The Art of LaTeX

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Contents

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The Grand History of TEX

This chapter gives you a general overview of the history of TEX/LATEX and helps you evaluate whether or not you actually need it. My personal attitude toward the comparison between TEX and Microsoft Word is also discussed in detail. It's a bit long and tedious, as I want to include the information I really like. Feel free to skip this chapter—no harm will come, except it might take longer for you to start appreciating the beauty of TEX.

Figure 1.1: Knuth (pronounced /knu:θ/) is the father of TEX. [My special thanks to Zhichu Chen for helping me troubleshoot the code for creating this marginal figure.]

1.1 How did LATEX come into existence?

The journey begins with Donald Ervin Knuth and his TEX. Knuth (born January 10, 1938) is a renowned computer scientist and Professor Emeritus of the Art of Computer Programming at Stanford University. He was the 1974 Turing Award winner and more or less defined the field "Computer Science" as it is today.

In 1977, Knuth devoted most of his time writing *The Art of Computer Programming*. After he got the proofs of the second volume on March 30, he felt greatly discouraged and wrote in his diary:

> *Galley proofs for vol. 2 finally arrive, they look awful (typographically) . . . I decide I have to solve the problem myself.*

And so he did. On May 5, he started his major design on TEX—a typesetting system that he could use to create beautiful books.

TEX is pronounced /tɛx/.

Knuth planned to finish the project in 1978, but it eventually took him more than a decade—it was not until 1989 that the language of TEX was frozen. Knuth invented what he called "literate programming," a way of producing compilable source code and high quality cross-linked documentation (typeset in TEX) from the same original file. The language used is called `WEB` and produces programs in Pascal.

The current and the next paragraphs use material from Wikipedia.

Since version 3, TEX has used an idiosyncratic version numbering system, where updates have been indicated by adding an extra digit at the end of the decimal, so that the version number asymptotically approaches π. The current version of TEX is 3.141592; it was last updated in December 2002. Knuth has stated that the "absolutely final change (to be made after [his] death)" will be to change the version number to π, at which point all remaining bugs will become features.

Although TEX is powerful, many people find it *too* powerful to master, especially when it comes to layout design. Based on the idea that authors should be able to concentrate on writing within the logical structure of their document, rather than spending their time on the details of formatting, Leslie Lamport implemented LATEX.

LATEX is pronounced /leitɛx/ or /la:tɛx/.

With LATEX, you are *not* supposed to be concerned about the style—everything should be pre-defined and fully at your call. You enter your text and LATEX takes care of the formatting. In this sense, LATEX is much easier to use than TEX. As a matter of fact, you can literally learn to compose a paper including a table of contents and an index within an hour or so.

The first popular release, LaTeX 2.09, appeared in early 1980s and Lamport claims that it "represents a balance between functionality and ease of use." After a few years' development, many new functionalities were added, along with which the problem of incompatibility arose. In hopes of bringing this situation to an end, the LaTeX3 Project was started by a group led by Frank Mittelbach. This is a long term project, and the first big step forward is the 1994 release, LaTeX 2_ε, which is the focus of this book.

In Duke University, LaTeX is required of all students in Pratt School of Engineering.

Today, LaTeX is used by most scientists, and many presses and academic societies require or prefer submission using LaTeX.

1.2 I saw many people arguing over the pros and cons of LaTeX versus Microsoft Word. What is your attitude?

For me, LaTeX and Word are two vastly different things, both of which do their own jobs within their own domains.

TeX, as Knuth proposed, is "a new typesetting system intended for the creation of beautiful books—and especially for books that contain a lot of mathematics." It is used by authors to write their manuscript, and many publishers use it in composition. When the major consideration is typographic quality, TeX should be chosen over Word. There are quite a few advantages:

ligature: Compare "fi" with "fi," the latter evidently looks unprofessional.

- TeX uses a very sophisticated scheme for setting type. It understands concepts that Word has so far ignored, e.g., ligature, kerning, and so forth.

kerning: Try "wolf" with the quotation marks in Word with Times New Roman—how pathetic can it be? To be fair, this is the font's fault, but to tune it in Word is tedious.

- TeX formats the entire paragraph at a time, while Word formats the text on a line-by-line basis. It is not rare for Word to produce a very tight line followed by a loose one. But this hardly ever happens in TeX, because TeX always looks back and forth to determine the best breakpoints possible.

In my opinion, only Adobe Indesign has a hyphenation algorithm that is comparable.

- TeX has one of the most advanced hyphenation schemes. It could hyphenate about 90% of permissible hyphen points in a dictionary. What's more, professional typesetting requires that no more than three hyphens should appear consecutively at the end of lines, which is a breeze to accomplish in TeX. But you have to pray that your soul is pure when using Word.

- TeX produces the most beautiful math equations in the world. A classic demo is shown in figure 1.2.

$$\sum_{p \text{ prime}} f(p) = \int_{t>1} f(t)\, d\pi(t) \qquad \sum_{p\,\text{prime}} f(p) = \int_{t>1} f(t)\, d\pi(t)$$

Figure 1.2: The equation on the left is produced with TeX, while the one on the right comes out of Microsoft Office 2003.

In short, Word is not suitable for professional typesetting—it is merely a word processor. I use it extensively for file exchange. Sometimes, I would even paste an entire TeX source file into a Word document, so that my friend can mark on it with the "Tracking" feature (figure 1.3). When I get the document back, it's very easy for me to see what changes are made and I can make my decision about whether or not to accept these changes.

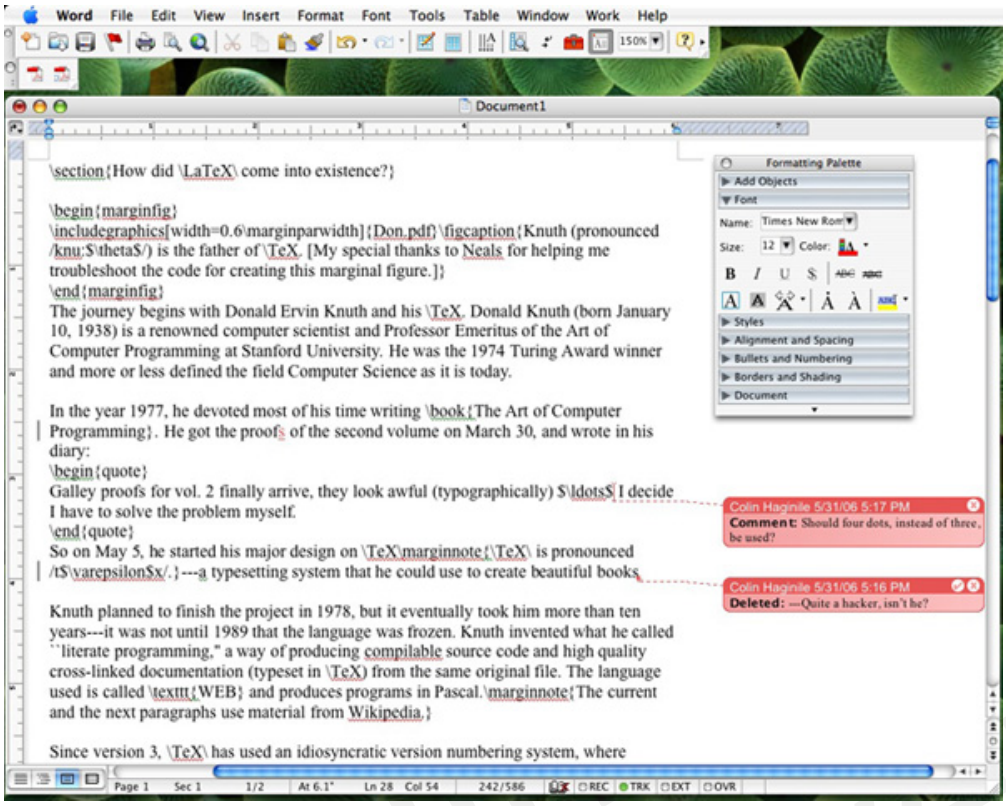

Figure 1.3: The Tracking feature in Microsoft Word is handy when a document is reviewed by other people.

1.3 How hard is LaTeX?

LaTeX is perceived to be much easier than Word in many countries. Most authors don't know much detail about TeX, and yet submit papers written in LaTeX with ease. The reason is that most publishers in, say the U.S., have prepared easy-to-use class files and templates for authors. Therefore, authors are not concerned about the style of their documents—all they are responsible for is to put text into the pre-estabished "framework." In fact, the editors will get very upset if you try to change the style.

The situation is quite different in China. Most authors in our country have far exceeded the responsibility of an author—they have to create style files so as to typeset their paper according to the specifications, and this is a task involving much expertise. The CTeX Society has done a great job creating templates and class files in hopes of easing authors' work, but there's much more that needs to be done. This manual is another effort in facilitating you in your endeavor.

CTeX has grown into a full-fledged TeX society. Its official website is www.ctex.org.

1.4 How to study LaTeX?

Many people agree that the best way to study LaTeX is simply to use it. So the best way to make full use of this book is to try out the examples and do the exercises. This helps you understand and memorize the commands better.

To get started, read chapters 2 and 3, and work on the examples. You'll understand most of the basic concepts in LaTeX. When you've completed these two chapters, you

An article telling my personal story of getting started with LaTeX can be accessed at http://bbs.ctex.org/forums/index.php?showtopic=12955.

do not need to read the remaining of the book chapter by chapter. Rather, start using LaTeX—refer to the related chapter when you're doing specific things in LaTeX. You shouldn't expect to master LaTeX in a day or two—your patience will pay off (as Master Yoda might say).

Actually, you probably never ever have to master LaTeX.

If you have a question and can't find an answer in this book, you can post it in the forum of the Chinese TeX Society (bbs.ctex.org), and you could expect to receive an answer within 24 hours. But do a search first! The forum has been running for over four years and the questions that people asked previously have created a huge knowledgebase. Most of the time, your question has already been answered and it's always a nice thing to save others their precious time.

2

LaTeX Singing on Your Computer

2.1 What's the easiest way to install LaTeX on Microsoft Windows?

The easiest way to set up LaTeX on Windows is to use the CTeX Suite. The CTeX Suite is based on MiKTeX, with various useful applications bundled. It provides complete support for CCT and CJK, two leading Chinese processing system. The advantage of the CTeX Suite is that it is foolproof—keep clicking "Next," and everything will be properly set up, including the difficult Chinese configuration. The current CTeX Suite includes MiKTeX, WinEdt, GSview, Ghostscript, etc.

The CTeX Suite is developed by Lingyun Wu.

1. Go to http://www.ctex.org/CTeXDownload and download the latest CTeX Suite. There are currently four choices available: the Full version, the Basic version, the Full Update version, and the Basic update version.

   I recommend the Basic version over Full. MiKTeX 2.4 and later supports "installation on-the-fly," so when you use a package that isn't installed yet, MiKTeX will automatically download and install it.

   The download might take a while. Be patient and God bless your Internet connection. When it's downloaded, double-click and follow the instruction on the screen.

2. On the same page, download CTeX-Fonts, and install it.

3. Register WinEdt if you're annoyed by the pop-up windows appearing like a bomb.

4. Congratulations. You're all set!

If you want more flexibility, you could also try the standalone MiKTeX. TeXLive developed by the TUG is also a nice choice.

2.2 What if I own a glorious Mac?

The easiest way to install TeX on a Mac is to use MacTeX.

1. Go to http://www.tug.org/ftp/tex/mactex/ and download the latest MacTeX. As of March 2006, MacTeX has been released as a universal binary and runs natively on both PowerPC- and Intel-based Macs.

   MacTeX will install TeX, XeTeX, Ghostscript, ConTeXt, MusixTeX, ImageMagick, TeXShop, BibDesk, Excalibur, i-Installer, etc.

2. The tricky part is to set up Chinese—it is a hard task because "GBKfont," the famous application for creating Chinese fonts, has not yet been ported to Mac OS X. As of this writing, the easiest way to install Chinese fonts on a Mac is to copy

everything in the `localtexmf` folder of CTEX Suite to `/usr/local/teTeX/share/texmf.local`.

Then go to `texmf.local/pdftex/config`, make a copy of `psfonts.map` and rename it to `pdftex.map`. In Terminal, type "`sudo mktexlsr`," and this should work.

(Some people have reported that the map file in certain versions of the CTEX Suite doesn't work. If you followed the instruction I give here and didn't solve the problem, please send an email to me hg9@duke.edu and I'll send you a map file that proves to work.)

Other installation options include i-installer, Fink, TEXLive, etc., which give you more flexibility.

2.3 How about us Linux users?

The best TEX distribution on Linux is teTEX. The following installation procedure is documented and maintained by lapackapi of the CTEX Society, and it works pretty well on Fedora Core.

1. Go to http://www.tug.org/tetex/ and download teTEX. Install it according to the instruction coming along with the distribution. If you are using Fedora Core, you could easily install it from your system installation disk.
2. Install `tetex-afm` and `fontforge`:

   ```
   yum install tetex-afm fontforge
   ```
3. Download CCT and CJK:

   ```
   wget ftp://ftp.cc.ac.cn/pub/cct/Linux/cct-0.6180-3a.i386.rpm
   wget ftp://ftp.cc.ac.cn/pub/cct/Linux/cct-fonts-1.2-0.i386.rpm
   wget ftp://ftp.cc.ac.cn/pub/cct/CJK/CJK-GBKfonts-0.3-15.i386.rpm
   wget ftp://ftp.cc.ac.cn/pub/cct/CJK/ctex-0.7-1.i386.rpm
   wget ftp://ftp.cc.ac.cn/pub/cct/CJK/CJK-4.6.0-0.src.rpm
   wget ftp://ftp.cc.ac.cn/pub/cct/CJK/dvipdfmx-20050307-3zlb.src.rpm
   ```
4. Compile the last two packages:

   ```
   rpmbuild --rebuild *.src.rpm
   ```

   A few rpm packages will be created in `/usr/src/redhat/RPMS/i386/`. We can now safely remove the source packages:

   ```
   rm *.src.rpm
   ```
5. Copy the rpm packages to the current working directory:

   ```
   cp /usr/src/redhat/RPMS/i386/* .
   ```
6. Install the packages:

   ```
   rpm -ivh *.rpm
   ```
7. Install Chinese fonts. Get the font files ready. Suppose you have a font file called `songti.ttf`, then simply enter

   ```
   gbkfont-inst songti.ttf song
   ```

3

Getting Started

3.1 The Basics: Control Sequence and Environment

One advantage/disadvantage of TEX is that it is not WYSIWYG (what-you-see-is-what-you-get), but WYTIWYG (what-you-think-is-what-you-get). The general procedure is:

1. Create a file with the extension `.tex` using any text editor, e.g., Notepad on Windows, or TextEditor on Mac OS X; but WinEdt and TeXShop are widely used for this purpose.

2. Enter your text along with commands to let LATEX know how to deal with your manuscript.

3. Compile it with LATEX to obtain the final result.

We get started by introducing two fundamental concepts: control sequence and environment.

A control sequence is a kind of command that starts with a backslash (\). There are two kinds of control sequences. A *control word* consists of a backslash followed by one or more letters. For example, the control word '`\tableofcontents`' instructs LATEX to automatically prepare, format, and output the table of contents. There are a few more notes about control words:

"\" is called the escape character.

- TEX is case sensitive, so `\pi`, `\Pi`, `\pI`, and `\PI` are four different commands.

- A space must be placed after a control sequence if it's followed by a letter. For example, the control word `\TeX` produces the logo "TEX." If you want to enter the word "TEXpert," the answer is not to enter `\TeXpert`, because TEX will think it's processing a command that is composed of seven letters. The correct way is to enter '`\TeX pert`'—the space terminates the command `\TeX` and will not actually produce a space.

  Interestingly, `\TeX3` does produce TEX3—that's because `3` is a digit, not a letter.

- Control sequences can be followed by declarations. There are two kinds of declarations: optional and required.

  One example is `\section[Duke]{Duke University}`. This command tells LATEX that we're going to start a new section and the section heading is "Duke University." But in the table of contents, we want the heading to be displayed as "Duke." In this example, `[Duke]` is optional, and can be simply omitted; `{Duke University}` is required, you *must* put something between the braces. In short, we put optional stuff between brackets and required declarations between braces.

The second kind of control sequence is a control symbol, consisting of a backslash followed by a single nonletter. In this case, you don't need a space to tell TEX where it ends. (Why does this make sense?) For example, `\,` produces a "thin space" (e.g., `1\,cm` produces '1 cm').

Example 3.1 What are the control sequences in '`\'m \exercise3.1\\!`'?
Answer There are three control sequences. `\'` is a control symbol; `\exercise` is a control word; and `\\` is another control symbol.

Example 3.2 `\LaTeX` can be used to produce the logo "LATEX." What do you think the result of '`\LaTeX is great`' be?
Answer The result would be 'LATEXis great'.

Example 3.3 The command `\input1` will input a file named `1.tex`. What do you think `\input123` will do?
Answer The command `\input123` will input a file named `1.tex` and then outputs the digits '23'. If you want to input a file named `123.tex`, you should enter `\input{123}`.

Example 3.4 Suppose you know that the control sequence `\includegraphics` can be used to put an external figure into your TEX output. How do you think you could include a figure `lee.jpg` with a width of 3 cm?
Answer We can imagine that `\includegraphics` definitely require a file name after it, so the file name should be a required argument. Meanwhile, since LATEX is super-smart, we have reason to believe that if we do not specify a width, LATEX can process that automatically; therefore, the width should be optional. So we guess that we should be entering `\includegraphics[width=3cm]{lee.jpg}`.

Another important concept I'm to introduce is *environment*. An environment takes the form of the following:

```
\begin{environment_name}
The content ...
\end{environment_name}
```

Example 3.5 How do you center a paragraph of text?
Answer Here's how:

```
\begin{center}
This line should be centered.
\end{center}
```

3.2 Your first masterpiece with LATEX

OK, let's get down to typeset our first glorious document. By the end of this section, you would have produced what is shown in figure 3.1.

Launch WinEdt or TeXShop. Then enter the following into the file:

The first section in this example is from *The Complete Manual of Typography*, and the second is from *The TEXbook*.

```
\documentclass{article}
\usepackage{amsmath}
\begin{document}
\title{My First \LaTeX\ Exercise}
\author{Helin Gai}
\maketitle
```

My First LaTeX Exercise

Helin Gai

May 5, 2006

Contents

1 The Changing Definition of Font

In the days of handset type, a *font*[1] comprised one or more drawers full of type blocks in a single size. With the advent of the Monotype and Linotype machines, a font then became a set of molds (or *matrices*) from which type could be cast as it was needed, on the fly.

All of this type was destined for a specific kind of printing press, the *letterpress*. On a letterpress the printed impression is created by inking a raised surface (which can be a photographic image as well as type) whose image is transferred under pressure to the paper. Recessed areas—those below *type-high*—receive no ink, do not come into contact with the paper, and so create the "blank" areas of the page.

2 The Glorious LaTeX

The first paragraph of a new section is not indented. TeX recognizes the end of a paragraph when it comes to a blank line in your manuscript file.

Subsequent paragraphs are indented.[2] (See?) The computer breaks a paragraph's text into lines in an interesting way–and hyphenates words *automatically* when necessary.

> "If there hadn't been room for this material on the present page, it would have been inserted on the next one."

[1] A term that comes from an early French word meaning "molding" or "casting."
[2] Oh, try to avoid footnotes!

1

Figure 3.1: The final result of your first masterpiece created with LaTeX.

```
7
8  \tableofcontents
9
10 \section[Fonts]{The Changing Definition of Font}
11
12 In the days of handset type, a \emph{font}\footnote{A term that
13 comes from an early French word meaning ``molding'' or
14 ``casting.''} comprised one or more drawers full of type blocks
15 in a single size. With the advent of the Monotype and Linotype
16 machines, a font then became a set of molds (or \emph{matrices})
17 from which type could be cast as it was needed, on the fly.
18
19 All of this type was destined for a specific kind of printing
20 press, the \emph{letterpress}. On a letterpress the printed
21 impression is created by inking a raised surface (which can be
22 a photographic image as well as type) whose image is transferred
23 under pressure to the paper. Recessed areas---those below
24 \emph{type-high}---receive no ink, do not come into contact with
25 the paper, and so create the ``blank'' areas of the page.
26
27 \end{document}
```

Save the file and name it `example-1.tex`. Press the button in WinEdt, or the button Typeset in TeXShop. A file `example-1.pdf` will be created and you can see the result in that file.

Now let's make sense of what you've just entered.

A class file is an actual physical file with the extension `.cls`.

Line 1: The control sequence `\documentclass` will appear in every single one of of your LaTeX file. It loads the correct "class file," a file that has defined all the formatting commands that you can use. In our case, we used the `article` class file, because all that we are writing is a short article. The idea of "class file" is very smart and powerful. Suppose that you decide to submit your paper to $\mathcal{AMS}$ (American Mathematical Society), all you have to do is to change `article` to `amsart`, and your paper will be reformatted according to the specifications required by $\mathcal{AMS}$. (Why don't you go ahead and give it a try?) Other widely used class files include `book` and `report`.

A style file is also a physical file with the extension `.sty`.

Line 2: Every once in a while, you'll want some features that are not built into LaTeX itself. But most of the features that you want have been implemented by people all over the world. They create what we call packages (style files) so that we can use those features. In our example, we loaded the amsmath package, which is provided by $\mathcal{AMS}$ and has many enhanced features for math typesetting.

The part before `\begin{document}` is called the *preamble*.

Line 3: `\begin{document}` tells LaTeX that you're officially ready to start your document.

Lines 4–6 create the title part. You enter the title of your article with the `\title` command, the `\author` command for author; everything is straightforward. Then `\maketitle` outputs this part.

You've probably noticed that LaTeX automatically added the date. This is controlled, as you might have guessed, by the `\date` command. Try enter `\date{March 35, 2020}` and see what happens. Enter `\date{}` if you don't want the date to be displayed.

You might also have realized that I put `\␣` after the command `\LaTeX`. As I've mentioned before, the space after `\LaTeX` will be considered as the end of the command. So we use a control space instead to output the space.

Line 8: `\tableofcontents` prepares the table of contents, as I've mentioned before.

Line 10: `\section` starts a new section, numbers it, and formats it. The section title is "The Changing Definition of Font," but we want it to be shown as "Font" in the table of contents. (Remember what optional and required declarations are respectively?)

Line 12: We start our text on this line. Note that pressing the "enter" (or "return") key once to go to the next line is the same as pressing the space bar; i.e., one return = one space. So you can end a line anywhere you want.

The `\emph` command tells LaTeX to emphasize the part of the text (in italic by default). `\footnote` creates a footnote and numbers it automatically.

Line 13: Note that " is produced with ` ` (pressing the key on the left of '1' twice), and " is produced with ' '.

Line 17: Remember what a ligature is? I used "fi" as an example in chapter 1. On line 17, we meet the "fl" ligature. You don't have to worry about it—TeX takes care of it automatically.

Line 19: Two returns starts a new paragraph!

Line 23: `---` is converted into —, what we call an *em dash*. (What do you think the result of `--` is?)

Now try to enter the remaining of the document yourself.

3.3 Typesetting Chinese in LaTeX

As I've mentioned before, there are two major Chinese typesetting system: CCT and CJK, each of which has its own advantages. CCT is developed by Linbo Zhang, a Chinese scholar, and has paid much attention to Chinese typographic conventions. CJK lacks these typographic consideration but is more flexible and provides better compatibility with LaTeX.

A comprehensive solution, the ctex package, is developed by Lingyun Wu, President of the CTeX Society. It uses CJK as its default formatting engine (although you could easily specify that it uses CCT instead), and also provides commands specially designed for typesetting Chinese (e.g., declaring Chinese fonts, setting up Chinese-style heading, and so forth).

We're going to typeset what is shown in figure 3.2 with the ctex package.

```
1  \documentclass{article}
2  \usepackage{ctex}
3  \usepackage{amsmath}
4  \begin{document}
5  \title{我的中文练习}
6  \author{鹤麟}
7  \maketitle
8
9  \tableofcontents
10
11 \section{入门知识}
12 中文间的空␣␣格␣␣都会消失的。所以，虽然你在此处打了空格，过一会儿它
13 们是不会显示出来的。你可以用\␣这\␣样的形式来强行加出空格。英文中间
14 的空格是不会被吃掉的，但注意输入一千个空格和一个空格，最终的结果是
15 一样的。比如：This␣␣is␣␣␣␣␣a␣sample~产生的效果和~This␣is␣a
16 sample~是没有区别的。这有点像命令后面的空格会被吃掉一样。所以，
17 \TeX␣perts~中间的那个空格是会消失的。当然，如果你一定要那个空格，
18 可以输入~\TeX\␣perts。
```

我的中文练习

鹤麟

2006 年 6 月 3 日

目录

1 入门知识

中文间的空格都会消失的。所以，虽然你在此处打了空格，过一会儿它们是不会显示出来的。你可以用 这 样的形式来强行加出空格。英文中间的空格是不会被吃掉的，但注意输入一千个空格和一个空格，最终的结果是一样的。比如：This is a sample 产生的效果和 This is a sample 是没有区别的。这有点像命令后面的空格会被吃掉一样。所以，TEXperts 的中间那个空格是会消失的。当然，如果你一定要那个空格，可以输入 TEX perts。

现在连续按两次回车，就开始了新的一段。CTeX 会自动帮你在前面空出两个汉字的距离。

2 什么是 TEX?

TEX 是一种优秀的电子排版系统。它提供了一套功能强大并且十分灵活的排版语言，它多达 900 多条指令，并且 TEX 有宏功能，用户可以不断地定义自己适用的新命令来扩展 TEX 系统的功能。许多人利用TEX 提供的宏定义功能对 TEX 进行了二次开发，其中比较著名的有美国数学学会推荐的非常适合于数学家使用的 AMS-TEX 以及适合于一般文章、报告、书籍的 LATEX 系统。

Figure 3.2: Typesetting Chinese in LaTeX

现在连续按两次回车，就开始了新的一段。CTeX~会自动帮你在前面空出两个汉字的距离。

Again, here's some explanation:

Line 2: To load ctex, simply use the \usepackage control sequence. Note how the style of section titles are different.

