporary directory. This will extract all the files needed from the `.dtx` file (which is why you must have both of them present in the temporary directory). Note down or print the

names of the files created if there are a lot of them (read the log file if you want to see their names again).

2. **Create the documentation** Run LaTeX on the `.dtx` file. You might need to run it twice or more, to get the cross-references right (just like any other LaTeX document). This will create a `.dvi` file of documentation explaining what the package is for and how to use it. If you prefer to create PDF then run pdfLaTeX instead. If you created a `.idx` as well, it means that the document contains an index, too. If you want the index to be created properly, follow the steps in the indexing section. Sometimes you will see that a `.glo` (glossary) file has been produced. Run the following command instead:

```
makeindex -s gglo.ist -o name.gls name.glo
```

3. **Install the files** While the documentation is printing, move or copy the files created in step 1 from your temporary directory to the right place[s] in your TeX local installation directory tree — always your 'local' directory tree, *a)* to prevent your new package accidentally overwriting files in the main TeX directories; and *b)* to avoid your newly-installed files being overwritten when you next update your version of TeX. The "right place" sometimes causes confusion, especially if your TeX installation is old or does not conform to the TeX Directory Structure. For a TDS-conformant system, this is either *a)* for LaTeX packages, a suitably-named subdirectory of `texmf-local/tex/latex/`; or *b)* a suitably-named sub-directory of `texmf-local/` for files like BIBTeX styles which are not just for LaTeX but can be used in other TeX systems. "Suitably-named" means sensible and meaningful (and probably short). For a package like paralist, for example, I'd call the directory `paralist`. Often there is just a `.sty` file to move but in the case of complex packages there may be more, and they may belong in different locations. For example, new BibTeX packages or font packages will typically have several files to install. This is why it is a good idea to create a sub-directory for the package rather than dump the files into misc along with other unrelated stuff. If there are configuration or other files, read the documentation to find out if there is a special or preferred location to move them to.

4. **Update your index** Finally, run your TeX indexer program to update the package database. This program comes with every modern version of TeX and is variously called depending on the LaTeX distribution you use (Read the documentation that came with your installation to find out which it is):

- teTeX, fpTeX: `texhash`
- web2c: `mktexlsr`
- MikTeX: `initexmf -update-fndb` (or use the GUI)

`This last step is utterly essential, otherwise nothing will work.`

The reason this process has not been automated widely is that there are still thousands of installations which do not conform to the TDS, such as old shared Unix systems and some Microsoft Windows systems, so there is no way for an installation program to guess where to put the files: you have to know this. There are also systems where the owner, user, or installer has chosen not to follow the recommended TDS directory structure, or is unable to do so for political or security reasons (such as a shared system where she cannot write to a protected directory). The reason for having the `texmf-local` directory (called `texmf.local` on some systems) is to provide a place for local modifications or personal updates, especially if you are a user on a shared or managed system (Unix, Linux, VMS, Windows NT/2000/XP, etc.) where you may not have write-access to the main TeX installation directory tree. You can also have a personal `texmf` subdirectory in your own login directory. Your installation must be configured to look in these directories first, however, so that any updates to standard packages will be found there before the superseded copies in the main `texmf` tree. All modern TeX installations should do this anyway, but if not, you can edit `texmf/web2c/texmf.cnf` yourself.

| **Type** | **Directory (under `texmf-local/`)** | **Description** |
|---|---|---|
| .cls | tex/latex/base | Document class file |
| .sty | tex/latex/*packagename* | Style file: the normal package content |
| .bst | bibtex/bst/*packagename* | BibTeX style |
| .mf | fonts/source/public/*typeface* | METAFONT outline |
| .fd | tex/latex/mfnfss | Font Definition files for METAFONT fonts |
| .fd | tex/latex/psnfss | Font Definition files for PostScript Type 1 fonts |
| .pfb | /fonts/type1/*foundry*/*typeface* | PostScript Type 1 outline |
| .afm | /fonts/afm/*foundry*/*typeface* | Adobe Font Metrics for Type 1 fonts |
| .tfm | /fonts/tfm/*foundry*/*typeface* | TeX Font Metrics for METAFONT and Type 1 fonts |
| .vf | /fonts/vf/*foundry*/*typeface* | TeX virtual fonts |
| .dvi | /doc | package documentation |
| .pdf | /doc | package documentation |
| others | tex/latex/*packagename* | other types of file unless instructed otherwise |

Table 20.1: Where to put files from packages

# Chapter 21

# Color

The package `color` adds the support for colored text: LaTeX does not support it by default. The best approach is to define the colors you want to use at the beginning of your document and then you can reference them whenever you want. For example, you can use them to type colored text or as an argument of another package that supports colors as arguments (for example, see the listings package). There are some standard colors that are already defined within the package, they are `white, black, red, green, blue, cyan, magenta, yellow`; you can reference them simply typing their name. You can define your own colors with:

```
\definecolor{name}{model}{color-spec}
```

- **name** is the name of the color; you can call it as you like
- **model** is the way you *describe* the color
- **color-spec** is the description of the color

The models you can use to describe the color are the following:

| **model:** | **description**: | **color-spec**: | **example**: |
|---|---|---|---|
| `gray` | you can only define shades of gray | just one number between 0 (black) and 1 (white), so 0.95 will be very light gray, 0.30 will be dark gray | \definecolor{light-gray}{gray}{0.95} |
| `rgb` | you refer to the *R*ed-*G*reen-*B*lue model | three number given in the form *red,green,blue*; the quantity of each color is represented with a number between 0 and 1 | \definecolor{orange} {rgb}{1,0.5,0} |
| `cmyk` | you refer to the *C*yan *M*agenta *Y*ellow blac*K* model | four numbers given in the form *cyan,magenta,yellow,black* | \definecolor{orange} {cmyk}{0,0.5,1,0} |

The simplest way to type colored text is by:

```
\textcolor{declared-color}{text}
```

where *declared-color* is a color that was defined before by `\definecolor`. Another possible way is by

```
\color{declared-color}
```

that will switch the standard text color to the color you want. It will work until the end of the current TeX group. For example:

```
this is standard black text, {\color{red} this will look red},
and this will look black again.
```

The difference between `\textcolor` and `\color` is the same difference between `\texttt` and `\ttfamily`, you can use the one you prefer.

Finally, you can also change the background color of the whole page by:

```
\pagecolor{declared-color}
```

# Chapter 22

# Hyperref

The package `hyperref` provides LaTeX the ability to create hyperlinks within the document. It works with *pdflatex* and also with standard "latex" used with dvips and ghostscript or dvipdfm to build a PDF file. If you load it, you will have the possibility to include interactive external links and all your internal references will be turned to hyperlinks. The compiler *pdflatex* makes it possible to create PDF files directly from the LaTeX source, and PDF supports more features than DVI. In particular PDF supports hyperlinks, and the only way to introduce them in LaTeX is using `hyperref`. Moreover, PDF can contain other information about a document such as the title, the author, etc., and you can edit those using this same package.

## Usage

The basic usage with the standard settings is straightforward. Just load the package in the preamble, at the end of *all* the other packages but prior to other settings:

```
\usepackage{hyperref}
```

This will automatically turn all your internal references into hyperlinks. It won't affect the way to write your documents: just keep on using the standard `\label`/`\ref` system; with `hyperref` those "connections" will become links and you will be able to click on them to be redirected to the right page. Moreover the table of contents, list of figures/tables and index will be made of hyperlinks, too.

The package provides three useful commands for inserting links pointing outside the document:

- `\hyperref[label_name]{link text}`: this will have the same effect as `\ref{label_name}` but will make the text *link text* a full link, instead. The two can be combined, for example in

```
we use \hyperref[mainlemma]{lemma \ref{mainlemma}}
```

If the lemma labelled as "mainlemma" was number 4.1.1, then the outputted text would be "we use lemma 4.1.1" with the hyperlink as expected.

- \url{my_url}: it will show the URL using a mono-spaced font and, if you click on it, your browser will be opened pointing at it.
- \href{my_url}{description}: it will show the string "description" using standard document font but, if you click on it, your browser will be opened pointing at "my_url". Here is an example:

```
\url{http://www.wikibooks.org}
\href{http://www.wikibooks.org}{wikibooks home}
```

both point at the same page, but in the first case the URL will be shown, while in the second case the URL will be hidden. Note that, if you print your document, the link stored using \href will not be shown anywhere in the document. You can use relative paths to link documents near the location of your current document; in order to do so, use the standard unix-like notation (./ is the current directory, ../ is the previous directory, etc.)

A possible way to insert emails is by

```
\textbackslash{}href\{mailto:my\_address@wikibooks.org\}
\{my\_address@wikibooks.org\}
```

it just shows your email address (so people can know it even if the document is printed on paper) but, if the reader clicks on it, (s)he can easily send you an email. Or, to incorporate the url package's formatting and line breaking abilities into the displayed text, use [1]

```
\textbackslash{}href\{mailto:my\_address@wikibooks.org\}
\{\textbackslash{}nolinkurl\{my\_address@wikibooks.org\}\}
```

When using this form, note that the \nolinkurl command is fragile and if the hyperlink is inside of a moving argument, it must be preceeded by a \protect command.

## Customization

The standard settings should be fine for most users, but if you want to change something, you can easily do it. There are several variables you can change and there are two methods to pass those to the package. You can pass the options as an argument of the package when you load it (that's the standard way packages work), or you can use the \hypersetup package:

```
\hypersetup{option1, option2}
```

you can pass as many options as you want, separate them with a comma. Those options have to be in the form:

```
variable_name=new_value
```

[1] Email link with hyperref, url packages — comp.text.tex User Group

exactly the same format has to be used if you pass those options to the package while loading it, like this:

```
\usepackage[pdftex,option1, option2]{hyperref}
```

Note that you always have to use the `pdftex` option, otherwise you will get an error; if you use the `\hypersetup` command, your code will be clearer and more readable (even if the effect is exactly the same).

Here is a list of the possible variables you can change (for the complete list, see the official documentation). The default values are written in an upright font:

| **variable** | **values** | **comment** |
|---|---|---|
| `bookmarks` | =true,*false* | show or hide the bookmarks bar when displaying the document |
| `unicode` | =false,*true* | allows to use characters of non-Latin based languages in Acrobat's bookmarks |
| `pdfborder` | ={text} | set the style of the border around a link e.g. {0 0 0} gives no border |
| `pdftoolbar` | =true,*false* | show or hide Acrobat's toolbar |
| `pdfmenubar` | =true,*false* | show or hide Acrobat's menu |
| `pdffitwindow` | =true,*false* | adjust the initial magnification of the PDF when displayed |
| `pdftitle` | ={text} | define the title that gets displayed in the "Document Info" window of Acrobat |
| `pdfauthor` | ={text} | the name of the PDF's author, it works like the one above |
| `pdfsubject` | ={text} | subject of the document, it works like the one above |
| `pdfnewwindow` | (=true,*false)* | define if a new window should get opened when a link leads out of the current document |
| `pdfkeywords` | ={text} | list of keywords |
| `colorlinks` | (=false,*true)* | surround the links by color frames (`false`) or colors the text of the links (`true`). The color of these links can be configured using the following options (default colors are shown): |
| `linkcolor` | =red | color of internal links (sections, pages, etc.) |
| `citecolor` | =green | color of citation links (bibliography) |
| `filecolor` | =magenta | color of file links |
| `urlcolor` | =cyan | color of URL links (mail, web) |

In order to speed up your customization process, here is a list with the variables with their default value. Copy it in your document and make the changes you want. Next to the variables, there is a short explanations of their meaning:

```
\hypersetup{
    bookmarks=true,         % show bookmarks bar?
    unicode=false,          % non-Latin characters in Acrobat's bookmarks
```

```
    pdftoolbar=true,        % show Acrobat's toolbar?
    pdfmenubar=true,        % show Acrobat's menu?
    pdffitwindow=true,      % page fit to window when opened
    pdftitle={My title},    % title
    pdfauthor={Author},     % author
    pdfsubject={Subject},   % subject of the document
    pdfnewwindow=true,      % links in new window
    pdfkeywords={keywords}, % list of keywords
    colorlinks=false,       % false: boxed links; true: colored links
    linkcolor=red,          % color of internal links
    citecolor=green,        % color of links to bibliography
    filecolor=magenta,      % color of file links
    urlcolor=cyan           % color of external links
}
```

If you don't need such a high customization, here are some smaller but useful examples. When creating PDFs destined for printing, colored links are not a good thing as they end up in gray in the final output, making it difficult to read. You can use color frames, which are not printed:

```
\usepackage{hyperref}
\hypersetup{colorlinks=false}
```

or make links black:

```
\usepackage[pdftex]{hyperref}
\hypersetup{
    colorlinks,%
    citecolor=black,%
    filecolor=black,%
    linkcolor=black,%
    urlcolor=black
}
```

When you just want to provide information for the Document Info section of the PDF file:

```
\usepackage[pdfauthor={Author's name},%
pdftitle={Document Title},%
pdftex]{hyperref}
```

By default, URLs are printed using mono-spaced fonts. If you don't like it and you want them to be printed with the same style of the rest of the text, you can use this: `\urlstyle{same}`

## Problems with Links

Messages like the following:

```
! pdfTeX warning (ext4): destination with the same
identifier (name{page.1}) has been already used,
duplicate ignored
```

appear when a counter gets reinitialized, for example by using the command `\mainmatter` provided by the book document class. It resets the page number counter to 1 prior to the first chapter of the book. But as the preface of the book also has a page number 1 all links to "page 1" would not be unique anymore, hence the notice that "duplicate has been ignored." The counter measure consists of putting `plainpages=false` into the `hyperref` options. This unfortunately only helps with the page counter. An even more radical solution is to use the option `hypertexnames=false`, but this will cause the page links in the index to stop working.

The best solution is to give each page a unique name by using the `\pagenumbering` command:

```
\pagenumbering{alph}    % a, b, c, ...
... titlepage, other front matter ...
\pagenumbering{roman}   % i, ii, iii, iv, ...
\setcounter{page}{1}
... table of contents, table of figures, ...
\pagenumbering{arabic}  % 1, 2, 3, 4, ...
\setcounter{page}{1}
... beginning of the main matter (chapter 1) ...
```

By changing the page numbering every time before the counter is reset, each page gets a unique name. In this case, the pages would be numbered a, b, c, i, ii, iii, iv, v, 1, 2, 3, 4, 5, ...

If you don't want the page numbers to be visible (for example, during the front matter part), use `\pagestyle{empty}` ... `\pagestyle{plain}`. The important point is that although the numbers are not visible, each page will have a unique name.

The problem can also occur with the `algorithms` package: because each algorithm uses the same line-numbering scheme, the line identifiers for the second and follow-on algorithms will be duplicates of the first.

## Problems with Bookmarks

The text displayed by bookmarks does not always look like you expect it to look. Because bookmarks are "just text", much fewer characters are available for bookmarks than for normal LATEX text. Hyperref will normally notice such problems and put up a warning:

```
Package hyperref Warning:
Token not allowed in a PDFDocEncoded string:
```

You can now work around this problem by providing a text string for the bookmarks, which replaces the offending text:

```
\texorpdfstring{TEX text}{Bookmark Text}
```

Math expressions are a prime candidate for this kind of problem:

```
\section{\texorpdfstring{$E=mc^2$}{E=mc2
```

which turns \section{$E=mc^2$} to E=mc2 in the bookmark area. Color changes also do not travel well into bookmarks:

```
\section{\textcolor{red}{Red !
```

produces the string "redRed!". The command \textcolor gets ignored but its argument (red) gets printed. If you use:

```
\section{\texorpdfstring{\textcolor{red}{Red !}{Red\ !
```

the result will be much more legible.

If you write your document in unicode and use the unicode option for the hyperref package you can use unicode characters in bookmarks. This will give you a much larger selection of characters to pick from when when using \texorpdfstring.

## Problems with tables and figures

Since hyperref points to the caption created within the float environment, which is always set below a figure or table, the figure or table itself will not be visible[2]. A workaround exists by using the package hypcap http://www.ctan.org/tex-archive/macros/latex/contrib/oberdiek/hypcap.pdf with: \usepackage[all]{hypcap} Be sure to call this package *after* loading hyperref, which should otherwise be loaded last.

[2] http://www.ctan.org/tex-archive/macros/latex/contrib/hyperref/README

# Chapter 23

# Listings

Using the package `listings` you can add non-formatted text as you would do with `\begin{verbatim}` but its main aim is to include the source code of any programming language within your document. It supports highlighting of all the most common languages and it is highly customizable. If you just want to write code within your document the package provides the *lstlisting* environment:

```
\begin{lstlisting}
put your code here
\end{lstlisting}
```

Another possibility, that is very useful if you created a program on several files and you are still editing it, is to import the code from the source itself. This way, if you modify the source, you just have to recompile the LaTeX code and your document will be updated. The command is: `\lstinputlisting{source_filename.py}` in the example there is a Python source, but it doesn't matter: you can include any file but you have to write the full file name. It will be considered plain text and it will be highlighted according to your settings, that means it doesn't recognize the programming language by itself.

It supports the following programming languages:

| | | |
|---|---|---|
| ABAP | IDL | Plasm |
| ACSL | inform | POV |
| Ada | Java | Prolog |
| Algol | JVMIS | Promela |
| Ant | ksh | Python |
| Assembler | Lisp | R |
| Awk | Logo | Reduce |
| bash | make | Rexx |
| Basic | Mathematica[1] | RSL |
| C | Matlab | Ruby |
| C++ | Mercury | S |
| Caml | MetaPost | SAS |

| | | |
|---|---|---|
| Clean | Miranda | Scilab |
| Cobol | Mizar | sh |
| Comal | ML | SHELXL |
| csh | Modula-2 | Simula |
| Delphi | MuPAD | SQL |
| Eiffel | NASTRAN | tcl |
| Elan | Oberon-2 | TeX |
| erlang | OCL | VBScript |
| Euphoria | Octave | Verilog |
| Fortran | Oz | VHDL |
| GCL | Pascal | VRML |
| Gnuplot | Perl | XML |
| Haskell | PHP | XSLT |
| HTML | PL/I | |

For some of them, several dialects are supported. For more information, refer to the documentation that comes with the package, it should be within your distribution under the name listings-*.dvi.

