The Not So Short Introduction to LaTeX 2_ε

Or LaTeX 2_ε in 131 minutes

by Tobias Oetiker

Hubert Partl, Irene Hyna and Elisabeth Schlegl

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Thank you!

Much of the material used in this introduction comes from an Austrian introduction to LaTeX 2.09 written in German by:

Hubert Partl <partl@mail.boku.ac.at>
Zentraler Informatikdienst der Universität für Bodenkultur Wien

Irene Hyna <Irene.Hyna@bmwf.ac.at>
Bundesministerium für Wissenschaft und Forschung Wien

Elisabeth Schlegl <noemail>
in Graz

If you are interested in the German document, you can find a version updated for LaTeX 2_ε by Jörg Knappen at
`CTAN:/tex-archive/info/lshort/german`

While preparing this document, I asked for reviewers on `comp.text.tex`. I got a lot of response. The following individuals helped with corrections, suggestions and material to improve this paper. They put in a big effort to help me get this document into its present shape. I would like to sincerely thank all of them. Naturally, all the mistakes you'll find in this book are mine. If you ever find a word that is spelled correctly, it must have been one of the people below dropping me a line.

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Preface

LaTeX [1] is a typesetting system that is very suitable for producing scientific and mathematical documents of high typographical quality. It is also suitable for producing all sorts of other documents, from simple letters to complete books. LaTeX uses TeX [2] as its formatting engine.

This short introduction describes LaTeX 2_ε and should be sufficient for most applications of LaTeX. Refer to [1, 3] for a complete description of the LaTeX system.

This introduction is split into 6 chapters:

Chapter 1 tells you about the basic structure of LaTeX 2_ε documents. You will also learn a bit about the history of LaTeX. After reading this chapter, you should have a rough understanding how LaTeX works.

Chapter 2 goes into the details of typesetting your documents. It explains most of the essential LaTeX commands and environments. After reading this chapter, you will be able to write your first documents.

Chapter 3 explains how to typeset formulae with LaTeX. Many examples demonstrate how to use one of LaTeX's main strengths. At the end of the chapter are tables listing all mathematical symbols available in LaTeX.

Chapter 4 explains indexes, bibliography generation and inclusion of EPS graphics. It introduces creation of PDF documents with pdfLaTeX and presents some handy extension packages.

Chapter 5 shows how to use LaTeX for creating graphics. Instead of drawing a picture with some graphics program, saving it to a file and then including it into LaTeX you describe the picture and have LaTeX draw it for you.

Chapter 6 contains some potentially dangerous information about how to alter the standard document layout produced by LaTeX. It will tell you how to change things such that the beautiful output of LaTeX turns ugly or stunning, depending on your abilities.

It is important to read the chapters in order—the book is not that big, after all. Be sure to carefully read the examples, because a lot of the information is in the examples placed throughout the book.

LaTeX is available for most computers, from the PC and Mac to large UNIX and VMS systems. On many university computer clusters you will find that a LaTeX installation is available, ready to use. Information on how to access the local LaTeX installation should be provided in the *Local Guide* [5]. If you have problems getting started, ask the person who gave you this booklet. The scope of this document is *not* to tell you how to install and set up a LaTeX system, but to teach you how to write your documents so that they can be processed by LaTeX.

If you need to get hold of any LaTeX related material, have a look at one of the Comprehensive TeX Archive Network (`CTAN`) sites. The homepage is at `http://www.ctan.org`. All packages can also be retrieved from the ftp archive `ftp://www.ctan.org` and its various mirror sites all over the world. They can be found e.g. at `ftp://ctan.tug.org` (US), `ftp://ftp.dante.de` (Germany), `ftp://ftp.tex.ac.uk` (UK). If you are not in one of these countries, choose the archive closest to you.

You will find other references to CTAN throughout the book, especially pointers to software and documents you might want to download. Instead of writing down complete urls, I just wrote `CTAN:` followed by whatever location within the CTAN tree you should go to.

If you want to run LaTeX on your own computer, take a look at what is available from `CTAN:/tex-archive/systems`.

If you have ideas for something to be added, removed or altered in this document, please let me know. I am especially interested in feedback from LaTeX novices about which bits of this intro are easy to understand and which could be explained better.

Tobias Oetiker `<oetiker@ee.ethz.ch>`

Department of Information Technology and
Electrical Engineering, Swiss Federal Institute of Technology

The current version of this document is available on
`CTAN:/tex-archive/info/lshort`

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Chapter 1

Things You Need to Know

The first part of this chapter presents a short overview of the philosophy and history of LaTeX 2$_\varepsilon$. The second part focuses on the basic structures of a LaTeX document. After reading this chapter, you should have a rough knowledge of how LaTeX works, which you will need to understand the rest of this book.

1.1 The Name of the Game

1.1.1 TeX

TeX is a computer program created by Donald E. Knuth [2]. It is aimed at typesetting text and mathematical formulae. 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 π and is now at 3.14159.

TeX is pronounced "Tech," with a "ch" as in the German word "Ach" or in the Scottish "Loch." In an ASCII environment, TeX becomes `TeX`.

1.1.2 LaTeX

LaTeX is a macro package that enables authors to typeset and print their work at the highest typographical quality, using a predefined, professional layout. LaTeX was originally written by Leslie Lamport [1]. It uses the TeX formatter as its typesetting engine. These days LaTeX is maintained by Frank Mittelbach.

LaTeX is pronounced "Lay-tech" or "Lah-tech." If you refer to LaTeX in an `ASCII` environment, you type `LaTeX`. LaTeX 2_ε is pronounced "Lay-tech two e" and typed `LaTeX2e`.

1.2 Basics

1.2.1 Author, Book Designer, and Typesetter

To publish something, authors give their typed manuscript to a publishing company. One of their book designers then decides the layout of the document (column width, fonts, space before and after headings, . . .). The book designer writes his instructions into the manuscript and then gives it to a typesetter, who typesets the book according to these instructions.

A human book designer tries to find out what the author had in mind while writing the manuscript. He decides on chapter headings, citations, examples, formulae, etc. based on his professional knowledge and from the contents of the manuscript.

In a LaTeX environment, LaTeX takes the role of the book designer and uses TeX as its typesetter. But LaTeX is "only" a program and therefore needs more guidance. The author has to provide additional information to describe the logical structure of his work. This information is written into the text as "LaTeX commands."

This is quite different from the WYSIWYG[1] approach that most modern word processors, such as *MS Word* or *Corel WordPerfect*, take. With these applications, authors specify the document layout interactively while typing text into the computer. They can see on the screen how the final work will look when it is printed.

When using LaTeX it is not normally possible to see the final output while typing the text, but the final output can be previewed on the screen after processing the file with LaTeX. Then corrections can be made before actually sending the document to the printer.

1.2.2 Layout Design

Typographical design is a craft. Unskilled authors often commit serious formatting errors by assuming that book design is mostly a question of aesthetics—"If a document looks good artistically, it is well designed." But as a document has to be read and not hung up in a picture gallery, the readability and understandability is much more important than the beautiful look of it. Examples:

- The font size and the numbering of headings have to be chosen to make the structure of chapters and sections clear to the reader.

[1] What you see is what you get.

- The line length has to be short enough not to strain the eyes of the reader, while long enough to fill the page beautifully.

With WYSIWYG systems, authors often generate aesthetically pleasing documents with very little or inconsistent structure. LaTeX prevents such formatting errors by forcing the author to declare the *logical* structure of his document. LaTeX then chooses the most suitable layout.

1.2.3 Advantages and Disadvantages

When people from the WYSIWYG world meet people who use LaTeX, they often discuss "the advantages of LaTeX over a normal word processor" or the opposite. The best thing you can do when such a discussion starts is to keep a low profile, since such discussions often get out of hand. But sometimes you cannot escape . . .

So here is some ammunition. The main advantages of LaTeX over normal word processors are the following:

- Professionally crafted layouts are available, which make a document really look as if "printed."
- The typesetting of mathematical formulae is supported in a convenient way.
- Users only need to learn a few easy-to-understand commands that specify the logical structure of a document. They almost never need to tinker with the actual layout of the document.
- Even complex structures such as footnotes, references, table of contents, and bibliographies can be generated easily.
- Free add-on packages exist for many typographical tasks not directly supported by basic LaTeX. For example, packages are available to include PostScript graphics or to typeset bibliographies conforming to exact standards. Many of these add-on packages are described in *The LaTeX Companion* [3].
- LaTeX encourages authors to write well-structured texts, because this is how LaTeX works—by specifying structure.
- TeX, the formatting engine of LaTeX 2_ε, is highly portable and free. Therefore the system runs on almost any hardware platform available.

LaTeX also has some disadvantages, and I guess it's a bit difficult for me to find any sensible ones, though I am sure other people can tell you hundreds `;-)`

- LaTeX does not work well for people who have sold their souls ...
- Although some parameters can be adjusted within a predefined document layout, the design of a whole new layout is difficult and takes a lot of time.[2]
- It is very hard to write unstructured and disorganized documents.
- Your hamster might, despite some encouraging first steps, never be able to fully grasp the concept of Logical Markup.

1.3 LaTeX Input Files

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.

1.3.1 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     spaces
after a word.

An empty line starts a new
paragraph.
```

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

An empty line starts a new paragraph.

1.3.2 Special Characters

The following symbols are reserved characters that either have a special meaning under LaTeX or are not available in all the fonts. If you enter them directly in your text, they will normally not print, but rather coerce LaTeX to do things you did not intend.

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

[2]Rumour says that this is one of the key elements that will be addressed in the upcoming LaTeX3 system.

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

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

\# \$ % ^ & _ { } ~

The other symbols and many more can be printed with special commands in mathematical formulae or as accents. The backslash character \ can *not* be entered by adding another backslash in front of it (\\); this sequence is used for line breaking.[3]

1.3.3 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.

LaTeX ignores whitespace after commands. If you want to get a space after a command, you have to put either {} and a blank or a special spacing command after the command name. The {} stops LaTeX from eating up all the space after the command name.

```
I read that Knuth divides the
people working with \TeX{} into
\TeX{}nicians and \TeX perts.\\
Today is \today.
```

I read that Knuth divides the people working with TeX into TeXnicians and TeXperts.
Today is 4th April 2004.

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 next examples use some LaTeX commands. Don't worry about them; they will be explained later.

```
You can \textsl{lean} on me!
```

You can *lean* on me!

```
Please, start a new line
right here!\newline
Thank you!
```

Please, start a new line right here!
Thank you!

[3] Try the $\backslash$ command instead. It produces a '\'.

1.3.4 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: Supercalifragilisticexpi-alidocious

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

For longer comments you could use the `comment` environment provided by the `verbatim` package. This means, to use the `comment` environment you have to add the command `\usepackage{verbatim}` to the preamble of your document.

```
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.

Note that this won't work inside complex environments, like math for example.

1.4 Input File Structure

When LaTeX 2_ε 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,[4] you start the body of the text with the command

[4]The area between `\documentclass` and `\begin{document}` is called the *preamble*.

```
\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.

Figure 1.1 shows the contents of a minimal LaTeX 2_ε file. A slightly more complicated input file is given in Figure 1.2.

1.5 A Typical Command Line Session

I bet you must be dying to try out the neat small LaTeX input file shown on page 7. Here is some help: LaTeX itself comes without a GUI or fancy buttons to press. It is just a program that crunches away at your input file. Some LaTeX installations feature a graphical front-end where you can click

```
\documentclass{article}
\begin{document}
Small is beautiful.
\end{document}
```

Figure 1.1: A Minimal LaTeX File.

```
\documentclass[a4paper,11pt]{article}
% define the title
\author{H.~Partl}
\title{Minimalism}
\begin{document}
% generates the title
\maketitle
% insert the table of contents
\tableofcontents
\section{Some Interesting Words}
Well, and here begins my lovely article.
\section{Good Bye World}
\ldots{} and here it ends.
\end{document}
```

Figure 1.2: Example of a Realistic Journal Article.

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.[5]

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 the extension `.tex`.

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
   ```

3. Now you may view the DVI file. There are several ways to do that. You can show the file on screen with

   ```
   xdvi foo.dvi &
   ```

   This only works on Unix with X11. If you are on Windows you might want to try `yap` (yet another previewer).

   You can also convert the dvi file to PostScript for printing or viewing with Ghostscript.

   ```
   dvips -Pcmz foo.dvi -o foo.ps
   ```

   If you are lucky your LaTeX system even comes with the `dvipdf` tool, which allows you to convert your `.dvi` files straight into pdf.

   ```
   dvipdf foo.dvi
   ```

[5] This is the case with most well groomed Unix Systems, and ... Real Men use Unix, so ... `;-)`

1.6 The Layout of the Document

1.6.1 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. Table 1.1 lists the document classes explained in this introduction. The LaTeX 2_ε distribution provides additional classes for other documents, including letters and slides. The *options* parameter customises the behaviour of the document class. The options have to be separated by commas. The most common options for the standard document classes are listed in Table 1.2.

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*.

1.6.2 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, coloured text or source code from a file into your document, you

Table 1.1: Document Classes.

`article` for articles in scientific journals, presentations, short reports, program documentation, invitations, …

`report` for longer reports containing several chapters, small books, PhD theses, …

`book` for real books

`slides` for slides. The class uses big sans serif letters. You might want to consider using FoilTeX[a] instead.

[a] `macros/latex/contrib/supported/foiltex`

Table 1.2: Document Class Options.

`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`. Besides that, `a5paper`, `b5paper`, `executivepaper`, and `legalpaper` can be specified.

`fleqn` Typesets displayed formulae left-aligned instead of centred.

`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.

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 2_ε base distribution (See Table 1.3). Others are provided separately. You may find more information on the packages installed at your site in your *Local Guide* [5]. The prime source for information about LaTeX packages is *The LaTeX Companion* [3]. It contains descriptions on hundreds of packages, along with information of how to write your own extensions to LaTeX 2_ε.

1.6.3 Page Styles

LaTeX supports three predefined header/footer combinations—so-called page styles. The *style* parameter of the

`\pagestyle{`*style*`}`

command defines which one to use. Table 1.4 lists the predefined page styles.

It is possible to change the page style of the current page with the command

`\thispagestyle{`*style*`}`

A description how to create your own headers and footers can be found in *The LaTeX Companion* [3] and in section 4.4 on page 69.

1.7 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 various file types you might encounter when working with TeX. Please note that this table does not claim to be a complete list of extensions, but if you find one missing that you think is important, please drop me a line.

`.tex` LaTeX or TeX input file. 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.

Table 1.3: Some of the Packages Distributed with LaTeX.

doc Allows the documentation of LaTeX programs.
Described in `doc.dtx`[a] and in *The LaTeX Companion* [3].

exscale Provides scaled versions of the math extension font.
Described in `ltexscale.dtx`.

fontenc Specifies which font encoding LaTeX should use.
Described in `ltoutenc.dtx`.

ifthen Provides commands of the form
'if. . . then do. . . otherwise do. . . .'
Described in `ifthen.dtx` and *The LaTeX Companion* [3].

latexsym To access the LaTeX symbol font, you should use the `latexsym` package. Described in `latexsym.dtx` and in *The LaTeX Companion* [3].

makeidx Provides commands for producing indexes. Described in section 4.3 and in *The LaTeX Companion* [3].

syntonly Processes a document without typesetting it.

inputenc Allows the specification of an input encoding such as ASCII, ISO Latin-1, ISO Latin-2, 437/850 IBM code pages, Apple Macintosh, Next, ANSI-Windows or user-defined one. Described in `inputenc.dtx`.

[a] This file should be installed on your system, and you should be able to get a `dvi` file by typing `latex doc.dtx` in any directory where you have write permission. The same is true for all the other files mentioned in this table.

Table 1.4: The Predefined Page Styles of LaTeX.

`plain` prints the page numbers on the bottom of the page, in the middle of the footer. This is the default page style.

`headings` prints the current chapter heading and the page number in the header on each page, while the footer remains empty. (This is the style used in this document)

`empty` sets both the header and the footer to be empty.

`.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.

The following files are generated when you run LaTeX on your input file:

`.dvi` Device Independent File. This is the main result of a LaTeX compile run. 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.

`.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`. Refer to section 4.3 on page 68 for more information on indexing.

`.ind` The processed .idx file, ready for inclusion into your document on the next compile cycle.

`.ilg` Logfile telling what `makeindex` did.

1.8 Big Projects

When working on big documents, you might want to split the input file into several parts. LaTeX has two commands that help you to do that.

`\include{`*filename*`}`

You can use this command in the document body to insert the contents of another file named *filename.tex*. Note that LaTeX will start a new page before processing the material input from *filename.tex*.

The second command can be used in the preamble. It allows you to instruct LaTeX to only input some of the `\include`d files.

`\includeonly{`*filename*`,`*filename*`,`…`}`

After this command is executed in the preamble of the document, only `\include` commands for the filenames that are listed in the argument of the `\includeonly` command will be executed. Note that there must be no spaces between the filenames and the commas.

The `\include` command starts typesetting the included text on a new page. This is helpful when you use `\includeonly`, because the page breaks will not move, even when some included files are omitted. Sometimes this might not be desirable. In this case, you can use the

`\input{`*filename*`}`

command. It simply includes the file specified. No flashy suits, no strings attached.

To make LaTeX quickly check your document you can use the syntonly package. This makes LaTeX skim through your document only checking for proper syntax and usage of the commands, but doesn't produce any (DVI) output. As LaTeX runs faster in this mode you may save yourself valuable time. Usage is very simple:

```
\usepackage{syntonly}
\syntaxonly
```

When you want to produce pages, just comment out the second line (by adding a percent sign).

Chapter 2

Typesetting Text

After reading the previous chapter, you should know about the basic stuff of which a LaTeX 2ε document is made. In this chapter I will fill in the remaining structure you will need to know in order to produce real world material.

2.1 The Structure of Text and Language

By Hanspeter Schmid <hanspi@schmid-werren.ch>

The main point of writing a text (some modern DAAC[1] literature excluded), 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.

The most important text unit in LaTeX (and in typography) is the paragraph. We call it "text unit" because a paragraph is the typographical form that should reflect one coherent thought, or one idea. You will learn in the following sections how you can force line breaks with e.g. `\\`, and paragraph breaks with e.g. leaving an empty line in the source code. Therefore, if a new thought begins, a new paragraph should begin, and if not, only line breaks should be used. If in doubt about paragraph breaks, think about your text as a conveyor of ideas and thoughts. If you have a paragraph break, but the old thought continues, it should be removed. If some totally new line of thought occurs in the same paragraph, then it should be broken.

Most people completely underestimate the importance of well-placed paragraph breaks. Many people do not even know what the meaning of

[1] Different At All Cost, a translation of the Swiss German UVA (Um's Verrecken Anders).

a paragraph break is, or, especially in LaTeX, introduce paragraph breaks without knowing it. The latter mistake is especially easy to make if equations are used in the text. Look at the following examples, and figure out why sometimes empty lines (paragraph breaks) are used before and after the equation, and sometimes not. (If you don't yet understand all commands well enough to understand these examples, please read this and the following chapter, and then read this section again.)

```
% Example 1
\ldots when Einstein introduced his formula
\begin{equation}
  e = m \cdot c^2 \; ,
\end{equation}
which is at the same time the most widely known
and the least well understood physical formula.


% Example 2
\ldots from which follows Kirchhoff's current law:
\begin{equation}
  \sum_{k=1}^{n} I_k = 0 \; .
\end{equation}

Kirchhoff's voltage law can be derived \ldots


% Example 3
\ldots which has several advantages.

\begin{equation}
  I_D = I_F - I_R
\end{equation}
is the core of a very different transistor model. \ldots
```

The next smaller text unit is a sentence. In English texts, there is a larger space after a period that ends a sentence than after one that ends an abbreviation. LaTeX tries to figure out which one you wanted to have. If LaTeX gets it wrong, you must tell it what you want. This is explained later in this chapter.

