

# Another Short Tutorial for L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>

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# 1 Introduction

Let's begin thinking about  $\text{\LaTeX} 2_{\epsilon}$  by considering the concept of *easy*. We don't often think of easiness as having a context, but it certainly does. For example, which is easier to use, a shovel and wheelbarrow, or an excavator and dump truck? If we were digging a hole to plant a bush we would choose the former, but if we were digging a swimming pool we would choose the latter. Again, which is easier to use, a pickup truck or an eighteen wheeler? If we were hauling a few garden supplies we would choose the former, but if we were hauling electric generators to California, we would choose the latter. Which is easier to use, a word processing program (e.g., Microsoft Word), or a professional typesetting program (e.g.,  $\text{\LaTeX} 2_{\epsilon}$ )? If we were writing a letter or a grocery list, we would choose the former, but if we were writing a mathematical, scientific, or engineering document, we would choose the latter. I can't say whether one choice is "easier" than the other, but I can say that it's easier to use the right tool for the job than to attempt a task using the wrong tool. It's in this spirit that I offer this tutorial.

This is a short, easy, nontechnical introduction to  $\text{\LaTeX} 2_{\epsilon}$ . It's a tutorial designed for students who do not have a lot of time, who do not need to become overnight experts in  $\text{\LaTeX} 2_{\epsilon}$ , and prefer a shallow learning curve to a boot camp approach. After you have worked through it, you will be able to create professional documents, and have the ability to teach yourself how to extend your  $\text{\LaTeX} 2_{\epsilon}$  skills — to become a  $\text{\LaTeX} 2_{\epsilon}$  guru if you want to or need to.

**What about  $\text{\LaTeX} 2_{\epsilon}$ ?** First, it's *free* in the sense that you do not have to pay for it. Second, it's *easy*, given that you know how to use it. As always, there are trade-offs, and "easy" to an expert tends to be hard for a beginner, and *vice versa*. Third, it's *stable*, the first version released in 1985. Fourth, it's *well documented*, not surprising since its purpose is document preparation. Fifth, it's *professional*, as you will soon come to see. Finally,  $\text{\LaTeX} 2_{\epsilon}$  is *universal*. It's pretty much everywhere, and can be reliably found on any computer that you use to do real work. I will touch on these points from time to time in this tutorial.

**How does this introduction work?** Each "lesson" consists of the introduction of a few commands, some text to copy, paste, and compile, and a couple of questions. Each lesson should not take more than fifteen minutes to complete. It uses the "baby talk" principle — you imitate what you see and explore it by making slight changes. If you complete one lesson a day, within several weeks you will have a good foundation with  $\text{\LaTeX} 2_{\epsilon}$ , and begin to create professional quality documents. You will also see how the things I wrote in the preceding paragraph are true.

Please note that this tutorial *is not* a  $\text{\LaTeX} 2_{\epsilon}$  reference; you will need to find a good reference that details the options and arguments for each command. It's also not a user guide. Nor is it a full introduction to  $\text{\LaTeX} 2_{\epsilon}$ , although it will introduce it to students not previously familiar with it. It gives an idiosyncratic view of  $\text{\LaTeX} 2_{\epsilon}$  (my own). It promises only to be short, easy, and useful, not long-winded or difficult, even if it does omit some necessary details.

## 2 Document Basics

A `tex` document consists of plain text, and special characters, commands, and environments. I will generally refer to special characters, commands, and environments with the word *commands*; you don't need to know the difference between them now, but you shortly will without being told. You *must* precede commands with a backslash (`\`) for the compiler to know that they are commands. This is easy to forget, so I will remind you the first couple of times.

**What should I have?** You should have a working  $\text{\LaTeX} 2_{\epsilon}$  program. If you do not have one, see Appendix A below on page 60. You will also need a text editor, and you will probably want to get an integrated editor, compiler, and printer. See Appendix B on page 60. You can also use the old fashioned command line, I cover this in Appendix C on page 60.

### 2.1 Basic document

- `documentclass`
- `begin/end` document
- plain text
- comments

A basic document begins with a document class, and has a preamble and contents. Type (or copy) the following, save it as a `.tex` document and compile it. The percent signs (%) are comments and do not have any effect on the document.

```
\documentclass{article}
    %this is the preamble
\begin{document}
    %this is the contents section
    It works! %plain text prints as it
\end{document}
```

**Exercise:**  $\text{\LaTeX} 2_{\epsilon}$  has a number of different document classes. Name four of them.

**Exercise:** A `documentclass` command can take optional arguments, like this: `documentclass[optional arguments]{document class}`.<sup>1</sup> Name two optional arguments.

---

<sup>1</sup>Don't forget to type a backslash before the command, like this: `\documentclass`

## 2.2 Basic title

- title
- author
- date
- maketitle

A basic document usually title and author information in the preamble. You specify the title with the `\title` command. You specify the author(s) with the `\author` command. You may optionally specify a date with the `\date` command. In the body of the document, you create the title with the `\maketitle` command. Create and compile a second document like this:

```
\documentclass{article}
  \title{Title, Author, and Date}
  \author{Charles Carter}
  \date{July 4, 1776}
\begin{document}
  \maketitle{}
  This document has a title, author, and date.
\end{document}
```

**Exercise:** What happens if you use the command `\today{}`<sup>2</sup> as the date parameter (replacing July 4, 1776)?

**Exercise:** What happens if you use the command `\thanks{email address}`<sup>3</sup> after your name in the `\author{}` command?