*Notes* 1 — It supports Mathematica code only if you are typing in plain text format. You can't include *.NB files `\lstinputlisting{...}` as you could with any other programming language, but Mathematica can export in a pretty-formatted LaTeX source.

you can modify several parameters that will affect how the code is shown. You can put the following code anywhere in the document (it doesn't matter whether before or after `\begin{document}`), change it according to your needs. The meaning is explained next to any line.

```
\lstset{ %
language=Octave,                % choose the language of the code
basicstyle=\footnotesize,       % the size of the fonts that are
                                % used for the code
numbers=left,                   % where to put the line-numbers
numberstyle=\footnotesize,      % the size of the fonts that are
                                % used for the line-numbers
stepnumber=2,                   % the step between two line-numbers.
                                % If it's 1 each line will be numbered
numbersep=5pt,                  % how far the line-numbers are from the code
backgroundcolor=\color{white}, % choose the background color. You must
                                  % add \usepackage{color}
showspaces=false,               % show spaces adding particular underscores
showstringspaces=false,         % underline spaces within strings
showtabs=false,                 % show tabs within strings adding
                                % particular underscores
frame=single,                   % adds a frame around the code
tabsize=2,                      % sets default tabsize to 2 spaces
captionpos=b,                   % sets the caption-position to bottom
```

```
breaklines=true,            % sets automatic line breaking
breakatwhitespace=false,    % sets if automatic breaks should
                            % only happen at whitespace
escapeinside={\%*}{*)}      % if you want to add a comment
                            % within your code
}
```

The last line needs an explanation. You need it if you want to add some text within the code that will not be printed. Note that, by default, comments of the language you are inserting will be printed; the command `escapeinside={A}{B}` will define comments for `listings` only. All the code between the string "A" and "B" will be ignored. In the example above, the comments for *Octave* start with *%*, and they are going to be printed in the document unless they start with *%**, but you have to remember to "close" the comment with another "*".

If you add the above paragraph, the following can be used to alter the settings within the code:

```
\lstset{language=C,caption=Descriptive Caption Text,label=DescriptiveLabel}
```

A lot more detailed information can be found in a PDF by Carsten Heinz.

Details and documentation about the Listings package can be found at its CTAN website.

# Chapter 24

# Rotating

The package `rotating` gives you the possibility to rotate any object of an arbitrary angle. Once you have loaded it with the standard command in the preamble:

```
\usepackage{rotating}
```

you can use three new environments:

```
\begin{sideways}
```

it will rotate the whole argument by 90 degrees counterclockwise. Moreover:

```
\begin{turn}{30}
```

it will turn the argument of 30 degrees. You can give any angle as an argument, whether it is positive or negative. It will leave the necessary space to avoid any overlapping of text.

```
\begin{rotate}{30}
```

like `turn`, but it will not add any extra space.

**NOTE**: Many DVI viewers do not support rotating of text and tables. The text will be displayed normally. You must convert your DVI file to a PDF document and view it in a PDF viewer to see the rotation in effect.

# Chapter 25

# Beamer

You can also make your presentation by using latex and the Beamer package.

The beamer package is provided with most of LaTeX distribution, but you can also find it on CTAN. A very good documentation comes with the package, explaining the usage of the package on more leveles of detail.

here is a simple template to create your first slide :

```
\documentclass{beamer}
\begin{document}
%the frame environnement creates a new slide
\begin{frame}
   %put the slide title like this
   \frametitle{My first Frame}
   %items are classy for presentations !!
   \begin{itemize}
      \item you can
      \item even put items
   \end{itemize}
\end{frame}
\end{document}
```

You can do a lot more with beamer animations, table of contents ..

# Chapter 26

# Xy

Xy-pic is a package for typesetting graphs and diagrams developed by K.H. Rose and R. Moore. There is already a number of tutorials and/or descriptions available at the internet how to use the package; see for example Xy-pic — Typesetting graphs and diagrams in TeX which contains further links.

## A simple diagram

However, in my own daily work I just need a subset of commands to create the neccessary diagrams and therefore I will only describe those commands.

## References

- Xy-pic — Typesetting graphs and diagrams in TeX
- K.H. Rose, Xy-pic User's Guide
- K.H. Rose & R. Moore, Xy-pic Reference Manual

# Chapter 27

# Producing Mathematical Graphics

Most people use LaTeX for typesetting their text. But as the non content and structure oriented approach to authoring is so convenient, LaTeX also offers the possibility for producing graphical output from textual descriptions. Furthermore, quite a number of LaTeX extensions have been created in order to overcome these restrictions. In this chapter, you will learn about a few of them.

## Overview

The `picture` environment allows programming pictures directly in LaTeX. On the one hand, there are rather severe constraints, as the slopes of line segments as well as the radii of circles are restricted to a narrow choice of values. On the other hand, the picture environment of LaTeX2e brings with it the `\qbezier` command, "q" meaning *quadratic*. Many frequently-used curves such as circles, ellipses, and catenaries can be satisfactorily approximated by quadratic Bézier curves, although this may require some mathematical toil. If a programming language like Java is used to generate `\qbezier` blocks of LaTeX input files, the picture environment becomes quite powerful.

Although programming pictures directly in LaTeX is severely restricted, and often rather tiresome, there are still reasons for doing so. The documents thus produced are "small" with respect to bytes, and there are no additional graphics files to be dragged along.

Packages like `epic`, `eepic` or `pstricks` enhance the original picture environment, and greatly strengthen the graphical power of LaTeX.

While the former two packages just enhance the picture environment, the `pstricks` package has its own drawing environment, `pspicture`. The power of `pstricks` stems from the fact that this package makes extensive use of PostScript possibilities. In addition, numerous packages have been written for specific purposes. One of them is *XY-pic,* described at the end of this chapter. A wide variety of these packages is

described in detail in *The LaTeX Graphics Companion* (not to be confused with *The LaTeX Companion*).

Perhaps the most powerful graphical tool related with LaTeX is MetaPost, the twin of Donald E. Knuth's METAFONT. MetaPost has the very powerful and mathematically sophisticated programming language of METAFONT. Contrary to METAFONT, which generates bitmaps, MetaPost generates encapsulated PostScript files, which can be imported in LaTeX. For an introduction, see *A User's Manual for MetaPost.* A very thorough discussion of LaTeX and TEX strategies for graphics (and fonts) can be found in *TEX Unbound.*

# The picture Environment

## Basic Commands

A `picture` environment is available in any LaTeX distribution, without the need of loading any external package. This environment is created with one of the two commands

```
\begin{picture}(x, y) ... \end{picture}
```

or

```
\begin{picture}(x, y)(x0, y0) ... \end{picture}
```

The numbers *x, y, x0, y0* refer to `\unitlength`, which can be reset any time (but not within a picture environment) with a command such as

```
\setlength{\unitlength}{1.2cm}
```

The default value of `\unitlength` is `1pt`. The first pair, $(x, y)$, effects the reservation, within the document, of rectangular space for the picture. The optional second pair, $(x_0, y_0)$, assigns arbitrary coordinates to the bottom left corner of the reserved rectangle.

Most drawing commands have one of the two forms

```
\put(x, y){object}
```

or

```
\multiput(x, y)(dx, dy){n}{object}
```

Bézier curves are an exception. They are drawn with the command

```
\qbezier(x1, y1)(x2, y2)(x3, y3)
```

## Line Segments

Line segments are drawn with the command: `\put(x, y){\line(x1, y1){length}}`

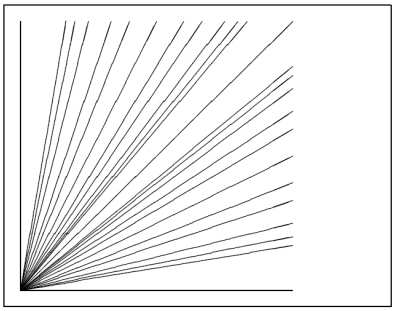
The `\line` command has two arguments:

1. a direction vector,

2. a length.

The components of the direction vector are restricted to the integers (*-6, -5, ... , 5, 6*) and they have to be coprime (no common divisor except 1). The figure below illustrates all 25 possible slope values in the first quadrant. The length is relative to `\unitlength`. The length argument is the vertical coordinate in the case of a vertical line segment, the horizontal coordinate in all other cases.

```
\setlength{\unitlength}{5cm}
\begin{picture}(1,1)
\put(0,0){\line(0,1){1}}
\put(0,0){\line(1,0){1}}
\put(0,0){\line(1,1){1}}
\put(0,0){\line(1,2){.5}}
\put(0,0){\line(1,3){.3333}}
\put(0,0){\line(1,4){.25}}
\put(0,0){\line(1,5){.2}}
\put(0,0){\line(1,6){.1667}}
\put(0,0){\line(2,1){1}}
\put(0,0){\line(2,3){.6667}}
\put(0,0){\line(2,5){.4}}
\put(0,0){\line(3,1){1}}
\put(0,0){\line(3,2){1}}
\put(0,0){\line(3,4){.75}}
\put(0,0){\line(3,5){.6}}
\put(0,0){\line(4,1){1}}
\put(0,0){\line(4,3){1}}
\put(0,0){\line(4,5){.8}}
\put(0,0){\line(5,1){1}}
\put(0,0){\line(5,2){1}}
\put(0,0){\line(5,3){1}}
\put(0,0){\line(5,4){1}}
\put(0,0){\line(5,6){.8333}}
\put(0,0){\line(6,1){1}}
\put(0,0){\line(6,5){1}}
\end{picture}
```



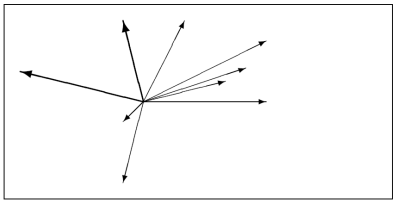
## Arrows

Arrows are drawn with the command

```
\put(x, y){\vector(x1, y1){length}}
```

For arrows, the components of the direction vector are even more narrowly restricted than for line segments, namely to the integers (*-4, -3, ... , 3, 4*). Components also have to be coprime (no common divisor except 1). Notice the effect of the `\thicklines` command on the two arrows pointing to the upper left.

```
\setlength{\unitlength}{0.75mm}
\begin{picture}(60,40)
\put(30,20){\vector(1,0){30}}
\put(30,20){\vector(4,1){20}}
\put(30,20){\vector(3,1){25}}
\put(30,20){\vector(2,1){30}}
\put(30,20){\vector(1,2){10}}
\thicklines
\put(30,20){\vector(-4,1){30}}
\put(30,20){\vector(-1,4){5}}
\thinlines
\put(30,20){\vector(-1,-1){5}}
\put(30,20){\vector(-1,-4){5}}
\end{picture}
```

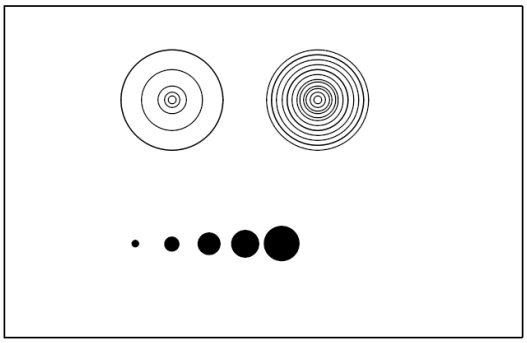


## Circles

The command `\put(x, y){\circle{diameter}}`

draws a circle with center (x, y) and diameter (not radius) diameter. The picture environment only admits diameters up to approximately 14mm, and even below this limit, not all diameters are possible. The `\circle*` command produces disks (filled circles). As in the case of line segments, one may have to resort to additional packages, such as `eepic` or `pstricks`.

```
\setlength{\unitlength}{1mm}
\begin{picture}(60, 40)
\put(20,30){\circle{1}}
\put(20,30){\circle{2}}
\put(20,30){\circle{4}}
\put(20,30){\circle{8}}
\put(20,30){\circle{16}}
\put(20,30){\circle{32}}
\put(40,30){\circle{1}}
\put(40,30){\circle{2}}
\put(40,30){\circle{3}}
\put(40,30){\circle{4}}
\put(40,30){\circle{5}}
\put(40,30){\circle{6}}
\put(40,30){\circle{7}}
\put(40,30){\circle{8}}
\put(40,30){\circle{9}}
\put(40,30){\circle{10}}
\put(40,30){\circle{11}}
\put(40,30){\circle{12}}
\put(40,30){\circle{13}}
\put(40,30){\circle{14}}
\put(15,10){\circle*{1}}
\put(20,10){\circle*{2}}
\put(25,10){\circle*{3}}
\put(30,10){\circle*{4}}
\put(35,10){\circle*{5}}
\end{picture}
```

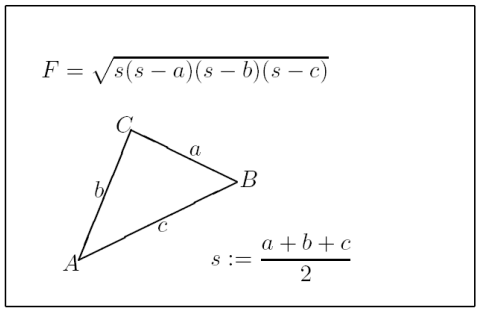


There is also a possibility within the picture environment. If one is not afraid of doing the necessary calculations (or leaving them to a program), arbitrary circles and ellipses can be patched together from quadratic Bézier curves. See *Graphics in LaTeX2e* for examples and Java source files.

## Text and formulas

As this example shows, text and formulas can be written environment with the `\put` command in the usual way:

```
\setlength{\unitlength}{0.8cm}
\begin{picture}(6,5)
\thicklines
\put(1,0.5){\line(2,1){3}}
\put(4,2){\line(-2,1){2}}
\put(2,3){\line(-2,-5){1}}
\put(0.7,0.3){$A$}
\put(4.05,1.9){$B$}
\put(1.7,2.95){$C$}
\put(3.1,2.5){$a$}
\put(1.3,1.7){$b$}
\put(2.5,1.05){$c$}
\put(0.3,4){$F=
\sqrt{s(s-a)(s-b)(s-c)}$}
\put(3.5,0.4){$\displaystyle
s:=\frac{a+b+c}{2}$}
\end{picture}
```

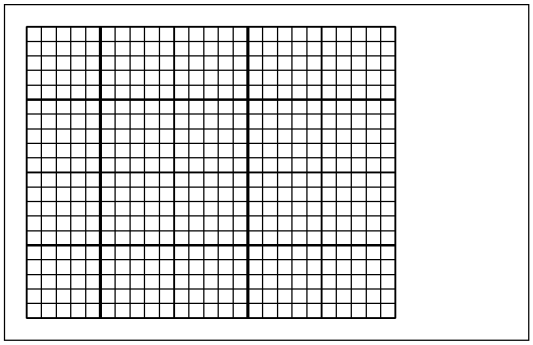



## \multiput and \linethickness

The command `\multiput(x, y)(dx, dy ){n}{object}`

has 4 arguments: the starting point, the translation vector from one object to the next, the number of objects, and the object to be drawn. The `\linethickness` command applies to horizontal and vertical line segments, but neither to oblique line segments, nor to circles. It does, however, apply to quadratic Bézier curves!

```
\setlength{\unitlength}{2mm}
\begin{picture}(30,20)
\linethickness{0.075mm}
\multiput(0,0)(1,0){26}%
{\line(0,1){20}}
\multiput(0,0)(0,1){21}%
{\line(1,0){25}}
\linethickness{0.15mm}
\multiput(0,0)(5,0){6}%
{\line(0,1){20}}
\multiput(0,0)(0,5){5}%
{\line(1,0){25}}
\linethickness{0.3mm}
\multiput(5,0)(10,0){2}%
{\line(0,1){20}}
\multiput(0,5)(0,10){2}%
{\line(1,0){25}}
\end{picture}
```



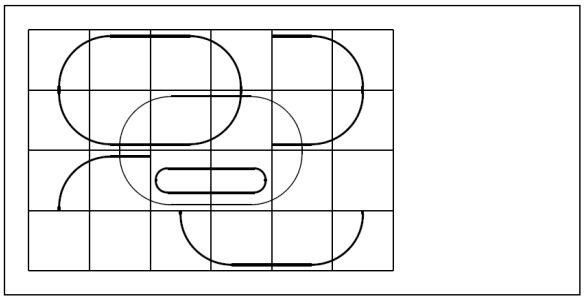
## Ovals

The command `\put(x, y){\oval(w, h)}`

or `\put(x, y){\oval(w, h)[position]}`

produces an oval centered at *(x, y)* and having width *w* and height *h*. The optional position arguments *b, t, l, r* refer to "top", "bottom", "left", "right", and can be combined, as the example illustrates. Line thickness can be controlled by two kinds of commands: `\linethickness{''length''}` on the one hand, `\thinlines` and `\thicklines` on the other. While `\linethickness{''length''}` applies only to horizontal and vertical lines (and quadratic Bézier curves), `\thinlines` and `\thicklines` apply to oblique line segments as well as to circles and ovals.

```
\setlength{\unitlength}{0.75cm}
\begin{picture}(6,4)
\linethickness{0.075mm}
\multiput(0,0)(1,0){7}%
{\line(0,1){4}}
\multiput(0,0)(0,1){5}%
{\line(1,0){6}}
\thicklines
\put(2,3){\oval(3,1.8)}
\thinlines
\put(3,2){\oval(3,1.8)}
\thicklines
\put(2,1){\oval(3,1.8)[tl]}
\put(4,1){\oval(3,1.8)[b]}
\put(4,3){\oval(3,1.8)[r]}
\put(3,1.5){\oval(1.8,0.4)}
\end{picture}
```



## Multiple Use of Predefined Picture Boxes

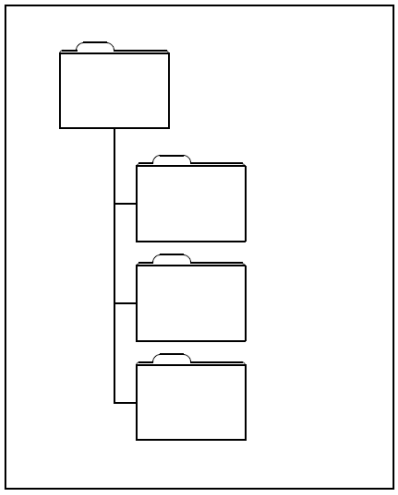
A picture box can be *declared* by the command `\newsavebox{name}` then *defined* by `\savebox{name}(width,height)[position]{content}`

and finally arbitrarily often be *drawn* by `\put(x, y)\usebox{name}`

The optional position parameter has the effect of defining the "anchor point" of the savebox. In the example it is set to "bl" which puts the anchor point into the bottom left corner of the savebox. The other position specifiers are top and right.