The structuring of text even extends to parts of sentences. Most languages have very complicated punctuation rules, but in many languages (including German and English), you will get almost every comma right if you remember what it represents: a short stop in the flow of language. If you are not sure about where to put a comma, read the sentence aloud and take a short breath at every comma. If this feels awkward at some place, delete that comma; if you feel the urge to breathe (or make a short stop) at some other place, insert a comma.

Finally, the paragraphs of a text should also be structured logically at a higher level, by putting them into chapters, sections, subsections, and so on. However, the typographical effect of writing e.g. `\section{The Structure of Text and Language}` is so obvious that it is almost self-evident how these high-level structures should be used.

2.2 Line Breaking and Page Breaking

2.2.1 Justified Paragraphs

Books are often typeset with each line having the same length. LaTeX inserts the necessary line breaks and spaces between words by optimizing the contents of a whole paragraph. If necessary, it also hyphenates words that would not fit comfortably on a line. How the paragraphs are typeset depends on the document class. Normally the first line of a paragraph is indented, and there is no additional space between two paragraphs. Refer to section 6.3.2 for more information.

In special cases it might be necessary to order LaTeX to break a line:

`\\` or `\newline`

starts a new line without starting a new paragraph.

`\\*`

additionally prohibits a page break after the forced line break.

`\newpage`

starts a new page.

`\linebreak[`*n*`]`, `\nolinebreak[`*n*`]`, `\pagebreak[`*n*`]` and `\nopagebreak[`*n*`]`

do what their names say. They enable the author to influence their actions with the optional argument n, which can be set to a number between zero and four. By setting n to a value below 4, you leave LaTeX the option of ignoring your command if the result would look very bad. Do not confuse these "break" commands with the "new" commands. Even when you give a "break" command, LaTeX still tries to even out the right border of the page and the total length of the page, as described in the next section. If you really want to start a "new line", then use the corresponding command. Guess its name!

LaTeX always tries to produce the best line breaks possible. If it cannot find a way to break the lines in a manner that meets its high standards, it lets one line stick out on the right of the paragraph. LaTeX then complains ("overfull hbox") while processing the input file. This happens most often when LaTeX cannot find a suitable place to hyphenate a word.[2] You can instruct LaTeX to lower its standards a little by giving the `\sloppy` command. It prevents such over-long lines by increasing the inter-word spacing—even if the final output is not optimal. In this case a warning ("underfull hbox") is given to the user. In most such cases the result doesn't look very good. The command `\fussy` brings LaTeX back to its default behaviour.

2.2.2 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}
```

[2] Although LaTeX gives you a warning when that happens (Overfull hbox) and displays the offending line, such lines are not always easy to find. If you use the option `draft` in the `\documentclass` command, these lines will be marked with a thick black line on the right margin.

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.

```
I think this is: su\-per\-cal\-%
i\-frag\-i\-lis\-tic\-ex\-pi\-%
al\-i\-do\-cious
```

I think this is: supercalifragilisticexpialido-cious

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.

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

The parameter
\mbox{\emph{filename}} should
contain the name of the file.
```

My phone number will change soon. It will be 0116 291 2319.

The parameter *filename* should contain the name of the file.

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

2.3 Ready-Made Strings

In some of the examples on the previous pages, you have seen some very simple LaTeX commands for typesetting special text strings:

Command	Example	Description
`\today`	4th April 2004	Current date in the current language
`\TeX`	TeX	The name of your favorite typesetter
`\LaTeX`	LaTeX	The Name of the Game
`\LaTeXe`	LaTeX 2_ε	The current incarnation of LaTeX

2.4 Special Characters and Symbols

2.4.1 Quotation Marks

You should *not* use the `"` for quotation marks as you would on a typewriter. In publishing there are special opening and closing quotation marks. In LaTeX, use two `` ` ``s (grave accent) for opening quotation marks and two `'`s (vertical quote) for closing quotation marks. For single quotes you use just one of each.

```
``Please press the `x' key.''
```

"Please press the 'x' key."

Yes I know the rendering is not ideal, it's really a back-tick or grave accent for opening quotes and vertical quote for closing, despite what the font chosen might suggest.

2.4.2 Dashes and Hyphens

LaTeX knows four kinds of dashes. 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:

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

2.4.3 Tilde ($\sim$)

A character often seen in web addresses is the tilde. To generate this in LaTeX you can use `\~` but the result: ˜ is not really what you want. Try this instead:

```
http://www.rich.edu/\~{}bush \\
http://www.clever.edu/$\sim$demo
```

http://www.rich.edu/˜bush
http://www.clever.edu/$\sim$demo

2.4.4 Degree Symbol ($\circ$)

The following example shows how to print a degree symbol in LaTeX:

```
It's $-30\,^{\circ}\mathrm{C}$.
I will soon start to
super-conduct.
```

It's $-30\,^{\circ}\mathrm{C}$. I will soon start to super-conduct.

The textcomp package makes the degree symbol also available as `\textcelsius`.

2.4.5 The Euro Currency Symbol (€)

When writing about money these days, you need the Euro symbol. Many current fonts contain a Euro symbol. After loading the textcomp package in the preamble of your document

```
\usepackage{textcomp}
```

you can use the command

```
\texteuro
```

to access it.

If your font does not provide its own Euro symbol or if you do not like the font's Euro symbol, you have two more choices:

First the eurosym package. It provides the official Euro symbol:

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

If you prefer a Euro symbol that matches your font, use the option `gen` in place of the `official` option.

If the Adobe Eurofonts are installed on your system (they are available for free from `ftp://ftp.adobe.com/pub/adobe/type/win/all`) you can use either the package europs and the command `\EUR` (for a Euro symbol that matches the current font) or the package eurosans and the command `\euro` (for the "official Euro").

The marvosym package also provides many different symbols, including a Euro, under the name `\EUR`. It's disadvantag is that it does not provide slanted and bold variants of the Euro symbol.

Table 2.1: A bag full of Euro symbols

package	command	roman	sans-serif	typewriter
eurosym	`\euro`	€	€	€
[gen]eurosym	`\euro`	€	€	€
europs	`\EUR`	€	€	€
eurosans	`\euro`	E	E	E
marvosym	`\EUR`	€	€	€

2.4.6 Ellipsis (. . .)

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, . . .

2.4.7 Ligatures

Some letter combinations are typeset not just by setting the different letters one after the other, but by actually using special symbols.

ﬀ ﬁ ﬂ ﬃ. . . instead of ff fi fl ffi . . .

These so-called ligatures can be prohibited by inserting an `\mbox{}` between the two letters in question. This might be necessary with words built from two words.

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

Not shelﬀul
but shelfful

2.4.8 Accents and Special Characters

LaTeX supports the use of accents and special characters from many languages. Table 2.2 shows all sorts of accents being applied to the letter o. Naturally other letters work too.

To place an accent on top of an i or a j, its dots have to be removed. This is accomplished by typing `\i` and `\j`.

```
H\^otel, na\"\i ve, \'el\`eve,\\
sm\o rrebr\o d, !`Se\~norita!,\\
Sch\"onbrunner Schlo\ss{}
Stra\ss e
```

Hôtel, naïve, élève,
smørrebrød, ¡Señorita!,
Schönbrunner Schloß Straße

2.5 International Language Support

When you write documents in languages other than English, there are three areas where LaTeX has to be configured appropriately:

1. All automatically generated text strings[3] have to be adapted to the new language. For many languages, these changes can be accomplished by using the babel package by Johannes Braams.

2. LaTeX needs to know the hyphenation rules for the new language. Getting hyphenation rules into LaTeX is a bit more tricky. It means rebuilding the format file with different hyphenation patterns enabled. Your *Local Guide* [5] should give more information on this.

3. Language specific typographic rules. In French for example, there is a mandatory space before each colon character (:).

If your system is already configured appropriately, you can activate the babel package by adding the command

```
\usepackage[language]{babel}
```

after the `\documentclass` command. A list of the *language*s 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.

[3]Table of Contents, List of Figures, ...

Table 2.2: Accents and Special Characters.

ò	\`o	ó	\'o	ô	\^o	õ	\~o
ō	\=o	ȯ	\.o	ö	\"o	ç	\c c
ŏ	\u o	ǒ	\v o	ő	\H o	o̧	\c o
ọ	\d o	o̲	\b o	o͡o	\t oo		
œ	\oe	Œ	\OE	æ	\ae	Æ	\AE
å	\aa	Å	\AA				
ø	\o	Ø	\O	ł	\l	Ł	\L
ı	\i	ȷ	\j	¡	!`	¿	?`

Babel also specifies new commands for some languages, which simplify the input of special characters. The German language, for example, contains a lot of umlauts (äöü). With babel, you can enter an ö by typing `"o` instead of `\"o`.

If you call babel with multiple languages

```
\usepackage[languageA,languageB]{babel}
```

you have to use the command

```
\selectlanguage{languageA}
```

to set the current 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[4]

Operating system	encodings: western latin	encodings: cyrillic
Mac	`applemac`	`macukr`
Unix	`latin1`	`koi8-ru`
Windows	`ansinew`	`cp1251`
DOS, OS/2	`cp850`	`cp866nav`

If you use multilingual document with conflicting input encodings, you might want to switch to unicode with the help of ucs package.

```
\usepackage{ucs}
\usepackage[utf8]{inputenc}
```

will enable you to create LaTeX input files in `utf8`, a multi-byte encoding in which each character can be encoded in as little as one byte and as many as

[4]To learn more about supported input encodings for Latin-based and Cyrillic-based languages, read the documentation for `inputenc.dtx` and `cyinpenc.dtx` respectively. Section 4.6 tells how to produce package documentation.

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 containins 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`.[5] 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.

2.5.1 Support for Portuguese

By Demerson Andre Polli <polli@linux.ime.usp.br>

To enable hyphenation and change all automatic text to Portuguese, use the command:

```
\usepackage[portuguese]{babel}
```

Or if you are in Brazil, substitute the language for `brazilian`.

[5]The list of languages supported by each of these encodings could be found in [11].

Table 2.3: Preamble for Portuguese documents.

```
\usepackage[portugese]{babel}
\usepackage[latin1]{inputenc}
\usepackage[T1]{fontenc}
```

As there are a lot of accents in Portuguese you might want to use

```
\usepackage[latin1]{inputenc}
```

to be able to input them correctly as well as

```
\usepackage[T1]{fontenc}
```

to get the hyphenation right.

See table 2.3 for the preamble you need to write in the Portuguese language. 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.

2.5.2 Support for French

By Daniel Flipo <daniel.flipo@univ-lille1.fr>

Some hints for those creating French documents with LaTeX: you can load French language support with the following command:

```
\usepackage[frenchb]{babel}
```

Note that, for historical reasons, the name of babel's option for French is either *frenchb* or *francais* but not *french*.

This enables French hyphenation, if you have configured your LaTeX system accordingly. It also changes 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 table 2.4 for inspiration.

Table 2.4: Special commands for French.

`\og guillemets \fg{}`	« guillemets »
`M\up{me}, D\up{r}`	$\mathrm{M^{me}}$, $\mathrm{D^{r}}$
`1\ier{}, 1\iere{}, 1\ieres{}`	1^{er}, 1^{re}, 1^{res}
`2\ieme{} 4\iemes{}`	2^{e} 4^{es}
`\No 1, \no 2`	$\mathrm{N^{o}}$ 1, $\mathrm{n^{o}}$ 2
`20~\degres C, 45\degres`	20 °C, 45°
`\bsc{M. 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 behaviour, run LaTeX on file `frenchb.dtx` and read the produced file `frenchb.dvi`.

2.5.3 Support for 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. 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.

Table 2.5: German Special Characters.

`"a`	ä	`"s`	ß
``"` ``	„	`"'`	“
`"<` or `\flqq`	«	`">` or `\frqq`	»
`\flq`	‹	`\frq`	›
`\dq`	"		

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 "$\ll$", 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}`)

2.5.4 Support for Korean[6]

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, Shift_JIS, and Big5. On the other hand, Hangul syllables, Hanjas (Chinese characters as used in Korea), Hangul Jamos, Hirakanas,

[6]Considering a number of issues Korean LaTeX users have to cope with. This section was written by Karnes KIM on behalf of the Korean lshort translation team. It was translated into English by SHIN Jungshik and shortened by Tobi Oetiker

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[7] 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 by Werner Lemberg.[8] 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.

[7] Korean Hangul is an alphabetic script with 14 basic consonants and 10 basic vowels (Jamos). Unlike Latin or Cyrillic scripts, the individual characters have to be arranged in rectangular clusters about the same size as Chinese characters. Each cluster represents a syllable. An unlimited number of syllables can be formed out of this finite set of vowels and consonants. Modern Korean orthographic standards (both in South Korea and North Korea), however, put some restriction on the formation of these clusters. Therefore only a finite number of orthographically correct syllables exist. The Korean Character encoding defines individual code points for each of these syllables (KS X 1001:1998 and KS X 1002:1992). So Hangul, albeit alphabetic, is treated like the Chinese and Japanese writing systems with tens of thousands of ideographic/logographic characters. ISO 10646/Unicode offers both ways of representing Hangul used for *modern* Korean by encoding Conjoining Hangul Jamos (alphabets: `http://www.unicode.org/charts/PDF/U1100.pdf`) in addition to encoding all the orthographically allowed Hangul syllables in *modern* Korean (`http://www.unicode.org/charts/PDF/UAC00.pdf`). One of the most daunting challenges in Korean typesetting with LaTeX and related typesetting system is supporting Middle Korean—and possibly future Korean—syllables that can be only represented by conjoining Jamos in Unicode. It is hoped that future TeX engines like Ω and Λ will eventually provide solutions to this so that some Korean linguists and historians will defect from MS Word that already has a pretty good support for Middle Korean.

[8] They can be obtained at `language/korean/HLaTeX/` `language/korean/CJK/` and `http://knot.kaist.ac.kr/htex/`

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 well-designed fonts. The HLaTeX distribution includes UHC PostScript fonts of 10 different families and Munhwabu[9] 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 TrueType 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

[9]Korean Ministry of Culture

http://www.ktug.or.kr/. There is also a Korean translation of this manual available.

2.5.5 Support for Cyrillic

By Maksym Polyakov <polyama@myrealbox.com>

Version 3.7h of babel includes support for the T2* encodings and for typesetting Bulgarian, Russian and Ukrainian texts using Cyrillic letters.

Support for Cyrillic is based on standard LaTeX mechanisms through the fontenc and inputenc packages. But, if you are going to use Cyrillics in math mode, you need to load mathtext package before fontenc:[10]

```
\usepackage{mathtext}
\usepackage[T1,T2A]{fontenc}
\usepackage[koi8-ru]{inputenc}
\usepackage[english,bulgarian,russian,ukranian]{babel}
```

Generally, babel will authomatically choose the default font encoding, for the above three languages this is T2A. However, documents are not restricted to a single font encoding. For multi-lingual documents using Cyrillic and Latin-based languages it makes sense to include latin font encoding explicitly. babel will take care of switching to the appropriate font encoding when a different language is selected within the document.

In addition to enabling hyphenations, translating automatically generated text strings, and activating some language specific typographic rules (like `\frenchspacing`), babel provides some commands allowing typesetting according to the standards of Bulgarian, Russian, or Ukrainian languages.

For all three languages, language specific punctuation is provided: The cyrillic dash for the text (it is little narrower than latin dash and surrounded by tiny spaces), a dash for direct speech, quotes, and commands to facilitate hyphenation, see Table 2.6.

The Russian and Ukrainian options of babel define the commands `\Asbuk` and `\asbuk`, which act like `\Alph` and `\alph`, but produce capital and small letters of Russian or Ukrainian alphabets (whichever is the active language of the document). The Bulgarian option of babel provides the commands `\enumBul` and `\enumLat` (`\enumEng`), which make `\Alph` and `\alph` produce letters of either Bulgarian or Latin (English) alphabets. The default behaviour of `\Alph` and `\alph` for the Bulgarian language option is to produce letters from the Bulgarian alphabet.

[10] If you use AMS-LaTeX packages, load them before fontenc and babel as well.

Table 2.6: The extra definitions made by Bulgarian, Russian, and Ukrainian options of babel

`"|`	disable ligature at this position.
`"-`	an explicit hyphen sign, allowing hyphenation in the rest of the word.
`"---`	Cyrillic emdash in plain text.
`"--~`	Cyrillic emdash in compound names (surnames).
`"--*`	Cyrillic emdash for denoting direct speech.
`""`	like |"-|, but producing no hyphen sign (for compound words with hyphen, e.g. |x-""y| or some other signs as "disable/enable").
`"~`	for a compound word mark without a breakpoint.
`"=`	for a compound word mark with a breakpoint, allowing hyphenation in the composing words.
`",`	thinspace for initials with a breakpoint in following surname.
``"` ``	for German left double quotes (looks like „).
`"'`	for German right double quotes (looks like “).
`"<`	for French left double quotes (looks like ≪).
`">`	for French right double quotes (looks like ≫).

2.6 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.

```
Mr.~Smith was happy to see her\\
cf.~Fig.~5\\
I like BASIC\@. What about you?
```

Mr. Smith was happy to see her
cf. Fig. 5
I like BASIC. What about you?

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.

2.7 Titles, Chapters, and Sections

To help the reader find his or her way through your work, you should divide it into chapters, sections, and subsections. LaTeX supports this with special commands that take the section title as their argument. It is up to you to use them in the correct order.

The following sectioning commands are available for the `article` class:

```
\section{...}
\subsection{...}
\subsubsection{...}
\paragraph{...}
\subparagraph{...}
```

If you want to split your document in parts without influencing the section or chapter numbering you can use

```
\part{...}
```

When you work with the `report` or `book` class, an additional top-level sectioning command becomes available

```
\chapter{...}
```

As the `article` class does not know about chapters, it is quite easy to add articles as chapters to a book. The spacing between sections, the numbering and the font size of the titles will be set automatically by LaTeX.

Two of the sectioning commands are a bit special:

- The `\part` command does not influence the numbering sequence of chapters.
- The `\appendix` command does not take an argument. It just changes the chapter numbering to letters.[11]

LaTeX creates a table of contents by taking the section headings and page numbers from the last compile cycle of the document. The command

```
\tableofcontents
```

expands to a table of contents at the place it is issued. A new document has to be compiled ("LaTeXed") twice to get a correct table of contents.

[11] For the article style it changes the section numbering.

Sometimes it might be necessary to compile the document a third time. LaTeX will tell you when this is necessary.

All sectioning commands listed above also exist as "starred" versions. A "starred" version of a command is built by adding a star `*` after the command name. This generates section headings that do not show up in the table of contents and are not numbered. The command `\section{Help}`, for example, would become `\section*{Help}`.