Lines 12–18 explain some weird phenomena you would come across in typesetting Chinese. For example, spaces between Chinese characters will disappear. You would also notice that I use a ~ (tilde) to connect Chinese and English—you don't have to, but for the purpose of perfect composition, I recommend that you start cultivating this great habit.

Try to typeset section 2 yourself.

3.4 A Short Summary

A lot of information has been presented in this chapter. And below is the most basic but important "template" you should remember. Make sure you understand every single command in the template.

```
\documentclass{article/book/report}
\usepackage{ctex} % if you want to typeset Chinese
\usepackage{package_name}
\begin{document}
\title{Title}
\author{Author_name}
\date{Date}
\maketitle

\tableofcontents

\section[Short_title]{Long_title}

--- produces an em dash. `` produces the left quote.
'' produces the right quote.
\end{document}
```

3.5 Dividing your text into parts, chapters, and sections

Headers help your reader find his or her way through your work. As you've already seen, the article class provides \section to fulfill this purpose. But there are more commands provided by article:

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

You should definitely try them out.

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

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

But if you try the following code (because you're an eager beaver),

```
\documentclass{book}
\begin{document}
\section{A new section}
\end{document}
```

you'll experience something you wouldn't expect—the section number is "0.1." The reason is that the Level-A heading in the `book` class is chapter, not section. (Have you heard of the saying "Divide your article into sections, but your book into chapters"?) So the following code fixes the problem:

```
\begin{document}
\chapter{A new chapter}
\section{The first section of the chapter}
\end{document}
```

The `\chapter` command is also provided in report.

Note that these commands could be followed by an optional argument, as is explained before. For example, a chapter title "Duke is one of the best universities in the United States of America" is a bit too long to be placed in the table of contents, and you decide that it be replaced with "Duke is one of the best universities in the U.S." in the TOC. What you should enter is the following:

```
\chapter[Duke is one of the best universities in the U.S.]
        {Duke is one of the best universities in the United
         States of America}
```

3.6 Options of standard document classes

I've already mentioned that a control sequence might be followed with an optional argument, enclosed in brackets. `\documentclass` is just another one of the kind.

Table 3.1 lists all available options for the standard `article`, `report`, and `book` classes.

The table should be studied carefully and the best way to study it is to try everything out.

This table is abstracted from *The Not So Short Introduction to LaTeX 2ε*, with some modification.

Table 3.1: Options of standard document classes

Command	Meaning
`10pt`, `11pt`, `12pt`	Sets the size of the main font in the document. If none is specified, 10 pt is assumed. Note that when you change the option from `10pt` to `12pt`, the sizes of section headings are adjusted automatically.
`a4paper`, `letterpaper`, ...	Defines the paper size. The default size is `letterpaper`. Besides that, `a5paper`, `b5paper`, `executivepaper`, and `legalpaper` can be specified.
`fleqn`	By default, all the displayed math formulas are centered. If you specify `fleqn`, they will left-align.
`leqno`	Places the numbering of formulas 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; i.e., whether the content before `\maketitle` should be placed on a separate page 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`	Starts a new chapter on the right hand page or on the next page. 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.

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4

Playing with Text

This chapter focuses on how you enter text and set type. Topics covered include: how to enter the characters not readily available on your keyboard, how to change the typeface of your text, etc.

4.1 International characters

Every once in a while, you'll bump into a word like cafè. If you're using Mac OS X, this won't present any difficulty for you. The keyboard shortcut Option + e creates a tilde, and when you press the key e again, it will be placed under the tilde:

Interestingly, if you press Option + e + i, the dot of "i" will disappear: ĩ.

```
é
```

é

If you're using other operation system, you could use TEX's built-in command to do the similar thing. Table 4.1 lists all the commands for producing accents and other international symbols.

Table 4.1: Accents and special characters

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

The dotless ı and ȷ are useful if you want to put accents over the letters i and j. Occasionally, they are also used when the baselines are very close (to achieve special typographic effect)—this is a special occasion when typography overrides logic.

```
\huge\baselineskip=8pt\lineskip=-2pt
\textbf{Buy\\
\hspace*{10.5pt}R\i ght}
```

Buy
Right

4.2 Punctuation—what makes life/reading easier

4.2.1 Dash—your first lesson with punctuation

If you can use dashes correctly, you've mastered more than half about TEX's treatment of punctuation. There are four kinds of dashes built into TEX:

There's actually a second kind of hyphen (a fifth kind of dash), called a soft hyphen, which is discussed in section about hyphenation.

- Hyphens (obtained from `-`) are used a lot for compound words, e.g., daughter-in-law. It's also used extensively for separating characters, e.g., 1-800-621-2376.
- En dashes (obtained from `--`) are widely used instead of "to," and for prefixing a compound word; e.g., pages 10–20, London–Paris train, post–World War II.
- Em dashes (obtained from `---`) are used for punctuating a sentence—they are what we often call simply dashes.

You will learn that all "inline" math equations are placed between dollar signs.

- Minus signs (obtained from `$-$`) are used in math formulas a lot, e.g., -1.

In some Asian countries, number ranges are indicated with a tilde ($\sim$) instead of an en dash. This is created with the command `$\sim$`. For example, `$-1\sim 2$` produces "$-1 \sim 2$." The advantage is that you can use negative signs with it without causing any confusion—the notation "$-1--2$" is weird and unattractive. However, if $\sim$ is not a tradition in your country, that is, if you're supposed to use en dash for number ranges, you should consider using the word "to," e.g., "-1 to -2."

In some European countries, an en dash is used in place of an em dash – like what you just saw. When an en dash is used in this way, you should place a space both before and after it. However, no spaces are required around an em dash.

Em dashes are sometimes used instead of quotation marks to set off dialogue. In this case, you should place a space after the dash:

```
--- Will Colin attend your wedding?\\
--- Of course.
```

— Will Colin attend your wedding?
— Of course.

4.2.2 Quotation marks

As is mentioned before, we use two ` (grave accent) for opening quotation marks and ' (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."

Quotes within quotes can be very tricky. For example, a single quote followed by a double quote, you can't simply type `'''` because LATEX will interpret it as a double quote followed by a single quote, resulting in "'. But `'␣''` is unacceptable either—the space is too big for this purpose. To solve this issue, we introduce thin spaces, which can be obtained with either `\,` or `\thinspace`:

```
'\,''
```

'"

4.2.3 Comma and Period

TEX was designed a long time ago, and occasionally it does follow some old typographic tradition. Take a look at the following result:

```
Colin, come downstairs. Lee's here.
```

Colin, come downstairs. Lee's here.

What you could observe is that the space after the period is slightly bigger than the one after the comma. TEX does this because traditional typography requires a larger space to indicate the end of a sentence. Following along the same logic, TEX puts more space after an exclamation point (!), and a question mark (?). However, this tradition is obsolete as this extra space is disturbing. So you should almost always execute `\frenchspacing` just before the beginning of every document, instructing TEX to treat commas and periods in the same way, like this:

```
\frenchspacing
Colin, come downstairs. Lee's here.
```

Colin, come downstairs. Lee's here.

TEXnicality
If you decide to follow along the old tradition (like the part you're currently reading does), there are a few technical details that you should pay attention to.

- "Mr. Lee" should be entered as `Mr.\ Lee` (or better yet, `Mr.~Lee`).
- A period following a capital letter does not produce the extra space. So if a sentence ends with "U.S.," you'll have to tell LATEX that the period actually indicates the end of a sentence by prefixing it with `\@`, i.e., `U.S\@`.
- Quotes and parentheses can be "transcended," i.e., if a period appears just before a right quote or right parenthesis, the space after the right quote and the right parenthesis is also bigger than you would imagine. Take care to treat these special conditions.

4.2.4 Ellipsis

Ellipsis should be used with great care. There are a few different conventions as to how to use ellipses, but the most widely adopted method is the three-or-four-dot method. Here's how *The Chicago Manual of Style* says about it:

> Three dots indicate an omission within a quoted sentence. Four mark the omission of one or more sentences. When three are used, space occurs both before the first dot and after the final dot. When four are used, the first dot is a true period—that is, there is no space between it and the preceding word. What precedes and, normally, what follows the four dots should be grammatically complete sentences as quoted, even if part of either sentence has been omitted.

So how to produce an ellipsis? The answer is not to type three periods—the result of ... is "..." The dots are too close to be pleasant for our eyes. LATEX provides a command for producing ellipsis, `\ldots` (low dots), which gives "…" But this is not

the end of the story, unfortunately. If you enter `H \ldots H`, what you get is "H . . . H," i.e., the space is "eaten" by TEX. The solution seems to be `H␣\ldots\␣H`, in which we use a control space, but the result became "H . . . H." Look closely! The space on the right hand side is slightly bigger than the one on the left. The reason is that the definition of `\ldots` includes a thin space after the third dots when it is used in text mode—this is handy if you want to put a comma after it, `\ldots,` gives the correct ". . . ,". The solution, which you probably couldn't understand, is to use `$\ldots$`, so `H $\ldots$ H` gives the "H . . . H," which is perfect.

Another question to explore is how to get four dots. The logical way to do so seems to be `. $\ldots$`, which gives ". . . ." But typographic convention dictates even spaces between the dots, so the solution seems to be use a thin space: `.\,$\ldots$` which gives ". . . ." But the best solution is to use the illogical '`\ldots.`'. (The reason is that LATEX treats the space after a period differently from a normal word space, as is talked about in "TEXnicality" in section 4.2.3.)

Here's a concrete example for your reference:

```
The spirit of our American radicalism is
destructive and aimless\ldots. On the
other side, the conservative party
$\ldots$ is timid, and merely
defensive\ldots. It does not build, nor
write, nor cherish the arts, nor foster
religion, nor establish schools.
```

The spirit of our American radicalism is destructive and aimless. . . . On the other side, the conservative party . . . is timid, and merely defensive. . . . It does not build, nor write, nor cherish the arts, nor foster religion, nor establish schools.

4.3 Changing typefaces

The default typefaces used by TEX includes Computer Modern Roman, **Computer Modern Bold Face**, *Computer Modern Italics*, *Computer Modern Slanted*, etc. The commands for changing the typefaces are shown in table 4.2.

The two words "font" and "typeface" are commonly misused. "A typeface is a collection of characters that are designed to work together like the parts of a coordinated outfit. . . . A font . . . is a physical thing, the description of a typeface. . . ." You can ask questions like "What font was used to set that typeface?" But you can't say, "What font is that?"

Table 4.2: Changing typefaces in LATEX

Command	Sample	Command	Sample
`\textrm{roman}`	roman	`\textit{italic}`	*italic*
`\textbf{bold face}`	**bold face**	`\textsl{slanted}`	*slanted*
`\texttt{typewriter}`	`typewriter`	`\textsc{Small Caps}`	Small Caps
`\textsf{sans serif}`	sans serif		

Notice that there are two kinds of oblique typefaces listed in the table. *Slanted typeface* could be considered skewed roman, while *italic type* is designed in a different style. This will be clear if you see letters that are in an unslanted italic typeface.

You could easily combine these commands to obtain more typefaces (but try not to abuse this power):

```
\textbf{\textit{bold italic}}\\
\textit{\texttt{italic typewriter}}
```

bold italic
`italic typewriter`

The tricky part is to decide the typeface of the punctuation. One commonly asked question is "Should the comma after an italic word be italic?" There is no consensus,

but I again conform to *The Chicago Manual of Style*, which states: "All punctuation marks should appear in the same font—roman or italic—as the main or surrounding text, except for punctuation that belongs to a title or an exclamation in a different font."

```
Smith played the title role in
\textit{Hamlet}, \textit{Macbeth}, and
\textit{King Lear}; after his final
performance, he announced his retirement.

She is the author of \textit{Who Next?}

\textbf{Note}: In what follows \dots
```

Smith played the title role in *Hamlet*, *Macbeth*, and *King Lear*; after his final performance, he announced his retirement.

She is the author of *Who Next?*

Note: In what follows . . .

4.4 Controlling the size of your text

We've already known that we can change the size of the main text by supplying the optional arguments of `\documentclass`. Most submission require a 12-point font, we can simply write something like `\documentclass[12pt]{article}` to achieve the effect. You'll realize that the section title is now bigger as well. The three pre-defined choices are `10pt`, `11pt`, and `12pt`.

But you could also change the size of your text within your main text. Table 4.3 tells you how. Note that these size changing commands are relative, e.g., tiny becomes bigger as you change the main text from 10 pt to 12 pt. Table 4.4 tells you the absolute size produced by these commands as your main font varies.

Table 4.3: Changing the size of the text in LaTeX

Command	Sample	Command	Sample
`\tiny`	tiny	`\scriptsize`	scriptsize
`\footnotesize`	footnotesize	`\small`	small
`\normalsize`	normalsize	`\large`	large
`\Large`	larger	`\LARGE`	even larger
`\huge`	huge	`\Huge`	largest

The next question to ask is how you obtain a line of text that is *exactly* 15 pt big? The answer is to use the `\fontsize{size}{skip}`. The `{size}` argument is the size of the text, while the `{skip}` argument specifies the baseline skip adopted. Notice that after the font size is chosen, you have to execute the font by using the `\selectfont` command.

```
\fontsize{15}{17}\selectfont
Happy Birthday!
```

Happy Birthday!

4.5 Is what you type what you get?

4.5.1 Special characters that make TeX scream

There are a few characters that require your special attention:

Table 4.4: Absolute point sizes in standard classes

Commands	`10pt` option	`11pt` option	`12pt` option
`\tiny`	5 pt	6 pt	6 pt
`\scriptsize`	7 pt	8 pt	8 pt
`\footnotesize`	8 pt	9 pt	10 pt
`\small`	9 pt	10 pt	11 pt
`\normalsize`	10 pt	11 pt	12 pt
`\large`	12 pt	12 pt	14 pt
`\Large`	14 pt	14 pt	17 pt
`\LARGE`	17 pt	17 pt	20 pt
`\huge`	20 pt	20 pt	25 pt
`\Huge`	25 pt	25 pt	25 pt

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

These characters are reserved by TEX to do unique things. To obtain them, prefix them with a backslash:

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

$ % ^ & _ { } ~

Some clarification:

- `\^` and `\~` are special—they're used for placing accents on letters, e.g., `\^{a}` produces â, `\~{e}` produces ẽ. That';s what the braces are about. They instruct ând t̃o put the accent on nothing.
- `\\` won't work because it's actually used to start a new line. To produce a backslash, enter `$\backslash$`.

4.5.2 Ligatures

Ligatures are standard to *every* professional typesetting system, e.g., TEX/LATEX, Adobe Indesign, QuarkXpress, etc. Even Apple's standard text editor, TextEdit, has built-in support for ligatures, but the most renowned Microsoft Office doesn't have this feature.

Let's take a look at some standard ligature in LATEX's computer modern font:

```
\textrm{fi, fl, ff, ffi, ffl}\\
\textbf{fi, fl, ff, ffi, ffl}\\
\textit{fi, fl, ff, ffi, ffl}\\
\textsl{fi, fl, ff, ffi, ffl}\\
\textsf{fi, fl, ff, ffi, ffl}\\
\textsc{fi, fl, ff, ffi, ffl}\\
\texttt{fi, fl, ff, ffi, ffl}
```

fi, fl, ff, ffi, ffl
fi, fl, ff, ffi, ffl
fi, fl, ff, ffi, ffl
fi, fl, ff, ffi, ffl
fi, fl, ff, ffi, ffl
FI, FL, FF, FFI, FFL
`fi, fl, ff, ffi, ffl`

Evidently, Computer Modern Small Caps and Computer Modern Typewriter do not have any ligatures at all. As a matter of fact, `\texttt{---}` produces `---`, not an em dash.

Some typographers think that ligatures should be turned off in headings. This sometimes doesn't produce the best result, so you should eyeball the result and make

an informed decision. But the way to disable ligatures in LaTeX is simply to divide the letters up:

```
fi, f{}i, {f}i, f{i}
```

fi, fi, fi, fi

4.6 Manual kerning

"In setting type, it's often the little things that count." Kerning adjusts the spaces between specific letter pairs to make the text look smooth and even. TeX automatically kerns letter pairs according to the metric information that comes along with the font. For example, letters A and V are automatically placed closer to show up as "AV." Without kerning, what you get is "AV," which is horrible.

But in the domain of typography, it is the optical aspect that really counts. The phrase "post–World War II" looks unpleasant—according to the metric files, TeX placed the correct amount of space before and after the en dash, but optically it still looks wrong. So we human have to interfere. Here's how:

```
post--\kern-0.5pt World War II
```

post–World War II

✌

5

Working with Paragraphs

Hyphenation and justification—H&J, for short—is the process a computer program uses to fit type into lines. TEX, as I've mentioned a couple of times, has one of the best H&J engines in the world by formating one paragraph at a time. This chapter helps you deal with paragraphs in TEX more effectively. We get started with basic controls over line breaks and such, and later get into the details of TEX's typesetting engine.

5.1 Manual line and page breaks

TEX, by default, automatically divides your paragraph into lines of the same length, using its sophisticated hyphenation and justification (H&J) scheme. But every once in a while, you'll want to start a new line without starting a new paragraph. You've actually seen a few examples—you can do so with `\\`.

```
Sometimes, {\large I}\\
just want to break the line.
```

Sometimes, I
just want to break the line.

The command `\newline` produces the same effect. In addition, `\\*` creates a line break but also prohibits a page break after the forced line break.

There's also the `\linebreak[`n`]` command. The optional argument n satisfies $n \in \mathbb{Z}$ and $n \in [0, 4]$, and denotes the level you encourage a line break here. So if breaking a line at the point you specified would produce something hideous, but meanwhile you specified that $n = 1$, this command might be possibly ignored. However, `\linebreak[4]` would almost always produce a line break. Also notice that the result of `\linebreak` differs from that of `\newline`:

```
Sometimes, {\large I}\linebreak
just want to break the line at
certain points to make \TeX\ unhappy.
```

Sometimes, I
just want to break the line at certain points to make TEX unhappy.

That is, `\linebreak` will justify the text. This command is quite useful when you are fine tuning your text and have to manually interfere with the text flow. One application is when you are setting a URL. As you'll see later in this book, you could use the `\url{...}` command provided by the URL package to typeset URLs, and these URLs will be broken into lines if necessary. However, the way this package works is to break after periods, while *The Chicago Manual of Style* requires breaking before a period. This is the time you'll have to interfere with LATEX. For example,

```
You could visit the site
www.admissions\linebreak[0].duke.edu
for more information about applying to Duke.
```

You could visit the site www.admissions
.duke.edu for more information about applying to Duke.

Similarly, LaTeX provides `\newpage` and `\pagebreak[`n`]` to create manual page breaks. `\newpage` terminates the line, fills the remaining of the page with blank space, and then goes onto the next page; `\pagebreak` justify the page so that the blank space is scattered into the text flow where additional vertical spaces is allowed (typically between paragraphs, before and after a heading, etc.).

5.2 Moving your text horizontally

The environments `flushleft` and `flushright` generate paragraphs that are either left- or right-aligned. The `center` environment generates centered 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 samelength.
\end{flushright}
```

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

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

At the centre
of the earth

5.3 Shaping a paragraph

Indentation is what controls the shape of a paragraph. And there are a couple of different indents.

The most well-known indents are the *first-line indents*, which flag the beginnings of new paragraphs. We've already known a great deal about first-line indents in LaTeX: 1) The first paragraph after a section heading will not be indented; if you do want to indent it, the indentfirst package will help; 2) Starting from the second paragraph, LaTeX will automatically inserts a first-line indents.

Paragraph indents are often measured in ems, and in LaTeX the size is controlled by `\parindent`, so `\setlength{\parindent}{2em}` (or simply `\partindent=2em`) sets the depth of the indent to be 2 em. If for mysterious reasons you want to cancel the indent of a specific paragraph, simply prefix it with `\noindent`.

There is no rule as to how big the first-line indent should be, but generally speaking, wider measures will profit from deeper indents. In this book, the section number plus

the white space before the section heading is exactly 20 points, so I set the paragraph indents to be that size in order to create a sense of balance.

The second kind is the *hanging indent*, which starts after at least one preceding line has been set "normal." To achieve this effect, you need to combine two control sequences:

- `\hangindent` specifies the depth of the indentation;
- `\hangafter` specifies the number of normal lines.

The following example demonstrates what you could achieve:

```
\hangindent=3em \hangafter=2
Duke University is a very young school. Our
history can be traced to as early as 1839,
when Brown's school house was established.
But it was not until 1924 that Duke came
into existence.
```

Duke University is a very young school. Our history can be traced to as early as 1839, when Brown's school house was established. But it was not until 1924 that Duke came into existence.

The third kind is the *running indent*, which affect a series of line, at the right or left margin, or even both. Interestingly, we could use the commands above to achieve this effect, except that `\hangindent` should be set negative:

```
\hangindent=-3em \hangafter=2
Duke University is a very young school. Our
history could be traced to as early as 1839,
when Brown's school house was established.
But it was not until 1924 that Duke came
into existence.
```

Duke University is a very young school. Our history could be traced to as early as 1839, when Brown's school house was established. But it was not until 1924 that Duke came into existence.

An interesting question to ask is whether or not the `\hangafter` could be negative. The answer is positive:

```
\hangindent=-3em \hangafter=-2
Duke University is a very young school. Our
history could be traced to as early as 1839,
when Brown's school house was established.
But it was not until 1924 that Duke came
into existence.
```

Duke University is a very young school. Our history could be traced to as early as 1839, when Brown's school house was established. But it was not until 1924 that Duke came into existence.

As you can see `\hangindent` and `\hangafter` are very powerful, so let's summarize their usage a little bit: If `\hangindent=`x, `\hangafter=`n, the width of the measure is h; then if $n \geq 0$, hanging indents will occur on lines $n+1$, $n+2$, ... of the paragraph, but if $n < 0$, it will occur on lines 1, 2, ..., $|n|$. The indented lines will be of width $h - |x|$; if $x \geq 0$, the lines will be indented at the left margin, otherwise at the right.

But most of the time, you probably don't need this much power. The most important running indents turn out to be used in quotations. And LaTeX provides two environments for this purpose: The `quote` environment doesn't indent the first line while the `quotation` environment does.

```
\parindent=2em
In discussing the reasons for political
disturbances Aristotle observes that
\begin{quote}
revolutions also break out when opposite
parties $\ldots$ are equally balanced\dots.
\end{quote}

In discussing the reasons for political
disturbances Aristotle observes that
\begin{quotation}
revolutions also break out when opposite
parties $\ldots$ are equally balanced\dots.
\end{quotation}
```

In discussing the reasons for political disturbances Aristotle observes that

> revolutions also break out when opposite parties . . . are equally balanced. . . .

In discussing the reasons for political disturbances Aristotle observes that

> revolutions also break out when opposite parties . . . are equally balanced. . . .

If you actually try them out, you'll see that the final result you obtain is different from what is shown above—both the left and the right margins are indented. And most of the time, you wouldn't like the default indentation value set by these two environments. Changing the style of these environments involves more expertise, and will be introduced in section 1.

Lastly, I'd like to introduce a command that gives you the *ultimate* power to control every single line of your paragraph: `\parshape`. Here's how *The TEXbook* describes it:

> In general, '`\parshape=`n i_1 l_1 i_2 l_2 $\ldots$ i_n l_n' specifies a paragraph whose first n lines will have lengths l_1, l_2, $\ldots$, l_n, respectively, and they will be indented from the left margin by the respective amounts i_1, i_2, $\ldots$, i_n. If the paragraph has fewer than n lines, the additional specifications will be ignored; if it has more than n lines, the specifications for line n will be repeated ad infinitum. You can cancel the effect of a previously specified `\parshape` by saying '`\parshape=0`'.

Below is a pretty sophisticated example. You could simply ignore the part that I use to insert the figure and focus on how I use `\parshape` to control the shape of the paragraph to leave room for the figure. You'll understand what I am doing here later in your life.