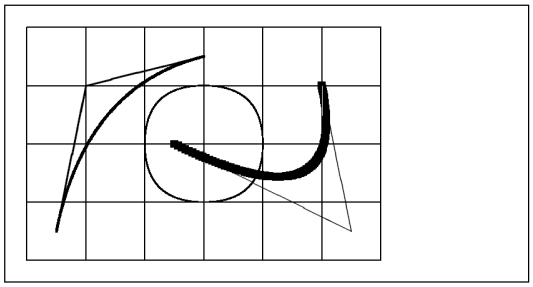
The *name* argument refers to a LaTeX storage bin and therefore is of a command nature (which accounts for the backslashes in the current example). Boxed pictures can be nested: In this example, `\foldera` is used within the definition of `\folderb`. The `\oval` command had to be used as the `\line` command does not work if the segment length is less than about 3 mm.

```
\setlength{\unitlength}{0.5mm}
\begin{picture}(120,168)
\newsavebox{\foldera}
\savebox{\foldera}
  (40,32)[bl]{% definition
  \multiput(0,0)(0,28){2}
    {\line(1,0){40}}
  \multiput(0,0)(40,0){2}
    {\line(0,1){28}}
  \put(1,28){\oval(2,2)[tl]}
  \put(1,29){\line(1,0){5}}
  \put(9,29){\oval(6,6)[tl]}
  \put(9,32){\line(1,0){8}}
  \put(17,29){\oval(6,6)[tr]}
  \put(20,29){\line(1,0){19}}
  \put(39,28){\oval(2,2)[tr]}
}

\newsavebox{\folderb}
\savebox{\folderb}
  (40,32)[l]{% definition
  \put(0,14){\line(1,0){8}}
  \put(8,0){\usebox{\foldera}}
}

\put(34,26){\line(0,1){102}}
\put(14,128){\usebox{\foldera}}
\multiput(34,86)(0,-37){3}
{\usebox{\folderb}}
\end{picture}
```



## Quadratic Bézier Curves

```
\setlength{\unitlength}{0.8cm}
\begin{picture}(6,4)
\linethickness{0.075mm}
\multiput(0,0)(1,0){7}
{\line(0,1){4}}
\multiput(0,0)(0,1){5}
{\line(1,0){6}}
\thicklines
\put(0.5,0.5){\line(1,5){0.5}}
\put(1,3){\line(4,1){2}}
\qbezier(0.5,0.5)(1,3)(3,3.5)
\thinlines
\put(2.5,2){\line(2,-1){3}}
\put(5.5,0.5){\line(-1,5){0.5}}
\linethickness{1mm}
\qbezier(2.5,2)(5.5,0.5)(5,3)
\thinlines
\qbezier(4,2)(4,3)(3,3)
\qbezier(3,3)(2,3)(2,2)
\qbezier(2,2)(2,1)(3,1)
\qbezier(3,1)(4,1)(4,2)
\end{picture}
```



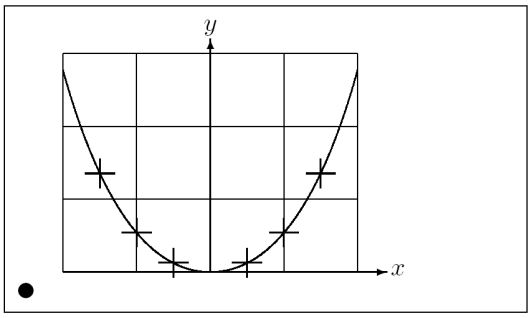
As this example illustrates, splitting up a circle into 4 quadratic Bézier curves is not satisfactory. At least 8 are needed. The figure again shows the effect of the `\linethickness` command on horizontal or vertical lines, and of the `\thinlines` and the `\thicklines` commands on oblique line segments. It also shows that both kinds of commands affect quadratic Bézier curves, each command overriding all previous ones. Let $P_1 = (x_1, y_1)$, $P_2 = (x_2, y_2)$ denote the end points, and $m_1$, $m_2$ the respective slopes, of a quadratic Bézier curve. The intermediate control point $S = (x, y)$ is then given by the equations

$$\begin{cases} x = \frac{m_2 x_2 - m_1 x_1 - (y_2 - y_1)}{m_2 - m_1} \\ y = y_i + m_i(x - x_i); \quad (i = 1, 2) \end{cases}$$

See *Graphics in LaTeX2e* for a Java program which generates the necessary `\qbezier` command line.

## Catenary

```
\setlength{\unitlength}{1cm}
\begin{picture}(4.3,3.6)(-2.5,-0.25)
\put(-2,0){\vector(1,0){4.4}}
\put(2.45,-.05){$x$}
\put(0,0){\vector(0,1){3.2}}
\put(0,3.35){\makebox(0,0){$y$}}
\qbezier(0.0,0.0)(1.2384,0.0)
(2.0,2.7622)
\qbezier(0.0,0.0)(-1.2384,0.0)
(-2.0,2.7622)
\linethickness{.075mm}
\multiput(-2,0)(1,0){5}
{\line(0,1){3}}
\multiput(-2,0)(0,1){4}
{\line(1,0){4}}
\linethickness{.2mm}
\put( .3,.12763){\line(1,0){.4}}
\put(.5,-.07237){\line(0,1){.4}}
\put(-.7,.12763){\line(1,0){.4}}
\put(-.5,-.07237){\line(0,1){.4}}
\put(.8,.54308){\line(1,0){.4}}
\put(1,.34308){\line(0,1){.4}}
\put(-1.2,.54308){\line(1,0){.4}}
\put(-1,.34308){\line(0,1){.4}}
\put(1.3,1.35241){\line(1,0){.4}}
\put(1.5,1.15241){\line(0,1){.4}}
\put(-1.7,1.35241){\line(1,0){.4}}
\put(-1.5,1.15241){\line(0,1){.4}}
\put(-2.5,-0.25){\circle*{0.2}}
\end{picture}
```

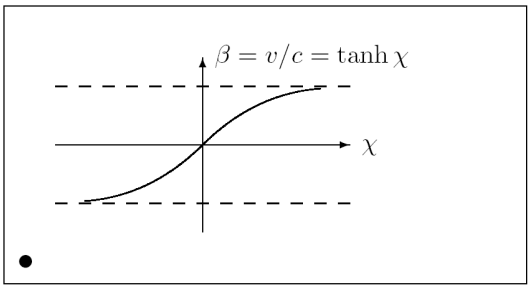



In this figure, each symmetric half of the catenary $y = \cosh x - 1$ is approximated by a quadratic Bézier curve. The right half of the curve ends in the point (2, 2.7622), the slope there having the value m = 3.6269. Using again equation (*), we can calculate the intermediate control points. They turn out to be (1.2384, 0) and (-1.2384, 0). The crosses indicate points of the real catenary. The error is barely noticeable, being less than one percent. This example points out the use of the optional argument of the \begin{picture} command. The picture is defined in convenient "mathematical" coordinates, whereas by the command `\begin{picture}(4.3,3.6)(-2.5,-0.25)`

its lower left corner (marked by the black disk) is assigned the coordinates (-2.5,-0.25).

### Plotting graphs

```
\setlength{\unitlength}{0.8cm}
\begin{picture}(6,4)(-3,-2)
\put(-2.5,0){\vector(1,0){5}}
\put(2.7,-0.1){$\chi$}
\put(0,-1.5){\vector(0,1){3}}
\multiput(-2.5,1)(0.4,0){13}
{\line(1,0){0.2}}
\multiput(-2.5,-1)(0.4,0){13}
{\line(1,0){0.2}}
\put(0.2,1.4)
{$\beta=v/c=\tanh\chi$}
\qbezier(0,0)(0.8853,0.8853)
(2,0.9640)
\qbezier(0,0)(-0.8853,-0.8853)
(-2,-0.9640)
\put(-3,-2){\circle*{0.2}}
\end{picture}
```




The control points of the two Bézier curves were calculated with formulas (*). The positive branch is determined by $P_1 = (0, 0)$, $m_1 = 1$ and $P_2 = (2, \tanh 2)$, $m_2 = 1/\cosh^2 2$. Again, the picture is defined in mathematically convenient coordinates, and the lower left corner is assigned the mathematical coordinates (-3,-2) (black disk).

### The `picture` environment and gnuplot

The powerful scientific plotting package "gnuplot" has the capability to output directly to a LaTeX `picture` environment. It is often far more convenient to plot directly to LaTeX, since this saves having to deal with potentially troublesome postscript files. Plotting scientific data (or, indeed, mathematical figures) this way gives much greater control, and of course typesetting ability, than is available from other means (such as postscript). Such pictures can then be added to a document by an `\include{}` command.

N.B. gnuplot is a powerful piece of software with a vast array of commands. A full discussion of gnuplot lies beyond the scope of this note.

## XY-pic

`xy` is a special package for drawing diagrams. To use it, simply add the following line to the preamble of your document: `\usepackage[options]{xy}` where *options* is a list of functions from *XY-pic* you want to load. These options are primarily useful

when debugging the package. I recommend you pass the `all` option, making LaTeX load all the *XY* commands.

*XY-pic* diagrams are drawn over a matrix-oriented canvas, where each diagram element is placed in a matrix slot:

```
\begin{displaymath}
    \xymatrix{A & B \\
              C & D }
\end{displaymath}
```

$$\begin{displaymath}
    \xymatrix{A & B \\
              C & D }
\end{displaymath}$$

The `\xymatrix` command must be used in math mode. Here, we specified two lines and two columns. To make this matrix a diagram we just add directed arrows using the `\ar` command.

```
\begin{displaymath}
    \xymatrix{ A \ar[r] & B \ar[d] \\
               D \ar[u] & C \ar[l] }
\end{displaymath}
```

$$\begin{displaymath}
    \xymatrix{ A \ar[r] & B \ar[d] \\
               D \ar[u] & C \ar[l] }
\end{displaymath}$$

The arrow command is placed on the origin cell for the arrow. The arguments are the direction the arrow should point to (up, down, right and left).

```
\begin{displaymath}
    \xymatrix{
        A \ar[d] \ar[dr] \ar[r] & B \\
        D                       & C }
\end{displaymath}
```

$$\begin{displaymath}
    \xymatrix{
        A \ar[d] \ar[dr] \ar[r] & B \\
        D                       & C }
\end{displaymath}$$

To make diagonals, just use more than one direction. In fact, you can repeat directions to make bigger arrows.

```
\begin{displaymath}
    \xymatrix{
        A \ar[d] \ar[dr] \ar[drr] &   &   \\
        B                         & C & D }
\end{displaymath}
```

$$\begin{displaymath}
    \xymatrix{
        A \ar[d] \ar[dr] \ar[drr] &   &   \\
        B                         & C & D }
\end{displaymath}$$

We can draw even more interesting diagrams by adding labels to the arrows. To do this, we use the common superscript and subscript operators.

```
\begin{displaymath}
    \xymatrix{
        A \ar[r]^f \ar[d]_g & B \ar[d]^{g'} \\
        D \ar[r]_{f'}       & C }
\end{displaymath}
```

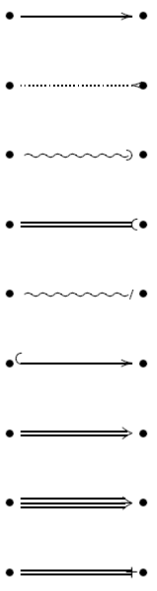
$$\begin{displaymath}
    \xymatrix{
        A \ar[r]^f \ar[d]_g & B \ar[d]^{g'} \\
        D \ar[r]_{f'}       & C }
\end{displaymath}$$

As shown, you use these operators as in math mode. The only difference is that that superscript means "on top of the arrow", and subscript means "under the arrow". There is a third operator, the vertical bar: | It causes text to be placed in the arrow.

```
\begin{displaymath}
    \xymatrix{
        A \ar[r]|f \ar[d]|g & B \ar[d]|{g'} \\
        D \ar[r]|{f'}       & C }
\end{displaymath}
```

$$\begin{displaymath}
    \xymatrix{
        A \ar[r]|f \ar[d]|g & B \ar[d]|{g'} \\
        D \ar[r]|{f'}       & C }
\end{displaymath}$$

To draw an arrow with a hole in it, use \ar[...]|\hole. In some situations, it is important to distinguish between different types of arrows. This can be done by putting labels on them, or changing their appearance

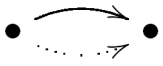


```
\shorthandoff{"}
\begin{displaymath}
    \xymatrix{
        \bullet\ar@{->}[rr]      && \bullet\\
        \bullet\ar@{.<}[rr]      && \bullet\\
        \bullet\ar@{~)}[rr]      && \bullet\\
        \bullet\ar@{=(}[rr]      && \bullet\\
        \bullet\ar@{~/}[rr]      && \bullet\\
        \bullet\ar@{^{(}->}[rr] && \bullet\\
        \bullet\ar@2{->}[rr]     && \bullet\\
        \bullet\ar@3{->}[rr]     && \bullet\\
        \bullet\ar@{=+}[rr]      && \bullet }
\end{displaymath}
\shorthandon{"}
```

Notice the difference between the following two diagrams:

```
\begin{displaymath}
    \xymatrix{ \bullet \ar[r] \ar@{.>}[r] & \bullet }
\end{displaymath}
```

```
\begin{displaymath}
    \xymatrix{
        \bullet \ar@/^/[r]
        \ar@/_/@{.>}[r] &
        \bullet }
\end{displaymath}
```



The modifiers between the slashes define how the curves are drawn. *XY-pic* offers many ways to influence the drawing of curves; for more information, check *XY-pic*

documentation.

If you are interested in a more thorough tutorial, see the XY-pic user's guide.

## Alternatives

In many cases, especially for more advanced diagrams, it may be easier to draw the graphics using external vector graphics software, and then import the file into the document (see Importing Graphics). However most software does not support LaTeX fonts or mathematical notation, which can result in ugly and inconsistent graphics.

A solution is to use textext, a plug-in for Inkscape which allows one to insert small LaTeX objects into .SVG images. These images can then be saved as .EPS (or .PDF) files which may then be imported into the LaTeX document proper.

# Chapter 28

# Advanced Topics

Here are some topics that are not really necessary to write a proper document, but could help you making your life easier and giving you some details to modify.

## Splitting the document into multiple files

As the typing goes on, your LaTeX file could get big and confusing, so it could be a good idea to split it into several other documents. For example, if you are writing a book, you could consider writing every chapter in its own `.tex` file. LaTeX makes this very easy thanks to the command: `\input{filename.tex}` While processing the document, the compiler will simply read the content of *filename.tex* and put it within the document instead of the *input* command. This way you can put all the formatting options in your "root" document and then *input* other files containing only text and very basic commands such as `\section`, etc. The code will be much cleaner and more readable.

Another method of including a file is to use `\include{filename}`. However, you cannot nest `\include` statements within a file added via `\include`, whereas you can using input. Note that this will also have an effect on the number of compiles you'll need to do. Note that using `\include` will force a page break, whereas the *input* command does not.

## Adding your own counters

In LaTeX it is fairly easy to create new counters and even counters that reset automatically when another counter is increased (think subsection in a section for example). With the command

```
\newcounter{TheNameForTheNewCounter}
```

you create a new counter that is automatically set to zero. If you want the counter to be reset to zero every time another counter is increased, use:

```
\newcounter{TheNameForTheNewCounter}[TheNameOfTheOtherCounter]
```

To increase the counter, either use

```
\stepcounter{TheNameForTheNewCounter}
```

or

```
\refstepcounter{TheNameForTheNewCounter} % used for labels and cross referencing
```

or

```
\addtocounter{TheNameForTheNewCounter}{number}
```

here the number can also be negative. For automatic reseting you need to use `\stepcounter`.

The values of the counters can be easily found by, for example:

```
\arabic{TheNameForTheNewCounter}
```

Instead of `\arabic` you could also use `\alph`, `\Alph`, `\roman`, or `\Roman`.

Here is an example for recreating something similar to a section and subsection counter that already exist in LaTeX:

```
\newcounter{mysection}
\newcounter{mysubsection}[mysection]
\addtocounter{mysection}{2} % set them to some other numbers than 0
\addtocounter{mysection}{10} % same
%
\arabic{mysection}.\arabic{mysubsection}
bla bla

\stepcounter{mysection}
\arabic{mysection}.\arabic{mysubsection}
bla bla

\stepcounter{mysubsection}
\arabic{mysection}.\arabic{mysubsection}
bla bla

\addtocounter{mysubsection}{25}
\arabic{mysection}.\arabic{mysubsection}
bla bla and more bla bla
```

12.0 bla bla
13.0 bla bla
13.1 bla bla
13.26 bla bla and more bla bla

## Creating your own package

As you know, you can easily include any package by the command: `\usepackage{packagename}` but what if you want to create your own? It is very simple:

1. create a simple text file called *mypack.sty* and open it with any text editor
2. at the beginning of the text document just write`\ProvidesPackage{mypack}`

note: it has to have the same name of the file without the extension

1. write whatever you want in it using all the LaTeX commands you know. Normally you should define new commands or import other packages.
2. import your new package with the known command`\usepackage{mypack}`

the file *mypack.sty* and the LaTeX source you are compiling must be in the same directory. It will be like that all you have written within your package were within the document itself.

It is also possible to create your own style file. Similar to the creation of your own package, you can call your own style file in the preamble of any document by the command: `\documentclass{mystyle}` The name of the style file is then *mystyle.cls* and can be opened with any text editor. At the beginning of this file, the following lines have to be provided: `\ProvidesClass{mystyle}` again, withing the style files other files or packages are imported by the requirepackage command.

See also: http://tex.loria.fr/general/new/clsguide.html

## Using different paths

When referring to an external file in the LaTeX document source, if you just write a filename the compiler will look for it in the same directory of the source. In general you can refer to any document on your hardisk, using both relative and absolute paths. In general, you might want to make your source portable (to another computer or to a different location of you hardisk), so always use relative paths. A relative path is always defined in terms of the current directory where you are running the compiler, i.e. the directory where the source you are compiling is. LaTeX uses the standard *nix notation: with a simple dot **.** you refer to the current directory, and by two dots **..** you refer to the previous directory, that is the upper one in the file system tree. By a slash **/** you can separate names of different directories. So by **./** you refer to the current directory, by **../** you refer to the previous directory, by **../../** you refer to two upper directories in the filesystem tree. Writing `\input{./filename.tex}` will have *exactly* the same effect as writing `\input{filename.tex}` but if you want to put all your files in a different directory called *myfiles*, you can refer to that file by `\input{./myfiles/filename.tex}` This lets you put your files wherever you want. Do not leave empty spaces in the filenames: they can cause ambiguous behavior. Use underscores _ instead.

It should be noted that LaTeX uses forward slashes / even when on a Microsoft Windows platform that normally uses backslashes \.

## Using \includeonly

When writing a large document, it is sometimes useful to work on one section of the document. In LaTeX, the command `\includeonly{filename1, filename2, ...}` includes only the files specified between the brackets when used in the preamble of the document.

This requires that there are `\include` commands in the document specifying these files. The filename should be written without the `.tex` file extension

```
\include{filename1}
\include{filename2}
```

## Boxes

LaTeX builds up its pages by pushing around boxes. At first, each letter is a little box, which is then glued to other letters to form words. These are again glued to other words, but with special glue, which is elastic so that a series of words can be squeezed or stretched as to exactly fill a line on the page.

I admit, this is a very simplistic version of what really happens, but the point is that TeX operates on glue and boxes. Letters are not the only things that can be boxes. You can put virtually everything into a box, including other boxes. Each box will then be handled by LATEX as if it were a single letter.

In the past chapters you have already encountered some boxes, although I did not tell you. The tabular environment and the `\includegraphics`, for example, both produce a box. This means that you can easily arrange two tables or images side by side. You just have to make sure that their combined width is not larger than the `\textwidth`.

You can also pack a paragraph of your choice into a box with either the

```
\parbox[pos]{width}{text}
```

command or the

```
\begin{minipage}[pos]{width} text \end{minipage}
```

environment. The *pos* parameter can take one of the letters `c`, `t` or `b` to control the vertical alignment of the box, relative to the baseline of the surrounding text. width takes a length argument specifying the width of the box. The main difference between a `minipage` and a `\parbox` is that you cannot use all commands and environments inside a parbox, while almost anything is possible in a minipage.