Normally the section headings show up in the table of contents exactly as they are entered in the text. Sometimes this is not possible, because the heading is too long to fit into the table of contents. The entry for the table of contents can then be specified as an optional argument in front of the actual heading.

```
\chapter[Title for the table of contents]{A long
    and especially boring title, shown in the text}
```

The title of the whole document is generated by issuing a

`\maketitle`

command. The contents of the title have to be defined by the commands

`\title{...}`, `\author{...}` and optionally `\date{...}`

before calling `\maketitle`. In the argument to `\author`, you can supply several names separated by `\and` commands.

An example of some of the commands mentioned above can be found in Figure 1.2 on page 7.

Apart from the sectioning commands explained above, LaTeX 2_ε introduced three additional commands for use with the `book` class. They are useful for dividing your publication. The commands alter chapter headings and page numbering to work as you would expect it in a book:

`\frontmatter` should be the very first command after `\begin{document}`. It will switch page numbering to Roman numerals and sections be non-enumerated. As if you were using the starred sectioning commands (eg `\chapter*{Preface}`) but the sections will still show up in the table of contents.

`\mainmatter` comes right before the first chapter of the book. It turns on Arabic page numbering and restarts the page counter.

`\appendix` marks the start of additional material in your book. After this command chapters will be numbered with letters.

`\backmatter` should be inserted before the very last items in your book, such as the bibliography and the index. In the standard document classes, this has no visual effect.

2.8 Cross References

In books, reports and articles, there are often cross-references to figures, tables and special segments of text. LaTeX provides the following commands for cross referencing

`\label{`*marker*`}`, `\ref{`*marker*`}` and `\pageref{`*marker*`}`

where *marker* is an identifier chosen by the user. LaTeX replaces `\ref` by the number of the section, subsection, figure, table, or theorem after which the corresponding `\label` command was issued. `\pageref` prints the page number of the page where the `\label` command occurred.[12] As with the section titles, the numbers from the previous run are used.

```
A reference to this subsection
\label{sec:this} looks like:
``see section~\ref{sec:this} on
page~\pageref{sec:this}.''
```

A reference to this subsection looks like: "see section 2.8 on page 35."

2.9 Footnotes

With the command

`\footnote{`*footnote text*`}`

a footnote is printed at the foot of the current page. Footnotes should always be put[13] after the word or sentence they refer to. Footnotes referring to a sentence or part of it should therefore be put after the comma or period.[14]

```
Footnotes\footnote{This is
  a footnote.} are often used
by people using \LaTeX.
```

Footnotes[a] are often used by people using LaTeX.

[a]This is a footnote.

[12]Note that these commands are not aware of what they refer to. `\label` just saves the last automatically generated number.

[13]"put" is one of the most common English words.

[14]Note that footnotes distract the reader from the main body of your document. After all, everybody reads the footnotes—we are a curious species, so why not just integrate everything you want to say into the body of the document?[15]

[15]A guidepost doesn't necessarily go where it's pointing to :-).

2.10 Emphasized Words

If a text is typed using a typewriter, `important words are emphasized by underlining them.`

`\underline{`*text*`}`

In printed books, however, words are emphasized by typesetting them in an *italic* font. LaTeX provides the command

`\emph{`*text*`}`

to emphasize text. What the command actually does with its argument depends on the context:

```
\emph{If you use
  emphasizing inside a piece
  of emphasized text, then
  \LaTeX{} uses the
  \emph{normal} font for
  emphasizing.}
```

If you use emphasizing inside a piece of emphasized text, then LaTeX uses the normal *font for emphasizing.*

Please note the difference between telling LaTeX to *emphasize* something and telling it to use a different *font*:

```
\textit{You can also
  \emph{emphasize} text if
  it is set in italics,}
\textsf{in a
  \emph{sans-serif} font,}
\texttt{or in
  \emph{typewriter} style.}
```

You can also emphasize *text if it is set in italics,* in a *sans-serif* font, or in *typewriter* style.

2.11 Environments

`\begin{`*environment*`}` *text* `\end{`*environment*`}`

Where *environment* is the name of the environment. Environments can be nested within each other as long as the correct nesting order is maintained.

```
\begin{aaa}...\begin{bbb}...\end{bbb}...\end{aaa}
```

In the following sections all important environments are explained.

2.11.1 Itemize, Enumerate, and Description

The `itemize` environment is suitable for simple lists, the `enumerate` environment for enumerated lists, and the `description` environment for descriptions.

```
\flushleft
\begin{enumerate}
\item You can mix the list
environments to your taste:
\begin{itemize}
\item But it might start to
look silly.
\item[-] With a dash.
\end{itemize}
\item Therefore remember:
\begin{description}
\item[Stupid] things will not
become smart because they are
in a list.
\item[Smart] things, though, can be
presented beautifully in a list.
\end{description}
\end{enumerate}
```

1. You can mix the list environments to your taste:
   - But it might start to look silly.
   - With a dash.
2. Therefore remember:

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

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

2.11.2 Flushleft, Flushright, and Center

The environments `flushleft` and `flushright` generate paragraphs that are either left- or right-aligned. The `center` environment generates centred text. If you do not issue \\ to specify line breaks, LaTeX will automatically determine line breaks.

```
\begin{flushleft}
This text is\\ left-aligned.
\LaTeX{} is not trying to make
each line the same length.
\end{flushleft}
```

This text is
left-aligned. LaTeX is not trying to make
each line the same length.

```
\begin{flushright}
This text is right-\\aligned.
\LaTeX{} is not trying to make
each line the same length.
\end{flushright}
```

This text is right-
aligned. LaTeX is not trying to make each
line the same length.

```
\begin{center}
At the centre\\of the earth
\end{center}
```

At the centre
of the earth

2.11.3 Quote, Quotation, and Verse

The `quote` environment is useful for quotes, important phrases and examples.

```
A typographical rule of thumb
for the line length is:
\begin{quote}
On average, no line should
be longer than 66 characters.
\end{quote}
This is why \LaTeX{} pages have
such large borders by default and
also why multicolumn print is
used in newspapers.
```

A typographical rule of thumb for the line length is:

> On average, no line should be longer than 66 characters.

This is why LaTeX pages have such large borders by default and also why multicolumn print is used in newspapers.

There are two similar environments: the `quotation` and the `verse` environments. The `quotation` environment is useful for longer quotes going over several paragraphs, because it indents the first line of each paragraph. The `verse` environment is useful for poems where the line breaks are important. The lines are separated by issuing a `\\` at the end of a line and an empty line after each verse.

```
I know only one English poem by
heart. It is about Humpty Dumpty.
\begin{flushleft}
\begin{verse}
Humpty Dumpty sat on a wall:\\
Humpty Dumpty had a great fall.\\
All the King's horses and all
the King's men\\
Couldn't put Humpty together
again.
\end{verse}
\end{flushleft}
```

I know only one English poem by heart. It is about Humpty Dumpty.

> Humpty Dumpty sat on a wall:
> Humpty Dumpty had a great
> fall.
> All the King's horses and all
> the King's men
> Couldn't put Humpty together
> again.

2.11.4 Abstract

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. Normally `abstract` is used in documents typeset with the article document class.

```
\begin{abstract}
The abstract abstract.
\end{abstract}
```

The abstract abstract.

2.11.5 Printing Verbatim

Text that is enclosed between `\begin{verbatim}` and `\end{verbatim}` will be directly printed, as if typed on a typewriter, with all line breaks and spaces, without any LaTeX command being executed.

Within a paragraph, similar behavior can be accessed with

`\verb+`*text*`+`

The `+` is just an example of a delimiter character. You can use any character except letters, `*` or space. Many LaTeX examples in this booklet are typeset with this command.

```
The \verb|\ldots| command \ldots

\begin{verbatim}
10 PRINT "HELLO WORLD ";
20 GOTO 10
\end{verbatim}
```

The `\ldots` command …

```
10 PRINT "HELLO WORLD ";
20 GOTO 10
```

```
\begin{verbatim*}
the starred version of
the      verbatim
environment emphasizes
the spaces   in the text
\end{verbatim*}
```

```
the␣starred␣version␣of
the␣␣␣␣␣␣verbatim
environment␣emphasizes
the␣spaces␣␣␣in␣the␣text
```

The `\verb` command can be used in a similar fashion with a star:

```
\verb*|like   this :-) |
```

```
like␣␣␣this␣:-)␣
```

The `verbatim` environment and the `\verb` command may not be used within parameters of other commands.

2.11.6 Tabular

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 *table spec* argument of the

`\begin{tabular}[`*pos*`]{`*table spec*`}`

command defines the format of the table. Use an `l` for a column of left-aligned text, `r` for right-aligned text, and `c` for centred text; `p{`*width*`}` for a column containing justified text with line breaks, and `|` for a vertical line.

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.

The *pos* argument specifies the vertical position of the table relative to the baseline of the surrounding text. Use either of the letters `t`, `b` and `c` to specify table alignment at the top, bottom or center.

Within a `tabular` environment, `&` jumps to the next column, `\\` starts a new line and `\hline` inserts a horizontal line. You can add partial lines by using the `\cline{`*j*-*i*`}`, where j and i are the column numbers the line should extend over.

```
\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

```
\begin{tabular}{|p{4.7cm}|}
\hline
Welcome to Boxy's paragraph.
We sincerely hope you'll
all enjoy the show.\\
\hline
\end{tabular}
```

Welcome to Boxy's paragraph. We sincerely hope you'll all en-joy the show.

The column separator can be specified with the `@{...}` construct. This command kills the inter-column space and replaces it with whatever is between the curly braces. One common use for this command is explained below in the decimal alignment problem. Another possible application is to suppress leading space in a table with `@{}`.

```
\begin{tabular}{@{} l @{}}
\hline
no leading space\\
\hline
\end{tabular}
```

no leading space

```
\begin{tabular}{l}
\hline
leading space left and right\\
\hline
\end{tabular}
```

leading space left and right

Since there is no built-in way to align numeric columns to a decimal point,[16] we can "cheat" and do it by using two columns: a right-aligned integer and a left-aligned fraction. The `@{.}` command in the `\begin{tabular}` line replaces the normal inter-column spacing with just a ".", giving the appearance of a single, decimal-point-justified column. Don't forget to replace the decimal point in your numbers with a column separator (`&`)! A column label can be placed above our numeric "column" by using the `\multicolumn` command.

```
\begin{tabular}{c r @{.} l}
Pi expression       &
\multicolumn{2}{c}{Value} \\
\hline
$\pi$               & 3&1416  \\
$\pi^{\pi}$         & 36&46   \\
$(\pi^{\pi})^{\pi}$ & 80662&7 \\
\end{tabular}
```

Pi expression	Value
π	3.1416
π^{π}	36.46
$(\pi^{\pi})^{\pi}$	80662.7

```
\begin{tabular}{|c|c|}
\hline
\multicolumn{2}{|c|}{Ene} \\
\hline
Mene & Muh! \\
\hline
\end{tabular}
```

Ene	
Mene	Muh!

Material typeset with the tabular environment always stays together on one page. If you want to typeset long tables, you might want to have a look at the supertabular and the longtabular environments.

2.12 Floating Bodies

Today most publications contain a lot of figures and tables. These elements need special treatment, because they cannot be broken across pages. One method would be to start a new page every time a figure or a table is too large to fit on the present page. This approach would leave pages partially empty, which looks very bad.

The solution to this problem is to 'float' any figure or table that does not fit on the current page to a later page, while filling the current page with

[16] If the 'tools' bundle is installed on your system, have a look at the dcolumn package.

body text. LaTeX offers two environments for floating bodies; one for tables and one for figures. To take full advantage of these two environments it is important to understand approximately how LaTeX handles floats internally. Otherwise floats may become a major source of frustration, because LaTeX never puts them where you want them to be.

Let's first have a look at the commands LaTeX supplies for floats:

Any material enclosed in a `figure` or `table` environment will be treated as floating matter. Both float environments support an optional parameter

`\begin{figure}[`*placement specifier*`]` or `\begin{table}[`*placement specifier*`]`

called the *placement specifier*. This parameter is used to tell LaTeX about the locations to which the float is allowed to be moved. A *placement specifier* is constructed by building a string of *float-placing permissions*. See Table 2.7.

A table could be started with the following line e.g.

```
\begin{table}[!hbp]
```

The placement specifier `[!hbp]` allows LaTeX to place the table right here (`h`) or at the bottom (`b`) of some page or on a special floats page (`p`), and all this even if it does not look that good (`!`). If no placement specifier is given, the standard classes assume `[tbp]`.

LaTeX will place every float it encounters according to the placement specifier supplied by the author. If a float cannot be placed on the current page it is deferred either to the *figures* or the *tables* queue.[17] When a new page is started, LaTeX first checks if it is possible to fill a special 'float' page

[17] These are FIFO—'first in first out'—queues!

Table 2.7: Float Placing Permissions.

Spec	Permission to place the float ...
`h`	*here* at the very place in the text where it occurred. This is useful mainly for small floats.
`t`	at the *top* of a page
`b`	at the *bottom* of a page
`p`	on a special *page* containing only floats.
`!`	without considering most of the internal parameters[a], which could stop this float from being placed.

Note that `pt` and `em` are TeX units. Read more on this in table 6.5 on page 109.

[a] Such as the maximum number of floats allowed on one page.

with floats from the queues. If this is not possible, the first float on each queue is treated as if it had just occurred in the text: LaTeX tries again to place it according to its respective placement specifiers (except 'h,' which is no longer possible). Any new floats occurring in the text get placed into the appropriate queues. LaTeX strictly maintains the original order of appearance for each type of float. That's why a figure that cannot be placed pushes all further figures to the end of the document. Therefore:

> If LaTeX is not placing the floats as you expected, it is often only one float jamming one of the two float queues.

While it is possible to give LaTeX single-location placement specifiers, this causes problems. If the float does not fit in the location specified it becomes stuck, blocking subsequent floats. In particular, you should never, ever use the [h] option—it is so bad that in more recent versions of LaTeX, it is automatically replaced by [ht].

Having explained the difficult bit, there are some more things to mention about the `table` and `figure` environments. With the

`\caption{`*caption text*`}`

command, you can define a caption for the float. A running number and the string "Figure" or "Table" will be added by LaTeX.

The two commands

`\listoffigures` and `\listoftables`

operate analogously to the `\tableofcontents` command, printing a list of figures or tables, respectively. These lists will display the whole caption, so if you tend to use long captions you must have a shorter version of the caption for the lists. This is accomplished by entering the short version in brackets after the `\caption` command.

```
\caption[Short]{LLLLLoooooonnnnnggggg}
```

With `\label` and `\ref`, you can create a reference to a float within your text.

The following example draws a square and inserts it into the document. You could use this if you wanted to reserve space for images you are going to paste into the finished document.

```
Figure~\ref{white} is an example of Pop-Art.
\begin{figure}[!hbp]
\makebox[\textwidth]{\framebox[5cm]{\rule{0pt}{5cm}}}
\caption{Five by Five in Centimetres.\label{white}}
\end{figure}
```

In the example above, LaTeX will try *really hard* (`!`) to place the figure right *here* (`h`).[18] If this is not possible, it tries to place the figure at the *bottom* (`b`) of the page. Failing to place the figure on the current page, it determines whether it is possible to create a float page containing this figure and maybe some tables from the tables queue. If there is not enough material for a special float page, LaTeX starts a new page, and once more treats the figure as if it had just occurred in the text.

Under certain circumstances it might be necessary to use the

`\clearpage` or even the `\cleardoublepage`

command. It orders LaTeX to immediately place all floats remaining in the queues and then start a new page. `\cleardoublepage` even goes to a new right-hand page.

You will learn how to include PostScript drawings into your LaTeX 2_ε documents later in this introduction.

2.13 Protecting Fragile Commands

Text given as arguments of commands like `\caption` or `\section` may show up more than once in the document (e.g. in the table of contents as well as in the body of the document). Some commands fail when used in the argument of `\section`-like commands. These commands are called fragile commands—for example, `\footnote` or `\phantom`. These fragile commands need protection (don't we all?). You can protect them by putting the `\protect` command in front of them.

`\protect` only refers to the command that follows right behind, not even to its arguments. In most cases a superfluous `\protect` won't hurt.

```
\section{I am considerate
      \protect\footnote{and protect my footnotes}}
```

[18] assuming the figure queue is empty.

Chapter 3

Typesetting Mathematical Formulae

Now you are ready! In this chapter, we will attack the main strength of TEX: mathematical typesetting. But be warned, this chapter only scratches the surface. While the things explained here are sufficient for many people, don't despair if you can't find a solution to your mathematical typesetting needs here. It is highly likely that your problem is addressed in AMS-LATEX[1]

3.1 General

LATEX has a special mode for typesetting mathematics. Mathematics can be typeset inline within a paragraph, or the paragraph can be broken to typeset it separately. Mathematical text *within* a paragraph is entered between `\(` and `\)`, between `$` and `$`, or between `\begin{math}` and `\end{math}`.

```
Add $a$ squared and $b$ squared
to get $c$ squared. Or, using
a more mathematical approach:
$c^{2}=a^{2}+b^{2}$
```

Add a squared and b squared to get c squared. Or, using a more mathematical approach: $c^2 = a^2 + b^2$

```
\TeX{} is pronounced as
\(\tau\epsilon\chi\).\\[6pt]
100~m$^{3}$ of water\\[6pt]
This comes from my
\begin{math}\heartsuit\end{math}
```

TEX is pronounced as $\tau\epsilon\chi$.

100 m^3 of water

This comes from my $\heartsuit$

[1]The *American Mathematical Society* has produced a powerful extension to LATEX. Many of the examples in this chapter make use of this extension. It is provided with all recent TEX distributions. If yours is missing it, go to `macros/latex/required/amslatex`.

When you want your larger mathematical equations or formulae to be set apart from the rest of the paragraph, it is preferable to *display* them, rather than to break the paragraph apart. To do this, you can either enclose them in `\[` and `\]`, or between `\begin{displaymath}` and `\end{displaymath}`.

```
Add $a$ squared and $b$ squared
to get $c$ squared. Or, using
a more mathematical approach:
\begin{displaymath}
c^{2}=a^{2}+b^{2}
\end{displaymath}
or you can type less with:
\[a+b=c\]
```

Add a squared and b squared to get c squared. Or, using a more mathematical approach:

$$c^2 = a^2 + b^2$$

or you can type less with:

$$a + b = c$$

If you want LaTeX to enumerate your equations, you can use the `equation` environment. You can then `\label` an equation number and refer to it somewhere else in the text by using `\ref` or `\eqref`:

```
\begin{equation} \label{eq:eps}
\epsilon > 0
\end{equation}
From (\ref{eq:eps}), we gather
\ldots{}From \eqref{eq:eps} we
do the same.
```

$$\epsilon > 0 \tag{3.1}$$

From (3.1), we gather . . . From (3.1) we do the same.

Note the difference in typesetting style between equations that are typeset and those that are displayed:

```
$\lim_{n \to \infty}
\sum_{k=1}^n \frac{1}{k^2}
= \frac{\pi^2}{6}$
```

$\lim_{n \to \infty} \sum_{k=1}^n \frac{1}{k^2} = \frac{\pi^2}{6}$

```
\begin{displaymath}
\lim_{n \to \infty}
\sum_{k=1}^n \frac{1}{k^2}
= \frac{\pi^2}{6}
\end{displaymath}
```

$$\lim_{n \to \infty} \sum_{k=1}^n \frac{1}{k^2} = \frac{\pi^2}{6}$$

There are differences between *math mode* and *text mode*. For example, in *math 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` or `\qquad`.

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 the `\textrm{...}` commands (see also section 3.7 on page 54).