```
\parshape=5
   0cm 4cm 0cm 4cm
   0cm 4cm 0cm 4cm 0cm \linewidth
\leavevmode\smash{\rlap{\hspace*{4.4cm}%
\lower1.2cm\hbox{%
\includegraphics[width=20mm]
        {ColinLee.jpg}}}}%
Lee is my superfriend. He goes to Fudan
University and majors in Software
Engineering. He's very smart and loves
playing World of Warcraft very much.
```

Lee is my superfriend. He goes to Fudan University and majors in Software Engineering. He's very smart and loves playing World of Warcraft very much.

The shapepar is a pretty cool package. Read ftp://ftp.duke.edu/pub/tex-archive/macros/latex/contrib/shapepar/shapepar.pdf for more information.

By using `\parshape`, you could literally make your paragraph any shape you want. But if you want your paragraph to be shaped a heart, there's a package, shapepar, that could ease your work. The package provides a few predefined shapes that you could call up by using `\diamondpar`, `\squarepar`, and `\heartpar`.

✌

```
\heartpar{A running indent draws the
margin of the type in from the right or
left edge of the text frame by a specified
distance. Typically page layout programs
refer to these as simply left and right
indents. Because it is construed as a
paragraph attribute, any left or right
indent will affect all lines in a paragraph.}
```

A running indent draws the margin of the type in from the right or left edge of the text frame by a specified distance. Typically page layout programs refer to these as simply left and right indents. Because it is construed as a paragraph attribute, any left or right indent will affect all lines in a paragraph.
♡

5.4 Reflowing the text

TEX is well-programmed, but by no means can it replace the eyes of a good typographer. Sometimes (although experience tells that this doesn't happen a lot when setting type in TEX), you'll observe some discrepancy showing up in the automatic flowed text that TEX cannot observe with its built-in mechanism. There are a few occasions on which you will need to reflow the text:

- When very loose or tight lines exist. These are actually rare because of TEX's engine is designed to avoid these. But if verbatim or URLs are in the text flow, they could cause trouble.
- The same word appear consecutively at the end of lines.
- "River" is another typographic "misbehavior" (figure 5.1). It occurs when word spaces stack one above the other in successive lines.
- When text is not justified but ragged, the ragged margins might end up in distracting shapes (e.g., a triangle).
- A very short word ending a paragraph is on an individual line and the paragraph indent is bigger than the word.

There are many ways to reflow the text. The first way to do so is to use the `\linebreak` command (section 5.1).

The example below contains a very loose line caused by a URL:

```
The website of the \ctex\ Society is
www.ctex.org.
```

The website of the CTEX Society is www.ctex.org.

We could reflow the text by specifying a "potential" breakpoint with the `\linebreak[0]` command:

```
The website of the \ctex\ Society is
www\linebreak[0].ctex.org.
```

The website of the CTEX Society is www .ctex.org.

Of all the great rivers of the world, none is as intriguing as the Pearl. short by world standards, it epitomizes the old expression that good things come in small packages. Though the Pearl measures less than 50 miles in total length from its modest source as a cool mountain spring to the screaming cascades and steaming estuary of its downstream reaches, over those miles, the river has in one place or another everything you could possibly ask for. You can roam among lush temperate rain forests, turgid white water canyons, contemplative meanders among aisles of staid aspens (with trout leaping to slurp all the afternoon insects from its calm surface), and forbidding swamp land as formidable as any that Humphrey Bogart muddled through in *The African Queen*.

Figure 5.1: This is an example of "river" from *The Complete Manual of Typography*. It is more dramatic when blurred. "There's no avoiding them, only fixing them."

Notice that if a linebreak at the point specified will cause dramatic ugliness, `\linebreak[0]` will be ignored. The optional argument `0` works pretty well in this case, but it takes practice to get to know the exact value that you should use.

```
The website of the Chinese \TeX\ Society
is www\linebreak[0].ctex.org.
```

The website of the Chinese TEX Society is www.ctex.org.

Now let's take a look at another example: a very short word ends a paragraph and is set on an individual line:

```
\parindent=25pt
The most amazing feature of \TeX\ is that it
typesets your document awfully fast and
always tries to find the best breakpoints
ever.

However, sometimes, it does make mistakes.
```

The most amazing feature of TEX is that it typesets your document awfully fast and always tries to find the best breakpoints ever.

However, sometimes, it does make mistakes.

This is specially bad if the paragraph indent is huge (as is shown in the previous example), which causes much visual discomfort. There's a simple command to deal with this problem: `\looseness`. If the optimum breakpoints that TEX obtained according to the normal procedure end up with n lines, and if `\looseness=1`, then TEX will try to reflow the text so as the make the final number of lines as close a possible to $n + l$ without exceeding the current tolerance. Notes: 1) l could be a negative integer so that

TEX will try to reduce the number of lines; 2) TEX only "tries" to make the number of lines as close to $n + l$ as possible—by no means does it mean it will actually succeed. Naturally, we could "try" to eliminate widows and orphans in the same way.

```
\parindent=25pt \looseness=-1
The most amazing feature of \TeX\ is that it
typesets your document awfully fast and
always tries to find the best breakpoints
ever.

However, sometimes, it does make mistakes.
```

The most amazing feature of TEX is that it typesets your document awfully fast and always tries to find the best breakpoints ever.

However, sometimes, it does make mistakes.

A third way is to change the value of `\tolerance`, which specifies how bad a paragraph could be. (Section 5.5 gives more detail on this question.)

```
Book printing differs significantly from
ordinary typing with respect to dashes,
hyphens, and minus signs. In good math
books, these symbols are all different;
in fact there usually are at least four
different symbols.
```

Book printing differs significantly from ordinary typing with respect to dashes, hyphens, and minus signs. In good math books, these symbols are all different; in fact there usually are at least four different symbols.

This paragraph is actually just fine, but maybe you think the word spaces are a big too close and want to enlarge them to your favor. Of course, you could execute `\looseness=1` to make the paragraph one line longer. But for experiment purposes, let's do something more dramatic—by reducing the value of `\tolerance`.

```
\tolerance=60
Book printing differs significantly from
ordinary typing with respect to dashes,
hyphens, and minus signs. In good math
books, these symbols are all different;
in fact there usually are at least four
different symbols.
```

Book printing differs significantly from ordinary typing with respect to dashes, hyphens, and minus signs. In good math books, these symbols are all different; in fact there usually are at least four different symbols.

5.5 Hyphenation and Justification technology

Now let's take a look at the detail of the H&J technology underlying TEX. We'll get started with hyphenation. Hyphenation is quite a difficult problem for a computer. Knuth, in his *The TEXbook*, gives some excellent examples to demonstrate this point:

> [T]he word 'record' is supposed to be broken as 'rec-ord' when it is a noun, but 're-cord' when it is a verb. The word 'hyphenation' itself is somewhat exceptional; if 'hy-phen-a-tion' is compared to similar words like 'con-cat-e-na-tion', it's not immediately clear why the 'n' should be attached to the 'e' in one case but not the other. Examples like 'dem-on-stra-tion' vs. 'de-mon-stra-tive' show that the alteration of two letters can actually affect hyphens that are nine positions away.

The current solution that is adopted by TEX is developed by Frank M. Liang. There are a few advantages to these algorithm: 1) It could find about 90% of permissible

hyphen points in a large dictionary, which is good enough. 2) When different sources have different ways to hyphenate a word, TEX generally follows Webster's, which is the golden standard in the publishing industry. But still, the truth is that TEX does make mistakes and cannot hyphenate every word. If the word "galaxy" needs to be hyphenated and TEX fails to do so, you could interfere by adding discretionary breaks (i.e., soft hyphens) manually. There are a few ways to do so. If the word galaxy appears only once in the document, you could add these breaks with `\-`, e.g., `gal\-axy`. Another useful command works as follows:

```
\discretionary{pre-break}{post-break}{no-break}
```

So you should enter `ga\discretionary{l-}{a}{la}xy`. If the word appears a lot in your document, write `\hyphenation{gal-axy}` at the beginning of your document, and TEX will work hard on this word every time.

Now let's turn to justification. To understand the H&J technology in TEX, we first go through a couple of basic concepts.

- *Glue*: LATEX treats every character as a box and glue is used to link the boxes together. It's not hard to understand what a glue is. A word space, for instance, is a glue—it separates two word and shows up on the screen and printout as a white space, and one fascinating feature of a word space is its ability to stretch and shrink. But word spaces are not the only kind of glue in TEX, the space before a heading, for example, is also a glue (at least by default).

  Suppose the widths of Boxes A and B are 5 points and 6 points respectively, and the glue between them has a natural width of 3 points, a stretchability of 3 points, and a shrinkability of 2 points. If Boxes A and B need to be fit on a line of 14 points, that's great, the natural width of the glue will be adopted. If the line is 16 points, then the glue will stretch by 2 points so that $5 + 6 + 3 + 2 = 16$ points.

- *Badness*: Although word spaces are glue and can shrink and stretch, we do not want them to shrink or stretch too much. And we first devise a way to measure the typographic quality of the glue. The badness is defined as an integer that is approximately 100 times the cube of the ratio by which the glue inside the line must stretch or shrink to make the line of the required measure. If the badness calculated exceeds 10 000, then the value 10 000 is used. For instance, if the line has a total shrinkability of 10 points, but the glue actually shrinks by 9 points, the badness is then $100 \times (9/10)^3 = 72.9 \approx 73$ (since we take the integer).

  A line whose badness is 13 or more is considered "bad." If its glue shrinks, it is considered *tight*; if its glue stretches, it is *loose*. If the badness is 100 or more and the line stretches, is is *very loose*. If the badness is 12 or less, then the line is regarded as *decent*. Two adjacent lines are said to be *visually incompatible* if their classifications are not adjacent.

- *Penalty*: A penalty represents the undesirability ("'aesthetic cost'") of breaking at a certain place. For example, if the line has to break at a discretionary hyphen (i.e., a soft hyphen), a value of 50 (as will be explained soon) will be used. In other words, hyphenation is not that desirable in TEX's eye[s?].

Now let's take a look at how TEX formats a paragraph.

TEX starts by breaking a paragraph into lines without hyphenating any word. This process succeeds if none of the resulting lines has a badness exceeding the value of `\pretolerance` (100 by default). If that fails, TEX hyphenates every word and makes

a second attempt by using `\tolerance` (200 by default). Here's a trick, if you make `\pretolerance=10000`, the first pass will almost always pass, therefore hyphenations will not be tried. But this generally results in very bad typographic quality and should be used with great care.

So TEX will now calculate the so-called demerits for every line, by using the formula below:

$$d = \begin{cases} (l+b)^2 + p^2, & \text{if } 0 \le p \le 10\,000; \\ (l+b)^2 - p^2, & \text{if } -10\,000 < p < 0; \\ (l+b)^2, & \text{if } p \le -10\,000; \end{cases}$$

where l is the current value of `\linepenalty` (10 by default), b is the badness of the line, and p is the penalty associated with the breakpoint.

What TEX does is simply to minimize the total demerits of an entire paragraph. In addition, there's a bit of more detail. If two consecutive lines are visually incompatible, the current value of `\adjdemerits` is added to d (10 000 by default); if two consecutive lines end with a soft hyphen, the `\doublehyphendemerits` are added (10 000 by default); and if the second-last line of the entire paragraph is hyphenated, the `\finalhyphendemerits` are added (5000 by default).

6 Elements of Your Document

6.1 Cross References

You, probably like me, like such statements as "Please refer to section bla." But here comes the "problem"—all the section numbers are automatically generated by LaTeX so you don't know what it is until you actually see the "final" result. (Well, how's it final without the "bla"?) LaTeX provides a powerful cross-referencing mechanism to solve this problem.

Put the command `\label{bla}` after the sectioning command, where `bla` can be any text, ranging from the name of the section to the name of a cat. Then `Please refer to \ref{bla}` gives you the correct output (the `bla` here should match the `bla` in the `\label` definition).

You can use this mechanism with almost any number that is automatically generated by LaTeX. One thing to notice, do *not* give the same argument to two or more `\label` commands—you'll get LaTeX confused.

6.2 Listing items

Admit it—you love making lists! Everywhere you go, you make lists: a mental lists of the things you're going to do between breakfast and lunch, a list of the pros and cons of reading this book instead of playing basketball, and so on. Luckily, it's no hard thing to create a list in LaTeX, with the `enumerate`, `itemize`, and `description` environments. Here's a demo:

```
\begin{enumerate}
\item Every item starts with \verb"\item":
      \label{list}
   \begin{itemize}
   \item You can nest listings;
   \item[-] You can easily change the symbol.
   \end{itemize}
\item Oh, you do achieve more:
   \begin{description}
   \item[Colin] The author of the book;
   \item[Lee]   Colin's super friend.
   \end{description}
\end{enumerate}

Refer to Item~\ref{list} in the list.
```

1. Every item starts with `\item`:
   - You can nest listings;
   - You can easily change the symbol.
2. Oh, you do achieve more:

   Colin The author of the book;

   Lee Colin's super friend.

Refer to Item 1 in the list.

Note how you can easily nest these environments, and oh, a special bonus is that you can also use cross referencing commands as is shown above.

Table 6.1: Commands controlling a list environment

Items	Levels in the List			
	First Level	Second Level	Third Level	Fourth Level
	Commands for controlling the enumerate environment			
Counter	`enumi`	`enumii`	`enumiii`	`enumiv`
Representation	`\theenumi`	`\theenumii`	`\theenumiii`	`\theenumiv`
Default Definition	`\arabic{enumi}`	`\alph{enumii}`	`\roman{enumiii}`	`\Alph{enumiv}`
Label Field	`\lebelenumi`	`\labelenumii`	`\labelenumiii`	`\labelenumiv`
Default Form	`\theenumi.`	`(\theenumii)`	`\theenumiii.`	`\theenumiv.`
Numbering Example	1., 2.	(a), (b)	i., ii.,	A., B.
	Commands for controlling the reference representation of enumerate			
Prefix	`\p@enumi`	`\p@enumii`	`\p@enumiii`	`\p@enumiv`
Default Definition	`{}`	`\theenumi`	`\theenumi(\theenumii)`	`\p@enumiii\theenumiii`
Reference Example	1, 2	1a, 2b	1(a)i, 2(b)ii	1(a)iA, 2(b)iiB
	Commands for controlling the itemize environment			
Command	`\labelitemi`	`\labelitemii`	`\labelitemiii`	`\labelitemiv`
Default Definition	`\textbullet`	`\normalfont\bfseries\textendash`	`\textasteriskcentered`	`\textperiodcentered`
Representation	•	–	*	.

This table is abstracted from *The LaTeX Companion*.

The `enumerate` and `itemize` environment supports up to four levels of nesting. Table 6.1 shows the default numbering the referencing scheme of the four levels, and what commands are used to control them.

You can control the appearance of your list environment with the information provided in the table. For example,

```
\renewcommand\labelenumi{\S\theenumi.}
\begin{enumerate}
\item Hello!
\item I'm a Mac!
\end{enumerate}
```

§1. Hello!

§2. I'm a Mac!

One of the most popular list style is the circled numbering style (①, ②, ...) The definition of the `\theenumi` command is tricky and you probably don't want to get into the detail. But the gist is the use of `\protect` to help such commands as `\setcounter` to survive the label-generating process. You need to first load the calc and pifont packages, then the following code will do the job:

```
\newcounter{local}
\renewcommand\theenumi
{\protect\setcounter{local}%
{171+\the\value{enumi}}
\protect\ding{\value{local}}}
\renewcommand\labelenumi{\theenumi}
\begin{enumerate}
\item Hello!
\item I'm a MacBook Pro!
\end{enumerate}
```

① Hello!

② I'm a MacBook Pro!

6.3 Columns—story in the world of wide documents

Column is a powerful weapon prepared for wide documents, e.g., newspapers. *The Elements of Typographic Style* states,

> Anything from 45 to 75 characters is widely regarded as a satisfactory length of line for a single-column page set in a serifed text face in a text size. The 66-character line (counting both letters and spaces) is widely regarded as ideal. For multiple-column work, a better average is 40 to 50 characters.

This should guide you to determine what measure to use and whether or not to divide your documents into columns.

You could simply use the `twocolumn` option of the standard document class. But a better solution is to use the multicol package, especially if you want more than two columns.

```
\begin{multicols}{3}\raggedright
Anything from 45 to 75 characters is widely
regarded as a satisfactory length of line
for a single-column page set in a serifed
text face in a text size.
\end{multicols}
```

Anything from 45 to 75 characters is widely regarded as a satisfactory length of line for a single-column page set in a serifed text face in a text size.

The two major parameters that you might want to set are `\columnseprule`, which controls the width of the rule (default to 0.0 pt), and `\columnsep`, controlling the distance between columns (default to 10.0 pt). Here's an example,

```
\setlength\columnseprule{0.5pt}
\setlength\columnsep{5pt}
\begin{multicols}{2}
Anything from 45 to 75 characters is widely
regarded as a satisfactory length of line
for a single-column page set in a serifed
text face in a text size.
\end{multicols}
```

Anything from 45 to 75 characters is widely regarded as a satisfactory length of line for a single-column page set in a serifed text face in a text size.

By default, the multicol package produces balanced columns. If you wish to place more text in the left columns, you can increase the value of the counter `unbalance`, which determines the number of additional lines in the columns in comparison to the number that the balancing routine has calculated.

```
\begin{multicols}{2}
\setcounter{unbalance}{1}
Anything from 45 to 75 characters is widely
regarded as a satisfactory length of line
for a single-column page set in a serifed
text face in a text size.
\end{multicols}
```

Anything from 45 to 75 characters is widely regarded as a satisfactory length of line for a single-column page set in a serifed text face in a text size.

```
{multicols}{2}
unter{unbalance}{2}
ng from 45 to 75 characters is widely
ed as a satisfactory length of line
single-column page set in a serifed
ace in a text size.
ulticols}
```

Anything from 45 to 75 characters is widely regarded as a satisfactory length of line for a single-column page set in a serifed text face in a text size.

6.4 Notes, notes, and notes

6.4.1 When footnotes rule ...

Before we get start with this topic, I'd like to have the honor to quote Jill Knuth, Donald's daughter, "Don't use footnotes in your books, Don." It's true that sometimes footnotes can be distractive, but this section assumes that they are a good thing.

To generate a footnote, simply use the command `\footnote{...}`. For example, `\footnote{Footnotes came ...}` produces the footnote at the bottom of the page.[1]

There are many things you can do to change the default appearance of footnotes:

- The `\thefootnote` command controls the numbering style of footnotes. For example, if you want to use symbols instead of numbers, simply type `\renewcommand\thefootnote{\fnsymbol{footnote}}`.
- The `\footnoterule` changes the appearance of the rule. For example, if you want to use dashed lines, use
  ```
  \renewcommand\footnoterule
     {\vspace*{-2pt}\dotfill\hfill\hfill\hfill\vspace{2pt}}.
  ```
- The distance between footnotes are affected with the length of `\footnotesep`.
- The distance between the main text and the start of the footnotes is defined by `\skip\footins`.

On most occasions, it is not a good idea to reset footnote numbers on every new page, especially you're cross referencing them. Even if you're not, the reader might be. It's always nice to bear the reader in mine when writing and designing....

- The article class numbers all footnotes throughout the entire document, while the book and report classes resets the footnotes every time a new chapter is started. If you want footnote numbers to be reset on every new page, try `\usepackage[perpage]{footnote}`.
- If you want all footnotes to show up only in the right column in a two-column document, you could use the ftnright package.

Two lower level command for controlling the footnote mark that I think worth mentioning are `\@makefnmark` and `\@makefntext`. The default definitions are:

```
\renewcommand\@makefnmark
      {\mbox{\textsuperscript{\normalfont\@thefnmark}}}
\renewcommand\@makefntext[1]
      {\noindent\makebox[1.8em][r]{\@makefnmark}#1}
```

The book you're reading uses a customized style, which is actually pretty popular in the publishing industry. It is defined with the following modification to the original definition:

```
\makeatletter
\renewcommand\@makefntext[1]{\noindent\@thefnmark\kern1em#1}
\makeatother
```

6.4.2 Notes at the end of a chapter

Endnotes are getting more and more popular nowadays, because they don't affect the page layout as dramatically as footnotes. What you need is the `endnotes` package. Now substitute `\endnote{...}` for `\footnote{...}`, and `\theendnotes` will now print out the endnotes at the designated place. Note that you can use multiple `\theendnotes` in a single document; e.g., you can use one at the end of every chapter.

```
\renewcommand\notesname{End NOTES}
\renewcommand\theendnote{\Roman{endnote}}
\renewcommand\makeenmark
  {\textsuperscript{(\theenmark)\enspace}}
In a world of endnotes,%
\endnote{Endnotes are popular.}
we can't resist the temptation.%
\endnote{Unless you have to.}
\theendnotes
```

In a world of endnotes,(I) we can't resist the temptation.(II)

End NOTES

(I) Endnotes are popular.

(II) Unless you have to.

6.4.3 Notes dancing in the margin

This book makes extensive use of marginal notes to accommodate tons of interesting, additional information that doesn't quite fit into the main text. These marginal notes can be generated with the `\marginpar{...}` command. For example, `\marginpar{Colin rules!}` Colin rules! generates what you see in the right margin.

By default, text goes to the right margin for one-sided documents, to the outside margin for the two-sided, and to the nearest margin for two-column formatting. The placement can be reversed with `\reversemarginpar`.

Sometimes, you may want a marginal note to vary depending upon which margin it's in. For example, to make an arrow pointing to the text, you need a left-pointing arrow in the right margin and a right-pointing one in the left margin. Here's how:

```
\margipar[$\Rightarrow$]{$\Leftarrow$}
```

6.5 Programming codes

When you reach this section, you must have been using LaTeX for at least 39 minutes (assuming you spend one minute reading each page), you should very much appreciate the capability and beauty of LaTeX, and you might be considering writing something to your friends about LaTeX with LaTeX. Here comes the problem, how can you tell them the way to produce the LaTeX logo? In LaTeX, you use commands related to verbatim to obtain such output:

```
\verb"Hello, \TeX!"
  and \verb*"Hello, \TeX!"
```

`Hello, \TeX!` and `Hello,␣\TeX!`

As you might have guessed, the star (`*`) version makes the spaces (more) visible. You could also use the `verbatim` environment to create typed texts that are more than one line long.

1 Footnotes should came after, not before, any punctuation.

An interesting package that you might want to try out is alltt, which implements the `alltt` environment—it is like `verbatim` except that backslashes (\) and braces ({ and }) retain their usual meanings.

```
\begin{alltt}
\TeX\ \emph{is cool}.

\begin{math}a+b\end{math}
\end{alltt}
```

TEX *is cool.*

$a+b$

A more comprehensive solution for typesetting program codes is provided by the listings package. Here's a simple example to show you what it can do:

```
\lstset{numberstyle=\tiny,
numbers=left}
\begin{lstlisting}[language=Pascal]
for i:=1 to maxint do
begin
  WrItE('This is stupid');
end.
\end{lstlisting}
```

```
1 for i:=1 to maxint do
2 begin
3   WrItE('This is stupid');
4 end.
```

The detail of the package is beyond the scope of the book. But you can find its documentation at http://www.ctan.org/tex-archive/macros/latex/contrib/listings/listings-1.3.pdf. Have fun with it!

6.6 Making boxes

```
\mbox{text}                    \fbox{text}
\makebox[width][pos]{text}     \framebox[width][pos]{text}
\raisebox{lift}[height][depth]{contents}
```

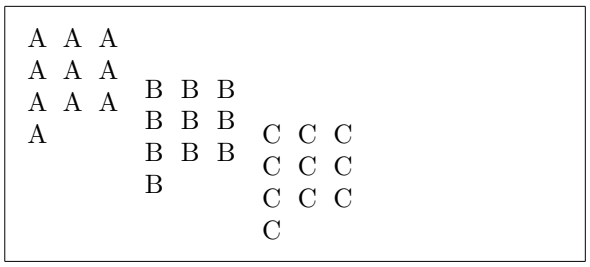
```
\setlength\fboxrule{2pt}
\setlength\fboxsep{2mm}
\framebox[5cm][r]{Some words}.
Test \raisebox{2pt}{Hello!}
```

Some words. Test Hello!

```
\parbox[pos]{width}{text}

\begin{minipage}[pos]{width}
...
\end{minipage}
```

```
{minipage}[b]{12mm}
A A A A A A A
inipage}\quad
{minipage}[c]{12mm}
B B B B B B B
inipage}\quad
{minipage}[t]{12mm}
C C C C C C C
inipage}
```




```
\rule[lift]{width}{height}
```

```
Hello. \rule[4pt]{2cm}{1mm}
```

Hello.

6.7 Index

```
page vi: \index{animal}
page 5:  \index{animal}
page 6:  \index{animal}
page 7:  \index{animal}
page 11: \index{animalism|see{animal}}
page 17: \index{animal@\emph{animal}}
         \index{mammal|textbf}
page 26: \index{animal!mammal!cat}
page 32: \index{animal!insect}
```

animal, vi, 5–7
  insect, 32
  mammal
    cat, 26
animal, 17
animalism, *see* animal

mammal, **17**

6.8 Bibliography

7

LaTeX with Designers

This chapter focuses on how to design with LaTeX. It deals with page layout, and the design of headers and headings. Although LaTeX has its built-in mechanism for working on these things, I will approach them with external packages for simplicity as well as power. The design of this book is also briefed in this chapter as well. When reading this chapter, bear in mind that the author of the book is not a professional full-time typographer and that typography composes probably only about 1/5 of his current life.

7.1 Balancing the elements that live on a page

As is stated in the introduction to this chapter, we'll not use LaTeX' own built-in mechanism for designing a page but the geometry package instead, because it provides a much better and easier-to-use interface.

Shaping a page is a definite art that I haven't quote mastered. Robert Bringhurst's *The Elements of Typographic Style* provides much insight into the topic, ranging from the history of different sizes of paper to the musical notation of them. My job is to tell you how to create what you want to create. Your first task should be to decide the size of the paper. Of course, you could simply provide an optional argument to the `\documentclass` command, but using the geometry package works better most of the time. The predefined paper size include `a0paper` to `a6paper`, `b0paper` to `b6paper`, `letterpaper`, `exectivepaper`, and `legalpaper`. To specify the paper size that you wanna use, simply say:

Here is a quote from Robert Bringhurst that I really want to share, "A book is a flexible mirror of the mind and the body. Its overall size and proportions, the color and texture of the paper, the sound it makes as the pages turn, and the smell of the paper, adhesive and ink, all blend with with the size and form and placement of the type to reveal a little about the world in which it was made."