While `\parbox` packs up a whole paragraph doing line breaking and everything, there is also a class of boxing commands that operates only on horizontally aligned material. We already know one of them; it's called `\mbox`. It simply packs up a series of boxes into another one, and can be used to prevent LaTeX from breaking two words. As you can put boxes inside boxes, these horizontal box packers give you ultimate flexibility.

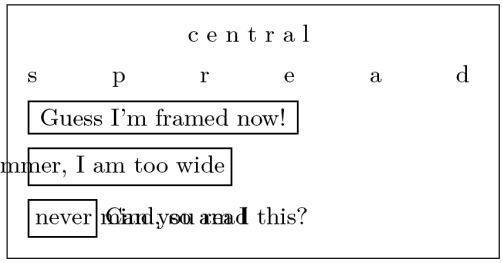
`\makebox[width][pos]{text}`

*width* defines the width of the resulting box as seen from the outside (This means it can be smaller than the material inside the box. You can even set the width to 0pt so that the text inside the box will be typeset without influencing the surrounding boxes). Besides the *length* expressions, you can also use `\width, \height, \depth,` and `\totalheight` in the width parameter. They are set from values obtained by measuring the typeset text. The *pos* parameter takes a one letter value: **c**enter, flush**l**eft, flush**r**ight, or **s**pread the text to fill the box.

The command `\framebox` works exactly the same as `\makebox`, but it draws a box around the text.

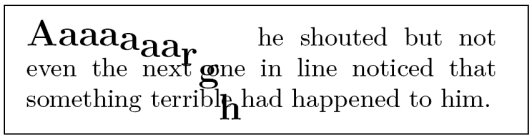
The following example shows you some things you could do with the `\makebox` and `\framebox` commands:

```
\makebox[\textwidth]{%
c e n t r a l}\par
\makebox[\textwidth][s]{%
s p r e a d}\par
\framebox[1.1\width]{Guess I'm
framed now!} \par
\framebox[0.8\width][r]{Bummer,
I am too wide} \par
\framebox[1cm][l]{never
mind, so am I}
Can you read this?
```




Now that we control the horizontal, the obvious next step is to go for the vertical. No problem for LaTeX. The `\raisebox{lift}[extend-above-baseline][extend-below-baseline]{text}` command lets you define the vertical properties of a box. You can use `\width, \height, \depth`, and `\totalheight` in the first three parameters, in order to act upon the size of the box inside the text argument:

```
\raisebox{0pt}[0pt][0pt]{\Large%
\textbf{Aaaa\raisebox{-0.3ex}{a}%
\raisebox{-0.7ex}{aa}%
\raisebox{-1.2ex}{r}%
\raisebox{-2.2ex}{g}%
\raisebox{-4.5ex}{h}}}
he shouted but not even the next
one in line noticed that something
terrible had happened to him.
```



## Rules and Struts

The \rule command in normal use produces a simple black box: \rule[lift]{width}{height}
Here is an example:

```
\rule{3mm}{.1pt}%
\rule[-1mm]{5mm}{1cm}%
\rule{3mm}{.1pt}%
\rule[1mm]{1cm}{5mm}%
\rule{3mm}{.1pt}
```

This is useful for drawing vertical and horizontal lines.

A special case is a rule with no width but a certain height. In professional typesetting, this is called a *strut*. It is used to guarantee that an element on a page has a certain minimal height. You could use it in a tabular environment to make sure a row has a certain minimum height.

# Chapter 29

# Fonts

In order to select another than the default typeface in Latex environment, it is necessary to include some command in the preamble of the document.

Consider the following example:

```
\usepackage[T1]{fontenc}
\usepackage[light,math]{iwona}
```

## Useful example

Following is an useful example found at google discussion groups http://groups.google.com/group/latexlovers/browse_thread/thread/ecd10df0d05f0501/0d3192fb8e3826da?#0d3192fb8e3826da . The example demonstrates how to select different fonts in a simple document.

```
\documentclass{book}

\newcommand\blah{blah blah blah blah blah }

\begin{document}

\blah \blah \blah \blah

\renewcommand*\rmdefault{ppl}\normalfont\upshape

\blah \blah \blah \blah

\renewcommand*\rmdefault{iwona}\normalfont\upshape

\blah \blah \blah \blah

\end{document}
```

## XeTeX

XeTeX and fontspec simplify font management considerably, additionaly enabling use of advanced typographic features.

See XeTeX entry on Wikipedia for a visual example.

## Some useful websites

The Latex Font Catalogue
LaTeX font commands
How to change fonts from Times Roman to Helvetica in Latex
LaTeX: Fonts

# Chapter 30

# Customizing LaTeX

Documents produced with the commands you have learned up to this point will look acceptable to a large audience. While they are not fancy-looking, they obey all the established rules of good typesetting, which will make them easy to read and pleasant to look at. However, there are situations where LaTeX does not provide a command or environment that matches your needs, or the output produced by some existing command may not meet your requirements.

In this chapter, I will try to give some hints on how to teach LaTeX new tricks and how to make it produce output that looks different from what is provided by default.

## New commands

To add your own commands, use the `\newcommand{name}[num]{definition}` command. Basically, the command requires two arguments: the *name* of the command you want to create, and the *definition* of the command. The *num* argument in square brackets is optional and specifies the number of arguments the new command takes (up to 9 are possible). If missing it defaults to 0, i.e. no argument allowed.

The following two examples should help you to get the idea. The first example defines a new command called `\wbal` that will print "The Wikibook about LaTeX". Such a command could come in handy if you had to write the title of this book over and over again.

```
\newcommand{\wbal}{The Wikibook about LaTeX}
This is ``\wbal'' \ldots{} ``\wbal''
```

This is "The Wikibook about LaTeX" ... "The Wikibook about LaTeX"

The next example illustrates how to define a new command that takes one argument. The `#1` tag gets replaced by the argument you specify. If you wanted to use more than one argument, use `#2` and so on, these arguments are added in an extra set of brackets.

```
\newcommand{\wbalsup}[1] {This is the Wikibook about LaTeX supported by #1}
\newcommand{\wbalTwo}[2] {This is the Wikibook about LaTeX supported by #1 #2}
% in the document body:
\begin{itemize}
\item \wbalsup{Wikimedia}
\item \wbalsup{lots of users!}
\item \wbalTwo{John}{Doe}
\end{itemize}
```

- This is the Wikibook about LaTeX supported by Wikimedia
- This is the Wikibook about LaTeX supported by lots of users!
- This is the Wikibook about LaTeX supported by John Doe

LaTeX will not allow you to create a new command that would overwrite an existing one. But there is a special command in case you explicitly want this: `\renewcommand`. It uses the same syntax as the `\newcommand` command.

In certain cases you might also want to use the `\providecommand` command. It works like `\newcommand`, but if the command is already defined, LaTeX will silently ignore it.

With LaTex2e, it is also possible to add a default parameter to a command with the following syntax: `\newcommand{name}[num][default]{definition}` If the default parameter of `\newcommand` is present, then the first of the number of arguments specified by num is optional with a default value of default; if absent, then all of the arguments are required.

```
\newcommand{\wbalTwo}[2][Wikimedia]{This is the Wikibook about LaTeX
supported by {#1} and {#2}!}
% in the document body:
\begin{itemize}
\item \wbalTwo{John Doe}
\item \wbalTwo[a lots of users]{John Doe}
\end{itemize}
```

- This is the Wikibook about LaTeX supported by Wikimedia and John Doe!
- This is the Wikibook about LaTeX supported by a lots of users and John Doe!

NOTE: when the command is used with an explicit first parameter it is given enclosed with brackets ( "`[a lots of users]`" ).

## New Environments

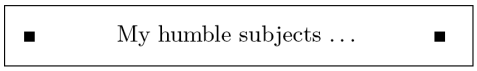
Just as with the `\newcommand` command, there is a command to create your own environments. The `\newenvironment` command uses the following syntax:

```
\newenvironment{name}[num]{before}{after}
```

Again \newenvironment can have an optional argument. The material specified in the *before* argument is processed before the text in the environment gets processed. The material in the *after* argument gets processed when the \end{''name''} command is encountered.

The example below illustrates the usage of the \newenvironment command:

```
\newenvironment{king}
{\rule{1ex}{1ex}\hspace{\stretch{1}}}
{\hspace{\stretch{1}}\rule{1ex}{1ex}}

\begin{king}
My humble subjects \ldots
\end{king}
```




The *num* argument is used the same way as in the \newcommand command. LaTeX makes sure that you do not define an environment that already exists. If you ever want to change an existing command, you can use the \renewenvironment command. It uses the same syntax as the \newenvironment command.

## Extra space

When creating a new environment you may easily get bitten by extra spaces creeping in, which can potentially have fatal effects. For example when you want to create a title environment which suppresses its own indentation as well as the one on the following paragraph. The \ignorespaces command in the begin block of the environment will make it ignore any space after executing the begin block. The end block is a bit more tricky as special processing occurs at the end of an environment. With the \ignorespacesafterend LaTeX will issue an \ignorespaces after the special 'end' processing has occurred.

```
\newenvironment{simple}%
{\noindent}%
{\par\noindent}

\begin{simple}
See the space\\to the left.
\end{simple}
Same\\here.
```

```
See the space
to the left.

  Same
here.
```

```
\newenvironment{correct}%
{\noindent\ignorespaces}%
{\par\noindent%              No space
\ignorespacesafterend}       to the left.

\begin{correct}              Same
No space\\to the left.       here.
\end{correct}
Same\\here.
```

## Command-line LaTeX

If you work on a Unix-like OS, you might be using Makefiles or any kind of script to build your LaTeX projects. In that connection it might be interesting to produce different versions of the same document by calling LaTeX with command-line parameters. If you add the following structure to your document:

```
\usepackage{ifthen}
\ifthenelse{\equal{\blackandwhite}{true}}{
% "black and white" mode; do something..
}{
% "color" mode; do something different..
}
```

Now you can call LaTeX like this:

```
latex '\newcommand{\blackandwhite}{true}\input{test.tex}'
```

First the command `\blackandwhite` gets defined and then the actual file is read with input. By setting `\blackandwhite` to false the color version of the document would be produced.

### Creating your own package

If you define a lot of new environments and commands, the preamble of your document will get quite long. In this situation, it is a good idea to create a LaTeX package containing all your command and environment definitions. You can then use the `\usepackage` command to make the package available in your document. Writing a package basically consists of copying the contents of your document preamble into a separate file with a name ending in `.sty`.

It is very simple, just follow the steps:

1. create a simple text file called *mypack.sty* (or any other name you like) and open it with any text editor
2. at the very beginning of the text document just write`\ProvidesPackage{mypack}`

3. note: it has to have the same name of the file without the extension. It tells LaTeX the name of the package and will allow it to issue a sensible error message when you try to include a package twice.

4. write whatever you want in it using all the LaTeX commands you know. Normally you should define new commands or import other packages.

5. import your new package with the known command`\usepackage{mypack}`

the file *mypack.sty* and the LaTeX source you are compiling must be in the same directory. It will be like that all you have written within your package were within the document itself.

# Creating your own style

It is also possible to create your own style file. The process is similar to the creation of your own package, you can call your own style file in the preamble of any document by the command: `\documentclass{mystyle}` The name of the style file is then *mystyle.cls* and can be opened with any text editor. At the beginning of this file, the following line has to be provided: `\ProvidesClass{mystyle}` again, within the style files other files or packages are imported by the requirepackage command.

# Spacing

## Line Spacing

If you want to use larger inter-line spacing in a document, you can change its value by putting the `\linespread{factor}`

command into the preamble of your document. Use `\linespread{1.3}` for "one and a half" line spacing, and `\linespread{1.6}` for "double" line spacing. Normally the lines are not spread, so the default line spread factor is 1.

## Paragraph formatting

In LATEX, there are two parameters influencing paragraph layout. By placing a definition like:

```
\setlength{\parindent}{0pt}
\setlength{\parskip}{1ex plus 0.5ex minus 0.2ex}
```

in the preamble of the input file, you can change the layout of paragraphs. These two commands increase the space between two paragraphs while setting the paragraph indent to zero.

The `plus` and `minus` parts of the length above tell TeX that it can compress and expand the inter paragraph skip by the amount specified, if this is necessary to properly fit the paragraphs onto the page. In continental Europe, paragraphs are often

separated by some space and not indented. But beware, this also has its effect on the table of contents. Its lines get spaced more loosely now as well. To avoid this, you might want to move the two commands from the preamble into your document to some place below the command `\tableofcontents` or to not use them at all, because you'll find that most professional books use indenting and not spacing to separate paragraphs.

If you want to indent a paragraph that is not indented, you can use `\indent` at the beginning of the paragraph. Obviously, this will only have an effect when `\parindent` is not set to zero. If you want to indent the beginning of every section, you can use the `indentfirst` package, see the chapter about LaTeX/Packages for more information.

To create a non-indented paragraph, you can use `\noindent`

as the first command of the paragraph. This might come in handy when you start a document with body text and not with a sectioning command.

## Horizontal Space

LATEX determines the spaces between words and sentences automatically. To add horizontal space, use: `\hspace{length}`

If such a space should be kept even if it falls at the end or the start of a line, use `\hspace*` instead of `\hspace`. The length in the simplest case is just a number plus a unit, e.g. `\hspace{1.5 cm}`. For a list of the possible units, see the Useful Measurement Macros appendix.

The command: `\stretch{n}` generates a special rubber space. It stretches until all the remaining space on a line is filled up. If two `\hspace{\stretch{n}}` commands are issued on the same line, they grow according to the stretch factor.

```
x\hspace{\stretch{1}}
x\hspace{\stretch{3}} x
```

x x x

## Vertical Space

The space between paragraphs, sections, subsections, etc. is determined automatically by LaTeX. If necessary, additional vertical space *between two paragraphs* can be added with the command: `\vspace{length}` This command should normally be used between two empty lines. If the space should be preserved at the top or at the bottom of a page, use the starred version of the command, `\vspace*`, instead of `\vspace`. The `\stretch` command, in connection with `\pagebreak`, can be used to typeset text on the last line of a page, or to center text vertically on a page.

Additional space between two lines of the same paragraph or within a table is specified with the `\\[length]` command.

# Chapter 31

# Collaborative Writing of LaTeX Documents

**Note:** This Wikibook is based on the article *Tools for Collaborative Writing of Scientific LaTeX Documents* by Arne Henningsen that is published in *The PracTeX Journal* 2007, number 3 (http://www.tug.org/pracjourn/).

## Abstract

Collaborative writing of documents requires a strong synchronisation among authors. This Wikibook describes a possible way to organise the collaborative preparation of LaTeX documents. The presented solution is primarily based on the version control system *Subversion* (http://subversion.tigris.org). The Wikibook describes how *Subversion* can be used together with several other software tools and LaTeX packages to organise the collaborative preparation of LaTeX documents.

## Introduction

The collaborative preparation of documents requires a considerable amount of coordination among the authors. This coordination can be organised in many different ways, where the best way depends on the specific circumstances.

In this Wikibook, I describe how the collaborative writing of LaTeX documents is organised at our department (Division of Agricultural Policy, Department of Agricultural Economics, University of Kiel, Germany). I present our software tools, and describe how we use them. Thus, this Wikibook provides some ideas and hints that will be useful for other LaTeX users who prepare documents together with their co-authors.

## Interchanging Documents

There are many ways to interchange documents among authors. One possibility is to compose documents by interchanging e-mail messages. This method has the advantage that common users generally do not have to install and learn the usage of any extra software, because virtually all authors have an e-mail account. Furthermore, the author who has modified the document can easily attach the document and explain the changes by e-mail as well. Unfortunately, there is a problem when two or more authors are working, at the same time, on the same document. So, how can authors synchronise these files?

A second possibility is to provide the document on a common file server, which is available in most departments. The risk of overwriting each others' modifications can be eliminated by locking files that are currently edited. However, generally the file server can be only accessed from within a department. Hence, authors, who are out of the building, cannot use this method to update/commit their changes. In this case, they will have to use another way to contour this problem. So, how can authors access these files?

A third possibility is to use a version control system. A comprehensive list of version control systems can be found at http://en.wikipedia.org/wiki/List_of_revision_control_software Version control systems keep track of all changes in files in a project. If many authors modify a document at the same time, the version control system tries to merge all modifications automatically. Only if two (or more) authors have modified the same line, the modifications cannot be merged automatically, but the user has to resolve this 'conflict' by deciding manually, which of the two changes should be kept. Authors can also comment their modifications so that the co-authors can easily understand the workflow of this file. As version control systems generally communicate over the internet (e.g. through TCP/IP connections), they can be used from different computers with internet connection. A restrictive firewall policy might prevent the version control system from connecting to the internet. In this case, the network administrator has to be asked to open the appropriate port. The internet is only used for synchronising the files. Hence, a permanent internet connection is not required. The only drawback of a version control system could be that a it has to be installed and configured.

Moreover, a version control system is useful even if a single user is working on a project. First, the user can track (and possibly revoke) all previous modifications. Second, this is a convenient way to have a backup of the files on other computers (e.g. on the version control server). Third, this allows the user to easily switch between different computers (e.g. office, laptop, home).

## The Version Control System *Subversion*

At our department, we decided to use the open source version control system *Subversion* (http://subversion.tigris.org/). This software is considered as an improvement of the popular version control system *CVS*. The *Subversion (SVN)* version control system is based on a central *Subversion* server that hosts the 'repositories'.

A Repository can be thought of as a library, where authors keep successive revisions of one or more documents. The version control systems acts as the librarian between the author and the repository. For instance, the authors can ask the librarian to get the latest version of their projects or to commit a new version to the librarian. (see http://blogs.linux.ie/balor/2007/05/23/)

Each user has a local 'working copy' of (a part of) a remote 'repository'. For instance, users can 'update' changes from the repository to their working copy, 'commit' changes from their own working copy to the repository, or (re)view the differences between working copy and repository.

To set up a *Subversion* version control system, the *Subversion* **server** software has to be installed on a (single) computer with permanent internet access. (If this computer has no static IP address, one can use a service like DynDNS (http://www.dyndns.com/) to be able to access the server with a static hostname.) It can run on many Unix, modern MS Windows, and Mac OS X platforms.

Users do not have to install the *Subversion* **server** software, but a *Subversion* **client** software. This is the unique way to access the 'repositories' on the server. Besides the basic *Subversion* command-line client, there are several Graphical User Interface Tools (GUIs) and plug-ins for accessing the *Subversion* server (see http://subversion.tigris.org/links.html). Additionally, there are very good manuals about *Subversion* freely available on the internet (e.g. http://svnbook.red-bean.com).

At our department, we run the *Subversion* server on a *GNU-Linux* system, because most *Linux* distributions include it. In this sense, installing, configuring, and maintaining *Subversion* is a very simple task.

Most MS Windows users access the *Subversion* server by the *TortoiseSVN* client (http://tortoisesvn.tigris.org/), because it provides the most usual interface for common users. Linux users usually use the *Subversion* command-line client or *eSvn* GUI (http://zoneit.free.fr/esvn/) with *KDiff3* (http://kdiff3.sourceforge.net/) for showing complex differences.