```
\begin{equation}
\forall x \in \mathbf{R}:
\qquad x^{2} \geq 0
\end{equation}
```

$$\forall x \in \mathbf{R}: \qquad x^{2} \geq 0 \tag{3.2}$$

```
\begin{equation}
x^{2} \geq 0\qquad
\textrm{for all }x\in\mathbf{R}
\end{equation}
```

$$x^{2} \geq 0 \qquad \textrm{for all } x \in \mathbf{R} \tag{3.3}$$

Mathematicians can be very fussy about which symbols are used: it would be conventional here to use 'blackboard bold', which is obtained using `\mathbb` from the package amsfonts or amssymb. The last example becomes

```
\begin{displaymath}
x^{2} \geq 0\qquad
\textrm{for all }x\in\mathbb{R}
\end{displaymath}
```

$$x^{2} \geq 0 \qquad \textrm{for all } x \in \mathbb{R}$$

3.2 Grouping in Math Mode

Most math mode commands act only on the next character, so if you want a command to affect several characters, you have to group them together using curly braces: `{...}`.

```
\begin{equation}
a^x+y \neq a^{x+y}
\end{equation}
```

$$a^x+y \neq a^{x+y} \tag{3.4}$$

3.3 Building Blocks of a Mathematical Formula

This section describes the most important commands used in mathematical typesetting. Take a look at section 3.10 on page 58 for a detailed list of commands for typesetting mathematical symbols.

Lowercase Greek letters are entered as `\alpha`, `\beta`, `\gamma`, ..., uppercase letters are entered as `\Gamma`, `\Delta`, ...[2]

[2]There is no uppercase Alpha defined in LaTeX 2ε because it looks the same as a normal roman A. Once the new math coding is done, things will change.

```
$\lambda,\xi,\pi,\mu,\Phi,\Omega$
```

$\lambda, \xi, \pi, \mu, \Phi, \Omega$

Exponents and Subscripts can be specified using the `^` and the `_` character.

```
$a_{1}$ \qquad $x^{2}$ \qquad
$e^{-\alpha t}$ \qquad
$a^{3}_{ij}$\\
$e^{x^2} \neq {e^x}^2$
```

a_{1} $\qquad$ x^{2} $\qquad$ $e^{-\alpha t}$ $\qquad$ a^{3}_{ij}
$e^{x^2} \neq {e^x}^2$

The **square root** is entered as `\sqrt`; the n^{th} root is generated with `\sqrt[`n`]`. The size of the root sign is determined automatically by LaTeX. If just the sign is needed, use `\surd`.

```
$\sqrt{x}$ \qquad
$\sqrt{ x^{2}+\sqrt{y} }$
\qquad $\sqrt[3]{2}$\\[3pt]
$\surd[x^2 + y^2]$
```

$\sqrt{x}$ $\qquad$ $\sqrt{ x^{2}+\sqrt{y} }$ $\qquad$ $\sqrt[3]{2}$
$\surd[x^2 + y^2]$

The commands `\overline` and `\underline` create **horizontal lines** directly over or under an expression.

```
$\overline{m+n}$
```

$\overline{m+n}$

The commands `\overbrace` and `\underbrace` create long **horizontal braces** over or under an expression.

```
$\underbrace{ a+b+\cdots+z }_{26}$
```

$\underbrace{ a+b+\cdots+z }_{26}$

To add mathematical accents such as small arrows or tilde signs to variables, you can use the commands given in Table 3.1 on page 58. Wide hats and tildes covering several characters are generated with `\widetilde` and `\widehat`. The `'` symbol gives a prime.

```
\begin{displaymath}
y=x^{2}\qquad y'=2x\qquad y''=2
\end{displaymath}
```

$$y=x^{2}\qquad y'=2x\qquad y''=2$$

Vectors often are specified by adding small arrow symbols on top of a variable. This is done with the `\vec` command. The two commands `\overrightarrow` and `\overleftarrow` are useful to denote the vector from A to B.

```
\begin{displaymath}
\vec a\quad\overrightarrow{AB}
\end{displaymath}
```

$$\vec a\quad\overrightarrow{AB}$$

Usually you don't typeset an explicit dot sign to indicate the multiplication operation; however sometimes it is written to help the reader's eyes in grouping a formula. You should use `\cdot` in these cases:

```
\begin{displaymath}
v = {\sigma}_1 \cdot {\sigma}_2
    {\tau}_1 \cdot {\tau}_2
\end{displaymath}
```

$$v = {\sigma}_1 \cdot {\sigma}_2 {\tau}_1 \cdot {\tau}_2$$

Names of log-like functions are often typeset in an upright font, and not in italics as variables are, so LaTeX supplies the following commands to typeset the most important function names:

`\arccos`	`\cos`	`\csc`	`\exp`	`\ker`	`\limsup`	`\min`
`\arcsin`	`\cosh`	`\deg`	`\gcd`	`\lg`	`\ln`	`\Pr`
`\arctan`	`\cot`	`\det`	`\hom`	`\lim`	`\log`	`\sec`
`\arg`	`\coth`	`\dim`	`\inf`	`\liminf`	`\max`	`\sin`
`\sinh`	`\sup`	`\tan`	`\tanh`			

```
\[\lim_{x \rightarrow 0}
\frac{\sin x}{x}=1\]
```

$$\lim_{x \rightarrow 0} \frac{\sin x}{x}=1$$

For the modulo function, there are two commands: `\bmod` for the binary operator "$a \bmod b$" and `\pmod` for expressions such as "$x\equiv a \pmod{b}$."

```
$a\bmod b$\\
$x\equiv a \pmod{b}$
```

$a\bmod b$
$x\equiv a \pmod{b}$

A built-up **fraction** is typeset with the `\frac{...}{...}` command. Often the slashed form 1/2 is preferable, because it looks better for small amounts of 'fraction material.'

```
$1\frac{1}{2}$~hours
\begin{displaymath}
\frac{ x^{2} }{ k+1 }\qquad
x^{ \frac{2}{k+1} }\qquad
x^{ 1/2 }
\end{displaymath}
```

$1\frac{1}{2}$ hours

$$\frac{ x^{2} }{ k+1 }\qquad x^{ \frac{2}{k+1} }\qquad x^{ 1/2 }$$

To typeset binomial coefficients or similar structures, you can use the command `\binom` from the `amsmath` package.

```
\begin{displaymath}
\binom{n}{k}\qquad\mathrm{C}_n^k
\end{displaymath}
```

$$\binom{n}{k}\qquad\mathrm{C}_n^k$$

For binary relations it may be useful to stack symbols over each other. `\stackrel` puts the symbol given in the first argument in superscript-like size over the second, which is set in its usual position.

```
\begin{displaymath}
\int f_N(x) \stackrel{!}{=} 1
\end{displaymath}
```

$$\int f_N(x) \stackrel{!}{=} 1$$

The **integral operator** is generated with `\int`, the **sum operator** with `\sum`, and the **product operator** with `\prod`. The upper and lower limits are specified with ^ and _ like subscripts and superscripts. [3]

```
\begin{displaymath}
\sum_{i=1}^{n} \qquad
\int_{0}^{\frac{\pi}{2}} \qquad
\prod_\epsilon
\end{displaymath}
```

$$\sum_{i=1}^{n} \qquad \int_{0}^{\frac{\pi}{2}} \qquad \prod_\epsilon$$

To get more control over the placement of indices in complex expressions, amsmath provides two additional tools: the `\substack` command and the `subarray` environment:

```
\begin{displaymath}
\sum_{\substack{0<i<n \\ 1<j<m}}
   P(i,j) =
\sum_{\begin{subarray}{l} i\in I\\
         1<j<m
      \end{subarray}}     Q(i,j)
\end{displaymath}
```

$$\sum_{\substack{0<i<n \\ 1<j<m}} P(i,j) = \sum_{\begin{subarray}{l} i\in I\\ 1<j<m \end{subarray}} Q(i,j)$$

TeX provides all sorts of symbols for **braces** and other delimiters (e.g. $[\ \langle\ \|\ \updownarrow$). Round and square braces can be entered with the corresponding keys and curly braces with `\{`, but all other delimiters are generated with special commands (e.g. `\updownarrow`). For a list of all delimiters available, check Table 3.8 on page 60.

```
\begin{displaymath}
{a,b,c}\neq\{a,b,c\}
\end{displaymath}
```

$$a,b,c \neq \{a,b,c\}$$

[3] $\mathcal{AMS}$-LaTeX in addition has multi-line super-/subscripts

If you put the command `\left` in front of an opening delimiter or `\right` in front of a closing delimiter, TeX will automatically determine the correct size of the delimiter. Note that you must close every `\left` with a corresponding `\right`, and that the size is determined correctly only if both are typeset on the same line. If you don't want anything on the right, use the invisible '`\right.`'!

```
\begin{displaymath}
1 + \left( \frac{1}{ 1-x^{2} }
    \right) ^3
\end{displaymath}
```

$$1 + \left(\frac{1}{ 1-x^{2} } \right) ^3$$

In some cases it is necessary to specify the correct size of a mathematical delimiter by hand, which can be done using the commands `\big`, `\Big`, `\bigg` and `\Bigg` as prefixes to most delimiter commands.[4]

```
$\Big( (x+1) (x-1) \Big) ^{2}$\\
$\big(\Big(\bigg(\Bigg($\quad
$\big\}\Big\}\bigg\}\Bigg\}$\quad
$\big\|\Big\|\bigg\|\Bigg\|$
```

$\Big((x+1) (x-1) \Big) ^{2}$
$\big(\Big(\bigg(\Bigg($ $\big\}\Big\}\bigg\}\Bigg\}$ $\big\|\Big\|\bigg\|\Bigg\|$

There are several commands to enter **three dots** into a formula. `\ldots` typesets the dots on the baseline and `\cdots` sets them centred. Besides that, there are the commands `\vdots` for vertical and `\ddots` for diagonal dots. You can find another example in section 3.5.

```
\begin{displaymath}
x_{1},\ldots,x_{n} \qquad
x_{1}+\cdots+x_{n}
\end{displaymath}
```

$$x_{1},\ldots,x_{n} \qquad x_{1}+\cdots+x_{n}$$

3.4 Math Spacing

If the spaces within formulae chosen by TeX are not satisfactory, they can be adjusted by inserting special spacing commands. There are some commands for small spaces: `\,` for $\frac{3}{18}$ quad (␣), `\:` for $\frac{4}{18}$ quad (␣) and `\;` for $\frac{5}{18}$ quad (␣). The escaped space character `\␣` generates a medium sized space and `\quad` (␣) and `\qquad` (␣) produce large spaces. The size of a `\quad` corresponds to the width of the character 'M' of the current font. The `\!` command produces a negative space of $-\frac{3}{18}$ quad (␣).

[4] These commands do not work as expected if a size changing command has been used, or the `11pt` or `12pt` option has been specified. Use the `exscale` or `amsmath` packages to correct this behaviour.

```
\newcommand{\ud}{\mathrm{d}}
\begin{displaymath}
\int\!\!\!\int_{D} g(x,y)
  \, \ud x\, \ud y
\end{displaymath}
instead of
\begin{displaymath}
\int\int_{D} g(x,y)\ud x \ud y
\end{displaymath}
```

$$\int\!\!\!\int_{D} g(x,y) \, \mathrm{d}x\, \mathrm{d}y$$

instead of

$$\int\int_{D} g(x,y)\mathrm{d}x\mathrm{d}y$$

Note that 'd' in the differential is conventionally set in roman.

$\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX provides another way for fine-tuning the spacing between multiple integral signs, namely the `\iint`, `\iiint`, `\iiiint`, and `\idotsint` commands. With the amsmath package loaded, the above example can be typeset this way:

```
\newcommand{\ud}{\mathrm{d}}
\begin{displaymath}
\iint_{D} \, \ud x \, \ud y
\end{displaymath}
```

$$\iint_{D} \, \mathrm{d}x \, \mathrm{d}y$$

See the electronic document testmath.tex (distributed with $\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX) or Chapter 8 of *The LaTeX Companion* [3] for further details.

3.5 Vertically Aligned Material

To typeset **arrays**, use the `array` environment. It works somewhat similar to the `tabular` environment. The `\\` command is used to break the lines.

```
\begin{displaymath}
\mathbf{X} =
\left( \begin{array}{ccc}
x_{11} & x_{12} & \ldots \\
x_{21} & x_{22} & \ldots \\
\vdots & \vdots & \ddots
\end{array} \right)
\end{displaymath}
```

$$\mathbf{X} = \left(\begin{array}{ccc} x_{11} & x_{12} & \ldots \\ x_{21} & x_{22} & \ldots \\ \vdots & \vdots & \ddots \end{array} \right)$$

The `array` environment can also be used to typeset expressions that have one big delimiter by using a "`.`" as an invisible `\right` delimiter:

```
\begin{displaymath}
y = \left\{ \begin{array}{ll}
 a & \textrm{if $d>c$}\\
 b+x & \textrm{in the morning}\\
 l & \textrm{all day long}
  \end{array} \right.
\end{displaymath}
```

$$y = \left\{ \begin{array}{ll} a & \textrm{if $d>c$}\\ b+x & \textrm{in the morning}\\ l & \textrm{all day long} \end{array} \right.$$

Just as with the `tabular` environment, you can also draw lines in the `array` environment, e.g. separating the entries of a matrix:

```
\begin{displaymath}
\left(\begin{array}{c|c}
 1 & 2 \\
\hline
3 & 4
\end{array}\right)
\end{displaymath}
```

$$\left(\begin{array}{c|c} 1 & 2 \\ \hline 3 & 4 \end{array}\right)$$

For formulae running over several lines or for equation systems, you can use the environments `eqnarray`, and `eqnarray*` instead of `equation`. In `eqnarray` each line gets an equation number. The `eqnarray*` does not number anything.

The `eqnarray` and the `eqnarray*` environments work like a 3-column table of the form `{rcl}`, where the middle column can be used for the equal sign, the not-equal sign, or any other sign you see fit. The `\\` command breaks the lines.

```
\begin{eqnarray}
f(x) & = & \cos x     \\
f'(x) & = & -\sin x   \\
\int_{0}^{x} f(y)dy &
 = & \sin x
\end{eqnarray}
```

$$\begin{aligned} f(x) &= \cos x & (3.5) \\ f'(x) &= -\sin x & (3.6) \\ \int_{0}^{x} f(y)dy &= \sin x & (3.7) \end{aligned}$$

Notice that the space on either side of the the equal signs is rather large. It can be reduced by setting `\setlength\arraycolsep{2pt}`, as in the next example.

Long equations will not be automatically divided into neat bits. The author has to specify where to break them and how much to indent. The following two methods are the most common ways to achieve this.

```
{\setlength\arraycolsep{2pt}
\begin{eqnarray}
\sin x & = & x -\frac{x^{3}}{3!}
     +\frac{x^{5}}{5!}-{}
                      \nonumber\\
 & & {}-\frac{x^{7}}{7!}+{}\cdots
\end{eqnarray}}
```

$$\begin{aligned} \sin x = {} & x - \frac{x^3}{3!} + \frac{x^5}{5!} - \\ & - \frac{x^7}{7!} + \cdots \qquad (3.8) \end{aligned}$$

```
\begin{eqnarray}
\lefteqn{ \cos x = 1
     -\frac{x^{2}}{2!} +{} }
                    \nonumber\\
 & & {}+\frac{x^{4}}{4!}
     -\frac{x^{6}}{6!}+{}\cdots
\end{eqnarray}
```

$$\cos x = 1 - \frac{x^2}{2!} + \\ + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots \qquad (3.9)$$

The `\nonumber` command tells LaTeX not to generate a number for this equation.

It can be difficult to get vertically aligned equations to look right with these methods; the package `amsmath` provides a more powerful set of alternatives. (see `align`, `flalign`, `gather`, `multline` and `split` environments).

3.6 Phantoms

We can't see phantoms, but they still occupy some space in many people's minds. LaTeX is no different. We can use this for some interesting spacing tricks.

When vertically aligning text using `^` and `_` LaTeX is sometimes just a little bit too helpful. Using the `\phantom` command you can reserve space for characters that do not show up in the final output. The easiest way to understand this is to look at the following examples.

```
\begin{displaymath}
{}^{12}_{\phantom{1}6}\textrm{C}
\qquad \textrm{versus} \qquad
{}^{12}_{6}\textrm{C}
\end{displaymath}
```

$${}^{12}_{6}\textrm{C} \qquad \textrm{versus} \qquad {}^{12}_{6}\textrm{C}$$

```
\begin{displaymath}
\Gamma_{ij}^{\phantom{ij}k}
\qquad \textrm{versus} \qquad
\Gamma_{ij}^{k}
\end{displaymath}
```

$$\Gamma_{ij}^{k} \qquad \textrm{versus} \qquad \Gamma_{ij}^{k}$$

3.7 Math Font Size

In math mode, TeX selects the font size according to the context. Superscripts, for example, get typeset in a smaller font. If you want to typeset part of an equation in roman, don't use the `\textrm` command, because the font size switching mechanism will not work, as `\textrm` temporarily escapes to text mode. Use \mathrm instead to keep the size switching mechanism active. But pay attention, \mathrm will only work well on short items. Spaces are still not active and accented characters do not work.[5]

```
\begin{equation}
2^{\textrm{nd}} \quad
2^{\mathrm{nd}}
\end{equation}
```

$$2^{\text{nd}} \quad 2^{\mathrm{nd}} \tag{3.10}$$

Sometimes you still need to tell LaTeX the correct font size. In math mode, this is set with the following four commands:

\displaystyle ($\displaystyle 123$), \textstyle ($\textstyle 123$), \scriptstyle ($\scriptstyle 123$) and \scriptscriptstyle ($\scriptscriptstyle 123$).

Changing styles also affects the way limits are displayed.

```
\begin{displaymath}
\mathop{\mathrm{corr}}(X,Y)=
 \frac{\displaystyle
   \sum_{i=1}^n(x_i-\overline x)
   (y_i-\overline y)}
  {\displaystyle\biggl[
 \sum_{i=1}^n(x_i-\overline x)^2
\sum_{i=1}^n(y_i-\overline y)^2
\biggr]^{1/2}}
\end{displaymath}
```

$$\mathop{\mathrm{corr}}(X,Y)=\frac{\displaystyle\sum_{i=1}^n(x_i-\overline x)(y_i-\overline y)}{\displaystyle\biggl[\sum_{i=1}^n(x_i-\overline x)^2\sum_{i=1}^n(y_i-\overline y)^2\biggr]^{1/2}}$$

This is an examples with larger brackets than \left[\right] provides. The \biggl and \biggr commands are used for left and right brackets respectively.

3.8 Theorems, Laws, . . .

When writing mathematical documents, you probably need a way to typeset "Lemmas", "Definitions", "Axioms" and similar structures. LaTeX supports this with the command

\newtheorem{*name*}[*counter*]{*text*}[*section*]

The *name* argument is a short keyword used to identify the "theorem." With the *text* argument you define the actual name of the "theorem," which will be printed in the final document.

The arguments in square brackets are optional. They are both used to specify the numbering used on the "theorem." Use the *counter* argument to

[5] The AMS-LaTeX (amsmath) package makes the \textrm command work with size changing.

specify the *name* of a previously declared “theorem.” The new “theorem” will then be numbered in the same sequence. The *section* argument allows you to specify the sectional unit within which the “theorem” should get its numbers.

After executing the `\newtheorem` command in the preamble of your document, you can use the following command within the document.