```
\usepackage[letterpaper]{geometry}
```

Sometimes, you may want to use a paper size that is not predefined. Here's how:

```
\usepackage[paperwidth=<dimen>, paperheight=<dimen>]{geometry}
```

or

```
\usepackage[papersize={width,height}]{geometry}
```

Going on, I'd like to introduce an easy way to place the text block. For instance, in most institutions, professors require that papers be written on the lettersize paper ($8.5\,\text{in} \times 11\,\text{in}$) and that all margins be 1 inch wide. With this information, we can calculate that the measure (width of the text body) and the text height should be $8.5 - 2 = 6.5\,\text{in}$ and $11 - 2 = 9\,\text{in}$, respectively. Simply enter the following:

```
\usepackage[letterpaper,body={6.5in,9in}]{geometry}
```

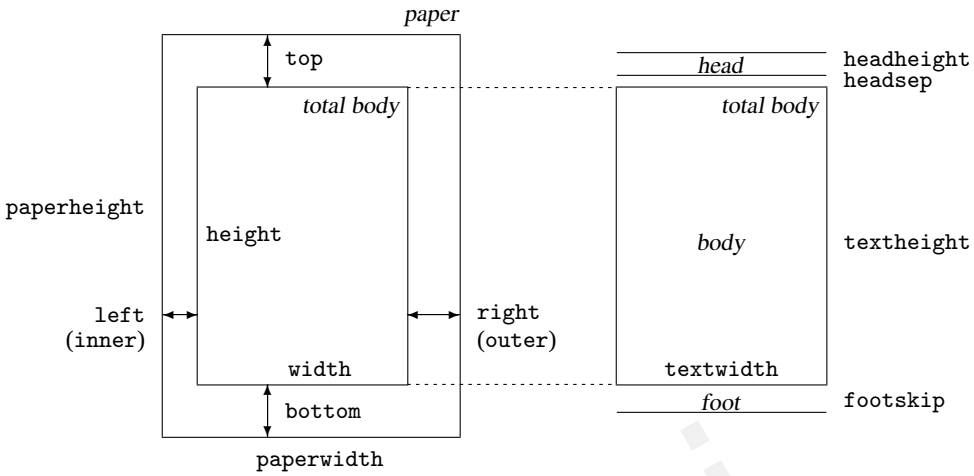


Figure 7.1: Dimension names used in the geometry package.

LaTeX will automatically get everything else properly set up.

However, if you want more control over the layout, refer to figure 7.1. Most of the parameters you might want to change is shown. A few missing ones are listed here:

footnotesep changes the dimension `\skip\footins`, separation between the bottom of text body and the top of footnote text.

marginparwidth changes the width of the marginal ntoes.

marginparsep changes the distance between body and margin notes.

You might have to play with these parameters many times and prepare a few different sample pages before you find the satisfactory layout. But there's a pretty useful package, layouts, which can help you visualize your layout parameter settings. For example, figure 7.2, which is a thumbnail of the layout of this book is generates with the following code:

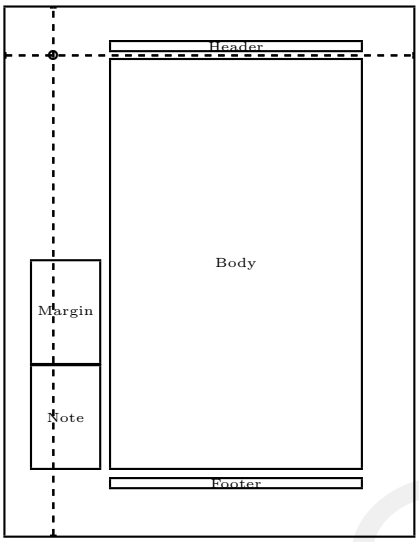
```
\newcommand\showpage{%
 \setlayoutscale{0.25}
 \setlabelfont{\tiny}
 %\printheadingsfalse
 %\printparametersfalse
 \currentpage\pagedesign}
\showpage
```

7.2 Dressing the headings

We will again skip LaTeX's built-in mechanism and go straight to the study of the titlesec package. There are two control sequences to be introduced. The first one affects the general layout of a heading:

```
\titleformat{cmd}[shape]{format}
                {label}{sep}{before-code}[after-code]
```

The circle is at 1 inch from the top and left of the page. Dashed lines represent (`\hoffset + 1 inch`) and (`\voffset + 1 inch`) from the top and left of the page.



Lengths are to the nearest pt.

page height = 795pt	page width = 614pt
\hoffset = 0pt	\voffset = 0pt
\evensidemargin = 87pt	\topmargin = -20pt
\headheight = 12pt	\headsep = 15pt
\textheight = 614pt	\textwidth = 376pt
\footskip = 29pt	\marginparsep = 18pt
\marginparpush = 5pt	\columnsep = 10pt
\columnseprule = 0.0pt	

Figure 7.2: The layout of the book you're currently reading.

Yeah, there are many arguments, and it will take a while before you get full grasp of its capability. (Believe me, it's very powerful!) Anyway, all the arguments are explained in table 7.1.

For example,

```
\titleformat{\section}[runin]{\normalfont\scshape}
           {\S\,\oldstylenums{\thesection}.}{0.5em}{}.\quad]
```

generates a title like this:

§1. The Title. The heading is separated from the section text by a dot and a space of one quad.

(This format is used a lot in legal documents.)

The second command deals with spacing issues related to headings:

```
\titlespacing*{cmd}{left-sep}{before-sep}{after-sep}[right-sep]
```

You don't have to use the starred version. The star would suppress the paragraph indentation for the paragraph following the heading. This command is much easier than `\titleformat`, and a paragraph of explanation will be more than enough:

Table 7.1: The arguments of the `titleformat` command

Argument	Explanation
cmd	*cmd* is the command name of the heading. If you are modifying the section heading, then you should enter `\titleformat{\section}...`
shape	The *shape* argument, which is optional, defines the general layout of the heading. There are nine predefined shapes: **hang**, the default, produces a hanging label (like `\section` in standard classes); **display** puts label and heading text on separate lines (think about the standard `\chapter`); **runin** generates a run-in heading; i.e., there won't be a line break after the heading (like `\paragraph`); **frame** is like **display** but the heading will be framed; **leftmargin** simply puts the heading into the left margin; **rightmargin** places the heading in the right margin (duh); **block** is the general-purpose shape, which simply typesets the heading as a single text block; **drop** wraps the first paragraph around the heading, using a fixed width for the heading; **wrap** is like **drop**, but uses the width of the widest heading line.
format	This argument applies formatting command to the whole title, both the label and the heading text; e.g., if you say `{\normalfont\scshape}`, then the heading will be typeset in the small cap typeface in the main text size.
label	This command only specifies the format of the label. For example, `{SECTION \thesection.}` will produce something like "SECTION n," where n is the current section number.
sep	This parameter determines the distance between the label and title text.
before-code	The code entered here will be executed immediately preceding the heading text. Its last command can take one argument, which will pick up the heading text. For example, you can say `\large\bfseries\filcenter` to make the heading printed out in a bold typeface and centered. Of course, there are `\filleft` and `\filright` to do similar tasks.
after-code	Similar to *before-code*, this is executed after formatting the heading text.

The *left-sep* argument specifies the increase of the left margin for headings with the **block**, **display**, **hang**, or **frame** shape. With **leftmargin**, **rightmargin**, or **drop** it specifies the width of the heading title, with **wrap** it specifies the maximum width for the title, and with **runin** it specifies the indentation before the title. *before-sep* specifies the vertical space added above the heading. *after-sep* is the distance between the title and the following paragraph. It could be vertical or horizontal depending on the shape. And finally, *right-sep* is the optional length specifying an increase of the right margin.

7.3 The flight of the navigator—headers

If headings have given you much headache, I suggest that you take a nap before reading on. Headers could be comparatively easier to deal with by using fancyhdr.

To illustrate its usage, I'll use two examples. Here comes example number 1, which demonstrates what you could do with a single-sided document. To create what is shown

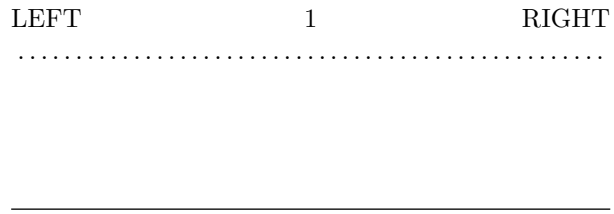


Figure 7.3: Headers in a single-sided document.

in figure 7.3, the following code is used:

```
\usepackage{fancyhdr}
\pagestyle{fancy}
\lhead{LEFT} \chead{\thepage} \rhead{RIGHT}
\lfoot{Foot\\ on the left}
\cfoot{}
\rfoot{Foot on the right}
\renewcommand\headrule{\dotfill}
\renewcommand\footrulewidth{0.5pt}
```

This is be pretty straightforward. You have to tell LaTeX the kind of page style you want to use is `fancy` provided by the `fancyhdr` package. You define the headers and footers with `\`*n*`head` and `\`*n*`foot`, where *n* could be `l` (left), `c` (centered), and `r` (right). You could customize the lines by modifying `\headrule`, `\footrulewidth`, etc.

Let's now go straight to the second example, shown in figure 7.4.

The code used to generate the example is here:

```
\usepackage{fancyhdr}
\pagestyle{fancy}
\fancyhead[RO,LE]{TITLE}
\fancyhead[LO]{\it\rightmark}
\fancyhead[RE]{\leftmark}
\fancyhead[C]{\thepage}
\fancyfoot[C]{}
\renewcommand\headrule{\hrule height2pt width\headwidth
\vspace{1pt}
\hrule height1pt width\headwidth \vspace{-4pt}}
```

Again, you have to specify that you'll be using the `fancy` page style. All the headers are defined with `\fancyhead` and `\fancyfoot`. (Actually you could first execute `\fancyhf{}` to reset everything). You use a combination of `L` (left), `R` (right), `C` (centered), `O` (odd-numbered pages), and `E` (even-numbered pages) to specify which parameter you want to modify. The two commands `\leftmark` and `\rightmark` will be explained in detail in section 7.4.

For example, to produce a running heading that spans marginal notes, load the `calc` package, then write

```
\fancyheadoffset[RO,LE]{\marginparsep+\marginparwidth}
```

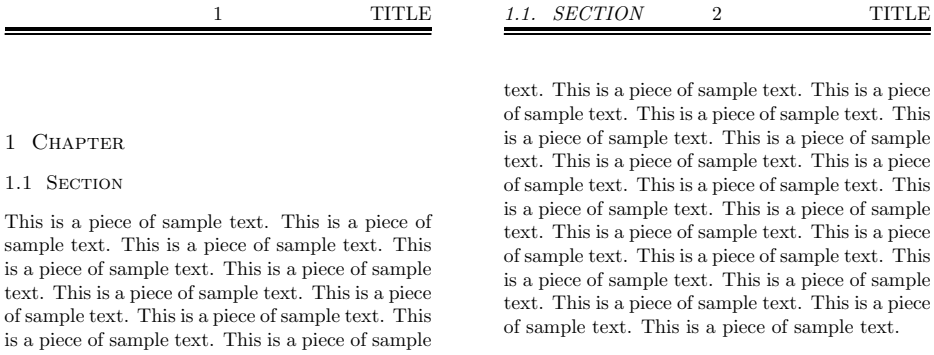


Figure 7.4: Headers in a double-sided document.

7.4 A not so short short introduction to markers

Introducing two commands to generate marks:

```
\markboth{main_mark}{sub_mark}
\markright{sub_mark}
```

The first command generates a pair of markers, while changes only the *sub-mark* one, inheriting the *main-mark* text from a previous `\markboth`. For instance, you can set chapter headings as the *main-marks* and section headings as *sub-marks*.

When LaTeX starts outputting pages, two other markers get involved in the picture; namely, `\leftmark` contains the *main-mark*, and the `\rightmark` command contains the current *sub-mark*.

These markers can be automatically generated from the corresponding heading commands. This scheme works as follows: all standard heading commands internally invoke a command `\`*name*`mark`, where *name* is the name of the heading command (e.g., `\chaptermark`, `\sectionmark`). For instance, in the `book` class these commands are defined (approximately) as follows:

```
\renewcommand\chaptermark[1]
             {\markboth{\chaptername\ \thechapter.#1}{}}
\renewcommand\sectionmark[1]{\markright{\thesection. #1}}
```

You'll see some examples or markers at work in section 7.5

7.5 The design of this book

Knowledge is best learned in practical life. In this section, I'll discuss how the book you're reading is designed, with the commands introduced in this and the preceding chapters.

First of all, I decided that this book would be distributed over the Internet; therefore, the only choices I have are the letter-size paper and the A4 paper. Since I'm able to print files free of charge in the computer labs at Duke, where my education and letter size paper are available, 8.5×11 inch because my apparent choice. Now let's get down to the design process.

7.5.1 Shaping the page

Letter size paper is intrinsically wide, and I personally love making notes in the margin and the bottom of the page, so I decided to give generous space to these areas. I chose top space = inner margin space = 1.1 inches; I decided that the outer margin will be twice as big as the inner margin space, which is 2.2 inches; and I made the bottom space to be 1.4 inches. Now the text block has the dimension 5.2 inches × 8.5 inches. I then decided that the running headers will be 15 points away from the text at the top. Although the generous margin at the bottom is deliberate, I found it too blank to be pleasing to the eye. So I decided to put some decoration symbols at the foot, which are 0.4 inches away from the text. (I could have put the page numbers here, but I decided to put them at the topic, sticking out in the margin to illustrate some other commands.) I made the marginal notes to be 1.4 inches wide and 0.25 inches away from the right margin of the text. Now everything is well planned. To get these specifications into LaTeX, I put

The dimension of the text block is chosen with the golden mean in mind; $8.5/5.2 \approx 1.63$, which is fairly close to the golden mean, 1.618.

```
\usepackage[letterpaper,inner=1.1in,outer=2.2in,bottom=1.4in,
        top=1.1in,headsep=15pt,headheight=12pt,marginparwidth=1.4in,
        marginparsep=0.25in,footskip=0.4in]{geometry}
```

into the style file.

7.5.2 Designing headings

I decided that there will be three levels of headings, A-heads being chapters, B-heads being sections, and C-heads being subsections.

I chose the bold sans serif typeface for chapter headings, used the Oxford style, and decided that all the nouns, verbs and other substantive be capitalized. Since I'm using very lively expressions (even sentences) in my section headings, I decided that only the first letters be capitalized. But I also chose small caps as the typeface for better visual effects. The same logic went with subsection headings. Here's how I implemented everything with the titlesec package:

```
\usepackage{titlesec}
\usepackage{color}
\definecolor{darkblue}{rgb}{0,0.08,0.45}
\titleformat{\chapter}[display]
        {\normalfont\huge\sffamily\bfseries\filcenter}
        {\vspace*{-2cm}
         \leavevmode\leaders\vrule height7pt width3pt depth0pt%
         \hfill\kern8pt\thechapter\kern8pt%
         \leaders\vrule height7pt width3pt depth0pt\hfill}{3pt}
        {\vspace*{-5pt}\hrule\vspace{6pt}}
        [\vspace{1pt}\hrule\vspace{1cm}]

\newcommand\Bheadfont{\fontsize{11pt}{\baselineskip}\selectfont}
\titleformat{\section}[hang]
        {\normalfont\sc\color{blue}\Bheadfont}
        {\thesection\hskip0.618em}{0em}{}
\titlespacing*{\section}
        {0pt}{15pt plus 2pt minus 2pt}{9pt plus 2pt minus 2pt}

\titleformat{\subsection}[hang]
```

```
        {\normalfont\sc\color{darkblue}}
        {\thesubsection\hskip0.618em}{0em}{}
\titlespacing*{\subsection}
        {0pt}{8pt plus 2pt minus 2pt}{8pt plus 2pt minus 2pt}

\titleformat{\subsubsection}[hang]{\normalfont\it}{}{0.618em}{}
\titlespacing*{\subsubsection}
        {0pt}{8pt plus 2pt minus 2pt}{4pt plus 2pt minus 2pt}
```

7.5.3 Designing running headers

I decided to make the page numbers stick out into the margin so that the wide margin looks less dramatic. I decided to use the chapter title (with no chapter numbers) on even-numbered pages and section headings (with section numbers) on odd-numbered pages. I also decided to put two small symbols at the bottom of the page to balance the generous margin. You'll see how I used the commands `\chaptermark` and `\sectionmark`.

```
\usepackage{fancyhdr}
\pagestyle{fancy}
\renewcommand{\chaptermark}[1]{\markboth{#1}{}}
\renewcommand{\sectionmark}[1]{\markright{\thesection\ #1}}
\fancyhf{}
\fancyhead[RO]
   {\itshape\rightmark\mbox{\rlap{\hskip0.6cm\normalfont\bfseries\thepage}}}
\fancyhead[LE]
   {\mbox{\llap{\bfseries\thepage\hskip0.6cm}}\normalfont\itshape\leftmark}
\fancyfoot[LE]{\ding{44}}
\fancyfoot[RO]{\ding{224}}
\renewcommand{\headrulewidth}{0pt}
\fancypagestyle{plain}{%
\fancyhead{}
\renewcommand{\headrulewidth}{0pt}
}
```

8

When TEX Dates Math

When TEX dates math, math feels happy. The story of mathematics in LATEX is long and interesting (at least for me), and no doubt that the length of the chapter is pretty amazing. It has much information about how to typeset your math properly.

You might be surprised to know that this chapter is actually an abstraction from my *The LATEX Mathematics Companion*. If you are interested in more typographic detail, you could read the full version at http://bbs.ctex.org/forums/index.php?showtopic=29603.

8.1 Extremely simple formulas

The simplest formulas are put between special math brackets, the dollar sign $ ("Because mathematics is supposedly expensive," said Knuth). Here are some examples:

```
$-a+2b=3c-4d(5e+6f)$\\
$(x+y)/(x-y)$\\
$\{a,b,c,d,e\}$
```

$-a+2b=3c-4d(5e+6f)$
$(x+y)/(x-y)$
$\{a,b,c,d,e\}$

Note how TEX automatically sets all variables in an italic typeface while all numerals are upright, which is a math tradition.

Also, if you look closely, you'll realize that there is some extra space surrounding the + and − sign, but none around the / sign. That's because TEX regards such expressions as "1 / 2" to be incorrect. Spacing in equations can be rather challenging, but TEX has a pretty good mechanism to cope with it automatically. So most of the time, you don't need to bother about that. As a matter of fact, TEX even prevents you from doing stupid things by ignoring any spaces that you put between $'s. For example,

```
$(x + y)/(x - z)$
```

$(x + y)/(x - z)$

However, if you really need a blank space in your formula, you can type '\␣'. For example, the output of '$2\␣a$' is '2 a', which doesn't make much sense (a little sense though).

OK, now that you know how to get '$a + b = c$', what about '$\alpha + \beta \neq \gamma$'? Well, you'll find that most symbols can be obtained simply by putting their names after '\'. For example, 'α' can be obtained by typing '`\alpha`', 'β' by '`\beta`', etc. Others might need to be memorized, but normally they are not that hard to remember. For example, '$\neq$' is obtained by typing '`\neq`', which is short for "**n**ot **eq**ual to." The symbol '$\in$' which means "is included **in**" can be obtained from '`\in`'.

An amazing document, "The Comprehensive LATEX Symbol List," can be download at http://www.ctan.org/tex-archive/info/symbols/comprehensive/symbols-letter.pdf. You can find virtually all the symbols you need to write anything—both good and horrifying mathematics.

So far, we've been talking about *inline* equations (also called *in-text* equations). What if you want to center an equation on an individual line (the so-called *displayed* equation)? There are a few LaTeX environments that can assist you:

```
\begin{equation}
\delta\times\varepsilon=\theta
\end{equation}
\begin{equation*}
\varphi-\rho\neq\kappa
\end{equation*}
```

$$\delta \times \varepsilon = \theta \tag{8.1}$$

$$\varphi - \rho \neq \kappa$$

The `equation` environment not only centers the equation and puts it on an individual line, it also numbers the equation automatically. The `equation*` environment is a variant of `equation`. It does pretty much the same thing except that it doesn't number the equation.

In addition to `equation*`, you may also try out the `displaymath` environment. You can even type a simple `\[...\]`. Some people might tell you to use `$$...$$`. Well, don't (unless you're using plain TeX, not LaTeX)! It probably gives the same result as you want *now*, but later it might cause you much headache as it is not compatible with some LaTeX commands.

8.2 Su$_{\text{b}}^{\text{per}}$scripts

Su$_{\text{b}}^{\text{per}}$scripts prevail in mathematics. In computers and calculators, we frequently use '`^`' to indicate a superscript, and '`_`' to indicate a subscript. The same method is adopted in LaTeX:

```
$z^2$, $b_n$,\\
$x^2y^2$, $x ^2y ^2$\\
$x_12$, $x^12$
```

z^2, b_n,
x^2y^2, x^2y^2
$x_1 2$, $x^1 2$

Notice that '`^`' and '`_`' apply only to the next *single* character. If you want more than one characters to get su$_{\text{b}}^{\text{per}}$scripted, you need to group them with braces:

```
$x^{2y}$, $y_{3z}$\\
$x^{x^2}$, $y_{y_2}$, $y_{x^2}$
```

x^{2y}, y_{3z}
x^{x^2}, y_{y_2}, y_{x^2}

Notice that it is illegal to type '`x^y^z`' and '`x_y_z`'. Even human beings cannot tell the exact meaning of these notations—obviously, `${x^y}^z$` (x^{y^z}) and `$x^{y^z}$` (x^{y^z}) are different. You have to tell TeX which one you want. As a matter of fact, the former is quite inappropriate, if not totally wrong. You should use $(x^y)^z$, which reduces ambiguity.

Sometimes, you might need to type something like '$_2F_3$', in which the subscript '2' follows nothing. You can just type '`$_2F_3$`'. However, the best way would be to insert an empty group: '`${}_2F_3$`'. (Do you know why?)

But how do we get superscripts and subscripts *simultaneously*, like su$_{\text{b}}^{\text{per}}$scripts? Well, you may enter the subscript and superscript in any order you want:

```
$x^{31415}_{92}+\pi$,
$x_{92}^{31415}+\pi$\\
$F_2^2$, $F{}_2^2$
```

$x_{92}^{31415}+\pi$, $x_{92}^{31415}+\pi$
F_2^2, F_2^2

One more problem about this topic: primes. To get a prime, simply enter ‘’’:

```
$y_1'+y''_2$
```

$y_1'+y''_2$

8.2.1 The tensor Package

We've already known that $R_i{}^j{}_{kl}$ can be obtained from `$R_i{}^j{}_{\!kl}$`. This is rather hard to enter! The tensor package provides an easier solution. Here's how:

```
$R\indices{_i^j_{\!kl}}$
```

$R_i{}^j{}_{kl}$

You can even do some very complex things with this package:

```
$\tensor[^a_b^c_d]{M}{^a_b^c_d}$
```

${}^{a}_{b}{}^{c}_{d}M{}^{a}_{b}{}^{c}_{d}$

The two commands mentioned above also have “starred” forms, which can collapse the spacing. This can be quite useful! For example,

```
$\tensor*[^{14}_6]{\text{C}}{}$
```

${}^{14}_{6}\text{C}$

8.2.2 The vector Package

Since we are talking about tensor, we might as well cover vectors here. The vector package provides some commands to ease the typesetting of vectors. Keep in mind that the designer of the package might not necessarily abide by the rules I proposed. Anyway, let me demonstrate some useful commands:

```
\begin{gather*}
\uvec{p}=\left(\irvec{q}\right)\\
\uuvec{q}=\left(\!\!\icvec{q}\!\!\right)\\
\buvec{r}=\{\rvec{r}{1}{6}\}\\
\bvec{s}=\left[
   \!\!\cvec{s}{0}{2}\!\!\right]
\end{gather*}
```

$$\underline{p} = (q_1, \ldots, q_n)$$
$$\hat{\underline{q}} = \begin{pmatrix} q_1 \\ \vdots \\ q_n \end{pmatrix}$$
$$\hat{\mathbf{r}} = \{r_1, r_2, r_3, r_4, r_5, r_6\}$$
$$\mathbf{s} = \begin{bmatrix} s_0 \\ s_1 \\ s_2 \end{bmatrix}$$

8.3 $\sqrt{\text{Roots}}$

Roots are produced by '`\sqrt[...]{...}`':

```
$\sqrt2$, $\sqrt2y$, $\sqrt{2y}$\\
$\sqrt[3]{2}$, $\sqrt[n+1]{x+y}$
```

$\sqrt{2}$, $\sqrt{2}y$, $\sqrt{2y}$
$\sqrt[3]{2}$, $\sqrt[n+1]{x+y}$

Some people might find the standard $\sqrt[\beta]{k}$ unacceptable. You can tune the position of the index with the amsmath package.

```
$\sqrt[\leftroot{2}\uproot{4}\beta]{k}$,
$\sqrt[\leftroot{1}\uproot{3}\beta]{k}$
```

$\sqrt[\beta]{k}$, $\sqrt[\beta]{k}$

Some obsessive ones might even find $\sqrt{x}+\sqrt{y}+\sqrt{z}$ unacceptable. (I'm *not* among them.) Two commands should be of help: (1) The command `\mathstrut` produces an invisible box whose width is zero and whose height and depth are the height and depth of a parenthesis '('. (2) The command `\smash{...}` typesets its contents but ignores both their height and depth. The amsmath package provides an optional argument, used as follows: `\smash[t]{...}` ignores the height of the box's contents, but retains the depth, while `\smash[b]{...}` ignores the depth and keeps the height. Compare:

```
$\sqrt{x}+\sqrt{y}+\sqrt{z}$\\
$\sqrt{x}+\sqrt{\mathstrut y}+\sqrt{z}$\\
$\sqrt{x}+\sqrt{\smash[b]{y}}+\sqrt{z}$
```

$\sqrt{x}+\sqrt{y}+\sqrt{z}$
$\sqrt{x}+\sqrt{\mathstrut y}+\sqrt{z}$
$\sqrt{x}+\sqrt{\smash[b]{y}}+\sqrt{z}$

8.4 (Fractions Binomials)

Let's now turn to something more challenging—fractions. A fraction is obtained by typing

```
\frac{numerator}{denominator}
```

What is challenging about this? Well, if you try typing a fraction in inline mode and in display mode, you'll find that the results are different:

```
$\frac{1}{2}$,
\begin{equation*}
\frac{1}{2}
\end{equation*}
```

$\frac{1}{2}$,

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

LaTeX does this for a good reason: an inline $\frac{a+b}{c+d}$ ruins the line spacing, as you can see here; a displayed

$$\frac{a+b}{c+d}$$

is equally unacceptable. However, you *can* change LaTeX's behavior by using a few commands provided by the amsmath package: (1) `\dfrac` always typesets a fraction as if it is being typeset in the display mode; (2) `\tfrac` always typesets a fraction as if it is being typeset in the inline mode. For example:

```
This is an inline formula: $\dfrac{1}{2}$.
But avoid it! Replace it with
$\frac{1}{2}$ or $1/2$.