## Hosting LaTeX files in *Subversion*

On our *Subversion* server, we have one repository for a common `texmf` tree. Its structure complies with the **TeX Directory Structure** guidelines (TDS, http://www.tug.org/tds/tds.html, see figure 31.1). This repository provides LaTeX classes, LaTeX styles, and BibTeX styles that are not available in the LaTeX distributions of the users, e.g. because they were bought or developed for the internal use at our department. All users have a working copy of this repository and have configured LaTeX to use this as their personal `texmf` tree. For instance, teTeX (http://www.tug.org/tetex/) users can edit their TeX configuration file (e.g. `/etc/texmf/web2c/texmf.cnf`) and set the variable `TEXMFHOME` to the path of the working copy of the common `texmf` tree (e.g. by `TEXMFHOME = $HOME/texmf`); MiKTeX (http://www.miktex.org/) users can add the path of the working copy of the common `texmf` tree in the 'Roots' tab of the MiKTeX Options.

If a new class or style file has been added (but not if these files have been modified), the users have to update their 'file name data base' (FNDB) before they can use these

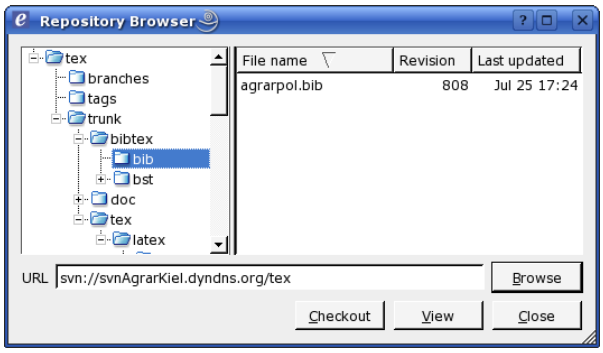



Figure 31.1: Common `texmf` tree shown in *eSvn*'s Repository Browser

classes and styles. For instance, teTeX users have to execute `texhash`; MiKTeX users have to click on the button 'Refresh FNDB' in the 'General' tab of the MiKTeX Options.

Furthermore, the repository contains manuals explaining the specific LaTeX software solution at our department (e.g. this document).

The *Subversion* server hosts a separate repository for each project of our department. Although branching, merging, and tagging is less important for writing text documents than for writing source code for software, our repository layouts follow the recommendations of the 'Subversion book' (http://svnbook.red-bean.com). In this sense, each repository has the three directories `/trunk`, `/branches`, and `/tags`.

The most important directory is `/trunk`. If a single text document belongs to the project, all files and subdirectories of this text document are in `/trunk`. If the project yields two or more different text documents, `/trunk` contains a subdirectory for each text document. A slightly different version (a **branch**) of a text document (e.g. for presentation at a conference) can be prepared either in an additional subdirectory of `/trunk` or in a new subdirectory of `/branches`. When a text document is submitted to a journal or a conference, we create a **tag** in the directory `/tags` so that it is easy to identify the submitted version of the document at a later date. This feature has been proven very useful. When creating branches and tags, it is important always to use the *Subversion* client (and not the tools of the local file system) for these actions, because this saves disk space on the server and it preserves information about the same history of these documents.

Often the question arises, which files should be put under version control. Generally, all files that are directly modified by the user and that are necessary for compiling the document should be included in the version control system. Typically, these are the LaTeX source code (`*.tex`) files (the main document and possibly some subdocuments) and all pictures that are inserted in the document (`*.eps`, `*.jpg`, `*.png`, and `*.pdf` files). All LaTeX classes (`*.cls`), LaTeX styles (`*.sty`), BibTeX data bases (`*.bib`), and BibTeX styles (`*.bst`) generally should be hosted in the repository of the common `texmf` tree, but they could be included in the respective repository, if

some (external) co-authors do not have access to the common `texmf` tree. On the other hand, all files that are automatically created or modified during the compilation process (e.g. `*.aut`, `*.aux`, `*.bbl`, `*.bix`, `*.blg`, `*.dvi`, `*.glo`, `*.gls`, `*.idx`, `*.ilg`, `*.ind`, `*.ist`, `*.lof`, `*.log`, `*.lot`, `*.nav`, `*.out`, `*.pdf`, `*.ps`, `*.snm`, and `*.toc` files) or by the (LaTeX or BibTeX) editor (e.g. `*.bak`, `*.bib~`, `*.kilepr`, `*.prj`, `*.sav`, `*.tcp`, `*.tmp`, `*.tps`, and `*.tex~` files) generally should be **not** under version control, because these files are not necessary for compilation and generally do not include additional information. Furthermore, these files are regularly modified so that conflicts are very likely.

## *Subversion* really makes the difference

A great feature of a version control system is that all authors can easily trace the workflow of a project by viewing the differences between arbitrary versions of the files. Authors are primarily interested in 'effective' modifications of the source code that change the compiled document, but not in 'ineffective' modifications that have no impact on the compiled document (e.g. the position of line breaks). Software tools for comparing text documents ('diff tools') generally cannot differentiate between 'effective' and 'ineffective' modifications; they highlight both types of modifications. This considerably increases the effort to find and review the 'effective' modifications. Therefore, 'ineffective' modifications should be avoided.

In this sense, it is very important not to change the positions of line breaks without cause. Hence, automatic line wrapping of the users' LaTeX editors should be turned off and line breaks should be added manually. Otherwise, if a single word in the beginning of a paragraph is added or removed, all line breaks of this paragraph might change so that most diff tools indicate the entire paragraph as modified, because they compare the files line by line. The diff tools *wdiff* (`http://www.gnu.org/software/wdiff/`) and *dwdiff* (`http://os.ghalkes.nl/dwdiff.html`) are not affected by the positions of line breaks, because they compare documents word by word. However, their output is less clear so that modifications are more difficult to track. Moreover, these tools cannot be used directly with the *Subversion* command-line switch `diff-cmd`, but a small wrapper script has to be used (`http://textsnippets.com/posts/show/1033`).

A reasonable convention is to add a line break after each sentence and start each new sentence in a new line. Note that this has an advantage also beyond version control: if you want to find a sentence in your LaTeX code that you have seen in a compiled (DVI, PS, or PDF) file or on a printout, you can easily identify the first few words of this sentence and screen for these words on the left border of your editor window.

Furthermore, we split long sentences into several lines so that each line has at most 80 characters, because it is rather inconvenient to search for (small) differences in long lines. (Note: For instance, the LaTeX editor *Kile* (`http://kile.sourceforge.net/`) can assist the user in this task when it is configured to add a vertical line that marks the 80th column.) We find it very useful to introduce the additional line breaks at logical breaks of the sentence, e.g. before a relative clause or a new part of the sentence starts. An example LaTeX code that is formatted according to these guidelines is the source

code of the article *Tools for Collaborative Writing of Scientific LaTeX Documents* by Arne Henningsen that is published (including the source code) in *The PracTeX Journal* 2007, Number 3 (http://www.tug.org/pracjourn/2007-3/henningsen/).

If the authors work on different operating systems, their LaTeX editors will probably save the files with different newline (end-of-line) characters (http://en.wikipedia.org/wiki/Newline). To avoid this type of 'ineffective' modifications, all users can agree on a specific newline character and configure their editor to use this newline character. Another alternative is to add the subversion property 'svn:eol-style' and set it to 'native'. In this case, *Subversion* automatically converts all newline characters of this file to the native newline character of the author's operating system (http://svnbook.red-bean.com/en/1.4/svn.advanced.props.file-portability.html#svn.advanced.props.special.eol-style).

There is also another important reason for reducing the number of 'ineffective' modifications: if several authors work on the same file, the probability that the same line is modified by two or more authors at the same time increases with the number of modified lines. Hence, 'ineffective' modifications unnecessarily increase the risk of conflicts (see section Interchanging Documents).

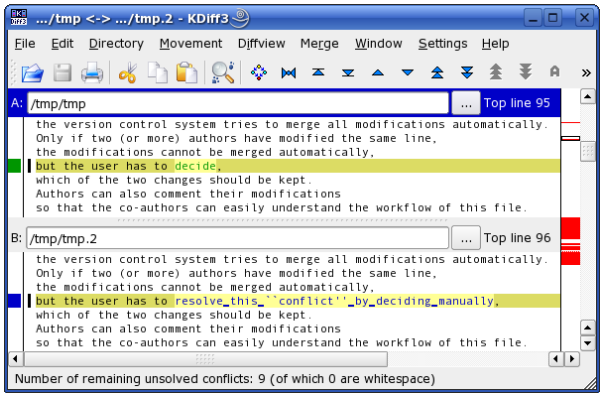



Figure 31.2: Reviewing modifications in *KDiff3*

Furthermore, version control systems allow a very effective quality assurance measure: all authors should critically review their own modifications before they commit them to the repository (see figure 31.2). The differences between the user's working copy and the repository can be easily inspected with a single *Subversion* command or with one or two clicks in a graphical *Subversion* client. Furthermore, authors should verify that their code can be compiled flawlessly before they commit their modifications to the repository. Otherwise, the co-authors have to pay for these mistakes when they want to compile the document. However, this directive is not only reasonable for version control systems but also for all other ways to interchange documents among authors.

*Subversion* has a feature called 'Keyword Substitution' that includes dynamic version information about a file (e.g. the revision number or the last author) into the con-

tents of the file itself (see e.g. http://svnbook.red-bean.com, chapter 3). Sometimes, it is useful to include these information not only as a comment in the LaTeX source code, but also in the (compiled) DVI, PS, or PDF document. This can be achieved with the LaTeX packages *svn* (http://www.ctan.org/tex-archive/macros/latex/contrib/svn/), *svninfo* (http://www.ctan.org/tex-archive/macros/latex/contrib/svninfo/), or (preferably) *svn-multi* (http://www.ctan.org/tex-archive/macros/latex/contrib/svn-multi/).

The most important directives for collaborative writing of LaTeX documents with version control systems are summarised in the following box.

**Directives for using LaTeX with version control systems**

1. Avoid 'ineffective' modifications.
2. Do not change line breaks without good reason.
3. Turn off automatic line wrapping of your LaTeX editor.
4. Start each new sentence in a new line.
5. Split long sentences into several lines so that each line has at most 80 characters.
6. Put only those files under version control that are directly modified by the user.
7. Verify that your code can be compiled flawlessly before committing your modifications to the repository.
8. Use *Subversion*'s diff feature to critically review your modifications before committing them to the repository.
9. Add a meaningful and descriptive comment when committing your modifications to the repository.
10. Use the *Subversion* client for copying, moving, or renaming files and folders that are under revision control.

If the users are willing to let go of the built-in *diff* utility of SVN and use *diff* tools that are local on their workstations, they can put to use such tools that are more tailored to text documents. The *diff* tool that comes with SVN was designed with source code in mind. As such, it is built to be more useful for files of short lines. Other tools, such as **Compare It!** allows to conveniently compare text files where each line can span hundreds of characters (such as when each line represents a paragraph). When using a *diff* tool that allows convenient views of files with long lines, the users can author the TeX files without a strict line-breaking policy.

## Managing collaborative bibliographies

Writing of scientific articles, reports, and books requires the citation of all relevant sources. BibTeX is an excellent tool for citing references and creating bibliographies (Markey 2005, Fenn 2006). Many different BibTeX styles can be found on CTAN (`http://www.ctan.org`) and on the LaTeX Bibliography Styles Database (`http://`

jo.irisson.free.fr/bstdatabase/). If no suitable BibTeX style can be found, most desired styles can be conveniently assembled with *custombib/makebst* (http://www.ctan.org/tex-archive/macros/latex/contrib/custom-bib/). Furthermore, BibTeX style files can be created or modified manually; however this action requires knowledge of the (unnamed) postfix stack language that is used in BibTeX style files (Patashnik 1988).

At our department, we have a common bibliographic data base in the BibTeX format (.bib file). It resides in our common `texmf` tree (see section 'Hosting LaTeX files in Subversion') in the subdirectory `/bibtex/bib/` (see figure 31.1). Hence, all users can specify this bibliography by only using the file name (without the full path) — no matter where the user's working copy of the common `texmf` tree is located.

All users edit our bibliographic data base with the graphical BibTeX editor *JabRef* (http://jabref.sourceforge.net/). As *JabRef* is written in *Java*, it runs on all major operating systems. As different versions of *JabRef* generally save files in a slightly different way (e.g. by introducing line breaks at different positions), all users should use the same (e.g. last stable) version of *JabRef*. Otherwise, there would be many differences between different versions of `.bib` files that solely originate from using different version of *JabRef*. Hence, it would be hard to find the real differences between the compared documents. Furthermore, the probability of conflicts would be much higher (see section 'Subversion really makes the difference'). As *JabRef* saves the BibTeX data base with the native newline character of the author's operating system, it is recommended to add the *Subversion* property 'svn:eol-style' and set it to 'native' (see section 'Subversion really makes the difference').

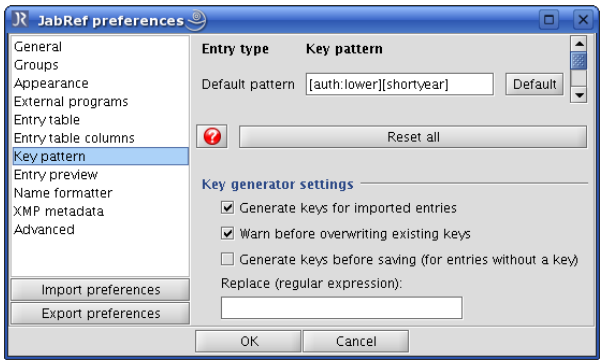



Figure 31.3: Specify default key pattern in *JabRef*

*JabRef* is highly flexible and can be configured in many details. We make the following changes to the default configuration of *JabRef* to simplify our work. First, we specify the default pattern for BibTeX keys so that *JabRef* can automatically generate keys in our desired format. This can be done by selecting `Options` → `Preferences` → `Key pattern` and modifying the desired pattern in the field `Default pattern`. For instance, we use `[auth:lower][shortyear]` to get the last name of the first author in lower case and the last two digits of the year of the publication (see figure 31.3).

Second, we add the BibTeX field `location` for information about the location,

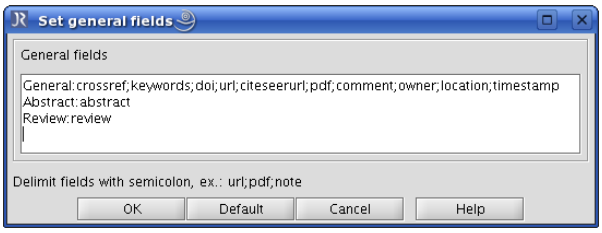



Figure 31.4: Set up general fields in *JabRef*

where the publication is available as hard copy (e.g. a book or a copy of an article). This field can contain the name of the user who has the hard copy and where he has it or the name of a library and the shelf-mark. This field can be added in *JabRef* by selecting `Options` → `Set up general fields` and adding the word `location` (using the semicolon (`;`) as delimiter) somewhere in the line that starts with `General:` (see figure 31.4).

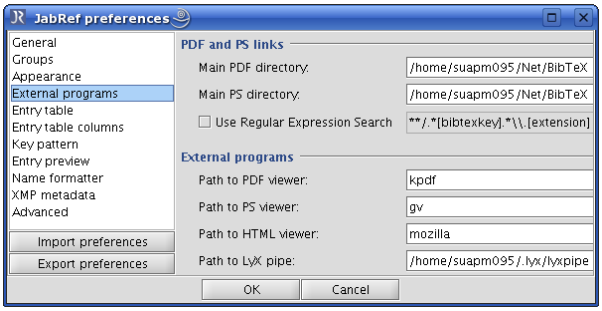



Figure 31.5: Specify 'Main PDF directory' in *JabRef*

Third, we put all PDF files of publications in a specific subdirectory in our file server, where we use the BibTeX key as file name. We inform *JabRef* about this subdirectory by selecting `Options` → `Preferences` → `External programs` and adding the path of the this subdirectory in the field `Main PDF directory` (see figure 31.5). If a PDF file of a publication is available, the user can push the `Auto` button left of *JabRef*s `Pdf` ***field to automatically add the file name of the PDF file. Now, all users who have access to the file server can open the PDF file of a publication by simply clicking on*** *JabRef*s PDF icon.

If we send the LaTeX source code of a project to a journal, publisher, or somebody else who has no access to our common `texmf` tree, we do not include our entire bibliographic data base, but extract the relevant entries with the Perl script *aux2bib* (http://www.ctan.org/tex-archive/biblio/bibtex/utils/bibtools/aux2bib/).

## Conclusion

This wikibook describes a possible way to efficiently organise the collaborative preparation of LaTeX documents. The presented solution is based on the *Subversion* version control system and several other software tools and LaTeX packages. However, there are still a few issues that can be improved.

First, we plan that all users install the same LaTeX distribution. As the *TeX Live* distribution (http://www.tug.org/texlive/) is available both for Unix and MS Windows operating systems, we might recommend our users to switch to this LaTeX distribution in the future. (Currently, our users have different LaTeX distributions that provide a different selection of LaTeX packages and different versions of some packages. We solve this problem by providing some packages on our common `texmf` tree.)

Second, we consider to simplify the solution for a common bibliographic data base. Currently it is based on the version control system *Subversion*, the graphical BibTeX editor *JabRef*, and a file server for the PDF files of publications in the data base. The usage of three different tools for one task is rather challenging for infrequent users and users that are not familiar with these tools. Furthermore, the file server can be only accessed by local users. Therefore, we consider to implement an integrated server solution like *WIKINDX* (http://wikindx.sourceforge.net/), *Aigaion* (http://www.aigaion.nl/), or *refBASE* (http://refbase.sourceforge.net/). Using this solution only requires a computer with internet access and a web browser, which makes the usage of our data base considerably easier for infrequent users. Moreover, the stored PDF files are available not only from within the department, but throughout the world. (Depending on the copy rights of the stored PDF files, the access to the server — or least the access to the PDF files — has to be restricted to members of the department.) Even Non-LaTeX users of our department might benefit from a server-based solution, because it should be easier to use this bibliographic data base in (other) word processing software packages, because these servers provide the data not only in BibTeX format, but also in other formats.

All readers are encouraged to contribute to this wikibook by adding further hints or ideas or by providing further solutions to the problem of collaborative writing of LaTeX documents.

## Acknowledgements

Arne Henningsen thanks Francisco Reinaldo and Géraldine Henningsen for comments and suggestions that helped him to improve and clarify this paper, Karsten Heymann for many hints and advices regarding LaTeX, BibTeX, and *Subversion*, and Christian Henning as well as his colleagues for supporting his intention to establish LaTeX and *Subversion* at their department.

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2. Markey, Nicolas (2005): Tame the BeaST. The B to X of BibTeX. http://www.ctan.org/tex-archive/info/bibtex/tamethebeast/ttb_en.pdf. Version 1.3.

3. Oren Patashnik. Designing BibTeX styles. http://www.ctan.org/tex-archive/info/biblio/bibtex/contrib/doc/btxhak.pdf.

## Other Methods

As the LaTeX system uses plain text, you can use collaborative editors like Gobby. In Gobby you can write your documents in collaboration with anyone in real time. It is strongly recommended that you use utf8 encoding (especially if there are users on multiple operating systems collaborating) and a stable network (typically wired networks). Google Documents also allows real-time editing of text files for anyone with a Google account.