```
\begin{name}[text]
This is my interesting theorem
\end{name}
```

This should be enough theory. The following examples should remove any remaining doubt, and make it clear that the `\newtheorem` environment is way too complex to understand.

```
% definitions for the document
% preamble
\newtheorem{law}{Law}
\newtheorem{jury}[law]{Jury}
%in the document
\begin{law} \label{law:box}
Don’t hide in the witness box
\end{law}
\begin{jury}[The Twelve]
It could be you! So beware and
see law~\ref{law:box}\end{jury}
\begin{law}No, No, No\end{law}
```

Law 1 *Don’t hide in the witness box*

Jury 2 (The Twelve) *It could be you! So beware and see law 1*

Law 3 *No, No, No*

The “Jury” theorem uses the same counter as the “Law” theorem, so it gets a number that is in sequence with the other “Laws.” The argument in square brackets is used to specify a title or something similar for the theorem.

```
\flushleft
\newtheorem{mur}{Murphy}[section]
\begin{mur}
If there are two or more
ways to do something, and
one of those ways can result
in a catastrophe, then
someone will do it.\end{mur}
```

Murphy 3.8.1 *If there are two or more ways to do something, and one of those ways can result in a catastrophe, then someone will do it.*

The “Murphy” theorem gets a number that is linked to the number of the current section. You could also use another unit, for example chapter or subsection.

3.9 Bold Symbols

It is quite difficult to get bold symbols in LaTeX; this is probably intentional as amateur typesetters tend to overuse them. The font change command `\mathbf` gives bold letters, but these are roman (upright) whereas mathematical symbols are normally italic. There is a `\boldmath` command, but *this can only be used outside mathematics mode.* It works for symbols too.

```
\begin{displaymath}
\mu, M \qquad \mathbf{M} \qquad
\mbox{\boldmath $\mu, M$}
\end{displaymath}
```

$$\mu, M \qquad \mathbf{M} \qquad \boldsymbol{\mu}\mathbf{,}\, \boldsymbol{M}$$

Notice that the comma is bold too, which may not be what is required.

The package amsbsy (included by amsmath) as well as the bm from the tools bundle make this much easier as they include a `\boldsymbol` command.

```
\begin{displaymath}
\mu, M \qquad
\boldsymbol{\mu}, \boldsymbol{M}
\end{displaymath}
```

$$\mu, M \qquad \boldsymbol{\mu}, \boldsymbol{M}$$

3.10 List of Mathematical Symbols

The following tables demonstrate all the symbols normally accessible from *math mode*.

To use the symbols listed in Tables 3.12–3.16,[6] the package amssymb must be loaded in the preamble of the document and the AMS math fonts must be installed on the system. If the AMS package and fonts are not installed on your system, have a look at `macros/latex/required/amslatex`. An even more comprehensive list of symbols can be found at `info/symbols/comprehensive`.

Table 3.1: Math Mode Accents.

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

Table 3.2: Lowercase Greek Letters.

α	`\alpha`	θ	`\theta`	o	`o`	υ	`\upsilon`
β	`\beta`	ϑ	`\vartheta`	π	`\pi`	ϕ	`\phi`
γ	`\gamma`	ι	`\iota`	ϖ	`\varpi`	φ	`\varphi`
δ	`\delta`	κ	`\kappa`	ρ	`\rho`	χ	`\chi`
ϵ	`\epsilon`	λ	`\lambda`	ϱ	`\varrho`	ψ	`\psi`
ε	`\varepsilon`	μ	`\mu`	σ	`\sigma`	ω	`\omega`
ζ	`\zeta`	ν	`\nu`	ς	`\varsigma`		
η	`\eta`	ξ	`\xi`	τ	`\tau`		

Table 3.3: Uppercase Greek Letters.

Γ	`\Gamma`	Λ	`\Lambda`	Σ	`\Sigma`	Ψ	`\Psi`
Δ	`\Delta`	Ξ	`\Xi`	Υ	`\Upsilon`	Ω	`\Omega`
Θ	`\Theta`	Π	`\Pi`	Φ	`\Phi`		

[6]These tables were derived from `symbols.tex` by David Carlisle and subsequently changed extensively as suggested by Josef Tkadlec.

Table 3.4: Binary Relations.

You can negate the following symbols by prefixing them with a `\not` command.

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

[a]Use the latexsym package to access this symbol

Table 3.5: Binary Operators.

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

Table 3.6: BIG Operators.

$\sum$	`\sum`	$\bigcup$	`\bigcup`	$\bigvee$	`\bigvee`	$\bigoplus$	`\bigoplus`
$\prod$	`\prod`	$\bigcap$	`\bigcap`	$\bigwedge$	`\bigwedge`	$\bigotimes$	`\bigotimes`
$\coprod$	`\coprod`	$\bigsqcup$	`\bigsqcup`			$\bigodot$	`\bigodot`
$\int$	`\int`	$\oint$	`\oint`			$\biguplus$	`\biguplus`

Table 3.7: Arrows.

$\leftarrow$	`\leftarrow` or `\gets`	$\longleftarrow$	`\longleftarrow`	$\uparrow$	`\uparrow`
$\rightarrow$	`\rightarrow` or `\to`	$\longrightarrow$	`\longrightarrow`	$\downarrow$	`\downarrow`
$\leftrightarrow$	`\leftrightarrow`	$\longleftrightarrow$	`\longleftrightarrow`	$\updownarrow$	`\updownarrow`
$\Leftarrow$	`\Leftarrow`	$\Longleftarrow$	`\Longleftarrow`	$\Uparrow$	`\Uparrow`
$\Rightarrow$	`\Rightarrow`	$\Longrightarrow$	`\Longrightarrow`	$\Downarrow$	`\Downarrow`
$\Leftrightarrow$	`\Leftrightarrow`	$\Longleftrightarrow$	`\Longleftrightarrow`	$\Updownarrow$	`\Updownarrow`
$\mapsto$	`\mapsto`	$\longmapsto$	`\longmapsto`	$\nearrow$	`\nearrow`
$\hookleftarrow$	`\hookleftarrow`	$\hookrightarrow$	`\hookrightarrow`	$\searrow$	`\searrow`
$\leftharpoonup$	`\leftharpoonup`	$\rightharpoonup$	`\rightharpoonup`	$\swarrow$	`\swarrow`
$\leftharpoondown$	`\leftharpoondown`	$\rightharpoondown$	`\rightharpoondown`	$\nwarrow$	`\nwarrow`
$\rightleftharpoons$	`\rightleftharpoons`	$\iff$	`\iff` (bigger spaces)	$\leadsto$	`\leadsto` [a]

[a] Use the latexsym package to access this symbol

Table 3.8: Delimiters.

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

Table 3.9: Large Delimiters.

$\lgroup$	`\lgroup`	$\rgroup$	`\rgroup`	$\lmoustache$	`\lmoustache`	$\rmoustache$	`\rmoustache`
$\arrowvert$	`\arrowvert`	$\Arrowvert$	`\Arrowvert`	$\bracevert$	`\bracevert`		

Table 3.10: Miscellaneous Symbols.

$\dots$	`\dots`	$\cdots$	`\cdots`	$\vdots$	`\vdots`	$\ddots$	`\ddots`
$\hbar$	`\hbar`	$\imath$	`\imath`	$\jmath$	`\jmath`	ℓ	`\ell`
$\Re$	`\Re`	$\Im$	`\Im`	$\aleph$	`\aleph`	$\wp$	`\wp`
$\forall$	`\forall`	$\exists$	`\exists`	$\mho$	`\mho` [a]	∂	`\partial`
$'$	`'`	$\prime$	`\prime`	$\emptyset$	`\emptyset`	∞	`\infty`
∇	`\nabla`	$\triangle$	`\triangle`	$\Box$	`\Box` [a]	$\Diamond$	`\Diamond` [a]
$\bot$	`\bot`	$\top$	`\top`	$\angle$	`\angle`	$\surd$	`\surd`
$\diamondsuit$	`\diamondsuit`	$\heartsuit$	`\heartsuit`	$\clubsuit$	`\clubsuit`	$\spadesuit$	`\spadesuit`
$\neg$	`\neg` or `\lnot`	$\flat$	`\flat`	$\natural$	`\natural`	$\sharp$	`\sharp`

[a] Use the latexsym package to access this symbol

Table 3.11: Non-Mathematical Symbols.

These symbols can also be used in text mode.

†	`\dag`	§	`\S`	©	`\copyright`	®	`\textregistered`
‡	`\ddag`	¶	`\P`	£	`\pounds`	%	`\%`

Table 3.12: AMS Delimiters.

$\ulcorner$	`\ulcorner`	$\urcorner$	`\urcorner`	$\llcorner$	`\llcorner`	$\lrcorner$	`\lrcorner`
$\lvert$	`\lvert`	$\rvert$	`\rvert`	$\lVert$	`\lVert`	$\rVert$	`\rVert`

Table 3.13: AMS Greek and Hebrew.

$\digamma$	`\digamma`	$\varkappa$	`\varkappa`	$\beth$	`\beth`	$\gimel$	`\gimel`	$\daleth$	`\daleth`

Table 3.14: AMS Binary Relations.

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

Table 3.15: AMS Arrows.

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

Table 3.16: AMS Negated Binary Relations and Arrows.

$\nless$	\nless	$\ngtr$	\ngtr	$\varsubsetneqq$	\varsubsetneqq
$\lneq$	\lneq	$\gneq$	\gneq	$\varsupsetneqq$	\varsupsetneqq
$\nleq$	\nleq	$\ngeq$	\ngeq	$\nsubseteqq$	\nsubseteqq
$\nleqslant$	\nleqslant	$\ngeqslant$	\ngeqslant	$\nsupseteqq$	\nsupseteqq
$\lneqq$	\lneqq	$\gneqq$	\gneqq	$\nmid$	\nmid
$\lvertneqq$	\lvertneqq	$\gvertneqq$	\gvertneqq	$\nparallel$	\nparallel
$\nleqq$	\nleqq	$\ngeqq$	\ngeqq	$\nshortmid$	\nshortmid
$\lnsim$	\lnsim	$\gnsim$	\gnsim	$\nshortparallel$	\nshortparallel
$\lnapprox$	\lnapprox	$\gnapprox$	\gnapprox	$\nsim$	\nsim
$\nprec$	\nprec	$\nsucc$	\nsucc	$\ncong$	\ncong
$\npreceq$	\npreceq	$\nsucceq$	\nsucceq	$\nvdash$	\nvdash
$\precneqq$	\precneqq	$\succneqq$	\succneqq	$\nvDash$	\nvDash
$\precnsim$	\precnsim	$\succnsim$	\succnsim	$\nVdash$	\nVdash
$\precnapprox$	\precnapprox	$\succnapprox$	\succnapprox	$\nVDash$	\nVDash
$\subsetneq$	\subsetneq	$\supsetneq$	\supsetneq	$\ntriangleleft$	\ntriangleleft
$\varsubsetneq$	\varsubsetneq	$\varsupsetneq$	\varsupsetneq	$\ntriangleright$	\ntriangleright
$\nsubseteq$	\nsubseteq	$\nsupseteq$	\nsupseteq	$\ntrianglelefteq$	\ntrianglelefteq
$\subsetneqq$	\subsetneqq	$\supsetneqq$	\supsetneqq	$\ntrianglerighteq$	\ntrianglerighteq
$\nleftarrow$	\nleftarrow	$\nrightarrow$	\nrightarrow	$\nleftrightarrow$	\nleftrightarrow
$\nLeftarrow$	\nLeftarrow	$\nRightarrow$	\nRightarrow	$\nLeftrightarrow$	\nLeftrightarrow

Table 3.17: AMS Binary Operators.

$\dotplus$	\dotplus	$\centerdot$	\centerdot	$\intercal$	\intercal
$\ltimes$	\ltimes	$\rtimes$	\rtimes	$\divideontimes$	\divideontimes
$\Cup$	\Cup or \doublecup	$\Cap$	\Cap or \doublecap	$\smallsetminus$	\smallsetminus
$\veebar$	\veebar	$\barwedge$	\barwedge	$\doublebarwedge$	\doublebarwedge
$\boxplus$	\boxplus	$\boxminus$	\boxminus	$\circleddash$	\circleddash
$\boxtimes$	\boxtimes	$\boxdot$	\boxdot	$\circledcirc$	\circledcirc
$\leftthreetimes$	\leftthreetimes	$\rightthreetimes$	\rightthreetimes	$\circledast$	\circledast
$\curlyvee$	\curlyvee	$\curlywedge$	\curlywedge		

Table 3.18: AMS Miscellaneous.

$\hbar$	`\hbar`	$\hslash$	`\hslash`	$\Bbbk$	`\Bbbk`
$\square$	`\square`	$\blacksquare$	`\blacksquare`	$\circledS$	`\circledS`
$\vartriangle$	`\vartriangle`	$\blacktriangle$	`\blacktriangle`	$\complement$	`\complement`
$\triangledown$	`\triangledown`	$\blacktriangledown$	`\blacktriangledown`	$\Game$	`\Game`
$\lozenge$	`\lozenge`	$\blacklozenge$	`\blacklozenge`	$\bigstar$	`\bigstar`
$\angle$	`\angle`	$\measuredangle$	`\measuredangle`	$\sphericalangle$	`\sphericalangle`
$\diagup$	`\diagup`	$\diagdown$	`\diagdown`	$\backprime$	`\backprime`
$\nexists$	`\nexists`	$\Finv$	`\Finv`	$\varnothing$	`\varnothing`
$\eth$	`\eth`	$\mho$	`\mho`		

Table 3.19: Math Alphabets.

Example	Command	Required package
$\mathrm{ABCDE abcde 1234}$	`\mathrm{ABCDE abcde 1234}`	
$\mathit{ABCDE abcde 1234}$	`\mathit{ABCDE abcde 1234}`	
$\mathnormal{ABCDE abcde 1234}$	`\mathnormal{ABCDE abcde 1234}`	
$\mathcal{ABCDE abcde 1234}$	`\mathcal{ABCDE abcde 1234}`	
$\mathscr{ABCDE abcde 1234}$	`\mathscr{ABCDE abcde 1234}`	mathrsfs
$\mathfrak{ABCDE abcde 1234}$	`\mathfrak{ABCDE abcde 1234}`	amsfonts or amssymb
$\mathbb{ABCDE abcde 1234}$	`\mathbb{ABCDE abcde 1234}`	amsfonts or amssymb

Chapter 4

Specialities

When putting together a large document, LaTeX will help you with some special features like index generation, bibliography management, and other things. A much more complete description of specialities and enhancements possible with LaTeX can be found in the *LaTeX Manual* [1] and *The LaTeX Companion* [3].

4.1 Including Encapsulated PostScript Graphics

LaTeX provides the basic facilities to work with floating bodies, such as images or graphics, with the `figure` and `table` environments.

There are also several ways to generate the actual graphics with basic LaTeX or a LaTeX extension package, but most users find them quite difficult to understand, so this manual will not explain them. Please refer to *The LaTeX Companion* [3] and the *LaTeX Manual* [1] for more information on that subject.

A much easier way to get graphics into a document is to generate them with a specialised software package[1] and then include the finished graphics into the document. Here again, LaTeX packages offer many ways to do this, but this introduction will only discuss the use of Encapsulated PostScript (EPS) graphics, because it is quite easy to do and widely used. In order to use pictures in the EPS format, you must have a PostScript printer[2] available for output.

A good set of commands for inclusion of graphics is provided in the graphicx package by D. P. Carlisle. It is part of a whole family of packages called the "graphics" bundle.[3]

[1] Such as XFig, CorelDraw!, Freehand, Gnuplot, ...

[2] Another possibility to output PostScript is the GhostScript program available from `support/ghostscript`. Windows and OS/2 users might want to look for GSview.

[3] `macros/latex/required/graphics`

Assuming you are working on a system with a PostScript printer available for output and with the graphicx package installed, you can use the following step by step guide to include a picture into your document:

1. Export the picture from your graphics program in EPS format.[4]

2. Load the graphicx package in the preamble of the input file with

   `\usepackage[`*driver*`]{graphicx}`

   where *driver* is the name of your "dvi to postscript" converter program. The most widely used program is called `dvips`. The name of the driver is required, because there is no standard on how graphics are included in TeX. Knowing the name of the *driver*, the graphicx package can choose the correct method to insert information about the graphics into the `.dvi` file, so that the printer understands it and can correctly include the `.eps` file.

3. Use the command

   `\includegraphics[`*key*=*value*, …`]{`*file*`}`

   to include *file* into your document. The optional parameter accepts a comma separated list of *keys* and associated *values*. The *keys* can be used to alter the width, height and rotation of the included graphic. Table 4.1 lists the most important keys.

Table 4.1: Key Names for graphicx Package.

`width`	scale graphic to the specified width
`height`	scale graphic to the specified height
`angle`	rotate graphic counterclockwise
`scale`	scale graphic

[4] If your software can not export into EPS format, you can try to install a PostScript printer driver (such as an Apple LaserWriter, for example) and then print to a file with this driver. With some luck this file will be in EPS format. Note that an EPS must not contain more than one page. Some printer drivers can be explicitly configured to produce EPS format.

The following example code may help to clarify things:

```
\begin{figure}
\begin{center}
\includegraphics[angle=90, width=0.5\textwidth]{test}
\end{center}
\caption{A caption, explaining that this is a test.}
\end{figure}
```

It includes the graphic stored in the file `test.eps`. The graphic is *first* rotated by an angle of 90 degrees and *then* scaled to the final width of 0.5 times the width of a standard paragraph. The aspect ratio is 1.0, because no special height is specified. The width and height parameters can also be specified in absolute dimensions. Refer to Table 6.5 on page 109 for more information. If you want to know more about this topic, make sure to read [9] and [13].

4.2 Bibliography

You can produce a bibliography with the `thebibliography` environment. Each entry starts with

`\bibitem[`*label*`]{`*marker*`}`

The *marker* is then used to cite the book, article or paper within the document.

`\cite{`*marker*`}`

If you do not use the *label* option, the entries will get enumerated automatically. The parameter after the `\begin{thebibliography}` command defines how much space to reserve for the number of labels. In the example below, `{99}` tells LaTeX to expect that none of the bibliography item numbers will be wider than the number 99.

```
Partl~\cite{pa} has
proposed that \ldots
\begin{thebibliography}{99}
\bibitem{pa} H.~Partl:
\emph{German \TeX},
TUGboat Volume~9, Issue~1 (1988)
\end{thebibliography}
```

Partl [1] has proposed that . . .

Bibliography

[1] H. Partl: *German TeX*, TUGboat Volume 9, Issue 1 (1988)

For larger projects, you might want to check out the BibTEX program. BibTEX is included with most TEX distributions. It allows you to maintain a bibliographic database and then extract the references relevant to things you cited in your paper. The visual presentation of BibTEX generated bibliographies is based on a style sheets concept that allows you to create bibliographies following a wide range of established designs.

4.3 Indexing

A very useful feature of many books is their index. With LaTEX and the support program `makeindex`,[5] an index can be generated quite easily. This introduction will only explain the basic index generation commands. For a more in-depth view, please refer to *The LaTEX Companion* [3].

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}
```

commands, 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. Table 4.2 explains the syntax of the *key* argument with several examples.