Instead of \begin{equation*}
\dfrac{1}{2}(a+b),
\end{equation*}
you can try \begin{equation*}
\tfrac{1}{2}(a+b).
\end{equation*}
```

This is an inline formula: $\dfrac{1}{2}$. But avoid it! Replace it with $\frac{1}{2}$ or $1/2$.

Instead of

$$\dfrac{1}{2}(a+b),$$

you can try

$$\tfrac{1}{2}(a+b).$$

Although amsmath makes it fairly easy to achieve whatever you want in your manuscript, you should try not to abuse it. A general principle is that a math formula should not affect the line spacing if at all possible. So most inline fractions should actually be set in the slashed form (e.g., a/b) except for numerical fractions (e.g., $\frac{1}{4}$); therefore, the command `\dfrac` should *never* be used in an inline equation. Also, fractions in subformulas (like sub- and superscripts) should also be set in the slashed form.

The amsmath package also provides a command for typesetting continued fractions, `\cfrac`. It can also be following by an optional `[r]` or `[l]` to specify the position of the numerator:

```
\begin{equation*}
a_0+\cfrac{b_1}{
a_1+\cfrac[l]{b_2}{
a_2+\cfrac[r]{b_3}{
a_3+\cdots}}}
\end{equation*}
```

$$a_0+\cfrac{b_1}{a_1+\cfrac{b_2}{a_2+\cfrac{b_3}{a_3+\cdots}}}$$

You may also use the alternative form:

```
\[a_0+\frac{b_1}{a_1+}
      \frac{b_2}{a_2+}
      \frac{b_3}{a_3+}\cdots\]
```

$$a_0+\frac{b_1}{a_1+}\frac{b_2}{a_2+}\frac{b_3}{a_3+}\cdots$$

Binomial coefficients, like fractions, ought to be treated very carefully. The most basic command for producing a binomial coefficient is '`\binom{...}{...}`':

```
In inline mode: $\binom{k}{2}$.\\
In display mode:
\begin{equation*} \binom{k}{2}
\end{equation*}
```

In inline mode: $\binom{k}{2}$.
In display mode:

$$\binom{k}{2}$$

I recommend that you use this command *all the time*. But if you do want to do some crazy things, you can also use the commands `\dbinom` and `\tbinom` provided by the amsmath package (Think a million times before you do so!!!):

```
In inline mode: $\dbinom{k}{2}$,
  which is horrible.\\
In display mode:
\begin{equation*} \tbinom{k}{2}.
\end{equation*}
```

In inline mode: $\dbinom{k}{2}$, which is horrible.
In display mode:

$$\tbinom{k}{2}.$$

It might be helpful to introduce the concept of "styles." In math mode, there are four styles:

display For normal symbols in a displayed formula.

text For normal symbols in an in-text formula.

script For subscripts and superscripts.

scriptscript For further levels of sub- and superscripting, such as subscripts of superscripts.

Take a look at the following examples:

```
Compare the small superscript in $a^{x}$
with the large one in $a^{\textstyle x}$.

Instead of using \verb"\dfrac", you can
do it this way: $\displaystyle\frac{1}{2}$.

And instead of using \verb"\tfrac", you
can try this:\begin{equation*}
\textstyle\frac{1}{2}.
\end{equation*}
```

Compare the small superscript in a^{x} with the large one in $a^{\textstyle x}$.

Instead of using `\dfrac`, you can do it this way: $\displaystyle\frac{1}{2}$.

And instead of using `\tfrac`, you can try this:

$$\textstyle\frac{1}{2}.$$

TEXnicality

In case you want to use displayed fractions in inline mode (sigh), I'd also like to introduce two more commands that would be helpful.

First take a look at the following output:

This is a test. This is a test. This is a test. This is a test. This is a test. $\displaystyle\frac{1}{2}$ This is a test. This is a test. This is a test. This is a test. This is a test.

The numerator and denominator almost touch the text above and below. But after adding the following two lines:

```
\lineskiplimit=3pt
\lineskip=4pt
```

things are much better:

This is a test. This is a test. This is a test. This is a test. This is a test. $\displaystyle\frac{1}{2}$ This is a test. This is a test. This is a test. This is a test. This is a test.

8.5 Sum and integration

Sum and integration are different in inline and display modes:

```
Inline: $\sum_{n=1}^k$, $\prod_{n=1}^k$,
        $\int_a^b$\\
Display: \begin{equation*}
\sum_{n=1}^k,\qquad \prod_{n=1}^k,
        \qquad\int_a^b.
\end{equation*}
```

Inline: $\sum_{n=1}^k$, $\prod_{n=1}^k$, $\int_a^b$
Display:

$$\sum_{n=1}^{k}, \qquad \prod_{n=1}^{k}, \qquad \int_a^b.$$

This is actually pretty nice output. However, you might sometimes want to change the position of the "limits." Here's how:

```
\begin{equation*}
\iint_A,\qquad \iint\limits_A
\end{equation*}
```

$$\iint_A, \qquad \iint\limits_A$$

There are a few more commands for producing different integral signs:

```
\begin{equation*}
\iiint\limits_V,
\idotsint\limits_V, \oint_V
\end{equation*}
```

$$\iiint\limits_V, \idotsint\limits_V, \oint_V$$

There is a special symbol representing the Cauchy principal value of $\int_a^b f(x)\,\mathrm{d}x$. It is not built into LaTeX, and is so far not provided by any packages available on the Internet. But here's how you can construct it:

```
\def\Xint#1{\mathchoice
{\XXint\displaystyle\textstyle{#1}}%
{\XXint\textstyle\scriptstyle{#1}}%
{\XXint\scriptstyle
      \scriptscriptstyle{#1}}%
{\XXint\scriptscriptstyle
      \scriptscriptstyle{#1}}%
\!\int}
\def\XXint#1#2#3{{
   \setbox0=\hbox{$#1{#2#3}{\int}$}
\vcenter{\hbox{$#2#3$}}\kern-.5\wd0}}
\def\dashint{\Xint-}
\[\dashint_a^bf(x)\,\rd x\]
```

$$\dashint_a^b f(x)\,\mathrm{d}x$$

Sometimes, you might have to produce limits of more than one line. The amsmath package provides the command '`\substack`' which is helpful:

```
\[\sum_{\substack{0\leq i\leq m\\
                  0<j<n}} P(i,j)\]
```

$$\sum_{\substack{0\leq i\leq m\\ 0<j<n}} P(i,j)$$

You could stop reading here. But if you want to do more crazy things, continue.

You can try the "style commands" introduced in section 8.4 to change the behavior of TEX:

```
Inline: $\displaystyle\sum_{n=1}^k$,
        $\displaystyle\int_a^b$.
        Don't do these!\\
Display: \begin{equation*}
\textstyle\sum_{n=1}^k,\int_a^b.
        \end{equation*}
```

Inline: $\displaystyle\sum_{n=1}^{k}$, $\displaystyle\int_{a}^{b}$. Don't do these!
Display:
$$\textstyle\sum_{n=1}^{k},\int_{a}^{b}.$$

The opposite of `\limits` is `\nolimits` (you need a *really* good reason to use it):

```
Inline: $\sum\limits_{n=1}^k$,
        $\int\limits_a^b$\\
Display: \begin{equation*}
\sum\nolimits_{n=1}^k,\int\limits_a^b
\end{equation*}
```

Inline: $\sum\limits_{n=1}^{k}$, $\int\limits_{a}^{b}$
Display:
$$\sum\nolimits_{n=1}^{k},\int\limits_{a}^{b}$$

8.6 Functions

Functions like sin and cos needs special treatment. For one thing, they should be typeset in an upright typeface. In addition, they should be followed by a thin space provided that what follows is not a parenthesis. Again, LATEX can handle the rules above most of the time. For example,

```
$5\sin(a+b)$, $8\cos 2A$
```

$5\sin(a+b)$, $8\cos 2A$

All the predefined functions are given in table 8.1.

Let's do some more experiments:

```
Inline: $\lim_{n\to0}((\sin^2x)/x^2)=1$\\
Display: \begin{equation*}
\lim_{n\to0}\frac{\sin^2x}{x^2}=1
\end{equation*}
```

Inline: $\lim_{n\to0}((\sin^2 x)/x^2)=1$
Display:
$$\lim_{n\to0}\frac{\sin^2 x}{x^2}=1$$

The behavior of the "limits" can be changed (I'm not saying that you should), in the same way we deal with $\int$ and $\sum$:

```
Inline: $\lim\limits_{n\to0}
((\sin^22x)/x^2)=1$\\
Display: \begin{equation*}
\lim\nolimits_{n\to0}\frac{\sin^2x}{x^2}=1
\end{equation*}
```

Inline: $\lim\limits_{n\to0}((\sin^2 2x)/x^2)=1$
Display:
$$\lim\nolimits_{n\to0}\frac{\sin^2 x}{x^2}=1$$

There are two more functions that are useful:

Table 8.1: Predefined operators and functions

Function	Command	Function	Command	Function	Command
arccos	`\arccos`	arcsin	`\arcsin`	arctan	`\arctan`
arg	`\arg`	cos	`\cos`	cosh	`\cosh`
cot	`\cot`	coth	`\coth`	csc	`\csc`
deg	`\deg`	det	`\det`	dim	`\dim`
exp	`\exp`	gcd	`\gcd`	hom	`\hom`
inf	`\inf`	inj lim	`\injlim`	ker	`\ker`
lg	`\lg`	lim	`\lim`	lim inf	`\liminf`
lim sup	`\limsup`	ln	`\ln`	log	`\log`
max	`\max`	min	`\min`	Pr	`\Pr`
proj lim	`\projlim`	sec	`\sec`	sin	`\sin`
sinh	`\sinh`	sup	`\sup`	tan	`\tan`
tanh	`\tanh`	$\varinjlim$	`\varinjlim`	$\varliminf$	`\varliminf`
$\varlimsup$	`\varlimsup`	$\varprojlim$	`\varprojlim`		

```
$1234567\bmod89=48$,\\
$y\pmod{a+b}$
```

$1234567 \bmod 89 = 48$,
$y \pmod{a+b}$

Occasionally, you'll come across functions that are not predefined, e.g., if you type `\arccot`, you'll get an error message.

The command `\DeclareMathOperator{cmd}{text}` provided by the `amsmath` package defines `cmd` to produce `text` in the appropriate font for "textual operators." If the new function being named is an operator that should, when used in displays, "take limits" (so that any subscripts and superscripts are placed above and below), then use the starred form `\DeclareMathOperator*`. For example, after defining:

```
\DeclareMathOperator{\arccot}{arccot}
\DeclareMathOperator\meas{meas}
\DeclareMathOperator*\esssup{ess\,sup}
```

you can type these commands to get amazing results:

```
\[\arccot x, \quad \meas_1,
  \quad \esssup_{x\in A}\]
```

$$\operatorname{arccot} x, \quad \operatorname{meas}_1, \quad \operatorname*{ess\,sup}_{x \in A}$$

8.7 Delimiters—never big enough

Sometimes, parentheses are not big enough to "enclose" things, in which cases you should use the commands '`\left(`' and '`\right)`' to precede the delimiters. For example:

```
\[
\left(\frac{a}{b}\right)
+\left(\frac{c}{d}\right]
\]
```

$$\left(\frac{a}{b}\right) + \left(\frac{c}{d}\right]$$

Table 8.2: Delimiters

Input	Delimiter	Input	Delimiter
`(`	(	`)`	)
`[` or `\lbrack`	[	`]`	]
`\{` or `\lbrace`	{	`\}` or `\rbrace`	}
`\lfloor`	⌊	`\rfloor`	⌋
`\lceil`	⌈	`\rceil`	⌉
`\langle`	⟨	`\rangle`	⟩
`/`	/	`\backslash`	\
`|` or `\vert`	|	`\\|` or `\Vert`	‖
`\uparrow`	↑	`\Uparrow`	⇑
`\downarrow`	↓	`\Downarrow`	⇓
`\updownarrow`	↕	`\Updownarrow`	⇕

Table 8.2 gives all the delimiters that are recognized by TEX.

If you type '`.`' after `\left` or `\right`, instead of specifying one of the basic delimiters, you get the so-called *null delimiter* (which is blank):

```
\begin{equation*}
\left(\frac{a}{b}\right.
\end{equation*}
```

$$\left(\frac{a}{b}\right.$$

This is actually very helpful, as we will see later.

Another use of the commands `\left` and `\right`:

```
$\left|-x\right|=\left|+x\right|$.
```

$\left|-x\right|=\left|+x\right|$.

If you leave out the `\left` and `\right`, what you get is $|-x| = |+x|$. The reason is that TEX does not really understand mathematics. It thinks that you are subtracting 'x' from '|' and adding 'x' to '|', resulting in the extra spaces.

However, the mechanism of `\left` and `\right` does not always work as well as you hope:

```
\begin{equation*}
\left(a+(a+b)\right)
\end{equation*}
```

$$\left(a+(a+b)\right)$$

Well, try this:

```
\begin{equation*}
\bigl(a+(a+b)\bigr)
\end{equation*}
```

$$\bigl(a+(a+b)\bigr)$$

The `\big` delimiters are just enough bigger than ordinary ones so that the difference can be perceived, yet small enough to be used in the text of a paragraph. Here are all of them, in the ordinary size and in the `\big` size:

$$() [] \{\} \lfloor\rfloor \lceil\rceil \langle\rangle / \backslash | \| \uparrow \Uparrow \downarrow \Downarrow \updownarrow \Updownarrow$$
$$\big(\big) \big[\big] \big\{ \big\} \big\lfloor \big\rfloor \big\lceil \big\rceil \big\langle \big\rangle \big/ \big\backslash \big| \big\| \big\uparrow \big\Uparrow \big\downarrow \big\Downarrow \big\updownarrow \big\Updownarrow$$

You can also type `\Bigl` or `\Bigr` to get larger symbols suitable for displays:

$$\Bigl(\Bigr)\Bigl[\Bigr]\Bigl\{\Bigr\}\Bigl\lfloor\Bigr\rfloor\Bigl\lceil\Bigr\rceil\Bigl\langle\Bigr\rangle\Bigl/\Bigr\backslash\Bigl\|\Bigr\|\Bigl\uparrow\Bigr\uparrow\Bigl\downarrow\Bigr\downarrow\Bigl\updownarrow\Bigr\updownarrow$$

There are `\biggl` and `\biggr` versions that are 50% taller than their `\big` counterparts:

$$\biggl(\biggr)\biggl[\biggr]\biggl\{\biggr\}\biggl\lfloor\biggr\rfloor\biggl\lceil\biggr\rceil\biggl\langle\biggr\rangle\biggl/\biggr\backslash\biggl\|\biggr\|\biggl\uparrow\biggr\uparrow\biggl\downarrow\biggr\downarrow\biggl\updownarrow\biggr\updownarrow$$

Finally, there are `\Biggl` and `\Biggr` versions, 2.5 times as tall as the `\bigl` and `\bigr` delimiters:

$$\Biggl(\Biggr)\Biggl[\Biggr]\Biggl\{\Biggr\}\Biggl\lfloor\Biggr\rfloor\Biggl\lceil\Biggr\rceil\Biggl\langle\Biggr\rangle\Biggl/\Biggr\backslash\Biggl\|\Biggr\|\Biggl\uparrow\Biggr\uparrow\Biggl\downarrow\Biggr\downarrow\Biggl\updownarrow\Biggr\updownarrow$$

Any '`\...l`' delimiter is an opening, and any '`\...r`' is a closing. There are also '`\...m`' for use in the middle of formulas.

```
\begin{equation*}
\left\{\,x\in\mathbb{R}\biggm|
0<\left|x\right|<\frac{5}{3}\,\right\},
\quad\frac{a+1}{b}\bigg/\frac{c+1}{d}
\end{equation*}
```

$$\left\{\,x\in\mathbb{R}\,\middle|\,0<\left|x\right|<\frac{5}{3}\,\right\},\quad\frac{a+1}{b}\Big/\frac{c+1}{d}$$

The '`\,`' in the first example is for fine tuning. They add the so-called thin spaces.

Also note that in the second example, we use `\bigg`, not `\biggm`. That's because there's no need to put extra space around '/'. Compare:

```
\begin{equation}
\frac{a+1}{b}\biggm/\frac{c+1}{d}
\end{equation}
```

$$\frac{a+1}{b}\Big/\frac{c+1}{d}\tag{8.2}$$

BTW, there's a pretty nice package called braket which can greatly reduce your effort in typesetting sets:

```
\begin{equation*}
\Set{x\in\mathbb{R}|
  0<\left|x\right|<\frac{5}{3}}\\
\end{equation*}
```

$$\left\{\,x\in\mathbb{R}\,\middle|\,0<\left|x\right|<\frac{5}{3}\,\right\}$$

Sometimes, `\left` and `\right` choose a larger delimiter than you want. You can tune them:

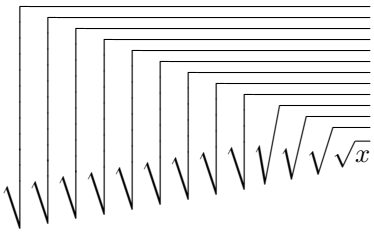
```
\begin{equation*}
\left(\sum_{k=1}^n A_k \right)\quad
\biggl(\sum_{k=1}^n A_{k}\biggr)
\end{equation*}
```

$$\left(\sum_{k=1}^{n}A_k\right)\quad\biggl(\sum_{k=1}^{n}A_k\biggr)$$

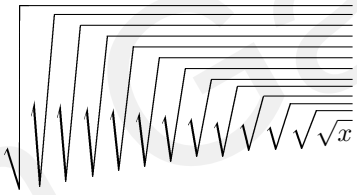
However, most of the time, `\left` and `\right` are the clear choice. The values of them are: (1) They are "automatic"—that's why they produce problems sometimes; and (2) They can produce arbitrarily large delimiters—much bigger than `\bigggggg`!

8.7.1 Largggggge Delimiters—The yhmath Package

An old saying goes, "Even TEX becomes dumb sometimes." (Well, maybe not that old.) And rightly so! Here is the default output of a series of root signs:



What's the word that comes up to your mind when you see the output? "Ugly," I suppose. This is what happens here: Only a few root signs were defined in TEX. When they are used out, TEX will "construct" new root signs—that's how the vertical ones come into being. However, if you load the yhmath package, the output would be very different and better:



An important feature of the yhmath package is that it provides a set of large delimiters. That is to say, virtually all large delimiters will be different from the original output of TEX. (I hardly ever use this package because although it does provide really neat root signs, the parentheses are way beyond my sense of aesthetic.)

Anyway, here are a few other features of the package. It also offers some wide accents. You might remember that there is a limit to TEX's commands such as `\widetilde`, e.g., `\widetilde{ABCDEFG}` would become $\widetilde{ABCDEFG}$, which is awful. But after loading the yhmath package, the output becomes:

$$\overbrace{ABCDEFG}^{\sim}$$

Yet, I still insist that $(ABCDEFG)^{\sim}$ is a better solution. Hopefully you would agree with me.

The yhmath package also provides the `amatrix` environment which is used the same as amsmath's `pmatrix`, but instead of parenthesis, angles are used. For example, you can easily construct the following:

$$\left\langle \begin{matrix} a_1 & a_2 \\ a_3 & a_4 \end{matrix} \right\rangle$$

I listed here some important features of yhmath which I think are most likely to be used. But it has other functions. Please refer to http://texcatalogue.sarovar.org/entries/yhmath.html.

8.8 Changing typefaces

A great difference between mathematicians and physicists is that the latter tend to use upright fonts a lot more frequently. But in some countries, including China and the UK, the difference is not that dramatic.

At the very beginning of this chapter, I mentioned that all variables should be set in italic type, and that all numerals should be set in an upright font. LATEX is capable of

✌

doing this automatically. But it cannot recognize a vector automatically. So you do have to learn some font-switching commands.

Many physicists set mathematical constants in an upright font, e.g., $\mathrm{i}^2 = -1$. Here's how:

```
$\mathrm{i}^2=-1$
```

$\mathrm{i}^2 = -1$

Although we *write* $\vec{a}$, vectors in printed documents are set in boldface. Some people like upright bold, some prefer italic bold. Both are acceptable, and here's how to produce them:

```
$\mathbf{a}$, $\bm{a}$.
```

$\mathbf{a}$, $\boldsymbol{a}$.

(To use the command `\bm`, you have to load the bm package first.)

As you've seen in section 8.7, sets of numbers are set in what we call the Blackboard font, e.g., $\mathbb{R}$ denotes the set of real numbers. Let's take a look how to produce this:

```
Load the \pcg{amsfonts} package!\\
$\mathbb{R}$: the set of real numbers.\\
$\mathbb{N}$: the set of natural
              numbers.
```

Load the amsfonts package!
$\mathbb{R}$: the set of real numbers.
$\mathbb{N}$: the set of natural numbers.

Table 8.3 gives different font switching commands in math mode.

Note that the default italic and the italic produced by `\mathit` are different:

```
rent \neq \mathit{different}$.
```

$different \neq \mathit{different}$.

If you use the upright 'd', 'e', and 'i' a lot, you should define them in your manuscript:

```
\newcommand\rd{\mathrm{d}}
\newcommand\re{\mathrm{e}}
\newcommand\ri{\mathrm{i}}
```

Now, you can get the upright 'd', 'e', and 'i' by simply typing '`\rd`', '`\re`', and '`\ri`':

```
$, $\ri^2=-1$, $\re=2.718\,28\ldots$
```

$\mathrm{d}x$, $\mathrm{i}^2 = -1$, $\mathrm{e} = 2.718\,28\ldots$

Now think of this problem: how do you get

$$P_{r-j} = 0 \text{ if } r - j \text{ is odd.}$$

You might be thinking of doing this, which doesn't work well:

```
-j}=0 \mathrm{if} r-j
   \mathrm{is odd}.\]
```

$$P_{r-j} = 0\mathrm{if}r - j\mathrm{isodd}.$$

Table 8.3: Math fonts

Command	Example
default	$ABCDEFGHIJKLMNOPQRSTUVWXYZ$ $abcdefghijklmnopqrstuvwxyz$
\mathit	$ABCDEFGHIJKLMNOPQRSTUVWXYZ$ $abcdefghijklmnopqrstuvwxyz$
\mathrm	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
\mathbf	**ABCDEFGHIJKLMNOPQRSTUVWXYZ** **abcdefghijklmnopqrstuvwxyz**
\mathsf	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
\mathtt	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
\bm[a]	$\boldsymbol{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\boldsymbol{abcdefghijklmnopqrstuvwxyz}$
\mathfrak[b]	$\mathfrak{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathfrak{abcdefghijklmnopqrstuvwxyz}$
\mathcal	$\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
\mathbb[c]	$\mathbb{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$

[a] Needs package bm.
[b] Needs package amsfonts.
[c] Needs package amsfonts.

That's because blank spaces are ignored in math mode. Now try this:

```
\[P_{r-j}=0\ \mathrm{if}\ r-j\
        \mathrm{is\ odd}.\]
```

$$P_{r-j}=0\ \mathrm{if}\ r-j\ \mathrm{is\ odd}.$$

However, the amsmath package provides a \text command which is really helpful:

```
\[P_{r-j}=0\text{ if
$r-j$ is odd.}\]
```

$$P_{r-j}=0\text{ if }r-j\text{ is odd.}$$

One question remains: how do we get an upright lowercase greek letter? For instance, some publishers mandates that all constants be typeset in an upright greek; this obviously includes "pi." Unfortunately, TEX doesn't have built-in upright lowercase Greek letters. But I've discovered a few approaches that you might want to try:

- Load the package upgreek. Then you can access upright lowercase Greek letters by typing \up..., e.g., \uppi. This is probably the easiest way on earth, but the bad news is that the letters produced in this method don't look that good (for me).
- Load the package txfonts. Then you can access lowercase Greek letters by typing \...up, e.g., \piup. But the txfonts packages affects the typeface of the whole documents. An alternative is not to load the package and put the following codes in your preamble:

```
\DeclareSymbolFont{lettersA}{U}{txmia}{m}{it}
```

```
\DeclareMathSymbol{\piup}{\mathord}{lettersA}{25}
\DeclareMathSymbol{\muup}{\mathord}{lettersA}{22}
\DeclareMathSymbol{\deltaup}{\mathord}{lettersA}{14}
......
```

- You can also use the PostScript symbols. Try the following codes:

```
\usepackage{ifthen}
\makeatletter
\newcommand{\allmodesymb}[2]{\relax\ifmmode{\mathchoice
{\mbox{\fontsize{\tf@size}{\tf@size}#1{#2}}}
{\mbox{\fontsize{\tf@size}{\tf@size}#1{#2}}}
{\mbox{\fontsize{\sf@size}{\sf@size}#1{#2}}}
{\mbox{\fontsize{\ssf@size}{\ssf@size}#1{#2}}}}
\else
\mbox{#1{#2}}\fi}
\makeatother
\newcommand{\greeksym}[1]{\usefont{U}{psy}{m}{n}#1}
\newcommand{\ualpha}{\allmodesymb{\greeksym}{a}}
\newcommand{\udelta}{\allmodesymb{\greeksym}{d}}
\newcommand{\upi}{\allmodesymb{\greeksym}{p}}
......
```

- The lowercase Greek letters provided by GreekTEX is rather good. But there are (at least) two problems: (1) It might cause compatibility issues; (2) If you put the letters in subscripts or superscripts, their size remain the same as in text style. Anyway, here are the codes:

```
\input{greektex}
\newcommand\uppi{\text{\gr p}}
\newcommand\upd{\text{\gr d}}
......
```

TEXnicality
Some publishers require that defined operator be typeset in an upright font; e.g., the 'd' in dx. Well, the 'd' operator shouldn't present any difficult for you, but the default partial operator produced by `\partial` is italic, like this '∂'. We can define the upright version ourselves:

```
\font\ursymbol=psyr at 10pt  % You also use other font sizes.
\def\urpartial{\mbox{\ursymbol\char"B6}}
```

Now the code '`\frac{\urpartial f}{\urpartial x}`' gives the following output:

$$\frac{\partial f}{\partial x},$$

which is perfect!

Table 8.4: Spaces in math mode

Positive Space	Example	Negative Space	Example
`$ab$`	ab		
`$a b$`	ab		
`$a\ b$`	$a\ b$		
`$a\,b$` (`a\thinspace b`)	$a\,b$	`a\!b`	$a\!b$
`$a\:b$` (`a\medspace b`)	$a\:b$	`a\negmedspace b`	$a\negmedspace b$
`$a\;b$` (`a\thickspace b`)	$a\;b$	`a\negthickspace b`	$a\negthickspace b$
`$a\quad b$`	$a\quad b$		
`$a\text{---}b$`	$a\text{---}b$		
`$a\qquad b$`	$a\qquad b$		
`$a\hspace{0.5cm}b$`	$a\hspace{0.5cm}b$	`$a\hspace{-0.5cm}b$`	$a\hspace{-0.5cm}b$
`$a\phantom{xx}b$`	ab		
`$axxb$`	$axxb$		

8.9 Spacing

We've seen the command '`\,`' which produces a thin space a couple of times. Here's another application:

```
123\,456\,\text{cm}
```

$123\,456\,\text{cm}$

But this is by no means the end of the story. LaTeX provides quite a few commands for producing horizontal spaces, as are listed in table 8.4.

A few words about the command `\phantom` in the table. By using the `\phantom` command, you can reserve space for characters that do not show up in the final output:

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

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

TEXnicality
Most of the time, TEX can producing the desired spacing. But there are a few occasions that require your attention:

- A thin space should be added before back subscripts, e.g., $a\,_0x_1bh$ is obtained from `$a\,{}_0x_1bh$`.
- A thin space should be added before and after ds, dp, dx, and similar combinations of d and another symbol following, e.g.,

$$\int f(x)\,\mathrm{d}x \qquad \iiint \mathrm{d}r\,\mathrm{d}\theta\,\mathrm{d}r$$

- A thin space should be added between a number and a unit, e.g., $1\,\mathrm{m} = 100\,\mathrm{cm}$.

- A thick space should be used before a mathematical condition in text, e.g., t_n $(n = 1, 2, \ldots)$
- An em quad should be used between a symbolic statement and a verbal expression in displayed expressions:

$$E_n(t) \to \mathrm{e}^{-t} \quad \text{as } t \to \infty.$$

- An em quad should be used around conjunctions:

$$x(a + b) \quad \text{or} \quad y(a - b)$$

- A two-em quad should be used between two separate formulas in the same line of a display

$$x^2 + y^2 = a, \qquad x + y = b.$$

  However, it is generally accepted that symbols in different formulas must be separated by words, e.g., instead of saying "consider S_q, $q < p$," write "consider S_q, where $q < p$."
- A two-em quad should be used between a symbolic statement and a condition on the statement.

$$x^n - y^n - z^n = A \qquad (n = 0, 1, \ldots, p)$$

The TEXbook provides the following fine-tuning examples:

```
$\sqrt{2}\,x$\\
$\sqrt{\,\lg x}$\\
$O\bigl(1/\sqrt{n}\,\bigr)$\\
$[\,0,1)$\\
$\lg n\,(\lg\lg n)^2$\\
$x^2\!/2$\\
$n/\!\lg n$\\
$\Gamma_{\!2}+\Delta^{\!2}$\\
$R_i{}^j{}_{\!kl}$\\
$\int_0^x\!\int_0^y\rd F(u,v)$\\
$(2n)!/\bigl(n!\,(n+1)!\bigr)$
```

$\sqrt{2}\,x$
$\sqrt{\lg x}$
$O\bigl(1/\sqrt{n}\,\bigr)$
$[\,0,1)$
$\lg n\,(\lg\lg n)^2$
$x^2/2$
$n/\lg n$
$\Gamma_{\!2}+\Delta^{\!2}$
$R_i{}^j{}_{\!kl}$
$\int_0^x\!\int_0^y \mathrm{d}F(u,v)$
$(2n)!/\bigl(n!\,(n+1)!\bigr)$

There are also a few commands controlling the vertical space in and around displays.

The vertical spaces before and after each display environment are controlled by the following rubber lengths, where the values in parentheses are those for `\normalsize` with the (default) `10pt` option in the standard LaTeX classes:

- `\abovedisplayskip`, `\belowdisplayskip`
  The normal vertical space added above and below a mathematical display (default `10pt plus 2pt minus 5pt`).
- `\abovedisplayshortskip`, `\belowdisplayshortskip`
  The (usually smaller) vertical space added above and below a "short display" (`0pt`

➠

`plus 3pt` and `6pt plus 3pt minus 3pt`, respectively). A *short display* is one that starts to the right of where the preceding text line ends.

Here's an example demonstrating the use of these commands:

```
\small
\abovedisplayshortskip=5pt
\belowdisplayshortskip=5pt
\abovedisplayskip=15pt
\belowdisplayskip=15pt
\noindent
Before \begin{equation}
f(x) = \int\frac{\sin x}{x}dx
\end{equation}
\noindent The line doesn't
end before the formula.
\begin{equation}
f(x) = \int\frac{\sin x}{x}dx
\end{equation}
\noindent And the next line starts as
usual with some text\dots.
```

Before

$$f(x) = \int \frac{\sin x}{x} dx \tag{8.3}$$

The line doesn't end before the formula.

$$f(x) = \int \frac{\sin x}{x} dx \tag{8.4}$$

And the next line starts as usual with some text....

8.10 Punctuation

In math mode, commas and semicolons are treated as punctuation marks, so TEX puts some extra spaces after them. For example,

```
$f(x,y;z)$
```

$f(x, y; z)$

This is a good mechanism, but it can cause problems. In the U.S., numbers are grouped by using commas, e.g., '123,456'. If you type `$123,456$`, what you get is '123, 456'. But I prefer to group numbers with a thin space, e.g., 123 456, as you've seen before.

Interestingly, a period is not treated as a punctuation mark, so `$123.456$` does produce the correct '123.456'.

Colon is also treated as a special punctuation in TEX—representing "ratio," e.g., '3 : 4'. But it's wrong to type something like $f : A \to B$. Instead, try the following:

```
$f\mathpunct{:}A\to B$
```

$f\mathpunct{:}A\to B$

As a matter of act, if you are using standard LATEX (without loading the amsmath package), you can type `$f\colon A\to B$`. However, the amsmath package makes unfortunate major changes to the spacing produced by the command `\colon`.

Now, let's talk about something more general. When a formula is followed by a period, comma, semicolon, question mark, exclamation point, etc., put the punctuation after the `$`, when the formula is in the text; but put the punctuation before the end of a display math environment. For example,

```
0$, we have shown that
{equation*} y=f(x). \end{equation*}
```

If $x < 0$, we have shown that

$$y = f(x).$$

Similarly, don't ever type anything like

```
for $x=a,b$, or $c$.
```

for $x = a, b$, or c.

It should be

```
for $x=a$, $b$, or $c$.
```

for $x = a$, b, or c.

(Better yet, use a tie: '`or~$c$`'.) The reason is that TEX will typeset expression '`$x=a,b$`' as a single formula, so it will put a "thin space" between the comma and the b. This space will not be the same as the space that TEX puts after the comma following the b, since spaces between words are always bigger than thin spaces.

Another reason for not typing `$x=a,b$` is that it inhibits breaking lines in a paragraph: TEX will never break at the space between the comma and the `b` because breaks after commas in formulas are usually wrong. For example, in the equation, we certainly don't want to break something like $P(1, 2)$.

We've talked much about ellipsis in texts. Now let's get into the math mode. Since we realize that `\ldots` does not produce a thin space after it when used in math mode, it might cause some problems. Look at the following examples:

```
$a_1,a_2,a_3,\ldots$.\\
$a_1,a_2,a_3,\ldots.$
```

$a_1, a_2, a_3, \ldots.$
$a_1, a_2, a_3, \ldots.$

The first one is logical, but the output is "awesome." The second one looks OK, but the space after the period would be distorted since it is not really considered an ending-a-sentence period. The correct way is to type this:

```
$a_1,a_2,a_3,\ldots\,$.
```

$a_1, a_2, a_3, \ldots.$

But the best way is actually '`$a_1$, $a_2$, $a_3$,~\ldots.`'.

The position of ellipsis is also an art. It is generally correct to produce formulas like

```
$x_1+\cdots+x_n$ and $(x_1,\ldots,x_n)$,
```

$x_1 + \cdots + x_n$ and $(x_1, \ldots, x_n)$,

but wrong to produce formulas like

```
$x_1+\ldots+x_n$ and $(x_1,\cdots,x_n)$.
```

$x_1 + \ldots + x_n$ and $(x_1, \cdots, x_n)$.

If you've loaded the amsmath package, try the following:

```
$x_1+\dots+x_n$ and $(x_1,\dots,x_n)$.
```

$x_1 + \cdots + x_n$ and $(x_1, \ldots, x_n)$.

The amsmath package decides the position of the ellipsis according to what kind of symbol follows `\dots`. If the next symbol is a plus sign, the dots will be centered; if it is a comma, they will be on the baseline. If the dots fall at the end of a mathematical formulas, the next object will be something like `\end` or `$`, etc., which does not give any information about how to place the dots. In such a case, you must help by using `\dotsc` for "dots with commas," `\dotsb` for "dots with binary operator/relation symbols," `\dotsm` for "multiplication dots," `\dotsi` for "dots with integrals," or even `\dotso` for "none of the above." For example,

```
A series $H_1, H_2, \dotsc\,$, a sum
$H_1+H_2+\dotsb\,$, an orthogonal product
$H_1\times H_2\times\dotsm\,$, and an
infinite integral: \[\int_{H_1}\!
   \int_{H_2}\dotsi\;
{-\Gamma}\,\rd\Theta.\]
```

A series $H_1, H_2, \ldots$, a sum $H_1 + H_2 + \cdots$, an orthogonal product $H_1 \times H_2 \times \cdots$, and an infinite integral:

$$\int_{H_1}\int_{H_2} \cdots \; -\Gamma \, \mathrm{d}\Theta.$$

I also adapt the following examples from *The TEXbook* to illustrate the proper use of ellipses:

```
$x_1+\dots+x_n$\\
$x_1=\dots=x_n$\\
$A_1\times\dots\times A_n$\\
$f(x_1,\dots,x_n)$\\
$x_1x_2\dots x_n$\\
$(1-x)(1-x^2)\dots(1-x^n)$\\
$n(n-1)\dots(1)$\\
$x_1\cdot x_2\cdot\ldots\cdot x_n$
```

$x_1 + \cdots + x_n$
$x_1 = \cdots = x_n$
$A_1 \times \cdots \times A_n$
$f(x_1, \ldots, x_n)$
$x_1 x_2 \ldots x_n$
$(1 - x)(1 - x^2) \ldots (1 - x^n)$
$n(n - 1) \ldots (1)$
$x_1 \cdot x_2 \cdot \ldots \cdot x_n$

Caution: the example on the last line is *not* a typo! But it does look odd, so try to avoid it.

8.11 More about Displayed Equations

You might want to put two equations on two individual lines, but

```
\begin{equation*}
(a+b)^2=a^2+2ab+b^2\\
\sin^2\eta+\cos^2\eta=1
\end{equation*}
```

is not valid, as no line breaks are allowed in an `equation*` environment. What about

```
{equation*}
2=a^2+2ab+b^2
quation*}
{equation*}
\eta+\cos^2\eta=1
quation*}
```

$$(a+b)^2 = a^2 + 2ab + b^2$$

$$\sin^2\eta + \cos^2\eta = 1$$

You'll find that there's too much space between the two equations.
OK, here comes the solution: you can try the `gather` or `gather*` environment:

```
{gather}
2=a^2+2ab+b^2\\
\eta+\cos^2\eta=1
ather}
```

$$(a+b)^2 = a^2 + 2ab + b^2 \tag{8.5}$$
$$\sin^2\eta + \cos^2\eta = 1 \tag{8.6}$$

If you do not want the equation number, just use the starred form. What if you want to number the first equation but not the second one?

```
\begin{gather}
(a+b)^2=a^2+2ab+b^2\\
\sin^2\eta+\cos^2\eta=1\notag
\end{gather}
```

$$(a+b)^2 = a^2 + 2ab + b^2 \tag{8.7}$$
$$\sin^2\eta + \cos^2\eta = 1$$

The `gather` environment is perfect for putting two or more equations on individual lines, centered. But sometimes, we want to "align" them at a relation symbol. We can use the `align` or `align*` environment.

```
\begin{align}
x^2+y^2 &= z^2\\
x^3+y^3 &< z^3+\cdots
\end{align}
```

$$x^2 + y^2 = z^2 \tag{8.8}$$
$$x^3 + y^3 < z^3 + \cdots \tag{8.9}$$

Again, if you do not want the equation numbers, use the starred form.

Another challenge, what if we want to "group" these equations and "center" the equation number vertically? The answer is to use the `...ed` variant of the environments above.

```
\begin{equation}
\begin{gathered}
(a+b)^2=a^2+2ab+b^2\\
\sin^2\eta+\cos^2\eta=1
\end{gathered}
\end{equation}
```

$$\begin{gathered}(a+b)^2 = a^2 + 2ab + b^2\\ \sin^2\eta + \cos^2\eta = 1\end{gathered} \tag{8.10}$$

Another example:

```
\begin{equation*}
\begin{aligned}
x^2+y^2 &= z^2\\
x^3+y^3 &< z^3+\cdots
\end{aligned}
\end{equation*}
```

$$\begin{aligned}x^2 + y^2 &= z^2\\ x^3 + y^3 &< z^3 + \cdots\end{aligned}$$

(What happened to the equation number?)

And another one!

```
\begin{equation}
\begin{split}
x^2+y^2 &= z^2\\
x^3+y^3 &< z^3+\cdots
\end{split}
\end{equation}
```

$$\begin{aligned} x^2+y^2 &= z^2 \\ x^3+y^3 &< z^3+\cdots \end{aligned} \tag{}$$

Remember how I talked about the "null delimiter"? Let's take a look at its application:

```
\begin{equation*}
\left.
\begin{aligned}
\bm{B}'&=-c\nabla\times\bm{E}\\
\bm{E}'&=c\nabla\times\bm{B}-4\pi\bm{J}
\end{aligned}\right\}
\text{Maxwell's}
\end{equation*}
```

$$\left.\begin{aligned} \boldsymbol{B}' &= -c\nabla\times\boldsymbol{E} \\ \boldsymbol{E}' &= c\nabla\times\boldsymbol{B}-4\pi\boldsymbol{J} \end{aligned}\right\} \text{Maxwell's}$$

One more command to introduce: `\intertext`.

```
\begin{align}
A_1&=N_0(\lambda;\Omega')-
     \phi(\lambda;\Omega')\\
A_2&=\phi(\lambda;\Omega')
     \phi(\lambda;\Omega)
\intertext{and finally} A_3&=
\mathcal{N}(\lambda;\omega)
\end{align}
```

$$\begin{aligned} A_1 &= N_0(\lambda;\Omega')-\phi(\lambda;\Omega') && (8.12)\\ A_2 &= \phi(\lambda;\Omega')\phi(\lambda;\Omega) && (8.13) \end{aligned}$$

and finally

$$A_3 = \mathcal{N}(\lambda;\omega) \qquad (8.14)$$

8.12 Breaking an Inline Equation

When you have formulas in a paragraph, TEX may have to break them between lines. This is a necessary evil, something like the hyphenation of words; we want to avoid it unless the alternative is worse.

By default, a formula will be broken only *after* a relation symbol like $=$ or $<$ or $\rightarrow$, or after a binary operation symbol like $+$ or $-$ or $\times$, where the relation or binary operation is on the "outer level" of the formula (i.e., not enclosed in `{...}`). For example,

```
equationbreakanequation
 $f(x,y)=x^2-y^2=(x+y)(x-y)$.
```

equationbreakanequation $f(x,y)=x^2-y^2=(x+y)(x-y)$.

There's a chance that TEX will break after either of the `=` signs (it prefers this) or after the `-` or `+` or `-` (in an emergency). But there won't be a break after the comma in any case.

If you don't want to permit breaking in this example except after the `=` signs, you could type

```
onbreakanequation
y)={x^2-y^2}={(x+y)(x-y)}$.
```

equationbreakanequation $f(x,y) = x^2 - y^2 = (x+y)(x-y)$.

On the other hand, if you do want to break after the comma, try this:

```
nequationbreakanequation
\allowbreak y)=x^2-y^2=(x+y)(x-y)$.
```

breakanequationbreakanequation $f(x,y) = x^2 - y^2 = (x+y)(x-y)$.

This is not a good example. But sometimes, you might want to break something like $(x_1, \ldots, x_m, y_1, \ldots, y_n)$.

Another interesting example:

```
anequation
 $f(x,y)=x^2-y^2=(x+y)(x-y)$\\
anequation
 $f(x,y)=x^2-y^2=(x+y)\*(x-y)$\\
equation
 $f(x,y)=x^2-y^2=(x+y)\*(x-y)$
```

anequation $f(x,y) = x^2 - y^2 = (x+y)(x-y)$
anequation $f(x,y) = x^2 - y^2 = (x+y)(x-y)$
equation $f(x,y) = x^2 - y^2 = (x+y)(x-y)$

The command `\*` acts like `\-`. However, instead of inserting a hyphen, a $\times$ sign is inserted in text size.

8.13 Breaking a Displayed Equation

Breaking a displayed equation is mostly not preferable, but sometimes you just have to. Two things that you have to keep in heart when breaking a displayed equation: (1) It is stated in *The TEXbook* that "Although formulas within a paragraph always break *after* binary operations and relations, displayed formulas break *before* binary operations and relations." (2) Retain the logic of your math equations! I formatted the equations in this section rather carefully, in the hope that you can figure out the rules lying behind the surface.

The first environment to introduce is the `multline` environment, which does the following:

```
\begin{multline}
\text{First line of a multline}\\
\text{Centered Middle line}\\
\shoveright{\text{A right Middle}}\\
\text{Another centered Middle}\\
\text{Yet another centered Middle}\\
\shoveleft{\text{A left Middle}}\\
\text{Last line of the multline}
\end{multline}
```

First line of a multline
Centered Middle line
A right Middle
Another centered Middle
Yet another centered Middle
A left Middle
Last line of the multline (8.15)

Let's look at a serious example:

```
\begin{multline}
A=\lim_{n\to\infty}\Delta x\Bigl(a^2+
        \bigl(a^2+2a\Delta x
         +(\Delta x)^2\bigr)\\
  +\bigl(a^2+2\times2a\Delta x+
           2^2(\Delta x)^2\bigr)\\
  +\bigl(a^2+2\times3a\Delta x+
           3^2(\Delta x)^2\bigr)\\
  +\cdots\\
  +\bigl(a^2+2\cdot(n-1)a\Delta x+
    (n-1)^2(\Delta x)^2\bigr)\Bigr)\\
  =\tfrac{1}{3}(b^3-a^3).
\end{multline}
```

$$\begin{aligned}A = \lim_{n\to\infty} \Delta x\Big(&a^2 + \big(a^2 + 2a\Delta x + (\Delta x\\ &+ \big(a^2 + 2\times 2a\Delta x + 2^2(\Delta x)^2\big)\\ &+ \big(a^2 + 2\times 3a\Delta x + 3^2(\Delta x)^2\big)\\ &+\cdots\\ &+ \big(a^2 + 2\cdot(n-1)a\Delta x + (n-1)^2(\Delta x)\\ &= \tfrac{1}{3}(b^3 - a^3). \quad (\end{aligned}$$

Now let's try the `align` environment.

```
\begin{align*}
(a+b)^3&=(a+b)(a+b)^2\\
       &=(a+b)(a^2+2ab+b^2)\\
       &=a^3+3a^2b+3ab^2+b^3
\end{align*}
```

$$\begin{aligned}(a+b)^3 &= (a+b)(a+b)^2\\ &= (a+b)(a^2+2ab+b^2)\\ &= a^3+3a^2b+3ab^2+b^3\end{aligned}$$

You can achieve the same effect with the `split` environment.

```
\begin{equation*}
\begin{split}
(a+b)^3&=(a+b)(a+b)^2\\
       &=(a+b)(a^2+2ab+b^2)\\
       &=a^3+3a^2b+3ab^2+b^3
\end{split}
\end{equation*}
```

$$\begin{aligned}(a+b)^3 &= (a+b)(a+b)^2\\ &= (a+b)(a^2+2ab+b^2)\\ &= a^3+3a^2b+3ab^2+b^3\end{aligned}$$

Another example. With the following codes (Pay attention to the use of the command `\quad`):

```
\begin{verbatim}
\begin{align*}
x_nu_1+\cdots+x_{n+t-1}u_t&=
  x_nu_1+(ax_n+c)u_2+\cdots\\
  &\quad+\bigl(a^{t-1}x_n+
     c(a^{t-2}+\cdots+1)\bigr)u_t\\
  &=(u_1+au_2+\cdots+a^{t-1}u_t)x_n
     +h(u_1,\ldots,u_t).
\end{align*}
\end{verbatim}
```

we can get the following output:

$$\begin{aligned}x_nu_1+\cdots+x_{n+t-1}u_t &= x_nu_1+(ax_n+c)u_2+\cdots\\ &\quad+\big(a^{t-1}x_n+c(a^{t-2}+\cdots+1)\big)u_t\\ &= (u_1+au_2+\cdots+a^{t-1}u_t)x_n+h(u_1,\ldots,u_t).\end{aligned}$$

Now we're going to take a look at a *very* complicated example.

$$\begin{aligned} f_{h,\varepsilon}(x,y) &= \varepsilon \mathbf{E}_{x,y} \int_0^{t_\varepsilon} L_{x,y_\varphi(\varepsilon u)}\varphi(x)\,\mathrm{d}u \\ &= h \int L_{x,z}\varphi(x) + \rho_x(\mathrm{d}z) \\ &\quad + h\left(\frac{1}{t_\varepsilon}\left(\mathbf{E}_y \int_0^{t_\varepsilon} L_{x,y^x(s)}\varphi(x)\,\mathrm{d}s \ - t_\varepsilon \int L_{x,z}\varphi(x)\rho_x(\mathrm{d}z)\right)\right. \\ &\qquad \left. + \frac{1}{t_\varepsilon}\left(\mathbf{E}_y \int_0^{t_\varepsilon} L_{x,y^x(s)}\varphi(x)\,\mathrm{d}s - \mathbf{E}_{x,y} \int_0^{t_\varepsilon} L_{x,y_\varphi(\varepsilon s)}\varphi(x)\,\mathrm{d}s\right)\right) \end{aligned} \tag{8.17}$$

Here are the codes to typeset the equation above.

```
\begin{verbatim}
\newcommand\ve{\varepsilon}   \newcommand\tve{t_{\varepsilon}}
\newcommand\vf{\varphi}       \newcommand\yvf{y_{\varphi}}
\newcommand\bfE{\mathbf{E}}
\newcommand\relphantom[1]{\mathrel{\phantom{#1}}}
\begin{equation}
\begin{split}
f_{h,\ve}(x,y)&=\ve\bfE_{x,y}\int_0^{\tve} L_{x,\yvf(\ve u)}\vf(x)\,\rd u\\
    &=h\int L_{x,z}\vf(x)+\rho_x(\rd z)\\
    &\relphantom{=}{}+h\Biggl(\frac{1}{\tve}\biggl(
        \bfE_y \int_0^{\tve} L_{x,y^x(s)}\vf(x)\,\rd s\
            -\tve \int L_{x,z}\vf(x)\rho_x(\rd z)\biggr)\\
     &\relphantom{=}\phantom{{}+h\Biggl(}+
     \frac{1}{\tve}
     \biggl(\bfE_y\int_0^{\tve} L_{x,y^x(s)}\vf(x)\,\rd s
     -\bfE_{x,y}\int_0^{\tve} L_{x,\yvf(\ve s)}\vf(x)\,\rd s\biggr)\Biggr)
\end{split}
\end{equation}
\end{verbatim}
```

Standard LaTeX also provides the `eqnarray` environment for typesetting equations that will spread onto a few lines. I hardly use it. But it is introduced below FYI.