# Chapter 32

# Tips and Tricks

## Add the Bibliography to the Table of Contents

If you are writing a *book* or *report*, you'll likely insert your bibliography using something like:

```
\begin{thebibliography}{99}
\bibitem{bib:one_book} some information
\bibitem{bib:one_article} other information
\end{thebibliography}
```

This will create a chapter-like output showing properly all your references. Anyway, even if it looks like a chapter, it will not be handled like that so it will not appear on the Table of Contents at the beginning of the document. If you want your bibliography to be in the table of contents, just add the following two lines just before the *thebibliography* environment:

```
\clearpage
\addcontentsline{toc}{chapter}{Bibliography}
```

The first line just terminates the current paragraph and page. If you are writing a *book*, you'd better use `\cleardoublepage`. The second line will add a line in the Table of Contents (first option, *toc*), it will be like the ones created by chapters (second option, *chapter*), and the third argument will be printed on the corresponding line in the Table of Contents; here *Bibliography* was chosen because it's the same text the *thebibliography* environment will automatically write when you use it, but you are free to write whatever you like.

This trick is particularly useful when you have to insert the bibliography in the Table of Contents, but it can work for anything. When LaTeX finds the code above, it will record the info as described and the current page number, inserting a new line in the Contents page.

### Add the Bibliography to the Table of Contents as numbered item

If you instead want bibliography to be numbered section or chapter, you'll likely use this way:

```
\clearpage
\section{Bibliography}

\renewcommand*{\refname}{}
\begin{thebibliography}{99}
```

This will define heading of bibliography to be empty, so you can start normal section before bibliography.

## id est & exempli gratia (i.e. & e.g.)

If you simply use the forms
i.e.
or e.g.
LaTeX will treat the periods as end of sentence periods. The correct syntax is
i.e.\
or e.g.\
which tells LaTeX not to consider the period as an end of sentence period. This syntax results in a shorter space.
Note:

1. In *Chicago* style, "i.e." and "e.g." are almost always followed by a comma.
2. If the command `\frenchspacing` has been given in the preamble, the space between sentences is already short.

## Referencing Figures or Equations

A reference to a figure/equation is normally done using the \ref{}-command.
`The result is shown in Figure \ref{fig:result}.`
To avoid that line break separated "Figure" and "\ref" use "~" to glue the reference to the description:
`The result is shown in Figure~\ref{fig:result}.`

## Grouping Figure/Equation Numbering by Section

For long documents the numbering can become cumbersome as the numbers reach into double and triple digits. To reset the counters at the start of each section and prefix the numbers by the section number, include the following in the preamble.

```
\usepackage{amsmath}
\numberwithin{equation}{section}
\numberwithin{figure}{section}
```

The same can be done with similar counter types and document units such as "subsection".

## New Square Root

While writing Mathematics, some people prefer writing the square root "closing" it over its content. This way it will look clearer what is inside the square root and what is not. This habit is not normally used while writing with the computer because the text is supposed to be clear anyway, but if you want to change the output of the square root anyway, LaTeX gives you this possibility. Just add the following code at the beginning of your document, where you would place a `\usepackage{...}` command:

```
% New definition of square root:
% it renames \sqrt as \oldsqrt
\let\oldsqrt\sqrt
% it defines the new \sqrt in terms of the old one
\def\sqrt{\mathpalette\DHLhksqrt}
\def\DHLhksqrt#1#2{%
\setbox0=\hbox{$#1\oldsqrt{#2\,}$}\dimen0=\ht0
\advance\dimen0-0.2\ht0
\setbox2=\hbox{\vrule height\ht0 depth -\dimen0}%
{\box0\lower0.4pt\box2}}
```

$$\sqrt{\frac{a}{b}} \qquad \sqrt{\frac{a}{b}}$$

This is a TeX code that first renames the `\sqrt` command as `\oldsqrt`, then redefines `\sqrt` in terms of the old one, adding something more. The new square root can be seen in the picture on the right, compared to the old one. Unfortunately this code won't work if you want to use multiple roots: if you try to write $\sqrt[b]{a}$ as `\sqrt[b]{a}` after you used the code above, you'll just get a wrong output. In other words, you can redefine the square root this way only if you are not going to use multiple roots in the whole document.

## A new *oiint* command

If you are writing about Mathematics you might need a symbol similar to `\oint` $\oint$ but with the double integral within the circle. Some LaTeX packages (e.g. esint) provide

this symbol by the command \oiint, but using such a package usually affect the output of all the formulas within your document. Since you want to keep the elegant style of LaTeX, you'd better find a way to have a new \oiint without using such packages. The only way to do it is by defining it by your own. The best approach would be to define another command using basic TeX, but by LaTeX is more straightforward. Note that we will not use the AMSmath package, so everything will work in any LaTeX document.

The symbols we will use are the integral \int $\int$ and a big circle \bigcirc . More-

over we have to be able to move those symbols on the right or on the left; the command \hspace{1cm} will introduce an horizontal space of 1 cm, it is possible to introduce negative spaces, thus moving an object on the left. We'll get the symbol we want with the following command:

```
\bigcirc \hspace{-1.4em} \int \hspace{-.8em} \int
```

The value of the negative spaces to add have been chosen after several attempts; By using the relative unit 'em' it is quite flexible. It seems to work correctly for font sizes 9 to 15 (with style extarticle) but it might not work properly for the particular font or compiler you are using. Make some tests to find the best values for you. The \int \hspace{-0.8em} \int creates the symbol of a double integral (we didn't use the standard \iint because we wanted the two integrals closer). The \bigcirc \hspace{-1.4em} creates the circus and moves the integral over it.

Obviously you don't want to type so much code whenever you need such a symbol, so just define the new command \oiint:

```
\newcommand{\oiint}{\bigcirc \hspace{-1.4em} \int \hspace{-.8em} \int}
```

Put this before the \begin{document} of your document and you can use \oiint whenever you want in Math mode. Since the last symbol within the definition is an integral, you can freely add subscripts and superscripts, they will be handled just like on the basic symbol of the integral $\int$ according to the settings you are using.

## Generic header

As explained in the previous sections, a LaTeX source can be used to generate both a DVI and a PDF file. For very basic documents the source is the same but, if the documents gets more complicated, it could be necessary to make some changes

in the source so that it will work for a format but it will not for the other. For example, all that is related to graphics has to be adapted according to the final format. As discussed in the section about floating objects, even if you should use different pictures according to the final format, you can override this limit putting in the same folder pictures in different formats (e.g., EPS and PNG) with the same name and link them without writing the extension. There is a simple way to solve this problem: `\usepackage{ifpdf}` or, if you don't have this package, you can add the following text just after `\documentclass[...]{...}`:

```
\newif\ifpdf
\ifx\pdfoutput\undefined
  \pdffalse
\else
  \ifnum\pdfoutput=1
    \pdftrue
  \else
    \pdffalse
  \fi
\fi
```

this is plain TeX code. The *ifpdf* package and this code, both define a new *if-else* you can use to change your code according to the compiler you are using. After you have used this code, you can use whenever you want in your document the following syntax:

```
\ifpdf
    % we are running pdflatex
\else
    % we are running latex
\fi
```

place after `\ifpdf` the code you want to insert if you are compiling with *pdflatex*, place after `\else` the code you want to insert if you are compiling with *latex*. For example, you can use this syntax to load different packages according to the compiler.

## Using graphs from gnuplot

A simple method to include graphs and charts in LaTeX documents is to create it within a common spreadsheet software (OpenOffice Calc or MS Office Excel etc.) and include it in the document as a cropped screenshot. However, this produces poor quality rasterized images.

It is much better is to render or draw the graphs in some vector image editor, like Inkscape or Xfig. But even this way does not allow us to use the same font and text size as the rest of the document has, not mentioning usage of mathematical formulae in the legend.

An excellent method to render graphs is through **gnuplot**, a free and versatile plotting software, that has a special output filter directly for exporting files to LaTeX. We assume, that the data is in a CSV file (comma separated text) in the first and third column. A simple gnuplot script to plot the data can look like this:

```
set format "$%g$"
set title "Graph 3: Dependence of $V_p$ on $R_0$"
set xlabel "Resistance $R_0$ [$\Omega$]"
set ylabel "Voltage $V_p$ [V]"
set border 3
set xtics nomirror
set ytics nomirror
set terminal epslatex
set output "graph1.eps"
plot "graph1.csv" using 1:3   #Plot the data
```

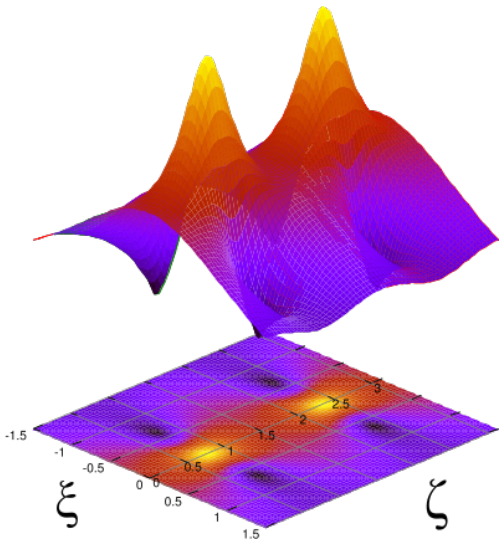


Figure 32.1: GNUPlot can plot various numerical data, functions, error distribution as well as 3D graphs and surfaces

Now gnuplot produces two files: the graph drawing in `graph.eps` and the text in `graph.tex`. The second includes the EPS image, so that we only need to include the file graph.tex in our document:

```
\input{graph1.tex}
```

The above steps can be automated by the package gnuplottex. By placing gnuplot commands inside \begin{gnuplot}\end{gnuplot}, and compiling with latex -shell-escape, the graphs are created and added into your document.

When using pdfLaTeX instead of simple LaTeX, we must convert the EPS image to PDF and to substitute the name in the `graph1.tex` file. If we are working with a Unix-like shell, it is simply done using:

```
eps2pdf graph1.eps
sed -i s/".eps"/".pdf"/g graph1.tex
```

With the included tex file we can work as with an ordinary image.

Instead of calling `eps2pdf` directly, we can also include the `epstopdf` package that automates the process. If we include a graphics now and leave out the file extension, `epstopdf` will automatically transform the .eps-file to PDF and insert it in the text.

```
\includegraphics{graph1}
```

This way, if we choose to output to PS or DVI, the EPS version is used and if we output to PDF directly, the converted PDF graphics is used. Please note that usage of `epstopdf` requires compiling with latex -shell-escape.

Note: Emacs AucTex users might want to check out Gnuplot-mode.

# Chapter 33

# General Guidelines

During this guide we have seen what it is possible to do and how this can be achieved, but the question is: I want to write a proper text with LaTeX, what to do then? where should I start from? This is a short step-by-step guide about how to start a document properly, keeping a good high-level structure. This way it will be very easy to make modifications even when the document is almost finished. These are all just suggestions, but you might take inspiration from that to create your own document.

## Project structure

Create a clear structure of the whole project this way:

1. create a directory only for the project. We'll refer to that in the following parts as the *root directory*

2. create two other directories inside the root, one for LaTeX documents, the other one for images. Since you'll have to write their name quite often, choose short names. A suggestion would be simply *tex* and *img*.

3. create your document (we'll call it document.tex, but you can use the name you prefer) and your own package (for example *mystyle.sty*); this second file will help you to keep the code cleaner.

If you followed all those steps, these files should be in your root directory, using "/" for each directory:

```
./document.tex
./mystyle.sty
./tex/
./img/
```

nothing else.

## The file `mystyle.sty`

Instead of putting all the packages you need at the beginning of your document as you could, the best way is to load all the packages you need inside another dummy package called *mystyle* you will create just for your document. The good point of doing this is that you will just have to add one single `\usepackage` in your document, keeping your code much cleaner. Moreover, all the info about your style will be within one file, so when you will start another document you'll just have to copy that file and include it properly, so you'll have exactly the same style you have used.

Creating your own style is very simple: create a file called `mystyle.sty` (you could name it as you wish, but it has to end with ".sty"). Write at the beginning: `\ProvidesPackage{mystyle}` Then add all the packages you want with the standard command `\usepackage{...}` as you would do normally, change the value of all the variables you want, etc. It will work like the code you put here would be copied and pasted within your document.

For a list of several packages you can use, see the List of Packages section.

## The main document `document.tex`

Then create a file called `document.tex`; this will be the main file, the one you will compile, even if you shouldn't need to edit it very often because you will be working on other files. It should be looking like this (it's the sample code for a *report*, but you might easily change it for an *article* or whatever else):

```
\ifx\pdfoutput\undefined % If you are running latex then:
\documentclass[12pt,a4paper]{report}
% put here packages only for the DVI:
\usepackage[dvips]{graphicx}

\else % else, you are running pdflatex:
\documentclass[pdftex,12pt,a4paper]{article}
% put here packages only for the PDF:
\usepackage[pdftex]{graphicx}
\DeclareGraphicsExtensions{.pdf,.png,.jpg,.mps}
\usepackage{hyperref}

\fi

% put all the other packages here:

\usepackage{mystyle}

\begin{document}

\input{./tex/title.tex}
%\maketitle
```

```
\tableofcontents
\listoffigures
\listoftables

\input{./tex/intro.tex}
\input{./tex/main_part.tex}
\input{./tex/conclusions.tex}

\appendix
\input{./tex/myappendix.tex}


% Bibliography:
\clearpage
\addcontentsline{toc}{chapter}{Bibliography}
\input{./tex/mybibliography.tex}

\end{document}
```

Here a lot of code expressed in previous sections has been used. At the beginning there is the header discussed in the Tips & Tricks section, so you will be able to compile in both DVI and PDF. Then you import the only package you need, that is your *mystyle.sty* (note that in the code it has to be imported without the extension), then your document starts. Then it inserts the title: we don't like the output of `\maketitle` so we created our own, the code for it will be in a file called `title.tex` in the folder called `tex` we created before. How to write it is explained in the Title Creation section. Then tables of contents, figure and tables are inserted. If you don't want them, just comment out those lines. Then the main part of the document in inserted. As you can see, there is no text in `document.tex`: everything is in other files in the `tex` directory so that you can easily edit them. We are separating our text from the structural code, so we are improving the "What You See is What You Mean" nature of LaTeX. Then we can see the appendix and finally the Bibliography. It is in a separated file and it is manually added to the table of contents using a tip suggested in the Tips & Tricks.

Once you created your `document.tex` you won't need to edit it anymore, unless you want to add other files in the `tex` directory, but this is not going to happen very often. Now you can write your document separating it in as many files as you want and adding many pictures without getting confused: thanks to the rigid structure you gave to the project, you will be able to keep track of all your edits clearly.

A suggestion: do not call your files like "chapter_01.tex" or "figure_03.png", i.e. try to avoid using numbers in file-names: if the numbering LaTeX gives them automatically is different from the one you gave (and this will likely happen) you will get really confused. When naming a file, stop for a second, think about a short name that can fully explain what is inside the file without being ambiguous, it will let you save a lot of time as soon as the document gets larger.

## Writing your document

While writing, whenever you have to take a decision about formatting, define your own command for it and add it to your `mystyle.sty`:let LaTeX work for you. If you do so, it will be very easy to change it if you change your mind. Here is an example: if you are writing a book about Mathematics and you have to use vectors, you have to decide how they will look like. There are several different standards, used in many books. If $a$ is a vector, some people like to add an arrow over it ($\vec{a}$), other people write it underlined ($\underline{a}$); another common version is to write it bold ($\mathbf{a}$). Let us assume you want to write your vectors with an arrow over them; then add the following line in your `mystyle.sty`. `\newcommand{\myvec}[1]{\vec{#1}}` and write your vectors inside the new `\myvec{...}` command. You can call it as you wish, but you'd better choose a short name because you will probably write it very often. Then, if you change your mind and you want your vectors to look differently you just have to change the definition of your `\myvec{...}`. Use this approach whenever you can: this will save you a lot of time.

# Chapter 34

# Export To Other Formats

Strictly speaking, LaTeX source can be used to directly generate two formats:

- DVI using *latex*, the first one to be supported
- PDF using *pdflatex*, more recent

Using other software freely available on Internet, you can easily convert DVI and PDF to other document formats. In particular, you can obtain the PostScript version using software coming within your LaTeX distribution. Some LaTeX IDE will give you the possibility to generate the PostScript version directly (even if it uses internally a DVI mid-step, e.g. LaTeX — DVI — PS). It is also possible to create PDF from DVI and vice versa. It doesn't seem logical to create a file with two steps when you can create it straight away, but some users might need it because, as you remember from the first chapters, the format you can generate depends upon the formats of the images you want to include (EPS for DVI, PNG and JPG for PDF). Here you will find sections about different formats with description about how to get it.

Other formats can be produced, such as RTF (which can be used in Microsoft Word) and HTML. However, these documents are produced from software that parses and interprets the LaTeX files, and do not implement all the features available for the primary DVI and PDF outputs. Nonetheless, they do work, and can be crucial tools for collaboration with colleague that do not edit documents with LaTeX.

## Convert to PDF

### DVI-> PDF

`dvipdfm my_file.dvi` will create `my_file.pdf`. Another way is to pass through PS generation:

```
dvi2ps myfile.dvi
ps2pdf myfile.ps
```

you will get also a file called *my_file.ps* that you can delete.

### Merging PDF

If you have created different PDF documents and you want to merge them into one single PDF file you can use the following command-line command. You need to have Ghostscript installed:

For Windows:

```
gswin32 -dNOPAUSE -sDEVICE=pdfwrite -sOUTPUTFILE=Merged.pdf
-dBATCH 1.pdf 2.pdf 3.pdf
```

For Linux:

```
gs -dNOPAUSE -sDEVICE=pdfwrite -sOUTPUTFILE=Merged.pdf
-dBATCH 1.pdf 2.pdf 3.pdf
```

Another option to check out is pdftk (or PDF toolkit), which is a command-line tool that can manipulate PDFs in many ways. To merge one or more files, use:

```
pdftk 1.pdf 2.pdf 3.pdf cat output 123.pdf
```

*Note:* If you are merging external PDF documents into a Latex document which is compiled with `pdflatex`, a much simpler option is to use the `pdfpages` package, e.g.:

```
\usepackage{pdfpages}
...
\includepdf[pages=-]{Document1.pdf}
\includepdf[pages=-]{Document2.pdf}
...
```

Three simple shell scripts using the pdfpages package are provided in the pdfjam bundle by D. Firth. They include options for merge several pdf (pdfjoin), put several pages in one physical sheet (pdfnup) and rotate pages (pdf90).