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.

```
makeindex filename
```

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

[5]On systems not necessarily supporting filenames longer than 8 characters, the program may be called `makeidx`.

Table 4.2: Index Key Syntax Examples.

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{eolienne@\'eolienne}`	éolienne, 4	Handling of accents

is processed again, this sorted index gets included into the document at the point where LaTeX finds

```
\printindex
```

The showidx package that comes with LaTeX 2_ε 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.

```
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.

4.4 Fancy Headers

The fancyhdr package,[6] written by Piet van Oostrum, provides a few simple commands that allow you to customize the header and footer lines of your document. If you look at the top of this page, you can see a possible application of this package.

The tricky problem when customising 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.

[6] Available from `macros/latex/contrib/supported/fancyhdr`.

```
\documentclass{book}
\usepackage{fancyhdr}
\pagestyle{fancy}
% with this we ensure that the chapter and section
% headings are in lowercase.
\renewcommand{\chaptermark}[1]{\markboth{#1}{}}
\renewcommand{\sectionmark}[1]{\markright{\thesection\ #1}}
\fancyhf{}  % delete current setting for header and footer
\fancyhead[LE,RO]{\bfseries\thepage}
\fancyhead[LO]{\bfseries\rightmark}
\fancyhead[RE]{\bfseries\leftmark}
\renewcommand{\headrulewidth}{0.5pt}
\renewcommand{\footrulewidth}{0pt}
\addtolength{\headheight}{0.5pt} % make space for the rule
\fancypagestyle{plain}{%
   \fancyhead{} % get rid of headers on plain pages
   \renewcommand{\headrulewidth}{0pt} % and the line
}
```

Figure 4.1: Example fancyhdr Setup.

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.

Figure 4.1 shows a possible setup for the fancyhdr package that makes the headers look about the same as they look in this booklet. In any case, I suggest you fetch the documentation for the package at the address mentioned in the footnote.

4.5 The Verbatim Package

Earlier in this book, you got to know the `verbatim` *environment*. In this section, you are going to learn about the verbatim *package*. The verbatim package is basically a re-implementation of the `verbatim` environment that works around some of the limitations of the original `verbatim` environment. This by itself is not spectacular, but the implementation of the verbatim package added new functionality, which is why I am mentioning the package here. The verbatim package provides the

```
\verbatiminput{filename}
```

command, which allows you to include raw ASCII text into your document as if it were inside a `verbatim` environment.

As the verbatim package is part of the 'tools' bundle, you should find it pre-installed on most systems. If you want to know more about this package, make sure to read [10].

4.6 Downloading and Installing LaTeX 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/`).

Packages such as geometry, hyphenat, and many others are typically made up of two files: a file with the extension `.ins` and another with the extension `.dtx`. There will often be a `readme.txt` with a brief description of the package. You should of course read this file first.

In any event, once you have copied the package files onto your machine, you still have to process them in a way that (a) tells your TeX distribution about the new style package and (b) gives you the documentation. Here's how you do the first part:

1. Run LaTeX on the `.ins` file. This will extract a `.sty` file.

2. Move the `.sty` file to a place where your distribution can find it. Usually this is in your `.../`*`localtexmf`*`/tex/latex` subdirectory (Windows or OS/2 users should feel free to change the direction of the slashes).

3. Refresh your distribution's file-name database. The command depends on the LaTeXdistribution you use: teTeX, fpTeX – `texhash`; web2c – `maktexlsr`; MikTeX – `initexmf -update-fndb` or use the GUI.

Now you can extract the documentation from the `.dtx` file:

1. Run LaTeX on the `.dtx` file. This will generate a `.dvi` file. Note that you may have to run LaTeX several times before it gets the cross-references right.

2. Check to see if LaTeX has produced a `.idx` file among the various files you now have. If you do not see this file, then you may proceed to step 5.

3. In order to generate the index, type the following:
   `makeindex -s gind.ist name`
   (where *name* stands for the main-file name without any extension).

4. Run LaTeX on the `.dtx` file once again.

5. Last but not least, make a `.ps` or `.pdf` file to increase your reading pleasure.

Sometimes you will see that a `.glo` (glossary) file has been produced. Run the following command between step 4 and 5:
`makeindex -s gglo.ist -o name.gls name.glo`
Be sure to run LaTeX on the `.dtx` one last time before moving on to step 5.

4.7 Working with pdfLaTeX

By Daniel Flipo <Daniel.Flipo@univ-lille1.fr>

PDF is a hypertext document format. Much like in a web page, some words in the document are marked as hyperlinks. They link to other places in the document or even to other documents. If you click on such a hyperlink you get transported to the destination of the link. In the context of LaTeX, this means that all occurrences of `\ref` and `\pageref` become hyperlinks. Additionally, the table of contents, the index and all the other similar structures become collections of hyperlinks.

Most web pages you find today are written in HTML *(HyperText Markup Language)*. This format has two significant disadvantages when writing scientific documents:

1. Including mathematical formulae into HTML documents is not generally supported. While there is a standard for it, most browsers used today do not support it, or lack the required fonts.

2. Printing HTML documents is possible, but the results vary widely between platforms and browsers. The results are miles removed from the quality we have come to expect in the LaTeX world.

There have been many attempts to create translators from LaTeX to HTML. Some were even quite successful in the sense that they are able to produce legible web pages from a standard LaTeX input file. But all of them cut corners left and right to get the job done. As soon as you start using more complex LaTeX features and external packages things tend to fall apart. Authors wishing to preserve the unique typographic quality of their documents even when publishing on the web turn to PDF *(Portable Document Format)*, which preserves the layout of the document and permits hypertext navigation. Most modern browsers come with plugins that allow the direct display of PDF documents.

Even though there are DVI and PS viewers for almost every platform, you will find that acrobat reader and xpdf for viewing PDF documents are more widely deployed. So providing PDF versions of your documents will make them much more accessible to your potential readers.

4.7.1 PDF Documents for the Web

The creation of a PDF file from LaTeX source is very simple, thanks to the pdfTeX program developed by Hàn Thế Thành. pdfTeX produces PDF output where normal TeX produces DVI. There is also a pdfLaTeX, which produces PDF output from LaTeX sources.

Both pdfTeX and pdfLaTeX are installed automatically by most modern TeX distributions, such as teTeX, fpTeX, MikTeX, TeXLive and CMacTeX.

To produce a PDF instead of DVI, it is sufficient to replace the command `latex file.tex` by `pdflatex file.tex`. On systems where LaTeX is not called from the command line, you may find a special button in the TeXControlCenter.

In LaTeX you can define the the paper size with an optional documentclass argument such as `a4paper` or `letterpaper`. This works in pdfLaTeX too, but on top of this pdfTeX also needs to know the physical size of the paper to determine the physical size of the pages in the pdf file. If you use the hyperref package (see page 76), the papersize will be adjusted automatically. Otherwise you have to do this manually by putting the following lines into the preamble of the document:

```
\pdfpagewidth=\paperwidth
\pdfpageheight=\paperheight
```

The following section will go into more detail regarding the differences between normal LaTeX and pdfLaTeX. The main differences concern three areas: the fonts to use, the format of images to include, and the manual configuration of hyperlinks.

4.7.2 The Fonts

pdfLaTeX can deal with all sorts of fonts (PK bitmaps, TrueType, PostScript type 1...) but the normal LaTeX font format, the bitmap PK fonts produce very ugly results when the document is displayed with Acrobat Reader. It is best to use PostScript Type 1 fonts exclusively to produce documents that display well. Modern TeX installations will be setup so that this happens automatically. Best is to try. If it works for you, just skip this whole paragraph.

The PostScript Type 1 implementation of the Computer Modern and AMSFonts was produced by Blue Sky Research and Y&Y, Inc., who then transferred copyright to the American Mathematical Society. The fonts were made publicly available in early 1997 and currently come with most of TEX distributions.

However, if you are using LATEX to create documents in languages other than English, you might want to use EC, LH, or CB fonts (see the discussion about `OT1` fonts on the page 25). Vladimir Volovich has created the cm-super font bundle which covers the entire EC/TC, EC Concrete, EC Bright and LH font sets. It is available from `CTAN:/fonts/ps-type1/cm-super` and is included with TEXLive7 and MikTEX. Similar type 1 CB Greek fonts created by Apostolos Syropoulos are available at `CTAN:/tex-archive/fonts/greek/cb`. Unfortunately, both of these font sets are not of the same typographic quality as the Type1 CM fonts by Blue Sky/Y&Y. They were automatically hinted, and the document might look not as neat on the screen as the ones using Blue Sky/Y&Y type 1 CM fonts, on high resolution output devices they produce results identical to the original bitmap EC/LH/CB fonts.

If you are creating document in one of Latin-based languages, you have several other options.

- You might want to use aeguill package, aka *Almost European Computer Modern with Guillemets*. Just put the line `\usepackage{aeguill}` into the preamble of your document, to enable AE virtual fonts instead of EC fonts.

- Alternatively, you can use mltex package, but this only works when your pdfTEX has been compiled with the mltex option.

The AE virtual fontset, like the MlTEX system, makes TEX believe it has a full 256 character fontset at its disposal by creating most of the missing letters from characters of the CM font and rearranging them in the EC order, this allows to use the excellent type 1 format CM fonts available on most systems. As the font is now in T1 encoding, hyphenation will work well in Latin-based European languages. The only disadvantage of this approach is that the artificial AE characters do not work with Acrobat Reader's `Find` function, so you cannot search for words with accented characters in your final PDF file.

For the Russian language a similar solution is to use C1 virtual fonts available at `ftp://ftp.vsu.ru/pub/tex/font-packs/c1fonts`. These fonts combine the standard CM type 1 fonts from Bluesky collection and CMCYR type 1 fonts from Paradissa and BaKoMa collection, all available on CTAN. Because Paradissa fonts contain only Russian letters, C1 fonts are missing other Cyrillic glyphs.

Another solution is to switch to other PostScript type 1 fonts. Actually, some of them are even included with every copy of Acrobat Reader. Because these fonts have different character sizes, the text layout on your pages will change. Generally these other fonts will use more space than the CM fonts, which are very space-efficient. Also, the overall visual coherence of your document will suffer because Times, Helvetica and Courier (the primary candidates for such a replacement job) have not been designed to work in harmony in a single document.

Two ready-made font sets are available for this purpose: pxfonts, which is based on *Palatino* as its main text body font, and the txfonts package, which is based on *Times*. To use them it is sufficient to put the following lines into the preamble of your document:

```
\usepackage[T1]{fontenc}
\usepackage{pxfonts}
```

Note: you may find lines like

```
Warning: pdftex (file eurmo10): Font eurmo10 at ... not found
```

in the `.log` file after compiling your input file. They mean that some font used in the document has not been found. You really have to fix these problems, as the resulting PDF document may *not display the pages with the missing characters at all*.

This whole font business, especially the lack of a good EC fontset equivalent in quality to the CM font in type 1 format, is occupying the minds of many people, so new solutions are cropping up all the time.

4.7.3 Using Graphics

Including graphics into a document works best with the graphicx package (see page 65). By using the special *driver* option `pdftex` the package will work with pdfLaTeX as well:

```
\usepackage[pdftex]{color,graphicx}
```

In the sample above I have included the color option, as using color in documents displayed on the web comes quite naturally.

So much for the good news. The bad news is that graphics in Encapsulated PostScript format do not work with PdfLaTeX. If you don't define a file extension in the `\includegraphics` command, graphicx will go looking for a suitable file on its own, depending on the setting of the *driver* option. For `pdftex` this is formats `.png`, `.pdf`, `.jpg`, `.mps` (METAPOST), and `.tif`—but *not* `.eps`.

The simple way out of this problem is to just convert your EPS files into PDF format using the `epstopdf` utility found on many systems. For vector graphics (drawings) this is a great solution. For bitmaps (photos, scans) this is not ideal, because the PDF format natively supports the inclusion of PNG and JPEG images. PNG is good for screenshots and other images with few colors. JPEG is great for photos, as it is very space-efficient.

It may even be desirable not to draw certain geometric figures, but rather describe the figure with a specialized command language, such as METAPOST, which can be found in most TEX distributions, and comes with its own extensive manual.

4.7.4 Hypertext Links

The hyperref package will take care of turning all internal references of your document into hyperlinks. For this to work properly some magic is necessary, so you have to put `\usepackage[pdftex]{hyperref}` as the *last* command into the preamble of your document.

Many options are available to customize the behaviour of the hyperref package:

- either as a comma separated list after the pdftex option `\usepackage[pdftex]{hyperref}`
- or on individual lines with the command `\hypersetup{`*options*`}`.

The only required option is `pdftex`; the others are optional and allow you to change the default behaviour of hyperref.[7] In the following list the default values are written in an upright font.

`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

`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

`pdfnewwindow (=true,`*`false`*`)` define if a new window should get opened when a link leads out of the current document

[7] It is worth noting that the hyperref package is not limited to work with pdfTEX. It can also be configured to embed PDF-specific information into the DVI output of normal LATEX, which then gets put into the PS file by `dvips` and is finally picked up by Adobe Distiller when it is used to turn the PS file into PDF.

`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)

If you are happy with the defaults, use

```
\usepackage[pdftex]{hyperref}
```

To have the bookmark list open and links in color (the `=true` values are optional):

```
\usepackage[pdftex,bookmarks,colorlinks]{hyperref}
```

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{hyperref}
\hypersetup{colorlinks,%
            citecolor=black,%
            filecolor=black,%
            linkcolor=black,%
            urlcolor=black,%
            pdftex}
```

When you just want to provide information for the `Document Info` section of the PDF file:

```
\usepackage[pdfauthor={Pierre Desproges}%
            pdftitle={Des femmes qui tombent},%
            pdftex]{hyperref}
```

In addition to the automatic hyperlinks for cross references, it is possible to embed explicit links using

$\boxed{\texttt{\textbackslash href\{}\textit{url}\texttt{\}\{}\textit{text}\texttt{\}}}$

The code

```
The \href{http://www.ctan.org}{CTAN} website.
```

produces the output "CTAN"; a click on the word "CTAN" will take you to the CTAN website.

If the destination of the link is not a URL but a local file, you can use the `\href` command:

```
The complete document is \href{manual.pdf}{here}
```

Which produces the text "The complete document is here". A click on the word "here" will open the file `manual.pdf`. (The filename is relative to the location of the current document).

The author of an article might want her readers to easily send email messages by using the `\href` command inside the `\author` command on the title page of the document:

```
\author{Mary Oetiker $<$\href{mailto:mary@oetiker.ch}%
       {mary@oetiker.ch}$>$
```

Note that I have put the link so that my email address appears not only in the link but also on the page itself. I did this because the link
`\href{mailto:mary@oetiker.ch}{Mary Oetiker}`
would work well within Acrobat, but once the page is printed the email address would not be visible anymore.

4.7.5 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.

4.7.6 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\ =\ mc\texttwosuperior}}
```

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.

Source Compatibility Between LaTeX and pdfLaTeX

Ideally your document would compile equally well with LaTeX and pdfLaTeX. The main problem in this respect is the inclusion of graphics. The simple solution is to *systematically drop* the file extension from `\includegraphics` commands. They will then automatically look for a file of a suitable format in the current directory. All you have to do is create appropriate versions of the graphics files. LaTeX will look for `.eps`, and pdfLaTeX will try to include a file with the extension `.png`, `.pdf`, `.jpg`, `.mps` or `.tif` (in that order).

For the cases where you want to use different code for the PDF version of your document, you can add:

```
\newif\ifPDF
\ifx\pdfoutput\undefined\PDFfalse
\else\ifnum\pdfoutput > 0\PDFtrue
     \else\PDFfalse
     \fi
\fi
```

as the very first few lines of your document. This defines a special command that will allow you to easily write conditional code:

```
\ifPDF
  \usepackage[T1]{fontenc}
  \usepackage{aeguill}
  \usepackage[pdftex]{graphicx,color}
  \usepackage[pdftex]{hyperref}
\else
  \usepackage[T1]{fontenc}
  \usepackage[dvips]{graphicx}
  \usepackage[dvips]{hyperref}
\fi
```

In the example above I have included the hyperref package even in the non-PDF version. The effect of this is to make the `\href` command work in all cases, which saves me from wrapping every occurrence into a conditional statement.

Note that in recent TEX distributions (TEXLive for example), the choice between `pdftex` and `dvips` when calling graphicx and color will happen automatically according to the settings made automatically in the configuration files `graphics.cfg` and `color.cfg`.

4.8 Creating Presentations with pdfscreen

By Daniel Flipo <Daniel.Flipo@univ-lille1.fr>

You can present the results of your scientific work on a blackboard, with transparencies, or directly from your laptop using some presentation software.

pdfLATEX combined with the pdfscreen package allows you to create presentations in PDF, equally as colorful and lively as is possible with *PowerPoint*, but much more portable because Acrobat Reader is available on many more systems.

The pdfscreen class uses graphicx, color and hyperref with options adapted to screen presentations.

To create this type of document you normally work within the `article` class. Figure 4.2 shows an example input file. First you have to load the pdfscreen package together with appropriate options:

`screen` for screen presentation. Use `print` to create a printable version.

`panelright` put a navigation panel on the right side of the screen. If the panel should be on the left side use `panelleft`. If you do not want panels use `nopanel`.

`french` or some other supported language will render the text on the navigation buttons appropriately. This option is independent of the options set with the babel package. If your language is not supported by

```
\documentclass[pdftex,12pt]{article}
%%% misc extensions %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\usepackage[latin1]{inputenc}
\usepackage[english]{babel}
\usepackage[T1]{fontenc}
\usepackage{aeguill}
%%% pdfscreen %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\usepackage[screen,panelleft,chocolate]{pdfscreen}
% Screen Format
\panelwidth=25mm
%%          height width
\screensize{150mm}{200mm}
%%          left right top  bottom
\marginsize{42mm}{8mm}{10mm}{10mm}
% Color or image for background
\overlayempty
\definecolor{mybg}{rgb}{1,0.9,0.7}
\backgroundcolor{mybg}
% Logo
\emblema{MyLogo}
%%% For PPower4 (post-processor) %%%%%%%%%%%%%%%%%%%%%%%%
\usepackage{pause}
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\begin{document}
\begin{slide}
\begin{itemize}
\item Good News\dots \pause
\item Bad News
\end{itemize}
\end{slide}
\end{document}
```

Figure 4.2: Example pdfscreen input file

pdfscreen, you still can localize navigation panel buttons by using file `pdfscreen.cfg`, see `pdfscreen.cfg..specimen` for an example.

`chocolate` color scheme for the navigation panel. Other choices are `gray`, `orange`, `palegreen`, `bluelace` and `blue`, which is the default.

Then you configure the display format. Because the presentation will always scale to the real size of the screen when displayed, this can be used to configure the overall font size:

`\panelwidth` defines the width of the navigation panel

`\screensize{`*width*`}{`*height*`}` define the width and height of the screen including the navigation panel.

`\marginsize{`*left*`}{`*right*`}{`*top*`}{`*bottom*`}` defines the margins of the document. In the example the document is not centered because the section numbers are kept in the left margin.

It is possible to use a background image in any of the image formats supported by pdfTEX using the command

`\overlay{`*image*`}`

or if you prefer a plain background you can define its color using

`\background{`*color*`}`

Finally if you want to place the logo of your organization into the navigation panel use the command

`\emblema{`*logo*`}`

If you believe in the presentational power of successive exposure of your bullet points you may want to make use of the pause package. It provides the command `\pause`. You can place this command right into the flow of your text wherever you want Acrobat to pause the display of your document. The pause package is part of the `ppower4` (P^4: *Pdf Presentation Post-Processor*) system, which can post-process pdf output from pdfTEX and make it sing and dance and beg for food. On the command line it looks like this:

```
ppower4 xy.pdf xyz.pdf
```

To control what goes onto a single slide, use the environment `\begin{slide}` . . . `\end{slide}`. The content of each slide will get displayed centered vertically on its page.

Compiling the example above, will end in an error message:

```
! pdfTeX warning (dest): name{contents} has been
  referenced but does not exist, replaced by a fixed one
```

This is because there is a button in the navigation panel that wants to point to the table of contents, because this example does not contain a `\tableofcontents` command the resolution of the link fails.

If you want the table of contents to be displayed right inside the navigation panel, you can use the option `paneltoc` when calling pdfscreen. This will only produce satisfactory results if your presentation has very few and short entries in the table of contents. You may want to provide short titles for your section headings in square brackets.

This short introduction only scratches the surface of what is possible with pdfscreen and `PPower4`. Both come with their own extensive documentation.

Chapter 5

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 a, if somewhat restricted, 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 section, you will learn about a few of them.

5.1 Overview

The `picture` environment allows programming pictures directly in LaTeX. A detailed description can be found in the *LaTeX Manual* [1]. 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 LaTeX 2_ε brings with it the `\qbezier` command, "`q`" meaning "quadratic". Many frequently used curves such as circles, ellipses, or catenaries can be satisfactorily approximated by quadratic Bézier curves, although this may require some mathematical toil. If, in addition, 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 and eepic (described, for instance, in *The LaTeX Companion* [3]), or pstricks help to eliminate the restrictions hampering 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* [4] (not to be confused with *The LaTeX Companion* [3]).

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* [15], or the tutorial on [17].

A very thorough discussion of LaTeX and TeX strategies for graphics (and fonts) can be found in *TeX Unbound* [16].

5.2 The `picture` Environment

By Urs Oswald <osurs@bluewin.ch>

5.2.1 Basic Commands

A `picture` environment[1] 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, x_0, y_0 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.

[1] Believe it or not, the picture environment works out of the box, with standard LaTeX 2_ε no package loading necessary.

Most drawing commands have one of the two forms

$\boxed{\texttt{\textbackslash put}(x,y)\texttt{\{}\mathit{object}\texttt{\}}}$

or

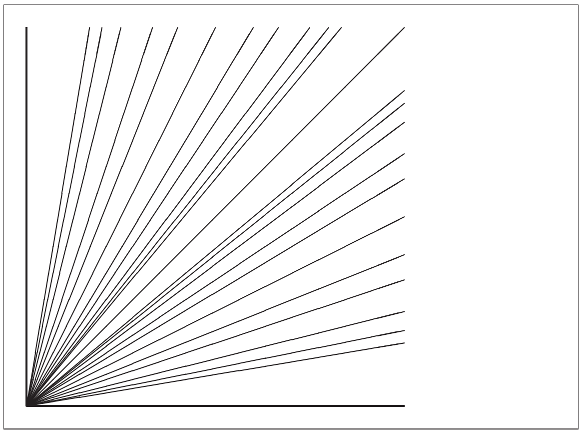
$\boxed{\texttt{\textbackslash multiput}(x,y)(\Delta x,\Delta y)\texttt{\{}n\texttt{\}\{}\mathit{object}\texttt{\}}}$

Bézier curves are an exception. They are drawn with the command

$\boxed{\texttt{\textbackslash qbezier}(x_1,y_1)(x_2,y_2)(x_3,y_3)}$

5.2.2 Line Segments

```
\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}
```



Line segments are drawn with the command

`\put(`x, y`){\line(`x_1, y_1`){`*length*`}}`

The `\line` command has two arguments:

1. a direction vector,
2. a length.

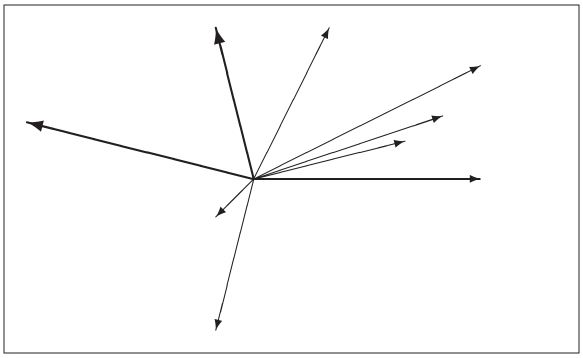
The components of the direction vector are restricted to the integers

$$-6, -5, \ldots, 5, 6,$$

and they have to be coprime (no common divisor except 1). The figure 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.

5.2.3 Arrows

```
\setlength{\unitlength}{1mm}
\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}
```



Arrows are drawn with the command

`\put(`x, y`){\vector(`x_1, y_1`){`*length*`}}`

For arrows, the components of the direction vector are even more narrowly restricted than for line segments, namely to the integers

$$-4, -3, \ldots, 3, 4.$$

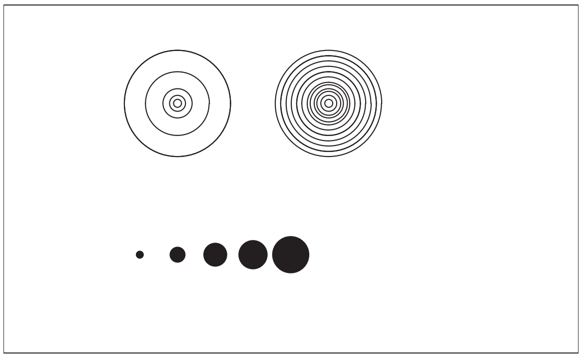
Components also have to be coprime (no common divisor except 1). Notice the effect of the `\thicklines` command on the two arrows pointing to the upper left.

5.2.4 Circles

```
\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}
```



The command

`\put(`x, y`){\circle{`*diameter*`}}`

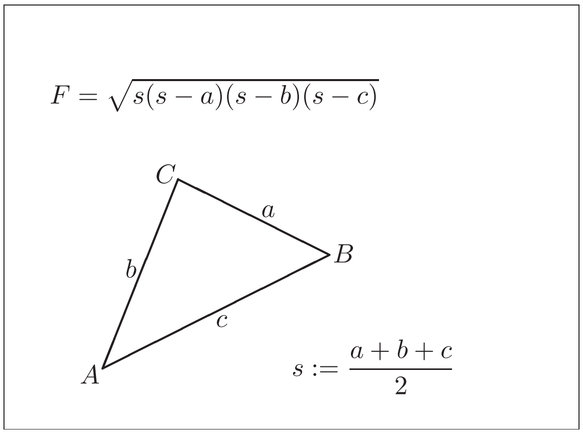
draws a circle with center (x, y) and diameter (not radius) *diameter*. The `picture` environment only admits diameters up to approximately 14 mm, and even below this limit, not all diameters are possible. The `\circle*` command produces disks (filled circles).

As in the case of line segments, one may have to resort to additional packages, such as eepic or pstricks. For a thorough description of these packages, see *The LaTeX Graphics Companion* [4].

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 LaTeX 2ε* [17] for examples and Java source files.

5.2.5 Text and Formulas

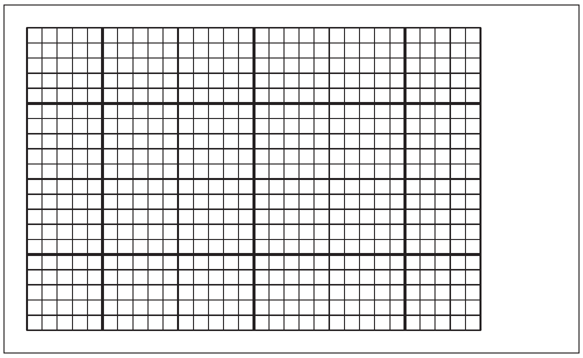
```
\setlength{\unitlength}{1cm}
\begin{picture}(6,5)
  \thicklines
  \put(1,0.5){\line(2,1){3}}
  \put(4,2){\line(-2,1){2}}
  \put(2,3){\line(-2,-5){1}}
  \put(0.7,0.3){$A$}
  \put(4.05,1.9){$B$}
  \put(1.7,2.95){$C$}
  \put(3.1,2.5){$a$}
  \put(1.3,1.7){$b$}
  \put(2.5,1.05){$c$}
  \put(0.3,4){$F=
    \sqrt{s(s-a)(s-b)(s-c)}$}
  \put(3.5,0.4){$\displaystyle
    s:=\frac{a+b+c}{2}$}
\end{picture}
```



As this example shows, text and formulas can be written into a `picture` environment with the `\put` command in the usual way.

5.2.6 The `\multiput` and the `\linethickness` command

```
\setlength{\unitlength}{2mm}
\begin{picture}(30,20)
  \linethickness{0.075mm}
  \multiput(0,0)(1,0){31}%
    {\line(0,1){20}}
  \multiput(0,0)(0,1){21}%
    {\line(1,0){30}}
  \linethickness{0.15mm}
  \multiput(0,0)(5,0){7}%
    {\line(0,1){20}}
  \multiput(0,0)(0,5){5}%
    {\line(1,0){30}}
  \linethickness{0.3mm}
  \multiput(5,0)(10,0){3}%
    {\line(0,1){20}}
  \multiput(0,5)(0,10){2}%
    {\line(1,0){30}}
\end{picture}
```



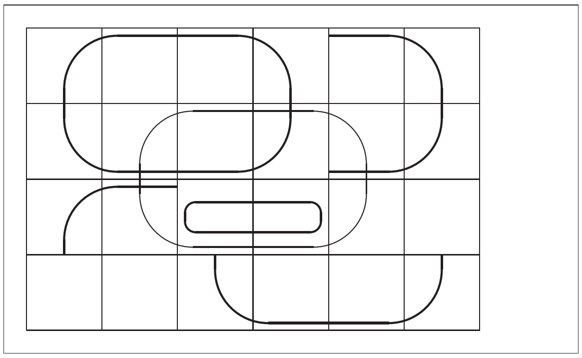
The command

$\boxed{\texttt{\textbackslash multiput}(x,y)(\Delta x,\Delta y)\{n\}\{object\}}$

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!

5.2.7 Ovals. The \thinlines and the \thicklines command

```
\setlength{\unitlength}{1cm}
\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}
```



The command

$\boxed{\texttt{\textbackslash put(}x,y\texttt{)\{\textbackslash oval(}w,h\texttt{)\}}}$

or

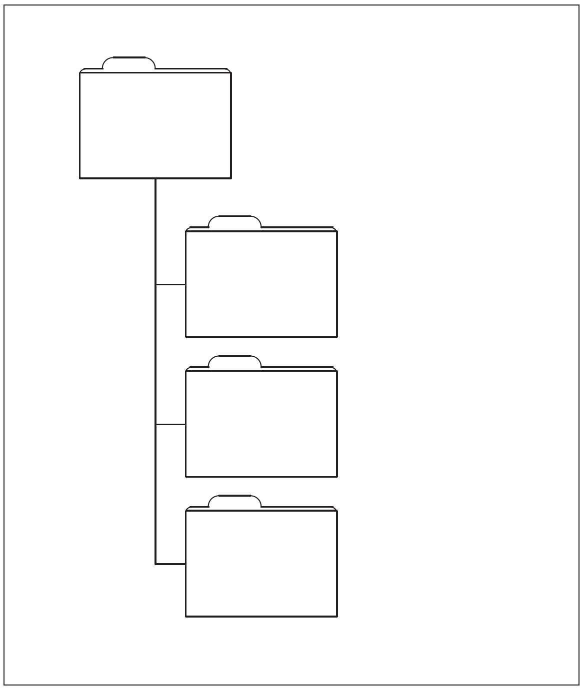
$\boxed{\texttt{\textbackslash put(}x,y\texttt{)\{\textbackslash oval(}w,h\texttt{)[}\textit{position}\texttt{]\}}}$

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.

5.2.8 Multiple Use of Predefined Picture Boxes

```
\setlength{\unitlength}{0.5mm}
\begin{picture}(120,168)
\newsavebox{\foldera}% declaration
\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}% declaration
\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}
```



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*`}`

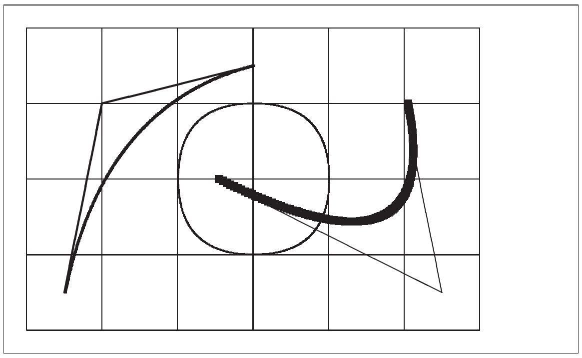
The optional *position* parameter has the effect of defining the 'anchor point' of the savebox. In the example it is set to `bl` which puts the anchor point into the bottom left corner of the savebox. The other position specifiers are `top` and `right`.

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.

5.2.9 Quadratic Bézier Curves

```
\setlength{\unitlength}{1cm}
\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.

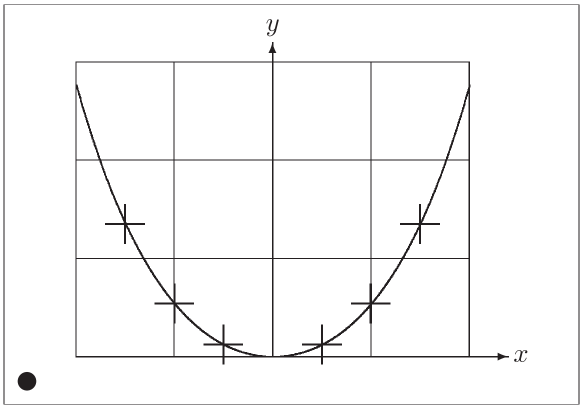
Let $P_1 = (x_1, y_1)$, $P_2 = (x_2, y_2)$ denote the end points, and m_1, m_2 the respective slopes, of a quadratic Bézier curve. The intermediate control point $S = (x, y)$ is then given by the equations

$$\left\{ \begin{array}{rcl} x & = & \dfrac{m_2 x_2 - m_1 x_1 - (y_2 - y_1)}{m_2 - m_1}, \\ y & = & y_i + m_i(x - x_i) \qquad (i = 1, 2). \end{array} \right. \tag{5.1}$$

See *Graphics in LaTeX 2ε* [17] for a Java program which generates the necessary `\qbezier` command line.

5.2.10 Catenary

```
\setlength{\unitlength}{1.3cm}
\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 (5.1), 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.

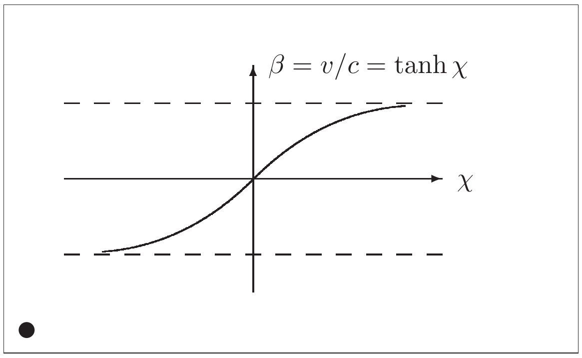
This example points out the use of the optional argument of the `\begin{picture}` command. The picture is defined in convenient "mathematical" coordinates, whereas by the command

```
\begin{picture}(4.3,3.6)(-2.5,-0.25)
```

its lower left corner (marked by the black disk) is assigned the coordinates $(-2.5, -0.25)$.

5.2.11 Rapidity in the Special Theory of Relativity

```
\setlength{\unitlength}{1cm}
\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 (5.1). 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).

5.3 XY-pic

By Alberto Manuel Brandão Simões <albie@alfarrabio.di.uminho.pt>

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}`

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}
```

$$\begin{array}{cc} A & B \\ \\ C & D \end{array}$$

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}
```

$$\begin{tikzcd} A \arrow[r] & B \arrow[d] \\ D \arrow[u] & C \arrow[l] \end{tikzcd}$$

The arrow command is placed on the origin cell for the arrow. The arguments are the direction the arrow should point to (`u`p, `d`own, `r`ight and `l`eft).

```
\begin{displaymath}
\xymatrix{
  A \ar[d] \ar[dr] \ar[r] & B \\
  D                       & C }
\end{displaymath}
```

$$\begin{tikzcd} A \arrow[d] \arrow[dr] \arrow[r] & B \\ D & C \end{tikzcd}$$

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}
```

$$\begin{tikzcd} A \arrow[d] \arrow[dr] \arrow[drr] & & \\ B & C & D \end{tikzcd}$$

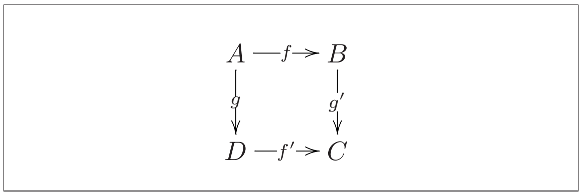
We can draw even more interesting diagrams by adding labels to the arrows. To do this, we use the common superscript and subscript operators.

```
\begin{displaymath}
\xymatrix{
  A \ar[r]^f \ar[d]_g &
            B \ar[d]^{g'} \\
  D \ar[r]_{f'}       & C }
\end{displaymath}
```

$$\begin{tikzcd} A \arrow[r, "f"] \arrow[d, "g"'] & B \arrow[d, "g'"] \\ D \arrow[r, "f'"'] & C \end{tikzcd}$$

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.

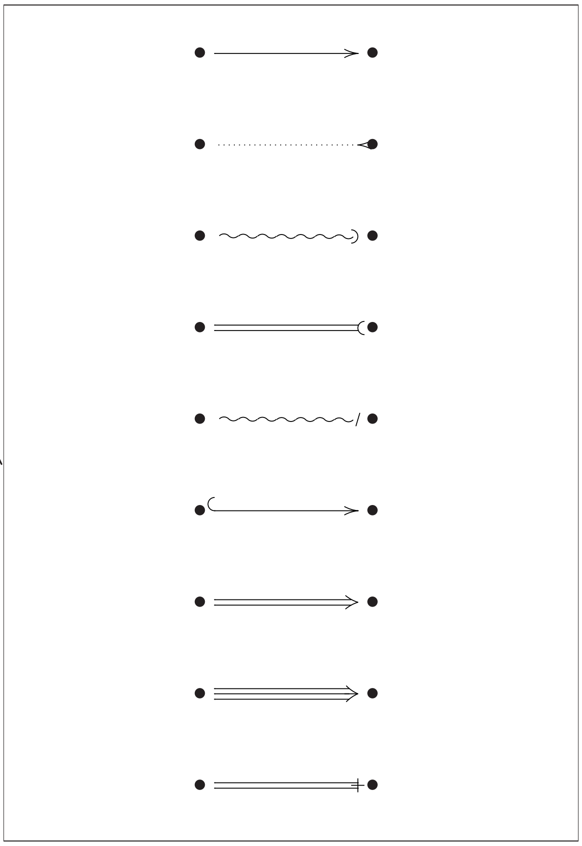
```
\begin{displaymath}
\xymatrix{
  A \ar[r]|f \ar[d]|g &
             B \ar[d]|{g’} \\
  D \ar[r]|{f’}       & C }
\end{displaymath}
```



To draw an arrow with a hole in it, use `\ar[...]|\hole`.

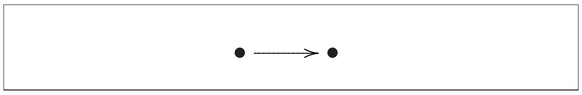
In some situations, it is important to distinguish between different types of arrows. This can be done by putting labels on them, or changing their appearance:

```
\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}
```

$$\begin{tikzcd} \bullet \arrow[r, bend left] \arrow[r, dotted, bend right] & \bullet \end{tikzcd}$$

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.

Chapter 6

Customising 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.

6.1 New Commands, Environments and Packages

You may have noticed that all the commands I introduce in this book are typeset in a box, and that they show up in the index at the end of the book. Instead of directly using the necessary LaTeX commands to achieve this, I have created a package in which I defined new commands and environments for this purpose. Now I can simply write:

```
\begin{lscommand}
\ci{dum}
\end{lscommand}
```

`\dum`

In this example, I am using both a new environment called `lscommand`, which is responsible for drawing the box around the command, and a new command named `\ci`, which typesets the command name and makes a corresponding entry in the index. You can check this out by looking up the `\dum` command in the index at the back of this book, where you'll find an entry for `\dum`, pointing to every page where I mentioned the `\dum` command.

If I ever decide that I do not like the commands to be typeset in a box any more, I can simply change the definition of the `lscommand` environment to create a new look. This is much easier than going through the whole document to hunt down all the places where I have used some generic LaTeX commands to draw a box around some word.

6.1.1 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 `\tnss`. This is short for "The Not So Short Introduction to LaTeX 2$_\varepsilon$." Such a command could come in handy if you had to write the title of this book over and over again.