```
\setlength\arraycolsep{2pt}
\begin{eqnarray}
y & = & a+b+c+d\nonumber\\
  &   & +e+f+g\nonumber\\
  &   & {}+h+i+j\nonumber\\
  & \geq & {}-k-l-m
\end{eqnarray}
```

$$\begin{aligned} y &= a+b+c+d \\ &\quad +e+f+g \\ &\quad +h+i+j \\ &\geq -k-l-m \end{aligned} \tag{8.18}$$

I have two comments: (1) Notice the use of the `{}`. (Can you explain what happens right here?) (2) Setting `\arraycolsep` to 2 pt could give better output. (It controls the space before and after the sign enclosed between `&`'s.)

By the way, by default LaTeX does not allow any page break within a displayed equation. If you do want to allow page breaks, put `\allowpagebreak` in the preamble of your document.

8.14 Array

Arrays, in mathematics, are produced with the `array` environment. It has a single argument that specifies the number of columns and the alignment of items within the columns. For each column in the array, there is a single letter in the argument that specifies how items in the column should be positioned: `c` for centered, `l` for flush left, or `r` for flush right. Within the body of the environment, adjacent rows are separated by a `\\` command and adjacent items within a row are separated by an `&` character. For example,

```
\[
\begin{array}{clcr}
a+b+c & uv  & x-y & 27\\
a+b   & u+v & z   & 134\\
a     & 3u+uw & xyz & 2\,978
\end{array}
\]
```

$$\begin{array}{clcr} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \\ a & 3u+uw & xyz & 2\,978 \end{array}$$

You can do a lot of amazing things with this structure:

```
\begin{equation*}
P_{r-j}=\left\{\!\!\!\!
\begin{array}{ll}
0 & \text{if $r-j$ is odd,}\\
r!\,(-1)^{(r-j)/2} &
   \text{if $r-j$ is even.}
\end{array}\right.
\end{equation*}
```

$$P_{r-j} = \begin{cases} 0 & \text{if } r-j \text{ is odd,} \\ r!\,(-1)^{(r-j)/2} & \text{if } r-j \text{ is even.} \end{cases}$$

The amsmath package provides an alternative:

```
\begin{equation*}
P_{r-j}=
\begin{cases}
0 & \text{if $r-j$ is odd,}\\
r!\,(-1)^{(r-j)/2} &
   \text{if $r-j$ is even.}
\end{cases}
\end{equation*}
```

$$P_{r-j} = \begin{cases} 0 & \text{if } r-j \text{ is odd,} \\ r!\,(-1)^{(r-j)/2} & \text{if } r-j \text{ is even.} \end{cases}$$

If you look closely at the two outputs, you'll find that they are actually *slightly* different. Coleen's Workgroup prefers the former one, though it is more difficult to enter.

Matrices are produced in the similar way:

```
\begin{equation*}
\left(\!\!\!\begin{array}{cc} 0& -1\\
1 & 0\end{array}\!\!\!\right)
\end{equation*}
```

$$\left(\begin{array}{cc} 0 & -1 \\ 1 & 0 \end{array}\right)$$

Again, the amsmath package provides some simpler solutions:

```
{gather*}
{matrix}0&1\\ 1&0\end{matrix}\quad
{pmatrix}0&1\\ 1&0\end{pmatrix}\\
{bmatrix}0&1\\ 1&0\end{bmatrix}\quad
{Bmatrix}0&1\\ 1&0\end{Bmatrix}\\
{vmatrix}0&1\\ 1&0\end{vmatrix}\quad
{Vmatrix}0&1\\ 1&0\end{Vmatrix}
gather*}
```

$$\begin{matrix}0&1\\1&0\end{matrix}\quad \begin{pmatrix}0&1\\1&0\end{pmatrix}\\ \begin{bmatrix}0&1\\1&0\end{bmatrix}\quad \begin{Bmatrix}0&1\\1&0\end{Bmatrix}\\ \begin{vmatrix}0&1\\1&0\end{vmatrix}\quad \begin{Vmatrix}0&1\\1&0\end{Vmatrix}$$

It is generally speaking not preferable to put a matrix in inline mode. However, if it is a small matrix, you can do it with the `smallmatrix` environment provided by the amsmath package:

```
To show the effect of the matrix on
surrounding lines in side a paragraph,
we put it here:
$\left(\begin{smallmatrix}
1&0\\0&-1
\end{smallmatrix}\right)$ and follow
it with enough text to ensure that there
is at least one full line below the matrix.
```

To show the effect of the matrix on surrounding lines in side a paragraph, we put it here: $\left(\begin{smallmatrix}1&0\\0&-1\end{smallmatrix}\right)$ and follow it with enough text to ensure that there is at least one full line below the matrix.

There's also a command provided by TEX that produces a special kind of matrix:

```
\[\bordermatrix{
  & 0 & 1 & 2\cr
0 & A & B & C\cr
1 & d & e & f\cr
2 & 1 & 2 & 3}\]
```

$$\bordermatrix{ & 0 & 1 & 2\cr 0 & A & B & C\cr 1 & d & e & f\cr 2 & 1 & 2 & 3}$$

A final trick. Some people (including me) feel the braces are too big when used with arrays. The following example might give you some insight:[1]

```
\[f(x)= \left\{%
\vphantom{\begin{array}{c} a\\[13ex]
\end{array}}\right.\kern-7pt
\begin{array}{ll}
4, & \text{if} \quad x\in (4,\infty), \\
3, & \text{if} \quad x\in (3,4], \\
2, & \text{if} \quad x \in (2,3], \\
1, & \text{if} \quad x \in (1,2], \\
0, & \text{if} \quad x \in (-\infty,1].
\end{array}\]
```

$$f(x)= \left\{% \vphantom{\begin{array}{c} a\\[13ex] \end{array}}\right.\kern-7pt \begin{array}{ll} 4, & \text{if} \quad x\in (4,\infty), \\ 3, & \text{if} \quad x\in (3,4], \\ 2, & \text{if} \quad x \in (2,3], \\ 1, & \text{if} \quad x \in (1,2], \\ 0, & \text{if} \quad x \in (-\infty,1]. \end{array}$$

8.14.1 The delarray Package

The delarray package is a useful general extension to the array package that allows you to specify opening and closing extensible delimiters to surround a mathematical `array` environment.

1 Provided by Neals of the CTEX Community.

```
\[\bm{Q}=
\begin{array}[t]({cc}) X&Y \end{array}
\begin{array}[t][{cc}]A&B\\ C&D\end{array}
\begin{array}[b]\lgroup{cc}\rgroup
 L\\M\end{array}\]
```

$$\boldsymbol{Q} = \begin{pmatrix} X & Y \end{pmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{pmatrix} L \\ M \end{pmatrix}$$

8.14.2 Partitioned matrices

The pmat package is designed for typesetting partitioned matrices. The \pmat macro takes three arguments. The first one is a left delimiter (the thing you put immediately after a \left command). The last one is a right delimiter (the thing you put immediately after a \right command). As usual, a delimiter may be omitted by using a dot (.). The middle argument specifies the dashed vertical lines that are to be placed between columns of the matrix. This argument must contain exactly $n-1$ characters, where n is the number of columns of the matrix. If a character is a | then a dashed vertical line will be placed between the appropriate columns. Otherwise, no dashed line will be placed between those columns (we recommend the use of the character dot (.) in these cases). The format of the entries of the partitioned matrix follows the conventions of plain TEX, i.e., entries are separated by a & (just like in LATEX), but lines are separated by a \cr (instead of the \\ used in LATEX). All entries are typeset in math mode (in \textstyle). For technical reasons, a \cr must also be placed at the end of the last line. The placement of horizontal dashed lines is done with the command \-, which must be placed immediately after the command \cr. For example,

```
\[
\begin{pmat}({.|})
a_{11} & a_{12} & b_{11} \cr
a_{21} & a_{22} & b_{21} \cr\-
c_{11} & c_{12} & d_{11} \cr
\end{pmat}
\]
```

$$\left(\begin{array}{cc:c} a_{11} & a_{12} & b_{11} \\ a_{21} & a_{22} & b_{21} \\ \hdashline c_{11} & c_{12} & d_{11} \end{array}\right)$$

A lot of parameters may be changed to modify the appearance. For more information, refer to ftp://ibiblio.org/pub/packages/TeX/macros/generic/pmat/pmat.pdf.

8.14.3 Case structures with the cases package

We already know that case structures can be constructed either with the array environment or the cases environment provided by the amsmath package. Here is another really useful package—cases. Its general syntax goes like this:

```
\begin{numcases}{left_side}
 case_1 & explanation_1 \\
 case_2 & explanation_2 \\
 ...
 case_n & explanation_n
\end{numcases}
```

Let's take a look at an example:

```
{numcases}{|x|=}
 for $x \geq 0$\\
& for $x < 0$
umcases}
```

$$|x| = \begin{cases} x, & \text{for } x \geq 0 \quad (8.19) \\ -x, & \text{for } x < 0 \quad (8.20) \end{cases}$$

And here is a more complex one:

```
\begin{verbatim}
 \begin{subnumcases}{\label{w} w\equiv}
  0    & $c = d = 0$\label{wzero}\\
 \sqrt{|c|}\,\sqrt{\frac{1 + \sqrt{1+(d/c)^2}}{2}}   & $|c| \geq |d|$ \\
 \sqrt{|d|}\,\sqrt{\frac{|c/d| + \sqrt{1+(c/d)^2}}{2}}   & $|c| < |d|$
 \end{subnumcases}
 Then, using $w$ from equation~(\ref{w}), the square root is
 \begin{subnumcases}{\sqrt{c+\ri d}=}
 0                    & $w=0$ (case \ref{wzero})\\
 w+\ri\frac{d}{2w}      & $w \neq 0$, $c \geq 0$ \\
 \frac{|d|}{2w} + \ri w  & $w \neq 0$, $c < 0$, $d \geq 0$ \\
 \frac{|d|}{2w} - \ri w  & $w \neq 0$, $c < 0$, $d < 0$
 \end{subnumcases}
\end{verbatim}
```

The above codes generates the following output:

$$w \equiv \begin{cases} 0 & c = d = 0 \quad (8.21a) \\ \sqrt{|c|}\sqrt{\dfrac{1+\sqrt{1+(d/c)^2}}{2}} & |c| \geq |d| \quad (8.21b) \\ \sqrt{|d|}\sqrt{\dfrac{|c/d|+\sqrt{1+(c/d)^2}}{2}} & |c| < |d| \quad (8.21c) \end{cases}$$

Then, using w from equation (8.21), the square root is

$$\sqrt{c+\mathrm{i}d} = \begin{cases} 0 & w = 0 \text{ (case 8.21a)} \quad (8.22a) \\ w + \mathrm{i}\dfrac{d}{2w} & w \neq 0,\ c \geq 0 \quad (8.22b) \\ \dfrac{|d|}{2w} + \mathrm{i}w & w \neq 0,\ c < 0,\ d \geq 0 \quad (8.22c) \\ \dfrac{|d|}{2w} - \mathrm{i}w & w \neq 0,\ c < 0,\ d < 0 \quad (8.22d) \end{cases}$$

8.15 Dress your letters!

Sometimes, you might want to put a "hat" on your letter, e.g., $\hat{a}$. All the related commands are given in table 8.5:

A few comments: (1) The notation $\vec{a}$ and $\hat{a}$ are only used in handwritten documents. In professional typesetting, use $\boldsymbol{a}$ and $\mathbf{a}$ instead. (2) If you do want to use the arrow notation, use `\imath` and `\jmath` instead of `i` and `j`, e.g., $\vec{\imath}$, $\hat{\jmath}$. (3) However, we do use $\overrightarrow{AB}$ instead of $\boldsymbol{AB}$. (4) Instead of $\widetilde{A+B}$, you might consider an alternative: $(A+B)^{\sim}$, which can be produced by typing `$(A+B)\sptilde$` provided by the amsxtra package. Here are more examples:

Table 8.5: Accents in math mode

Command	Sample	Command	Sample	Command	Sample
\acute	$\acute{a}$	\bar	$\bar{a}$	\breve	$\breve{a}$
\check	$\check{a}$	\dot	$\dot{a}$	\ddot	$\ddot{a}$
\dddot	$\dddot{a}$	\grave	$\grave{a}$	\hat	$\hat{a}$
\mathring	$\mathring{a}$	\tilde	$\tilde{a}$	\vec	$\vec{a}$
\underbar	$\underline{a}$				
\overline	$\overline{AB}$	\underline	$\underline{AB}$	\overrightarrow	$\overrightarrow{AB}$
\overleftarrow	$\overleftarrow{AB}$	\overleftrightarrow	$\overleftrightarrow{AB}$	\underleftarrow	$\underleftarrow{AB}$
\underrightarrow	$\underrightarrow{AB}$	\underleftrightarrow	$\underleftrightarrow{AB}$	\widetilde	$\widetilde{AB}$
\widehat	$\widehat{AB}$				

```
$(xyz)\spdddot$\quad$(xyz)\spddot$\\
$(xyz)\spdot$  \quad$(xyz)\spbreve$\\
$(xyz)\spcheck$\quad$(xyz)\sphat$\\
$(xyz)\sptilde$
```

$(xyz)^{\cdots}$ $(xyz)^{\cdot\cdot}$
$(xyz)^{\cdot}$ $(xyz)^{\breve{}}$
$(xyz)^{\vee}$ $(xyz)^{\hat{}}$
$(xyz)^{\sim}$

There are two more commands there are really useful: \underbrace and \overbrace.

```
\begin{align*}
y&=x^2+bx+c\\
 &=x^2+2\cdot\frac{b}{2}x+c\\
 &=\underbrace{x^2+2\cdot\frac{b}{2}x+
    \left(\frac{b}{2}\right)^2}_{\left(x+
    (b/2)\right)^2}
      -\left(\frac{b}{2}\right)^2+c
\end{align*}
```

$$\begin{aligned} y &= x^2 + bx + c \\ &= x^2 + 2 \cdot \frac{b}{2}x + c \\ &= \underbrace{x^2 + 2 \cdot \frac{b}{2}x + \left(\frac{b}{2}\right)^2}_{(x+(b/2))^2} - \left(\frac{b}{2}\right)^2 + c \end{aligned}$$

8.15.1 More Accents: The accents Package

We've talked about accents in section 4.1. But how do we produce stuff like $\overset{*}{d}$. The accents packages can help. Here are a few examples:

```
$\accentset{*}{d}$\\
$\accentset{*}{h}$
```

$\overset{*}{d}$
$\overset{*}{h}$

If you look at the examples very carefully, you'll find that the accents package even takes the skewness of letters into consideration.

The accents package also allows you to dress your letters with "shoes":

```
$\underaccent{\bar}{x}$\\
$\underaccent{*}{x}$
```

$\underline{x}$
$\underset{*}{x}$

Refer to http://texcatalogue.sarovar.org/entries/accents.html for more details.

8.15.2 "$\imath$" in Different Fonts—The dotlessi package

I mentioned in section 4.1 that if you want to "dress" the letter "i" or "j," you should first remove the dot by using the commands `\imath` and `\jmath`. Question: how can we make the dotless i and j upright? You might want to try `$\mathrm{\imath}$`, which still gives '$\imath$'. The solution is provided by the dotlessi package. After loading the package, you can do the following:

```
\mathsf{\dotlessj}}$\\
e{\bm{\dotlessi}}$
```

$$\vec{\jmath}$$
$$\tilde{\boldsymbol{\imath}}$$

8.15.3 The undertilde Package

The undertilde package provides the `\utilde` command, which behaves more or less like TEX's `\widetilde`, except that the resulting accent is placed under the letter.

```
$\utilde{a} \neq \widetilde{a}$
```

$$\underset{\sim}{a} \neq \widetilde{a}$$

8.16 Constructing New Symbols

In *ISO 31-11:1992* , the symbol '$a \stackrel{\text{def}}{=} b$' is used to denote "$a$ is by definition equal to b." You can easily define it with the '`\stackrel`' command provided by the amsmath package:

```
\newcommand\eqdef{%
\stackrel{\mathrm{def}}{=}}
$a\eqdef b$
```

$$a \stackrel{\text{def}}{=} b$$

8.17 Extensible arrows

The commands `\xleftarrow` and `\xrightarrow` produce horizontal relation arrows; they are intended to have textual decorations above and/or below the arrow and the length of the arrow is chosen automatically to accommodate the text. These arrows are normally available in only one size. Thus, they will probably not be suited for use in fractions, subscripts, or superscripts. For example.

```
\[
0\xleftarrow[\zeta]{} F\times
  \Delta(n-1)
   \xrightarrow{\partial_0\alpha(b)}
    E^{\partial_0 b}\]
```

$$0 \xleftarrow[\zeta]{} F \times \Delta(n-1) \xrightarrow{\partial_0 \alpha(b)} E^{\partial_0 b}$$

`\xlongequal:`	$A \xlongequal[sub]{\text{we love to love}} Z$
`\xLongleftarrow:`	$A \xLongleftarrow[sub]{\text{we love to love}} Z$
`\xLongrightarrow:`	$A \xLongrightarrow[sub]{\text{we love to love}} Z$
`\xLongleftrightarrow:`	$A \xLongleftrightarrow[sub]{\text{we love to love}} Z$
`\xLeftrightarrow:`	$A \xLeftrightarrow[sub]{\text{we love to love}} Z$
`\xlongleftrightarrow:`	$A \xlongleftrightarrow[sub]{\text{we love to love}} Z$
`\xlongrightarrow:`	$A \xlongrightarrow[sub]{\text{we love to love}} Z$
`\xleftrightarrow:`	$A \xleftrightarrow[sub]{\text{we love to love}} Z$
`\xlongleftarrow:`	$A \xlongleftarrow[sub]{\text{we love to love}} Z$
(*amsmath*) `\xleftarrow:`	$A \xleftarrow[sub]{\text{we love to love}} Z$
(*amsmath*) `\xrightarrow:`	$A \xrightarrow[sub]{\text{we love to love}} Z$
`\xlongleftarrow:`	$A \longleftarrow Z$
`\xlongrightarrow:`	$A \longrightarrow Z$
(*amsmath*) `\xleftarrow:`	$A \leftarrow Z$
(*amsmath*) `\xrightarrow:`	$A \rightarrow Z$

Table 8.6: Extendible arrows of the extarrows package

8.17.1 Extensible arrows with the extarrows package

The amsmath package provides a few simple extendable arrows. The extarrows package is pretty much a supplement. It follows the same syntax of amsmath:

```
\arrowname[subscript]{superscript}
```

Examples are listed in table 8.6.

8.17.2 The harpoon Package

Let's talk a bit more about the notation for directed line segments. Some people do not like the notation $\overrightarrow{AB}$ and want a change. The harpoon package is a good choice.

```
$\overrightharp{AB}$, $\overleftharp{AB}$,
$\overrightharpdown{AB}$,
$\overleftharpdown{AB}$,
$\underrightharp{AB}$,
$\underleftharp{AB}$,
$\underrightharpdown{AB}$,
$\underleftharpdown{AB}$
```

$\overrightharp{AB}$, $\overleftharp{AB}$, $\overrightharpdown{AB}$, $\overleftharpdown{AB}$, $\underrightharp{AB}$, $\underleftharp{AB}$, $\underrightharpdown{AB}$, $\underleftharpdown{AB}$

8.18 Framed Math

You can use the '`\fbox`' command to get any inline equation framed. For example:

```
frame \fbox{$f(x)=\sqrt{x}$}!
```

Let's frame $f(x)=\sqrt{x}$!

Now let's do a more complex example:

```
ep=1mm \fboxrule=1mm
frame \fbox{$f(x)=\sqrt{x}$}!
```

Let's frame $f(x)=\sqrt{x}$!

After loading the color package, we can even frame an inline math formula in a colored box:

```
\colorbox{yellow}{ $f(x)=\sqrt{x}$}!
```

$f(x)=\sqrt{x}$!

Now let's do the same thing with displayed equation. Some good news for you: the `\fbox` command still works.

```
\fbox{\parbox{0.9\linewidth}{%
\begin{equation}
f(x)=\sqrt{x}\end{equation}}}
```

$$f(x)=\sqrt{x} \tag{8.23}$$

And `\colorbox` works as well:

```
\colorbox{yellow}{\parbox{0.9\linewidth}{%
\begin{equation}
f(x)=\sqrt{x}\end{equation}}}
```

$$f(x)=\sqrt{x} \tag{8.24}$$

If you don't want to frame the equation number, try the `\boxed` command provided by the amsmath package:

```
\begin{equation}
\boxed{W_t-F\subseteq V(P_i)\subseteq W_t}
\end{equation}
```

$$\boxed{W_t - F \subseteq V(P_i) \subseteq W_t} \qquad ($$

What if you want the box to be colored as well? We can try the empheq package. It supports different frames for math environments of the amsmath package.

```
\begin{empheq}[box=\fbox]{align}
f(x)=\int_1^\infty \frac{1}{x^2}\,\rd t=1
\end{empheq}
\begin{empheq}[box={\fboxsep=10pt
 \colorbox{yellow}}]{align}
f(x)=\int_1^\infty \frac{1}{x^2}\,\rd t=1
\end{empheq}
\begin{subequations}
\begin{empheq}[box={
\fboxsep=1pt\colorbox{cyan}}]{align}
f(x)&=\int_1^\infty
\frac{1}{x^2}\,\rd
   t=1\\
f(x)&=\int_2^\infty \frac{1}{x^2}\,\rd
   t=0.25
\end{empheq}
\end{subequations}
```

$$\boxed{f(x) = \int_1^\infty \frac{1}{x^2}\,\mathrm{d}t = 1} \qquad ($$

$$f(x) = \int_1^\infty \frac{1}{x^2}\,\mathrm{d}t = 1 \qquad ($$

$$f(x) = \int_1^\infty \frac{1}{x^2}\,\mathrm{d}t = 1 \qquad (8$$

$$f(x) = \int_2^\infty \frac{1}{x^2}\,\mathrm{d}t = 0.25 \qquad (8$$

8.19 Aligning Your Equations

Let's now turn to a variant of the `align` environment:

```
\begin{flalign}
x&=y & X&=Y & a&=b+c\\
x'&=y' & X'&=Y' & a'&=b
\end{flalign}
```

$$\begin{aligned} x &= y & X &= Y & a &= b + c && (8.29)\\ x' &= y' & X' &= Y' & a' &= b && (8.30) \end{aligned}$$

Isn't that smart? You can set the space between "column-pairs" by changing `\minalignsep`, whose default value is `10pt`.

```
\renewcommand\minalignsep{25pt}
\begin{flalign}
x&=y & X&=Y & a&=b+c\\
x'&=y' & X'&=Y' & a'&=b
\end{flalign}
```

$$\begin{aligned} x &= y & X &= Y & a &= b + c && (8.31)\\ x' &= y' & X' &= Y' & a' &= b && (8.32) \end{aligned}$$

OK, now you're ready for the following:

```
\begin{flalign}
x&=y && \text{by hypothesis}\tag{1}\\
x'&=y'&&\text{by definition}\tag{*}\\
x+x'&=y+y'&&\text{by Axiom 1}\tag{$*$}
\end{flalign}
```

$$\begin{aligned} x &= y && \text{by hypothesis} && (1)\\ x' &= y' && \text{by definition} && (*)\\ x + x' &= y + y' && \text{by Axiom 1} && (*) \end{aligned}$$

Notice the use of `\tag`.

8.20 Footnotes in Math Mode

Let's do something eccentric. If you want to add a footnote to a displayed equation, you'll find that the command `\footnote` works in a very *mysterious* way. The correct solution is to use the `\footnotemark` and `\footnotetext` commands.

For example, the following code:

```
\begin{verbatim}
\begin{displaymath}
a+b=c+d\footnotemark
\end{displaymath}
\footnotetext{Here comes the footnote
 in math mode. Hooray!!!}
\end{verbatim}
```

should give the following glorious output:

$$a + b = c + d^{2}$$

8.21 Equation Numbers

The first "crazy" thing you might want to do is to put the equation number on the left side of your document. To do this is easy—you just turn "on" the `leqno` option of your document class, e.g., `\documentclass[leqno]{article}`. The premise is that the document class in question provides the `leqno` option. If not, you can achieve this by giving options to your amsmath package. To place equation numbers on the left, say '`\usepackage[leqno]{amsmath}`'. To place equation numbers on the right, say '`\usepackage[reqno]{amsmath}`', which is the default value.

Going on, let's talk about the style of equation numbers. This book is prepared with the standard LaTeX book class. Equation numbers take the form "chapter number + equation number within the chapter." You can change this by redefining the `\theequation` command. For example,

```
\renewcommand\theequation{
\thesection-\roman{equation}}
\begin{equation}
a+b=c+d
\end{equation}
```

$$a + b = c + d \qquad \text{(8.21-xxxiii)}$$

If you want to make the equation numbers to go like "chapter number + equation number within section," the amsmath package provides a useful command:

`\numberwithin{equation}{section}.`

Another topic: sub-equations. The amsmath package provides some useful commands:

2 Here comes the footnote in math mode. Hooray!!!

```
\begin{subequations}
\begin{align}
y&=d\\
y&=cx+d\\
y&=bx^2+cx+d\\
y&=ax^3+bx^2+cx+d
\end{align}
\end{subequations}
```

$$y = d \tag{8}$$
$$y = cx + d \tag{8}$$
$$y = bx^2 + cx + d \tag{8}$$
$$y = ax^3 + bx^2 + cx + d \tag{8}$$

OK, now let's try modifying the equation numbers of the sub-equations:

```
\renewcommand\theequation{%
\theparentequation{}-\arabic{equation}}
\begin{subequations}
\begin{align}
y&=d\\
y&=cx+d\\
y&=bx^2+cx+d\\
y&=ax^3+bx^2+cx+d
\end{align}
\end{subequations}
```

$$y = d \tag{34-}$$
$$y = cx + d \tag{34-}$$
$$y = bx^2 + cx + d \tag{34-}$$
$$y = ax^3 + bx^2 + cx + d \tag{34-}$$

8.21.1 Prime Equation Numbers

```
First an equation.
\begin{equation}\label{e:previous}
A=B
\end{equation}
That was equation \eqref{e:previous}.

Then the same, with a prime on the number.
\begin{equation}
\tag{\ref{e:previous}$'$}
\label{e:prevprime}
C=D
\end{equation}
And that was equation \eqref{e:prevprime}.
```

First an equation.

$$A = B \tag{8.36}$$

That was equation (8.36).

Then the same, with a prime on the number.

$$C = D \tag{8.36′}$$

And that was equation (8.36′).

Notice, by the way, that when a `\ref` occurs inside a `\tag`, and that `\tag` is then `\label`'d, a `\ref` for the the second `\label` requires *three* runs of LaTeX in order to get the proper value. (If you run through the logic of LaTeX's cross-referencing mechanisms as they apply in this case, you will see that this is necessary.) Note the use of `\eqref`: instead of simply giving the "number," it also enclose the equation number in parentheses.

8.21.2 Equation Numbers on Both Sides

I don't know why anyone wants to do this, but here is the solution just in case.[3]

3 Provided by mytex of the CTEX Community.