## Convert to PostScript

#### from PDF

```
pdf2ps my_file.pdf
```

#### from DVI

```
dvi2ps my_file.dvi
```

# Convert to RTF

LaTeX can be converted into an RTF file, which in turn can be opened by Microsoft Word and OpenOffice.org Writer. This conversion is done through latex2rtf, which can run on any computer platform. The program operates by reading the LaTeX source, and mimicking the behaviour of the LaTeX program. `latex2rtf` supports most of the standard implementations of LaTeX, such as standard formatting, some math typesetting, inclusion of EPS, PNG or JPG graphics, and tables. As well, it has some limited support for packages, such as varioref, and natbib. However, many other packages are not supported.

latex2rtf is simple to use. The Windows version has a GUI, which is straightforward to use. The command-line version is offered for all platforms, and can be used on an example `mypaper.tex` file:

```
latex mypaper
bibtex mypaper # if you use bibtex
latex2rtf mypaper
```

Both `latex` and (if needed) `bibtex` commands need to be run *before* `latex2rtf`, because the `.aux` and `.bbl` files are needed to produce the proper output. The result of this conversion will create `myfile.rtf`, which you may open in many modern word processors. Microsoft Word users can save this file as a `myfile.doc` to use features included with that program, such as "Track changes".

# Conversion to HTML

There are many converters to HTML. One option is the HEVEA program:

**LaTeX**

```
hevea mylatexfile
```

**BibTeX**

```
bibtex2html mybibtexfile
```

**TeX4ht**

TeX4ht is a very powerful conversion program, but its configuration is not straightforward. Basically a configuration file has to be prepared, and then the program is called.

# Conversion to image formats

## PNG

To convert from PDF, open your file with GIMP. It will ask you which page you want to convert, whether you want to use anti-aliasing (choose *strong* if you want to get

something similar to what you see on the screen). Try different resolutions to fit your needs, but 100 dpi should be enough. Once you have the image within GIMP, you can post-process it as you like and save it to any format supported by GIMP, as PNG for example. A method for DVI files is dvipng (usage is the same as dvipdfm). Also, the "convert" command from the ImageMagick suite can convert both DVI and PDF files to PNG.

You can optimize the resulting image using optipng so that it will take up less space.

## SVG

Convert it to PS as described before, then use the bash script ps2svg.sh (it could be possible to write a step-by-step guide for Windows as well; all the software it uses is multiplatform).

One can also use dvisvgm, an open source utility that converts from DVI to SVG.

# Chapter 35

# Internationalization

When you write documents in languages other than English, areas where LaTeX has to be configured appropriately:

1. All automatically generated text strings have to be adapted to the new language.
2. Language specific typographic rules. In French for example, there is a mandatory space before each colon character (:).
3. LaTeX needs to know the hyphenation rules for the new language.
4. You want to be able to insert all the language-specific special characters directly, without using any strange coding.

About the first, second and part of the third point, if your system is already configured appropriately (and it is, unless your LaTeX distribution has a bug), the `babel` package by Johannes Braams will take care of everything. You can use it loading in your preamble, providing as an argument the language you want to use: `\usepackage[language]{babel}`

you'd better place it soon after the `\documentclass` command, so that all the other packages you will know the language you are using. A list of the languages built into your LaTeX system will be displayed every time the compiler is started. Babel will automatically activate the appropriate hyphenation rules for the language you choose. If your LaTeX format does not support hyphenation in the language of your choice, babel will still work but will disable hyphenation, which has quite a negative effect on the appearance of the typeset document. Babel also specifies new commands for some languages, which simplify the input of special characters. See the sections about languages for more information

If you call babel with multiple languages:

```
\usepackage[languageA,languageB]{babel}
```

then the last language in the option list will be active (i.e. languageB) you can to use the command `\selectlanguage{languageA}`

to change the active language.

Most of the modern computer systems allow you to input letter of national alphabets directly from the keyboard. In order to handle variety of input encoding used for different groups of languages and/or on different computer platforms LaTeX employs the `inputenc` package: `\usepackage[encoding]{inputenc}`

When using this package, you should consider that other people might not be able to display your input files on their computer, because they use a different encoding. For example, the German umlaut ä on OS/2 is encoded as 132, on Unix systems using ISO-LATIN 1 it is encoded as 228, while in Cyrillic encoding cp1251 for Windows this letter does not exist at all; therefore you should use this feature with care. The following encodings may come in handy, depending on the type of system you are working on:

| **Operating system** | **Encodings** | |
|---|---|---|
| | Western Latin | Cyrillic |
| Mac | `applemac` | `macukr` |
| Unix | `latin1` | `koi8-ru` |
| Windows | `ansinew` | `cp1251` |
| DOS, OS/2 | `cp850` | `cp866nav` |

If you have a multilingual document with conflicting input encodings, you might want to switch to unicode, using the ucs package.

```
\usepackage{ucs}
\usepackage[utf8x]{inputenc}
```

will enable you to create LaTeX input files in utf8x, a multi-byte encoding in which each character can be encoded in as little as one byte and as many as four bytes.

Font encoding is a different matter. It defines at which position inside a TeX-font each letter is stored. Multiple input encodings could be mapped into one font encoding, which reduces number of required font sets. Font encodings are handled through fontenc package:

`\usepackage[encoding]{fontenc}`

where encoding is font encoding. It is possible to load several encodings simultaneously.

The default LaTeX font encoding is OT1, the encoding of the original Computer Modern TeX font. It contains only the 128 characters of the 7-bit ASCII character set. When accented characters are required, TeX creates them by combining a normal character with an accent. While the resulting output looks perfect, this approach stops the automatic hyphenation from working inside words containing accented characters. Besides, some of Latin letters could not be created by combining a normal character with an accent, to say nothing about letters of non-Latin alphabets, such as Greek or Cyrillic.

To overcome these shortcomings, several 8-bit CM-like font sets were created. *Extended Cork* (EC) fonts in T1 encoding contains letters and punctuation characters for most of the European languages based on Latin script. The LH font set contains letters necessary to typeset documents in languages using Cyrillic script. Because of

the large number of Cyrillic glyphs, they are arranged into four font encodings—T2A, T2B, T2C, and X2. The CB bundle contains fonts in LGR encoding for the composition of Greek text. By using these fonts you can improve/enable hyphenation in non-English documents. Another advantage of using new CM-like fonts is that they provide fonts of CM families in all weights, shapes, and optically scaled font sizes

Here is a collection of suggestions about writing a LaTeX document in a language other than English. If you have experience in a language not listed below, please add some notes about it.

## Arabic script

For languages which use the Arabic script, including Arabic, Persian, Urdu, Pashto, Kurdish, Uyghur, etc., add the following code to your preamble:

```
\usepackage{arabtex}
```

You can input text in either romanized characters or native Arabic script encodings. Use any of the following commands/environment to enter in text:

```
\< ... >
\RL{ ... }
\begin{arabtext} ... \end{arabtext}.
```

See the ArabTeX Wikipedia article for further details.

## Cyrillic script

See also the Bulgarian translation of the "Not so Short Introduction to LaTeX 2e" from http://www.ctan.org/tex-archive/info/lshort/bulgarian/lshort-bg.pdf

## Czech

Czech is fine using

```
\usepackage[czech]{babel}
\usepackage[T1]{fontenc}
\usepackage[utf8x]{inputenc}
```

You may use different encoding, but UTF-8 is becoming standard and it allows you to have „czech quotation marks“ directly in your text. Otherwise, there are macros *\glqq* and *\grqq* to produce left and right quote.

## French

Some hints for those creating French documents with LaTeX: you can load French language support with the following command: `\usepackage[frenchb]{babel}`

There are multiple options for typesetting French documents, depending on the flavor of French: `french`, `frenchb`, and `francais` for Parisian French, and `acadian` and `canadien` for new-world French. All enable French hyphenation, if you have configured your LaTeX system accordingly. All of these also change all automatic text into French: `\chapter` prints *Chapitre*, `\today` prints the current date in French and so on. A set of new commands also becomes available, which allows you to write French input files more easily. Check out the following table for inspiration:

| input code | rendered output |
|---|---|
| `\og guillemets \fg{}` | « guillemets » |
| `M\up{me}, D\up{r}` | $M^{me}$, $D^{r}$ |
| `1\ier{}, 1\iere{}, 1\ieres{}` | $1^{er}$, $1^{re}$, $1^{res}$ |
| `2\ieme{} 4\iemes{}` | $2^{e}$ $4^{es}$ |
| `\No 1, \no 2` | $N^{o}$ 1, $n^{o}$ 2 |
| `20~\degres C, 45\degres` | 20 °C, 45° |
| `M. \bsc{Durand}` | M. Durand |
| `\nombre{1234,56789}` | 1 234,567 89 |

You will also notice that the layout of lists changes when switching to the French language. For more information on what the *frenchb* option of babel does and how you can customize its behavior, run LaTeX on file frenchb.dtx and read the produced file frenchb.pdf or frenchb.dvi.

## German

Some hints for those creating German documents with LaTeX: you can load German language support with the following command: `\usepackage[german]{babel}` This enables German hyphenation, if you have configured your LaTeX system accordingly. There are multiple options for typesetting german language. Use `german` for old or `ngerman` for the new german orthography. It also changes all automatic text into German. Eg. “Chapter” becomes “Kapitel.” A set of new commands also becomes available, which allows you to write German input files more quickly even when you don’t use the inputenc package. Check out table 2.5 for inspiration. With inputenc, all this becomes moot, but your text also is locked in a particular encoding world.

| | |
|---|---|
| `"a` | ä |
| `"s` | ß |
| `"‘` or `\glqq` | „ |
| `"’` or `\grqq` | “ |
| `"<` or `\flqq` | ≪ |
| `">` or `\frqq` | ≫ |
| `\flq` | < |
| `\frq` | > |
| `\dq` | ” |

Table 35.1: German Special Characters.

In German books you often find French quotation marks (≪guillemets≫). German typesetters, however, use them differently. A quote in a German book would look like ≫this≪. In the German speaking part of Switzerland, typesetters use ≪guillemets≫ the same way the French do. A major problem arises from the use of commands like `\flq`: If you use the OT1 font (which is the default font) the guillemets will look like the math symbol ”≪“, which turns a typesetter's stomach. T1 encoded fonts, on the other hand, do contain the required symbols. So if you are using this type of quote, make sure you use the T1 encoding. (`\usepackage[T1]{fontenc}`)

## Greek

This is the preamble you need to write in the Greek language.

```
\usepackage[english,greek]{babel}
\usepackage[iso-8859-7]{inputenc}
```

This preamble enables hyphenation and changes all automatic text to Greek. A set of new commands also becomes available, which allows you to write Greek input files more easily. In order to temporarily switch to English and vice versa, one can use the commands `\textlatin{english text}` and `\textgreek{greek text}` that both take one argument which is then typeset using the requested font encoding. Otherwise you can use the command `\selectlanguage{...}` described in a previous section. Use `\euro` for the Euro symbol.

## Hungarian

Similar to Italian, but use the following lines:

```
\usepackage[magyar]{babel}
\usepackage[latin2]{inputenc}
\usepackage[T1]{fontenc}
```

- More information in hungarian.

## Italian

Italian is well supported by LaTeX. Just add *usepackage[italian]*{*babel*}* at the beginning of your document and the output of all the commands will be translated properly. You can add letters with accents without any particular setting, just write `\‘a \‘e \’e \‘i \‘o \‘u` and you will get *à è é ì ò ù* (NB: the symbol changes if the inclination of the accent changes). Anyway, if you do so, it could be quite annoying since it's time-wasting. Moreover, if you are using any spell-checking program, "città" is correct, but "citt\‘a" will be seen as a mistake. If you add *usepackage[latin1]*{*inputenc*}* at the beginning of your document, LaTeX will include correctly all your accented letters. To sum up, just add

```
\usepackage[italian]{babel}
\usepackage[latin1]{inputenc}
```

at the beginning of your document and you can write in Italian without being worried of translations and fonts. If you are writing your document without getting any error, then don't worry about anything else. If you start getting some unknown errors whenever you use an Italian letter, then you have to worry about the encoding of your files. As known, any LaTeX source is just plain text, so you'll have to insert accented letters properly within the text file. If you write your document using always the same program on the same computer, you should not have any problem. If you are writing your document using different programs, if could start getting some strange errors from the compiler. The reason could be that the accented letters were not included properly within your source file and LaTeX can't recognize them. The reason is that an editor modified your document with a different encoding from the one that was used when creating it. Most of the operating systems use UTF-8 as default, but this could create problems if are using programs based on different libraries or different operating systems. The best way to solve this problem is to change the encoding to ISO-8859-1, that includes all the letters you need. Some text editors let you change the encoding in the settings.

## Korean

To use LATEX for typesetting Korean, we need to solve three problems:

1. We must be able to edit Korean input files. Korean input files must be in plain text format, but because Korean uses its own character set outside the repertoire of US-ASCII, they will look rather strange with a normal ASCII editor. The two most widely used encodings for Korean text files are EUC-KR and its upward compatible extension used in Korean MS-Windows, CP949/Windows-949/UHC. In these encodings each US-ASCII character represents its normal ASCII character similar to other ASCII compatible encodings such as ISO-8859-x, EUC-JP, Big5, or Shift_JIS. On the other hand, Hangul syllables, Hanjas (Chinese characters as used in Korea), Hangul Jamos, Hiraganas, Katakanas, Greek and Cyrillic characters and other symbols and letters drawn from KS

X 1001 are represented by two consecutive octets. The first has its MSB set. Until the mid-1990's, it took a considerable amount of time and effort to set up a Korean-capable environment under a non-localized (non-Korean) operating system. You can skim through the now much-outdated `http://jshin.net/faq` to get a glimpse of what it was like to use Korean under non-Korean OS in mid-1990's. These days all three major operating systems (Mac OS, Unix, Windows) come equipped with pretty decent multilingual support and internationalization features so that editing Korean text file is not so much of a problem anymore, even on non-Korean operating systems.

2. TEX and LATEX were originally written for scripts with no more than 256 characters in their alphabet. To make them work for languages with considerably more characters such as Korean or Chinese, a subfont mechanism was developed. It divides a single CJK font with thousands or tens of thousands of glyphs into a set of subfonts with 256 glyphs each. For Korean, there are three widely used packages; HLATEX by UN Koaunghi, hLATEXp by CHA Jaechoon and the CJK package byWerner Lemberg. HLATEX and hLATEXp are specific to Korean and provide Korean localization on top of the font support. They both can process Korean input text files encoded in EUC-KR. HLATEX can even process input files encoded in CP949/Windows-949/UHC and UTF-8 when used along with Λ, Ω. The CJK package is not specific to Korean. It can process input files in UTF-8 as well as in various CJK encodings including EUC-KR and CP949/Windows-949/UHC, it can be used to typeset documents with multilingual content (especially Chinese, Japanese and Korean). The CJK package has no Korean localization such as the one offered by HLATEX and it does not come with as many special Korean fonts as HLATEX.

3. The ultimate purpose of using typesetting programs like TEX and LATEX is to get documents typeset in an 'aesthetically' satisfying way. Arguably the most important element in typesetting is a set of welldesigned fonts. The HLATEX distribution includes UHC PostScript fonts of 10 different families and Munhwabu fonts (TrueType) of 5 different families. The CJK package works with a set of fonts used by earlier versions of HLATEX and it can use Bitstream's cyberbit True-Type font.

To use the HLATEX package for typesetting your Korean text, put the following declaration into the preamble of your document: `\usepackage{hangul}` This command turns the Korean localization on. The headings of chapters, sections, subsections, table of content and table of figures are all translated into Korean and the formatting of the document is changed to follow Korean conventions. The package also provides automatic "particle selection." In Korean, there are pairs of post-fix particles grammatically equivalent but different in form. Which of any given pair is correct depends on whether the preceding syllable ends with a vowel or a consonant. (It is a bit more complex than this, but this should give you a good picture.) Native Korean speakers have no problem picking the right particle, but it cannot be determined which particle to use for references and other automatic text that will change while you edit

the document. It takes a painstaking effort to place appropriate particles manually every time you add/remove references or simply shuffle parts of your document around. HLATEX relieves its users from this boring and error-prone process.

In case you don't need Korean localization features but just want to typeset Korean text, you can put the following line in the preamble, instead. `\usepackage{hfont}` For more details on typesetting Korean with HLATEX, refer to the HLATEX Guide. Check out the web site of the Korean TEX User Group (KTUG) at http://www.ktug.or.kr/.

## Polish

If you plan to use Polish in your UTF-8 encoded document, use the following code

```
\usepackage[utf8]{inputenc}
\usepackage{polski}
\usepackage[polish]{babel}
```

## Portuguese

Add the following code to your preamble:

```
\usepackage[portuguese]{babel}
\usepackage[latin1]{inputenc}
\usepackage[T1]{fontenc}
```

if you are in Brazil, you can substitute the language for `brazilian`. The first line is to get everything translated properly, the second is for being able to input text correctly and the third one to get hyphenation right. Note that we are using the latin1 input encoding here, so this will not work on a Mac or on DOS. Just use the appropriate encoding for your system. If you are using Linux, use

`\usepackage[utf8]{inputenc}`

## Spanish

To enable Spanish writing, besides installing the appropriate hyphenation patterns, you type:

`\usepackage[spanish]{babel}`

The trick is that Spanish has several options and commands changing the layout. The options may be loaded either at the call to Babel, after calling spanish, or before, defining the `\spanishoptions` macro. So the following commands are roughly equivalent:

```
\def\spanishoptions{mexico}
\usepackage[spanish]{babel}
```

`\usepackage[spanish,mexico]{babel}`

On average, the former syntax should be preferred, as the latter is a deviation from standard Babel behavior, and thus may break other programs (LyX, latex2rtf2e) interacting with LaTeX.

Two particularly useful options are `es-noquoting,es-nolists`: some packages and classes are known to collide with Spanish in the way they handle active characters, and these options disable the internal workings of Spanish to allow you to overcome these common pitfalls. Moreover, these options may simplify the way LyX customizes some features of the Spanish layout from inside the GUI.

The options `mexico,mexico-com` provide support for local custom in Mexico: the former using decimal dot, as customary, and the latter allowing decimal comma, as required by the Mexican Official Norm (NOM) of the Department of Economy for labels in foods and goods. More localizations are in the making.

Two particularly useful commands are `\spanishoperators` and `\spanishdeactivate`.

The macro `\spanishoperators{`*list of operators*`}` contains a list of spanish mathematical operators, and may be redefined at will. For instance, the command `\def\spanishoperators{sen}` only defines sen, overriding all other definitions; the command `\let\spanishoperators\relax` disables them all. This command supports accented or spaced operators. For instance, the following operators are stated by default.

```
l\acute{i}m l\acute{i}m\,sup l\acute{i}m\,inf m\acute{a}x \acute{i}nf m\acute{i}n
sen tg arc\,sen arc\,cos arc\,tg cotg cosec senh tgh
```

The `\acute{`*<letter>*`}` command puts an accent, and the `\,` command adds a small space.

Finally, the macro `\spanishdeactivate{`*list of characters*`}` disables some active characters, to keep you out of trouble if they are redefined by other packages. The candidates for deactivation are the set `<>."'`.

Please check the documentation for Babel or spanish.dtx for further details.