```
\newcommand{\tnss}{The not
    so Short Introduction to
    \LaTeXe}
This is ‘‘\tnss’’ \ldots{}
‘‘\tnss’’
```

This is "The not so Short Introduction to LaTeX 2$_\varepsilon$" … "The not so Short Introduction to LaTeX 2$_\varepsilon$"

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.

```
\newcommand{\txsit}[1]
 {This is the \emph{#1} Short
      Introduction to \LaTeXe}
% in the document body:
\begin{itemize}
\item \txsit{not so}
\item \txsit{very}
\end{itemize}
```

- This is the *not so* Short Introduction to LaTeX 2$_\varepsilon$
- This is the *very* Short Introduction to LaTeX 2$_\varepsilon$

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 2$_\varepsilon$ will silently ignore it.

There are some points to note about whitespace following LaTeX commands. See page 5 for more information.

6.1.2 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}
```

■	My humble subjects …	■

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.

The commands used in this example will be explained later. For the `\rule` command see page 115, for `\stretch` go to page 108, and more information on `\hspace` can be found on page 108.

6.1.3 Extra Space

When creating a new environemnt you may easily get bitten by extra spaces creaping in, which can potentially have fatal effects. For example when you want to create a title environemnt which supresses 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 occured.

```
\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\ignorespacesafterend}

\begin{correct}
No space\\to the left.
\end{correct}
Same\\here.
```

No space
to the left.

Same
here.

6.1.4 Commandline LaTeX

If you work on a Unix like OS, you might be using Makefiles to build your LaTeX projects. In that connection it might be interesting to produce different versions of the same document by calling LaTeX with commandline 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.

6.1.5 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.

```
% Demo Package by Tobias Oetiker
\ProvidesPackage{demopack}
\newcommand{\tnss}{The not so Short Introduction to \LaTeXe}
\newcommand{\txsit}[1]{The \emph{#1} Short
                        Introduction to \LaTeXe}
\newenvironment{king}{\begin{quote}}{\end{quote}}
```

Figure 6.1: Example Package.

Writing a package basically consists of copying the contents of your document preamble into a separate file with a name ending in `.sty`. There is one special command,

`\ProvidesPackage{`*package name*`}`

for use at the very beginning of your package file. `\ProvidesPackage` 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. Figure 6.1 shows a small example package that contains the commands defined in the examples above.

6.2 Fonts and Sizes

6.2.1 Font Changing Commands

LaTeX chooses the appropriate font and font size based on the logical structure of the document (sections, footnotes, …). In some cases, one might like to change fonts and sizes by hand. To do this, you can use the commands listed in Tables 6.1 and 6.2. The actual size of each font is a design issue and depends on the document class and its options. Table 6.3 shows the absolute point size for these commands as implemented in the standard document classes.

```
{\small The small and
\textbf{bold} Romans ruled}
{\Large all of great big
\textit{Italy}.}
```

The small and **bold** Romans ruled all of great big *Italy*.

One important feature of LaTeX 2$_\varepsilon$ is that the font attributes are independent. This means that you can issue size or even font changing commands, and still keep the bold or slant attribute set earlier.

In *math mode* you can use the font changing *commands* to temporarily exit *math mode* and enter some normal text. If you want to switch to another font for math typesetting you need another special set of commands; refer to Table 6.4.

In connection with the font size commands, curly braces play a significant role. They are used to build *groups*. Groups limit the scope of most LaTeX commands.

```
He likes {\LARGE large and
{\small small} letters}.
```

He likes large and small letters.

The font size commands also change the line spacing, but only if the paragraph ends within the scope of the font size command. The closing curly brace `}` should therefore not come too early. Note the position of the `\par` command in the next two examples. [1]

[1] `\par` is equivalent to a blank line

Table 6.1: Fonts.

`\textrm{...}`	roman	`\textsf{...}`	sans serif
`\texttt{...}`	`typewriter`		
`\textmd{...}`	medium	`\textbf{...}`	**bold face**
`\textup{...}`	upright	`\textit{...}`	*italic*
`\textsl{...}`	*slanted*	`\textsc{...}`	SMALL CAPS
`\emph{...}`	*emphasized*	`\textnormal{...}`	document font

Table 6.2: Font Sizes.

`\tiny`	tiny font	`\Large`	larger font
`\scriptsize`	very small font	`\LARGE`	very large font
`\footnotesize`	quite small font	`\huge`	huge
`\small`	small font	`\Huge`	largest
`\normalsize`	normal font		
`\large`	large font		

Table 6.3: Absolute Point Sizes in Standard Classes.

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 6.4: Math Fonts.

`\mathrm{...}`	$\mathrm{Roman\ Font}$
`\mathbf{...}`	$\mathbf{Boldface\ Font}$
`\mathsf{...}`	$\mathsf{Sans\ Serif\ Font}$
`\mathtt{...}`	$\mathtt{Typewriter\ Font}$
`\mathit{...}`	$\mathit{Italic\ Font}$
`\mathcal{...}`	$\mathcal{CALLIGRAPHIC\ FONT}$
`\mathnormal{...}`	$\mathnormal{Normal\ Font}$

```
{\Large Don't read this! It is not
true. You can believe me!\par}
```

Don't read this! It is not true. You can believe me!

```
{\Large This is not true either.
But remember I am a liar.}\par
```

This is not true either. But remember I am a liar.

If you want to activate a size changing command for a whole paragraph of text or even more, you might want to use the environment syntax for font changing commands.

```
\begin{Large}
This is not true.
But then again, what is these
days \ldots
\end{Large}
```

This is not true. But then again, what is these days ...

This will save you from counting lots of curly braces.

6.2.2 Danger, Will Robinson, Danger

As noted at the beginning of this chapter, it is dangerous to clutter your document with 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 a \oops{machine}
of unknown origin and purpose.
```

Do not **enter** this room, it's occupied by a **machine** 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.

6.2.3 Advice

To conclude this journey into the land of fonts and font sizes, here is a little word of advice:

Remember! *The* MO RE fonts YOU use **in** a `document`, *the* more READABLE and *beautiful it becomeS*.

6.3 Spacing

6.3.1 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.

Note that the effect of the `\linespread` command is rather drastic and not appropriate for published work. So if you have a good reason for changing the line spacing you might want to use the command:

`\setlength{\baselineskip}{1.5\baselineskip}`

```
{\setlength{\baselineskip}%
          {1.5\baselineskip}
This paragraph is typeset with the
baseline skip set to 1.5 of what
it was before. Note the par command
at the end of the paragraph.\par}

This paragraph has a clear purpose,
it shows that after the curly brace
has been closed, everything is back
to normal.
```

This paragraph is typeset with the baseline skip set to 1.5 of what it was before. Note the par command at the end of the paragraph.

This paragraph has a clear purpose, it shows that after the curly brace has been closed, everything is back to normal.

6.3.2 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 after the `\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.[2] Obviously, this will only have an effect when `\parindent` is not set to zero.

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.

6.3.3 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. The most important units are listed in Table 6.5.

```
This\hspace{1.5cm}is a space
of 1.5 cm.
```

This   is a space of 1.5 cm.

The command

`\stretch{`*n*`}`

generates a special rubber space. It stretches until all the remaining space

[2] To indent the first paragraph after each section head, use the indentfirst package in the 'tools' bundle.

Table 6.5: TEX Units.

`mm`	millimetre ≈ 1/25 inch
`cm`	centimetre = 10 mm
`in`	inch = 25.4 mm
`pt`	point ≈ 1/72 inch ≈ $\frac{1}{3}$ mm
`em`	approx width of an ‘M’ in the current font
`ex`	approx height of an ‘x’ in the current font

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

When using horizontal space together with text, it may make sense to make the space adjust its size relative to the size of the current font. This can be done by using the text-relative units `em` and `ex`:

```
{\Large{}big\hspace{1em}y}\\
{\tiny{}tin\hspace{1em}y}
```

big y
tin y

6.3.4 Vertical Space

The space between paragraphs, sections, subsections, ... 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 centre text vertically on a page.

```
Some text \ldots

\vspace{\stretch{1}}
This goes onto the last line of the page.\pagebreak
```

Additional space between two lines of *the same* paragraph or within a table is specified with the

`\\[length]`

command.

With `\bigskip` and `\smallskip` you can skip a predefined amount of vertical space without having to worry about exact numbers.

6.4 Page Layout

LaTeX 2_ε allows you to specify the paper size in the `\documentclass` command. It then automatically picks the right text margins, but sometimes you may not be happy with the predefined values. Naturally, you can change them. Figure 6.2 shows all the parameters that can be changed. The figure was produced with the layout package from the tools bundle.[3]

WAIT! ... before you launch into a "Let's make that narrow page a bit wider" frenzy, take a few seconds to think. As with most things in LaTeX, there is a good reason for the page layout to be as it is.

Sure, compared to your off-the-shelf MS Word page, it looks awfully narrow. But take a look at your favourite book[4] and count the number of characters on a standard text line. You will find that there are no more than about 66 characters on each line. Now do the same on your LaTeX page. You will find that there are also about 66 characters per line. Experience shows that the reading gets difficult as soon as there are more characters on a single line. This is because it is difficult for the eyes to move from the end of one line to the start of the next one. This is also why newspapers are typeset in multiple columns.

So if you increase the width of your body text, keep in mind that you are making life difficult for the readers of your paper. But enough of the cautioning, I promised to tell you how you do it ...

LaTeX provides two commands to change these parameters. They are usually used in the document preamble.

The first command assigns a fixed value to any of the parameters:

`\setlength{parameter}{length}`

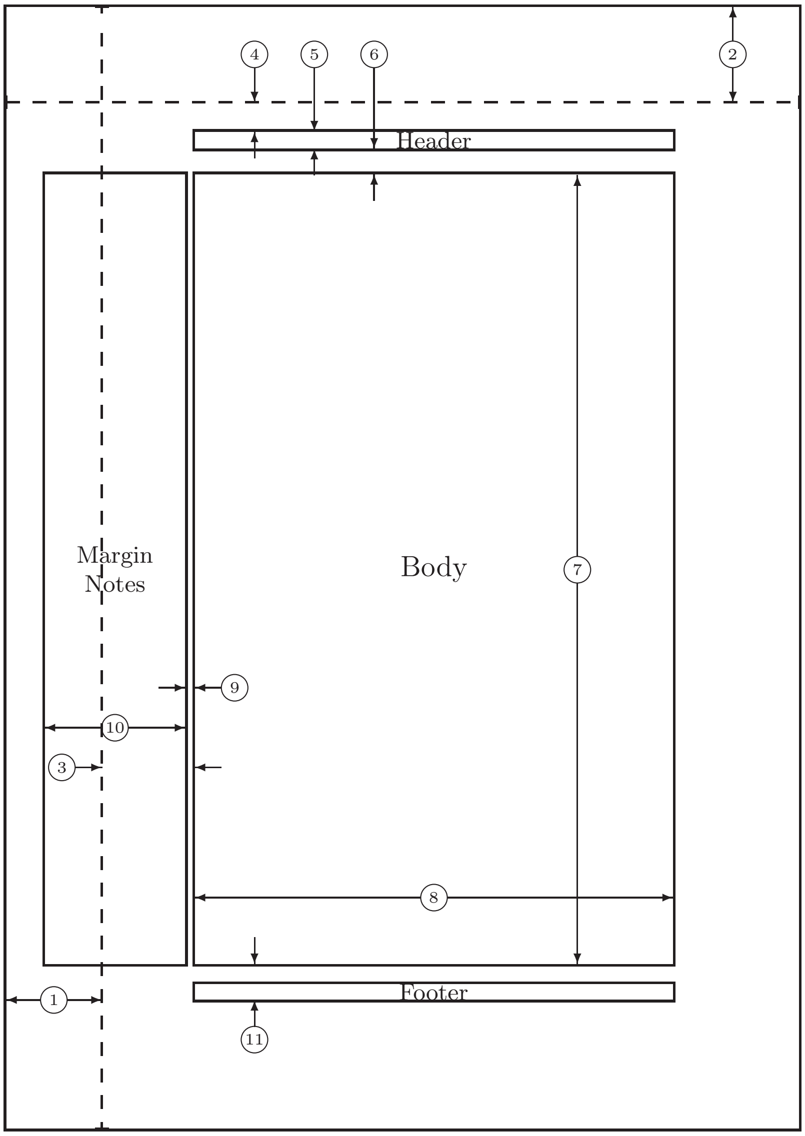
The second command adds a length to any of the parameters:

`\addtolength{parameter}{length}`

This second command is actually more useful than the `\setlength` com-

[3] `macros/latex/required/tools`

[4] I mean a real printed book produced by a reputable publisher.



1	`one inch + \hoffset`	2	`one inch + \voffset`
3	`\oddsidemargin = 22pt` `or \evensidemargin`	4	`\topmargin = 22pt`
5	`\headheight = 13pt`	6	`\headsep = 19pt`
7	`\textheight = 595pt`	8	`\textwidth = 360pt`
9	`\marginparsep = 7pt`	10	`\marginparwidth = 106pt`
11	`\footskip = 27pt`		`\marginparpush = 5pt (not shown)`
	`\hoffset = 0pt`		`\voffset = 0pt`
	`\paperwidth = 597pt`		`\paperheight = 845pt`

Figure 6.2: Page Layout Parameters.

mand, because you can now work relative to the existing settings. To add one centimetre to the overall text width, I put the following commands into the document preamble:

```
\addtolength{\hoffset}{-0.5cm}
\addtolength{\textwidth}{1cm}
```

In this context, you might want to look at the `calc` package. It allows you to use arithmetic operations in the argument of `\setlength` and other places where you can enter numeric values into function arguments.

6.5 More Fun With Lengths

Whenever possible, I avoid using absolute lengths in LaTeX documents. I rather try to base things on the width or height of other page elements. For the width of a figure this could be `\textwidth` in order to make it fill the page.

The following 3 commands allow you to determine the width, height and depth of a text string.

`\settoheight{`*variable*`}{`*text*`}`
`\settodepth{`*variable*`}{`*text*`}`
`\settowidth{`*variable*`}{`*text*`}`

The example below shows a possible application of these commands.

```
\flushleft
\newenvironment{vardesc}[1]{%
  \settowidth{\parindent}{#1:\ }
  \makebox[0pt][r]{#1:\ }}{}

\begin{displaymath}
a^2+b^2=c^2
\end{displaymath}

\begin{vardesc}{Where}$a$,
$b$ -- are adjoin to the right
angle of a right-angled triangle.

$c$ -- is the hypotenuse of
the triangle and feels lonely.

$d$ -- finally does not show up
here at all. Isn't that puzzling?
\end{vardesc}
```

$$a^2 + b^2 = c^2$$

Where: a, b – are adjoin to the right angle of a right-angled triangle.

c – is the hypotenuse of the triangle and feels lonely.

d – finally does not show up here at all. Isn't that puzzling?

6.6 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.[5] Be-

[5] 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.

sides 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?
```

c e n t r a l

s p r e a d

Guess I'm framed now!

Bummer, I am too wide

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.[6] 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.
```

Aaaaaargh he shouted but not even the next one in line noticed that something terrible had happened to him.

[6] Total control is only to be obtained by controlling both the horizontal and the vertical …

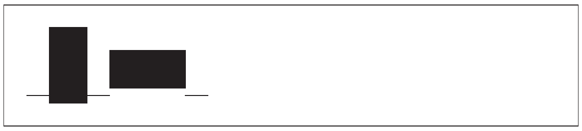
6.7 Rules and Struts

A few pages back you may have noticed the command

\rule[*lift*]{*width*}{*height*}

In normal use it produces a simple black box.

```
\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. The line on the title page, for example, has been created with a `\rule` command.

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.

```
\begin{tabular}{|c|}
\hline
\rule{1pt}{4ex}Pitprop \ldots\\
\hline
\rule{0pt}{4ex}Strut\\
\hline
\end{tabular}
```

Pitprop …
Strut

The End.

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[2] Donald E. Knuth. *The TeXbook,* Volume A of *Computers and Typesetting*, Addison-Wesley, Reading, Massachusetts, second edition, 1984, ISBN 0-201-13448-9.

[3] Michel Goossens, Frank Mittelbach and Alexander Samarin. *The LaTeX Companion.* Addison-Wesley, Reading, Massachusetts, 1994, ISBN 0-201-54199-8.

[4] Michel Goossens, Sebastian Rahtz and Frank Mittelbach. *The LaTeX Graphics Companion.* Addison-Wesley, Reading, Massachusetts, 1997, ISBN 0-201-85469-4.

[5] Each LaTeX installation should provide a so-called *LaTeX Local Guide*, which explains the things that are special to the local system. It should be contained in a file called `local.tex`. Unfortunately, some lazy sysops do not provide such a document. In this case, go and ask your local LaTeX guru for help.

[6] LaTeX3 Project Team. *LaTeX 2ε for authors.* Comes with the LaTeX 2ε distribution as `usrguide.tex`.

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[12] Graham Williams. *The TeX Catalogue* is a very complete listing of many TeX and LaTeX related packages. Available online from `CTAN:/tex-archive/help/Catalogue/catalogue.html`

[13] Keith Reckdahl. *Using EPS Graphics in LaTeX 2ε Documents*, which explains everything and much more than you ever wanted to know about EPS files and their use in LaTeX documents. Available online from `CTAN:/tex-archive/info/epslatex.ps`

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[15] John D. Hobby. *A User's Manual for MetaPost*. Downloadable from `http://cm.bell-labs.com/who/hobby/`

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