```
\makeatletter
\def\xlabel#1#2{%
{\@bsphack\protected@write\@auxout{}%
{\string\newlabel{#2}{{#1}{\thepage}}}%
\@esphack}{\mathrm(#1)}}
\makeatother

\begin{flalign}
\xlabel{H1}{eq:refL}&&x=y+z&&
                \label{eq:ee1}\\
\xlabel{H2}{eq:xxy}&&a=b^2+c^2-a&&
                \label{eq:ee2}
\end{flalign}
```

$$(H1) \qquad x = y + z \qquad (1)$$
$$(H2) \qquad a = b^2 + c^2 - a \qquad (2)$$

8.21.3 Equation numbers with the subeqnarray package

The subeqnarray package defines the `subeqnarray` and `subeqnarray*` environments, which behave like the equivalent `eqnarray` and `eqnarray*` environments, except that the individual lines are numbered like 1a, 1b, 1c, etc. Here's an application:

```
\begin{subeqnarray}
\label{eqw} \slabel{eq0}
 x & = & a \times b \\
\slabel{eq1}
 & = & z + t\\
\slabel{eq2}
 & = & z + t
\end{subeqnarray}
The first equation is number~\eqref{eq0},
the last is~\eqref{eq2}. The
equation as a whole can be referred to as
equation~\eqref{eqw}.
```

$$x = a \times b \qquad (8.37a)$$
$$= z + t \qquad (8.37b)$$
$$= z + t \qquad (8.37c)$$

The first equation is number (8.37a), the last is (8.37c). The equation as a whole can be referred to as equation (8.37).

Exercise

1. There is a more powerful package called subeqn. Study it!

8.22 A List of Options of the amsmath Package

The amsmath package has the following options:

- `centertags`
  (default) Place equation numbers vertically centered on the total height of the equation when using the `split` environment.

- `tbtags`
  If the equation numbers are on the right, place equation numbers level with the last line. If the equation numbers are on the left, place equation numbers level with the first line.

- `sumlimimts`
  (default) Place the subscripts and superscripts of summation symbols above and below, in displayed equations. It also affects other symbols of the same type, e.g., $\prod$, $\bigotimes$. However, it doesn't affect integrals.

- `nosumlimits`
  Place the subscripts and superscripts of summation-type symbols to the side, even in displayed equations.

- `intlimits`
  It is just like `sumlimits`, but it works for integral symbols.

- `nointlimits`
  (default) Opposite of `intlimits`.

- `namelimits`
  (default) It is just like `sumlimits`, but it works for functions, e.g., det, lim, etc., which traditionally have subscripts placed underneath when they occur in a displayed equation.

- `nonamelimits`
  You can guess its function, can't you?

8.23 Commutative Diagrams—The amscd Package

Some commands for producing simple commutative diagrams based on arrays are available in the amscd package. It provides some useful shorthand forms for specifying the decorated arrows and other connectors.

In the `CD` environment the notations `@>>>`, `@<<<`, `@VVV`, and `@AAA` give right, left, down, and up arrows, respectively. For example,

```
\[\begin{CD}
\cov(L) @>>> \non(K) @>>> \cf(K)\\
@VVV @AAA @AAA \\
\add(L) @>>> \add(K) @>>> \cov(K)\\
\end{CD}\]
```

$$\begin{array}{ccccc} \mathrm{cov}(L) & \longrightarrow & \mathrm{non}(K) & \longrightarrow & \mathrm{cf}(K) \\ \downarrow & & \uparrow & & \uparrow \\ \mathrm{add}(L) & \longrightarrow & \mathrm{add}(K) & \longrightarrow & \mathrm{cov}(K) \end{array}$$

Decorations on the arrows are specified as follows. For the horizontal arrows, material between the first and second `>` or `<` symbols will be typeset as a superscript, and material between the second and third will be typeset as a subscript. Similarly, material between the first and second, or second and third, `A`s or `V`s of vertical arrows will be typeset as left or right "side-scripts".

The notations `@=` and `@|` give horizontal and vertical double lines.

A "null arrow" (produced by `@`) can be used instead of a visible arrow to fill out an array where needed.

```
in{CD}
Lambda}\otimes T @>j>>
\\
VV{\mathop{\rm End} P}V\\
mes T)/I @= (Z\otimes T)/J
D}\]
```

$$\begin{array}{ccc} S^{W_\Lambda}\otimes T & \xrightarrow{j} & T \\ \downarrow & & \downarrow{\scriptstyle \mathrm{End}\,P} \\ (S\otimes T)/I & = & (Z\otimes T)/J \end{array}$$

8.24 Coloring Your Math—The color Package

There is no difference in producing colored text and colored math expression. With the color package, you can do this:

```
{equation}
olor{blue}{f(x)}=\int_1^\infty
tcolor{red}{\frac{1}{x^2}}\,\rd x=1
quation}
```

$$f(x) = \int_1^\infty \frac{1}{x^2}\,\mathrm{d}x = 1 \qquad (8.38)$$

8.25 Packages Smarter Than Me

8.25.1 The polynom package

Here comes a package that is better at math than I am. An example should shed some light on its usage:

```
\polylongdiv{x^3+x^2-1}{x-1}
```

$$\begin{array}{r|l} & x^2+2x+2 \\ \hline x-1 & x^3+x^2-1 \\ & -x^3+x^2 \\ \hline & 2x^2 \\ & -2x^2+2x \\ \hline & 2x-1 \\ & -2x+2 \\ \hline & 1 \end{array}$$

Here are more examples:

```
\polyhornerscheme[x=1]{x^3+x^2-1}
```

$$\begin{array}{c|cccc} & 1 & 1 & 0 & -1 \\ 1 & & 1 & 2 & 2 \\ \hline & 1 & 2 & 2 & 1 \end{array}$$

```
\polyfactorize{2x^3+x^2-7x+3}
```

$$2\left(x-\tfrac{1}{2}\right)\left(x+\tfrac{1}{2}+\tfrac{\sqrt{13}}{2}\right)\left(x+\tfrac{1}{2}-\tfrac{\sqrt{13}}{2}\right)$$

Also, the output of `\polylonggcd{(x-1)(x-1)(x^2+1)}{(x-1)(x+1)(x+1)}` is:

$$x^4 - 2x^3 + 2x^2 - 2x + 1 = \left(x^3 + x^2 - x - 1\right) \cdot \left(x - 3\right) + \left(6x^2 - 4x - 2\right)$$
$$x^3 + x^2 - x - 1 = \left(6x^2 - 4x - 2\right) \cdot \left(\tfrac{1}{6}x + \tfrac{5}{18}\right) + \left(\tfrac{4}{9}x - \tfrac{4}{9}\right)$$
$$6x^2 - 4x - 2 = \left(\tfrac{4}{9}x - \tfrac{4}{9}\right) \cdot \left(\tfrac{27}{2}x + \tfrac{9}{2}\right) + 0$$

8.25.2 The longdiv package

The longdiv is actually a TEX package. So you should load it with '`\input longdiv.tex`'. Now take a look at what you can do with it:

```
\longdiv{31415}{2}
```

$$\begin{array}{r} 15707 \\ 2\overline{)\,31415} \\ \underline{20000} \\ 11415 \\ \underline{10000} \\ 1415 \\ \underline{1400} \\ 15 \\ \underline{14} \\ 1 \end{array}$$

8.26 The mathlig Package

The mathlig is a TEX package and should be loaded by '`\input mathlig.tex`'. It can produce special "math ligatures," like these:

```
\mathlig{->}{\rightarrow}
\mathlig{<-}{\leftarrow}
\mathlig{<->}{\leftrightarrow}
$->$, $<-$, $<->$
```

$\rightarrow$, $\leftarrow$, $\leftrightarrow$

8.27 Miscellaneous

8.27.1 Canceling out—The cancel Package

Another short section. (Happy?) After loading the cancel package, you can do this:

```
\[f(x)=\frac{(x^2+1)\cancel{(x-1)}}
{\cancel{(x-1)}(x+1)}\]
```

$$f(x) = \frac{(x^2+1)\cancel{(x-1)}}{\cancel{(x-1)}(x+1)}$$

8.27.2 The units and nicefrac Packages

About the loading of the packages: (1) When you load the units package, the nicefrac package is loaded automatically; (2) The units package itself has two options, `tight` and `loose`. The default value, `tight`, indicates a thin space will be added between the number and the unit. The option `loose` will add a normal word spacing between the number and the unit. You should remember that I have said that a thin space is

preferable! (3) The nicefrac package has two options, `nice` and `ugly`. We'll talk a little bit about them in a short while. (4) Options specified for the units package will be passed on to the nicefrac package. (5) The nicefrac package can be used independently.

Let's now take a look how this package can be used. Suppose no options are specified; i.e., the options `tight` and `nice` are used, this is what you are going to get:

```
20]{cm}\\
rac[20]{m}{s}\\
rac[\textsf]{m}{s}
```

20 cm
20 m/s
m/s

However, if the `\ugly` option is specified, the command `\unitfrac[20]{m}{s}` will produce 20 m/s.

My recommendation is to use `\usepackage[ugly]{units}` which would produce the output I've been proposing in this book.

8.27.3 Math in Titles—The maybemath Package

The maybemath package provides a set of commands for adjusting math mode typesetting to match the context of the surrounding paragraph.

For context-sensitive boldness use `\maybebm`:

```
 $x^2+\maybebm{x^3}+\cdots$\\
f{$x^2+\maybebm{x^3}+\cdots$}
```

Normal $x^2 + x^3 + \cdots$
$x^2 + \boldsymbol{x^3} + \cdots$

For context-sensitive upright math typesetting use `\mayberm`:

```
Normal $x^2+\mayberm{x^3}+\cdots$\\
\textit{$x^2+\mayberm{x^3}+\cdots$}
```

Normal $x^2 + \mathrm{x}^3 + \cdots$
$x^2 + x^3 + \cdots$

Alternatively, to force `\mathit` in italic contexts use `\maybeit`:

```
Normal $x^2+\maybeit{x^3}+\cdots$\\
\textit{$x^2+\maybeit{x^3}+\cdots$}
```

Normal $x^2 + x^3 + \cdots$
$x^2 + x^3 + \cdots$

The functionality of both `\mayberm` and `\maybeit` is combined for convenience in the command `\maybeitrm`:

```
Normal $x^2+\maybeitrm{x^3}+\cdots$\\
\textit{$x^2+\maybeitrm{x^3}+\cdots$}
```

Normal $x^2 + \mathrm{x}^3 + \cdots$
$x^2 + x^3 + \cdots$

For context-sensitive sans-serif math typesetting use `\maybesf`:

```
Normal $x^2+\maybesf{x^3}+\cdots$\\
\textit{$x^2+\maybesf{x^3}+\cdots$}
```

Normal $x^2 + x^3 + \cdots$
$x^2 + x^3 + \cdots$

For combined bold-and-sans-serif context handling, a `\maybebmsf` command is provided:

```
Normal $x^2+\maybebmsf{x^3}+\cdots$\\
\textbf{$x^2+\maybebmsf{x^3}+\cdots$}\\
\textsf{$x^2+\maybebmsf{x^3}+\cdots$}\\
\textbf{\textsf{$x^2+\maybebmsf{x^3}+
     \cdots$}}
```

Normal $x^2+x^3+\cdots$
$x^2+\boldsymbol{x^3}+\cdots$
$x^2+\mathsf{x}^3+\cdots$
$x^2+\mathbf{x^3}+\cdots$

The most important application of this package is to control the font in titles. If you are using the default book or article class files, type things like '`\section{... $\maybebm{...}$}`' to get the correct font.

8.27.4 The nccmath Package

The nccmath package extends the amsmath package. It also improves spacing control before display equations and fixes a bug of ignoring the `\displaybreak` in the amsmath version of the `equation` environment.

Its first feature is a modification to the `\intertext` command:

```
\begin{align*}
a+b&=c+d.
\intertext[1cm]{Therefore,}
e+f&=g+h.
\end{align*}
```

$$a+b=c+d.$$

Therefore,

$$e+f=g+h.$$

As you can see, the additional option can specify a vertical space inserted before and after the text. If it is omitted, standard TEX's skips are inserted.

It also allows you to create a series of medium-sized mathematics:

```
\[\medmath{\cfrac{1}{\sqrt 2 +
      \cfrac{1}{\sqrt 2 +\dotsb}}}
\quad \cfrac{1}{\sqrt 2 +\cfrac{1}
       {\sqrt 2 +\dotsb}}\]
```

$$\medmath{\cfrac{1}{\sqrt 2+\cfrac{1}{\sqrt 2+\dotsb}}} \quad \cfrac{1}{\sqrt 2+\cfrac{1}{\sqrt 2+\dotsb}}$$

Now medium-sized operators:

```
$\sum_{i=1}^n \medop\sum_{i=1}^n
\displaystyle\sum\nolimits_{i=1}^n$
\quad $\sum\limits_{i=1}^n
\displaystyle \medop\sum_{i=1}^n
\sum_{i=1}^n$
```

$$\sum_{i=1}^n \medop\sum_{i=1}^n \displaystyle\sum\nolimits_{i=1}^n \quad \sum\limits_{i=1}^n \displaystyle \medop\sum_{i=1}^n \sum_{i=1}^n$$

There are also commands for producing medium-sized integral, fractions, binomial coefficient, and matrix.

```
a^b\medint\int_a^b
laystyle\int_a^b$\quad
_a^b\medint\iint_a^b$
```

$$\int_a^b \int_a^b \int_a^b \quad \iint_a^b \iint_a^b$$

```
{x+y}{a-b} \mfrac{x+y}{a-b}
ac{x+y}{a-b}$\quad
m{n}{k} \mbinom{n}{k}
nom{n}{k}$
```

$$\frac{x+y}{a-b}\ \mfrac{x+y}{a-b}\ \mfrac{x+y}{a-b} \quad \binom{n}{k}\ \mbinom{n}{k}\ \mbinom{n}{k}$$

```
(\begin{smallmatrix}  a&b\\c&d
mallmatrix}\bigr)$
(\begin{mmatrix}  a&b\\c&d
matrix}\Bigr)$
n{pmatrix}  a&b\\c&d
matrix}$
```

$$\left(\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right)\ \left(\begin{mmatrix} a & b \\ c & d \end{mmatrix}\right)\ \begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

This package actually has more features. Please refer to ftp://ftp.sunsite.utk.edu/pub/CTAN/macros/latex/contrib/ncctools/doc/nccmath.pdf.

8.28 Two Powerful Packages Mentioned Merely in Passing

There are two more amazing, brilliant packages I really want to show you. However, they cause some compatibility issues which disturb the compilation of my book. What's more, they themselves come with easy-to-read and well-written documentations. Anyway, I'd like to give you an overview.

The first package to mention is the nath package. Here is an excerpt from the documentation of the package:

> Nath is a LaTeX style to separate presentation and content in mathematical typography. The style delivers a particular context-dependent presentation on the basis of a rather coarse context-independent notation. Although essentially backward compatible with LaTeX, Nath aims at producing traditional math typography even from sources devoid of aesthetic ambitions. Its name is derived from "*na*tural ma*th* notation."

This description is quite accurate: The nath package has quite some compatibility issues, but its functions are amazing! I strongly recommend that you read its marvelous documentation, which could be obtained at http://texcatalogue.sarovar.org/entries/nath.html.

Another one is the mathenv package, which can ease your work to a large extent. The documentation is available at ftp://ftp.sunsite.utk.edu/pub/CTAN/macros/latex/contrib/bosisio/mathenv
.html.

✌

9

Tables and Graphics

9.1 External graphics are a lot of fun

Graphics are always a good thing—they are not miserable to look at, they increase the length of your paper dramatically.... They are just great!

In Microsoft Word, you can insert a graphics by "drag-and-drop." In LaTeX, you don't even need to drag and drop. For example, if you have a photo named `ColinLee.jpg`, you need to: 1) drag and picture into the folder where the TeX file you're compiling lives, 2) load the grahpicx package, and 3) now you could insert the picture into your document like this:

```
\includegraphics[width=3cm]{ColinLee.jpg}
```

This book recommends that you use the PDF-LaTeX typesetting engine which support JPEG and PDF files pretty well. If you're using the default LaTeX engine, your best choice is to use EPS files. If you use files that are not in the EPS format, you'll have to specify the bounding box yourself or create a `.bb` file to help LaTeX decides the bounding box of the image. On the contrary, PDF-LaTeX does not support EPS files.

As you've seen in the example, the `\includegraphics` command could be followed by optional argument. `width` is one of them; there are also `height`, `totalheight`, `scale` (this should be a number), `angle`, `origin` (the point that the image rotates along) and `bb`.

bb=10 20 100 200 sets the left bottom point of the bounding box to be $(10, 20)$ and the top right point to be $(100, 200)$.

9.2 Structuring a table

We get started with a simple table that illustrates most of LaTeX's own commands for constructing tables.

```
\begin{tabular}{|r|c|r|}
\hline
\multicolumn{3}{|c|}{AT\&T Common Stock}\\
\hline
Year & Price & \multicolumn{1}{c|}{Dividend}\\
\hline
1971 & 41--54 & \$2.60\\\hline
2 & 41--54 & 2.70\\\cline{2-3}
3 & 46--55 & 2.97\\\hline
\end{tabular}
```

AT&T Common Stock		
Year	Price	Dividend
1971	41–54	$2.60
2	41–54	2.70
3	46–55	2.97

As you can see, a table is created with the `tabular` environment. We set up the general layout of the table by providing special argument right after `\begin{tabular}`, using a combination of `c` (centered), `r` (right-aligned), `l` (left-aligned), and `p{width}` (a column with automatic line breaks to cater to the specified width). Vertical lines are specified with '`|`'.

Columns are separated with `&` (You don't need to put a `&` before the first column though). In other words, a `&` indicates a jump to the next column. `\\` simply starts a new row and the `\hline` command produces a horizontal line. Of course, two `\hline`'s produce two consecutive horizontal lines. Sometimes, you might want a horizontal line for just a few of the columns; this is done with the "`\cline{`*a*`-`*b*`}`" command, where *a* is the index number of starting column, and *b* is the number of the ending column. For instance, in our example, `\cline{2-3}` produces a partial horizontal line under the second and the third columns.

We could "merge cells" with `\multicolumn{`*number*`}{`*position*`}{`*text*`}`. The *number* parameter specifies the total number of cells to merge; the *position* parameter specifies how to align the text in the cell; and of course, you need to provide what text to be placed in the merged cell. You might be wondering why I "merged" one cell in the example. The reason is that all the text in this column has been specified to be right-aligned, and I want to center the text in this cell. The `\multicolumn` command provides a perfect work around.

There's one more thing that can be useful in specifying the general layout of the table: `@{...}`. It eliminates the space between any two columns and replaces it with the `...` that you provide. As you could imagine, if you say `r@{}l`, then the right-aligned column will literally "kiss" the left-aligned column. Here's a very good example from *The Not So Short Introduction to LaTeX 2ε* with some minor modification:

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

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

A recent trend is that the design of tables is getting simpler—most modern tables have no vertical lines and few horizontal lines (like the ones you've seen in this book). LaTeX is quite capable of producing these tables, but the `booktabs` provides a few commands that is going to ease your work a lot!

Table 1: The ISOGRK3 entity set

Entity	Unicode Name	Unicode
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA

Continued on next page

Continued from previous page

Entity	Unicode Name	Unicode
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
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alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA
alpha	GREEK SMALL LETTER ALPHA	03BA

Figure 9.1: Tables that travel a long way

```
\tiny
\def\figurespace{\phantom{0}}

\begin{tabular}{@{}crrrr@{}}
\toprule
&\multicolumn{2}{c}{Export contracts (\%)}
&\multicolumn{2}{c}{Import contracts (\%)}\\
\cmidrule(lr){2-3} \cmidrule(l){4-5}
Year & In yen & In dollars
     & In yen & In dollars\\
\midrule
1970 & \figurespace0.9 & 90.4 & 0.3 & 80.0\\
1975 & 17.5 & 78.0 & 0.9 & 89.9\\
1980 & 28.9 & 66.3 & 2.4 & 93.1\\
\bottomrule
\end{tabular}
```

	Export contracts (%)		Import contracts (%)	
Year	In yen	In dollars	In yen	In dollars
1970	0.9	90.4	0.3	80.0
1975	17.5	78.0	0.9	89.9
1980	28.9	66.3	2.4	93.1

The commands `\toprule`, `\midrule`, and `\bottomrule` are self-explanatory. The `\cmidrule` is like `\cline`, but you could use `r` and `l` put in parentheses to specify which side of the line to truncate.

9.3 Tables that travel a long way

After loading the longtable package, the work is easy:

```
\begin{longtable}{@{}lll@{}}
\caption{The ISOGRK3 entity set}\\
\toprule
Entity & Unicode Name &  Unicode \\ \midrule
\endfirsthead
\multicolumn{3}{r}{Continued from previous page}\\
\toprule
Entity & Unicode Name &  Unicode \\ \midrule
```

Figure 9.2: A picture of Colin and his super friend, Lee.

```
\endhead
\midrule
\multicolumn{3}{r}{Continued on next page}
\endfoot
\bottomrule
\endlastfoot
alpha & GREEK SMALL LETTER ALPHA & 03BA\\
alpha & GREEK SMALL LETTER ALPHA & 03BA\\
alpha & GREEK SMALL LETTER ALPHA & 03BA\\
alpha & GREEK SMALL LETTER ALPHA & 03BA\\
alpha & GREEK SMALL LETTER ALPHA & 03BA\\
alpha & GREEK SMALL LETTER ALPHA & 03BA\\
......
```

9.4 Floating tables and figures around

Using `\begin{tabular}` and `\includegraphics` orders LaTeX to place the table and image "here," and without a caption. But most publications today require a more flexible mechanism—tables and figures are hardly placed right after a paragraph, and it is generally agreed that such statements as "Refer to the figure below:" are bad and should be replaced with something similar to "Refer to figure 3.14." Luckily, LaTeX is born with the support for such "floating bodies."

A floating figure is created with the `figure` environment and a floating table is constructed with `table`.

For example, figure 9.2 is created with

```
\begin{figure}[bt]
\includegraphics[width=3cm]{ColinLee.jpg}
\caption{A picture of Colin and his super friend, Lee.}
\label{samplefigure}
\end{figure}
```

Similarly, you can create a floating table with something like:

```
\begin{table}[tbhp]
\centering
\caption{...}
\begin{tabular}
...
\end{tabular}
\end{table}
```

Table 9.1: Parameters for controlling the float bodies.

`topnumber`	The maximum number of floats allowed at the top of the page (default to 2). It can be changed with `\setcounter`.
`bottomnumber`	The maximum number of floats allowed at the bottom of the page (default to 1). It can be changed with `\setcounter`.
`totalnumber`	The maximum number of floats allowed on a page (default to 3). It can be changed with `\setcounter`.
`\topfraction`	Maximum fraction of the page that can be occupied by floats at the top of the page (default to 0.7). It can be changed with `\renewcommand`.
`\bottomfraction`	Maximum fraction of the page that can be occupied by floats at the bottom of the page (default to 0.3). It can be changed with `\renewcommand`.
`\floatsep`	Rubber length specifying the vertical space added between floats (default to `12pt plus 2pt minus 2pt` for 10 pt and 11 pt documents, and `14pt plus 2pt minus 4pt` for 12 pt documents). This can be changed with `\setlength`.
`\textfloatsep`	Rubber length specifying the vertical space added between floats and the text (default to `20pt plus 2pt minus 4pt`).
`\intextsep`	Rubber length specifying the vertical space added below and above a float that is positioned in the middle of the text.

You might have noticed that there are a few optional arguments immediately following `\begin{table}` and `\begin{figure}`. There are actually give of them in total and you can use a combination of any one of them. `t` stands for top, `b` for bottom, `p` for page, `h` for here, and `!` means to ignore most of the internal parameters (e.g., the maximum number of floats allowed on a page). Then `[tb]` means that LaTeXcould place the figure at the top or at the bottom of a page. Note that `h` doesn't necessarily mean that LaTeX will place the figure here, but that LaTeX will try its best to put it here. If the page doesn't have enough space to hold the figure, a different parameter will be chosen.

Table 9.1 lists some of the most important parameters for controlling the floating environments.

9.5 Customizing your captions

Captions can be easily customized with the caption package.

All the most useful parameters are listed in table **??**.

caption2 used to be my choice, but it is not obsolete. Sigh ...

You could pass these options to the package itself, like what you do with the geometry package. For example, the following code is legitimate:

```
\usepackage[textfont={rm,it},labelfont{sf}]{caption}
```

An alternative is to use the `\captionsetup` command:

```
\captionsetup[type]{option-value-list}
```

The advantage is that you'll be able to specify the "type" of caption that you want to define. For example, if you say `\captionsetup[figure]`, only the caption of figures will be affected.

Table 9.2: Parameters for changing captions.

Parameter	Explanation
`singlelinecheck`	Checks if the whole option fits on a single line. If so, it will be centered.
`format`	The `default` format is the the standard LaTeX format. The alternative is `hang`, which specifies that the caption be set with the label to the left of the caption text; i.e., continuation lines are indented by the width of the label.
`margin, width`	Sets the width and the margin of the caption.
`indentation`	Sets the indentation of continuation lines.
`font`	Defines the font characteristics for the entire caption. It can take a set of keywords values including `rm`, `sf`, `tt`, `md`, `bf`, `up`, `it`, `sl`, `sc`, `scriptsize`, `footnotesize`, `small`, `normalsize`, `large`, or `Large`. For example, `font={sf,bf}` sets the caption in the bold sans serif typeface.
`labelfont`	Sets the font of the label.
`textfont`	Sets the font of the text of the caption.
`labelsep`	Sets the separation between the label and the text. Keywords include `colon`, `period`, `space`, and `newline`.
`justification`	Specifies how the paragraph should be justified. Available keywords are `raggedleft`, `raggedright`, `centerfirst`, and `centerlast`.
`parskip`	Sets the space between paragraphs in multi-paragraph captions.
`aboveskip`	Sets the space between the caption and float body.
`belowskip`	Space on the opposite side of the caption.

The captions in this book are set up with the following code:

```
\DeclareCaptionFont{blue}{\color{blue}}
\captionsetup{justification=raggedright,
              singlelinecheck=false,font={blue,sf,small}}
```