# Chapter 36

# Links

See in Wikipedia: TeX
See in Wikipedia: LaTeX

Here are some other online resources available:

### Community

- The TeX Users Group Includes links to free versions of (La)TeX for many kinds of computer.
- Newsgroup for (La)TeX related questions
- CTAN hundreds of add-on packages and programs

### Tutorials/FAQs

- Tobias Oetiker's Not So Short Introduction to LaTex2e: http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf also at http://people.ee.ethz.ch/~oetiker/lshort/lshort.pdf
- Peter Flynn's beginner's guide (formatting): http://www.ctan.org/tex-archive/info/beginlatex/beginlatex-3.6.pdf
- The AMS Short Math Guide for LaTeX, a concise summary of math formula typesetting features </br> http://www.ams.org/tex/amslatex.html
- amsmath users guide (PDF) and related files: http://www.ctan.org/tex-archive/macros/latex/required/amslatex/math/
- LaTeX Primer from the Indian TeX Users Group: http://sarovar.org/projects/ltxprimer/
- LaTeX Primer http://www.maths.tcd.ie/~dwilkins/LaTeXPrimer/
- PSTricks–fancy graphics exploiting PDF capabilities http://sarovar.org/projects/pstricks/

- PDFScreen–create LaTeX PDF files that have navigation buttons used for presentations: http://sarovar.org/projects/pdfscreen/
- David Bausum's list of TeX primitives (these are the fundamental commands used in TeX): http://www.tug.org/utilities/plain/cseq.html
- Leslie Lamport's manual for the commands that are unique to LaTeX (commands not used in plain TeX): http://www.tex.uniyar.ac.ru/doc/latex2e.pdf
- The UK TeX FAQ List of questions and answers that are frequently posted at comp.text.tex http://www.tex.ac.uk/faq
- TeX on Mac OS X: Guide to using TeX and LaTeX on a Mac http://www.rna.nl/tex.html
- Text Processing using LaTeX http://www-h.eng.cam.ac.uk/help/tpl/textprocessing/
- The (La)TeX encyclopaedia http://tex.loria.fr/index.html
- Hypertext Help with LaTeX http://www.giss.nasa.gov/latex/
- EpsLatex: a very comprehensive guide to images, figures and graphics http://www.ctan.org/tex-archive/info/epslatex.pdf
- The Comprehensive LaTeX Symbol List (in PDF) http://www.ctan.org/tex-archive/info/symbols/comprehensive/symbols-a4.pdf
- Getting to Grips with LaTeX (HTML) Collection of Latex tutorials taking you from the very basics towards more advanced topics http://www.andy-roberts.net/misc/latex/index.html
- Chapter 8 (about typesetting mathematics) of the *LaTeX companion* http://www.macrotex.net/texbooks/latexcomp-ch8.pdf

## Reference

- LaTeX Project Site
- The Comprehensive TeX Archive Network Latest (La)TeX-related packages and software
- TeX Directory Structure, used by many (La)TeX distributions
- Natural Math converts natural language math formulas to LaTeX representation
- Obsolete packages and commands
- Lamport's book *LaTeX: A Document Preparation System*

### Templates

- LaTeX template for writing PhD thesis, 2007
- UCL computer department thesis template
- UT thesis template, 2006

# Chapter 37

# Authors

## Included books

The following books have been included in this wikibook (or we are working on it!), with permission of the author:

- Andy Roberts' Getting to grips with Latex. **(Done!)**
- Not So Short Introduction to LaTex2e by Tobias Oetiker, Hubert Partl and Irene Hyna. We have contacted the authors by email asking for permission: they allowed us to use their material, but they never edited directly this wikibook. That book is released under the GPL, that is not compatible with the GFDL used here in Wikibooks. Anyway, we have the permission of the authors to use their work. You can freely copy text from that guide to here. If you find text on both the original book and here on Wikibooks, then that text is double licensed under GPL and GFDL. For more information about Tobias Oetiker and Hubert Partl, their websites are `http://it.oetiker.ch/` and `http://homepage.boku.ac.at/partl/` respectively. **(Done!)**
- Peter Flynn's Formatting information, a beginner's guide to typesetting with LaTeX. We have contacted him by email asking for permission to use his work. The original book is released under the *GNU Free Documentation License*, the same as Wikibooks. For more information, his personal website is `http://imbolc.ucc.ie/~pflynn/` **(Working...)**
- LaTeX Primer from the Indian TeX Users Group. Their document is released under the *GNU Free Documentation License*, the same as Wikibooks, so we can include parts of their document as we wish. In any case, we have contacted Indian TeX Users Group and they allowed us to do it. **(Working...)**
- David Wilkins' Getting started with LaTeX. The book is not released under any free license, but we have contacted the author asking him for the permission to use parts of his book on Wikibooks. He agreed: his work is still protected

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## Wiki users

Major contributors to the book on Wikibooks are:

- Alessio Damato
- Jtwdog

# Appendix A

# Installation

Installing "LaTeX" is not a simple one-click download and install. Multiple programs often need to be downloaded and installed in order to have a suitable computer system that can be used to create publishable output, such as PDFs. The basic requirement is to have TeX and LaTeX. Optional, and recommended installations include an attractive editor to write LaTeX source documents (this is probably where you will spend most of your time), and a bibliographic management program to manage references.

## TeX and LaTeX

TeX and LaTeX are available for most computer platforms, since they were programed to be very portable. They are most commonly installed using a distribution, such as teTeX, MiKTeX, or MacTeX. This, however, does not include any editor or advanced graphical user interface. Other programs, that are not part of the distribution, are used to write and prepare TeX and LaTeX files.

### UNIX/Linux

UNIX and Linux users have a wide choice of distributions; the most common are **teTeX** and **TeX Live**. Ubuntu and Debian users can install one (not both!) of these systems using the system's apt package manager.

### Mac OS X

Mac OS X users may use the MacTeX, supporting TeX, LaTeX, AMSTeX, ConTeXt, XeTeX and many other core packages.

### Microsoft Windows

Microsoft Windows users can install MiKTeX onto their computer. This distribution has advanced features, such as automatic installation of packages, and simple interfaces to modify settings, such as default paper sizes.

## Editors

TeX and LaTeX source documents (as well as related files) are all text files, and can be opened and modified in almost any text editor. A few recommended editors include:

**Cross-platform**

- Texmaker
- Vim

**Linux-only**

- Kile

**Mac OS X-only**

- TeXShop

**Windows-only**

- LEd
- TeXnicCenter
- WinEdt
- WinShell

## Bibliography management

Bibliography files (`*.bib`) are most easily edited and modified using a management system. These graphical user interfaces all feature a database form, where information is entered for each reference item, and the resulting text file can be used directly by BibTeX.

**Cross-platform**

- JabRef

**Mac OS X-only**

- BibDesk

# Graphics tools

## Xfig

Xfig is a basic program that can produce vector graphics, which can be exported to PSTEX. It can be installed on UNIX/Linux platforms. With, Ubuntu or Debian distributions, it can be easily installed using apt.

On Microsoft Windows systems, Xfig can only be installed using Cygwin-X; however, this will require a fast internet connection and about 2 gigabytes of space on you computer. With Cygwin, to run Xfig, you need to first start the "Start X — Server", then launch "xterm" to bring up a terminal. In this terminal type "xfig" (without the double quotes of course) and press return.

## Inkscape

Inkscape is an open source vector graphics editor, which can export images to .EPS files, which may then be imported into LaTeX (see Importing Graphics). It can run natively under Windows, Linux or Mac OS.

An extremely useful plug-in is textext, which can import LaTeX objects. This can be used for inserting mathematical notation or LaTeX fonts into graphics (which may then be imported into LaTeX documents).

# See also

- Installing Extra Packages

# Appendix B

# Useful Measurement Macros

*A list of macros and their values*

## Units

First, we introduce the LaTeX measurement units. You can choose from a variety of units.

| | |
|---|---|
| **pt** | a point is 1/72.27 inch, that means about 0.0138 inch or 0.3515 mm. |
| **bp** | a big point is 1/72 inch, that means about 0.0139 inch or 0.3527 mm. |
| **mm** | a millimeter |
| **cm** | a centimeter |
| **in** | inch |
| **ex** | roughly the height of an 'x' in the current font |
| **em** | roughly the width of an 'M' (note the uppercase) of the current font |

## Length 'macros'

Some length commands are;

**\baselineskip** The normal vertical distance between lines in a paragraph

**\baselinestretch** Multiplies \baselineskip

**\columnsep** The distance between columns

**\columnwidth** The width of the column

**\evensidemargin** The margin for 'even' pages (think of a printed booklet)

**\linewidth** The width of a line in the local environment

**\oddsidemargin** The margin for 'odd' pages (think of a printed booklet)

**\pagewidth** The width of the page

**\pageheight** The height of the page

**\parindent** The normal paragraph indentation

**\parskip** The extra vertical space between paragraphs

**\tabcolsep** The default separation between columns in a tabular environment

**\textheight** The height of text on the page

**\textwidth** The width of the text on the page

**\topmargin** The size of the top margin!

**\unitlength** Units of length in Picture Environment

## Length manipulation macros

You can change the values of the variables defining the page layout with two commands. With this one you can set a new value:

```
\setlength{parameter}{length}
```

with this other one, you can add a value to the existing one:

```
\addtolength{parameter}{length}
```

See LaTeX/Page Layout for samples using these.

## Samples

Resize an image to take exactly half the text width :

```
\includegraphics[width=0.5\textwidth]{mygraphic}
```

Make distance between items larger (inside an itemize environment) :

```
\addtolength{\itemsep}{0.5\baselineskip}
```

# Appendix C

# Useful Size Commands

The following type size commands, in order of increasing font size, are supported by LaTeX.

- \tiny
- \scriptsize
- \footnotesize
- \small
- \normalsize (default)
- \large
- \Large (capital "l")
- \LARGE (all caps)
- \huge
- \Huge (capital "h")

The default for \normalsize is 10-point, but it may differ for some Document Styles or their options. The actual size produced by these commands also depends on the Document Style and, in some styles, more than one of these size commands may produce the same actual size.

The new size takes effect immediately after the size command; if an entire paragraph or unit is set in a certain size, the size command should include the blank line or the \end{} which delimites the unit. (See Declarations.)

These commands cannot be used in math mode. However, part of a formula may be set in a different size by using an \mbox command containing the size command.

See also Formatting

# Appendix D

# Sample LaTeX documents

The easiest way to learn how to use latex is to look at how other people use it. Here is a list of *real world* latex sources that are freely available on the internet. The information here is sorted by application area, so that it is grouped by the scientific communities that use similar notation and LaTeX constructs.

## General examples

Tutorial examples, books, and real world uses of LaTeX.

- small2e.tex and sample2e.tex. The "official" sample documents...
- A short example of how to use LaTeX for scientific reports by Stephen J. Eglen.
- The not so Short Introduction to LaTeX by Tobias Oetiker is distributed with full latex sources.

## Semantics of Programming Languages

Articles on programming language research, from syntax to semantics, including source code listings, type rules, proof trees, and even some category theory. A good place to start is Mitchell Wand's Latex Resources, including a sample file that also demonstrates Didier Remy's mathpartir package. The following are latex sources of some articles, books, or presentations from this field:

- Pugs: Bootstrapping Perl 6 with Haskell. This paper by Audrey Tang contains nice examples on configuring the listings package to format source code.

# Appendix E

# Glossary

List of commands (brackets "[]" are optional arguments and braces "{}" are required arguments) :

## #

/ see slash marks

\@ following period ends sentence

\\[* [extra-space]] new line. See Page Layout.

\, thin space, math mode

\; thick space, math mode

\: medium space, math mode

\! negative thin space, math mode

\- hyphenation; tabbing

\= set tab, see tabbing

\> tab, see tabbing

\< back tab, see tabbing

\+ see tabbing

\' accent or tabbing

\` accent or tabbing

\| double vertical lines, math mode

\( start math environment

\) end math environment

\[ begin displaymath environment

\ ] end displaymath environment

## A

**\addcontentsline{file}{sec_unit}{entry}** adds an entry to the specified list or table

**\addtocontents{file}{text}** adds text (or formatting commands) directly to the file that generates the specified list or table

**\addtocounter{counter}{value}** increments the counter

**\address{Return address}**

**\addtolength{len-cmd}{len}** increments a length command, see Useful Measurement Macros

**\addvspace** adds a vertical space of a specified height

**\alph** causes the current value of a specified counter to be printed in alphabetic characters

**\appendix** changes the way sectional units are numbered so that information after the command is considered part of the appendix

**\arabic** causes the current value of a specified counter to be printed in Arabic numbers

**\author** declares the author(s). See Document Structure

## B

**\backslash** prints a backslash

**\baselineskip** a length command (see Useful Measurement Macros), which specifies the minimum space between the bottom of two successive lines in a paragraph

**\baselinestretch** scales the value of \baselineskip

**\bf** Boldface typeface

**\bibitem** generates a labeled entry for the bibliography

**\bigskipamount**

**\bigskip** equivalent to \vspace{\bigskipamount}

**\boldmath** bold font in math mode

## C

**\cal** Calligraphic style in math mode

**\caption** generate caption for figures and tables

**\cdots** Centered dots

**\centering** Used to center align LaTeX environments

**\chapter** Starts a new chapter. See Document Structure.

**\circle**

**\cite** Used to make citations from the provided bibliography

**\cleardoublepage**

**\clearpage** Ends the current page and causes any floats to be printed. See Page Layout.

**\cline** Adds horizontal line in a table that spans only to a range of cells. See \hline and Tables/ chapter.

**\closing**

**\copyright** makes © sign. See Formatting.

## D

**\dashbox**

**\date**

**\ddots**

**\documentclass[options** {style}] Used to begin a latex document

**\dotfill**

## E

**\em** Italicizes the text which is inside curly braces with the command. Such as {\em This is in italics}. This command allows nesting.

**\ensuremath (LaTeX2e)**

**\euro** Prints euro € symbol. Requires `eurosym` package.

## F

**\fbox**

**\flushbottom**

**\fnsymbol**

**\footnote** Creates a footnote.

**\footnotemark**

**\footnotesize** Sets font size. See Formatting.

**\footnotetext**

**\frac**

**\frame**

**\framebox**

**\frenchspacing**

## G

## H

**\hfill** Abbreviation for \hspace{\fill}.

**\hline** adds a horizontal line in a tabular environment. See also \cline, Tables chapter.

**\hrulefill**

**\hspace** Produces horizontal space.

**\huge** Sets font size. See Formatting.

**\Huge** Sets font size. See Formatting.

**\hyphenation**

## I

**\include**

**\includegraphics** Inserts an image. Requires `graphicx` package.

**\includeonly**

**\indent**

**\input** Used to read in LaTex files

**\it** Italicizes the text which is inside curly braces with the command. Such as {\it This is in italics}. \em is generally preferred since this allows nesting.

**\item** Creates an item in a list. Used in list structures.

## K

**\kill**

## L

**\label** Used to create label which can be later referenced with `\ref`. See Labels and Cross-referencing.

**\large** Sets font size. See Formatting.

**\Large** Sets font size. See Formatting.

**\LARGE** Sets font size. See Formatting.

**\LaTeX** Prints LaTeX logo. See Formatting.

**\LaTeXe** Prints current LaTeX version logo. See Formatting.

**\ldots** Prints sequence of three dots. See Formatting.

**\left**

**\lefteqn**

**\line**

**\linebreak** Suggests LaTeX to break line in this place. See Page Layout.

**\linethickness**

**\linewidth**

**\listoffigures**

**\listoftables**

**\location**

## M

**\makebox**

**\maketitle**

**\markboth \markright**

**\mathcal**

**\mathop**

**\mbox**

**\medskip**

**\multicolumn**

**\multiput**

## N

**\newcommand**

**\newcounter**

**\newenvironment**

**\newfont**

**\newlength**

**\newline** Ends current line and starts a new one. See Page Layout.

**\newpage** Ends current page and starts a new one. See Page Layout.

**\newsavebox**

**\newtheorem**

**\nocite**

**\noindent**

**\nolinebreak**

**\normalsize** Sets default font size. See Formatting.

**\nopagebreak** Suggests LaTeX not to break page in this place. See Page Layout.

**\not**

## O

**\onecolumn**

**\opening**

**\oval**

**\overbrace**

**\overline** Draws a line over the argument.

## P

**\pagebreak** Suggests LaTeX breaking page in this place. See Page Layout.

**\pagenumbering**

**\pageref** Used to reference to number of page where a previously declared `\label` is located. See Floats, Figures and Captions.

**\pagestyle**

**\par** Starts a new paragraph

**\paragraph** Starts a new paragraph. See Document Structure.

**\part** Starts a new part of a book. See Document Structure.

**\parbox**

**\parindent** Normal paragraph indentation. See Useful Measurement Macros.

**\parskip**

**\protect**

**\providecommand (LaTeX2e)**

**\put**

## R

**\raggedbottom**

**\raggedleft**

**\raggedright**

**\raisebox**

**\ref** Used to reference to number of previously declared `\label`. See Labels and Cross-referencing.

**\renewcommand**

**\right**

**\rm**

**\roman**

**\rule**

## S

**\savebox** Makes a box and saves it in a named storage bin.

**\sbox** The short form of \savebox with no optional arguments.

**\sc**

**\scriptsize** Sets font size. See Formatting.

**\section** Starts a new section. See Document Structure.

**\setcounter**

**\setlength**

**\settowidth**

**\sf**

**\shortstack**

**\signature**

**\sl**

**\slash** See slash marks

**\small** Sets font size. See Formatting.

**\smallskip**

**\sout** Strikes out text. Requires `ulem` package. See Formatting.

**\space** force ordinary space

**\sqrt** Creats a root (default square, but magnitude can be given as an optional parameter).

**\stackrel**

**\subparagraph** Starts a new subparagraph. See Document Structure.

**\subsection** Starts a new subsection. See Document Structure.

**\subsubsection** Starts a new sub-subsection. See Document Structure.

## T

**\tableofcontents**

**\telephone**

**\TeX** Prints TeX logo. See Formatting.

**\textbf{}** Sets bold font style. See Formatting.

**\textit{}** Sets italic font style. See Formatting.

**\textmd{}** Sets medium weight of a font. See Formatting.

**\textnormal{}** Sets normal font. See Formatting.

**\textrm{}** Sets roman font family. See Formatting.

**\textsc{}** Sets font style to small caps. See Formatting.

**\textsf{}** Sets sans serif font family. See Formatting.

**\textsl{}** Sets slanted font style. See Formatting.

**\texttt{}** Sets typewriter font family. See Formatting.

**\textup{}** Sets upright shape of a font. See Formatting.

**\textwidth**

**\textheight**

**\thanks**

**\thispagestyle**

**\tiny** Sets font size. See Formatting.

**\title**

**\today** Writes current day. See Formatting.

**\tt**

**\twocolumn**

**\typeout**

**\typein**

## U

**\uline** Underlines text. Requires `ulem` package. See Formatting.

**\underbrace**

**\underline**

**\unitlength**

**\usebox**

**\usecounter**

**\uwave** Creates wavy underline. Requires `ulem` package. See Formatting.

## V

**\value**

**\vbox{text}** Encloses a paragraph's text to prevent it from running over a page break

**\vdots**

**\vector**

**\verb**

**\vfill**

**\vline**

**\vphantom**

**\vspace**

# Appendix F

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