## 2.3 Basic sections

- section
- subsection
- subsubsection
- label

L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> provides a number of useful section levels, including part and chapter. Two of the most useful are `section` and `subsection`. Create and compile the following document.

---

<sup>2</sup>Remember, `\date{}`

<sup>3</sup>`\thanks{}`

The `label{}` is used to create cross-references in documents. It's also very helpful in organizing your thoughts. The argument to `label{argument}` does not appear in the document. I cover the `ref` and `pageref` commands below in subsection 4.2 on page 23. These are used to create references back to the label.

```
\documentclass{article}
  \title{Basic Sections}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:** What do the commands `subsection{}` and `subsubsection{}` do?

**Exercise:** What does `section*{}` do? Note the asterisk (\*) after `section`. You can also use this starred version for `subsections` and `subsubsections`.

## 2.4 Basic paragraphs

- paragraph
- subparagraph

We have reached the point where you need some real content. I will use the text of Abraham Lincoln's Gettysburg Address to illustrate paragraphs. Notice that ordinary paragraphs do not need a special command – the “paragraph command” is simply two blank lines to create an empty new line between the paragraphs, as if they were double spaced. Create and compile the following document.

```
\documentclass{article}
  \title{Basic Paragraphs}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
```

Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty, and dedicated to the proposition that all men are created equal.

Now we are engaged in a great civil war, testing whether that nation, or any nation so conceived and so dedicated, can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field, as a final resting place for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this.

But, in a larger sense, we can not dedicate, we can not consecrate, we can not hallow this ground. The brave men, living and dead, who struggled here, have consecrated it, far above our poor power to add or detract. The world will little note, nor long remember what we say here, but it can never forget what they did here. It is for us the living, rather, to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us, that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion, that we here highly resolve that these dead shall not have died in vain, that this nation, under God, shall have a new birth of freedom, and that government of the people, by the people, for the people, shall not perish from the earth.

```
\section{Conclusion}
\label{Conclusion}
\end{document}
```

**Exercise:** What happens if you include the `paragraph{}` or `subparagraph{}` commands before each paragraph?

**Exercise:** What happens if you include arguments with the `paragraph{argument}` or `subparagraph{argument}` commands?

## 2.5 Basic packages

- `usepackage`
- `lipsum`

Much of L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> functionality is contained in external packages. To use this functionality, you include the command `usepackage{}` in the preamble. Of course, you first have to install the package on your computer, but the MiKTeX distribution does that automatically. The `lipsum` package generates generic text (in Latin, of course). The `lipsum{}` command generates text. Notice that you can control the

number of paragraphs to include. Below, I have included paragraph 1 in the introduction, paragraphs 2 through 4 in the body, and paragraph 5 in the conclusion.

Notice the paragraph indentation. First paragraphs are *not* indented. Following paragraphs *are* indented. This is normal typographic practice.

```
\documentclass{article}
  \usepackage{lipsum}
  \title{Using Packages}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \lipsum[1]{}
  \section{Body}
  \label{Body}
  \lipsum[2-4]{}
  \section{Conclusion}
  \label{Conclusion}
  \lipsum[5]{}
\end{document}
```

**Exercise:** What is CTAN, the Comprehensive T<sub>E</sub>X Archive Network? How many packages are currently on CTAN?

**Exercise:** What are the most popular L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> packages?

## 2.6 Basic contents

- tableofcontents

Creating a table of contents is easy. Just include the `tableofcontents{}` command. You may have to compile the document twice to ensure that the table of contents is generated properly.

```
\documentclass{article}
  \usepackage{lipsum}
  \title{Table of Contents}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \tableofcontents{}
  \section{Introduction}
  \label{Introduction}
  \lipsum[1]{}
\end{document}
```



```

\section{Body}
\label{Body}
\lipsum[2-4]{}
\section{Conclusion}
\label{Conclusion}
\lipsum[5]{}
\end{document}

```

**Exercise:** The `section[argument]{Section Title}` command takes an optional argument. How does this argument affect the table of contents?

**Exercise:** What other kinds of content tables can L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> generate? To start with, look at figures and tables.

## 2.7 Basic decorations

- `textit`
- `textsf`
- `texttt`
- `textbf`
- `textsc`
- `underline`

In this section, you will fiddle with the appearance of text. To *create text in italics*, use `textit`. To create text in sans serif, use `textsf`. To create text in monospace font, use `texttt`. To **create text in boldface**, use `textbf`. To CREATE TEXT USING SMALL CAPS, use `textsc`. You should almost never underline text! If you choose to do so, use `underline`.

To *create text in italics*, use `textit`.

To create text in sans serif, use `textsf`.

To create text in monospace font, use `texttt`.

To **create text in boldface**, use `textbf`.

To CREATE TEXT USING SMALL CAPS, use `textsc`.

You should almost never underline text! If you choose to do so, use `\underline`.

```
\documentclass{article}
  \title{Font Appearance}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
    \paragraph{}In this section, you will fiddle with the appearance of text.
    \paragraph{}To \textit{create text in italics}, use \texttt{\textit{}}.
    \paragraph{}To \textsf{create text in sans serif}, use \texttt{\textsf{}}.
    \paragraph{}To \texttt{create text in monospace font}, use \texttt{\texttt{}}.
    \paragraph{}To \textbf{create text in boldface}, use \texttt{\textbf{}}.
    \paragraph{}To \textsc{create text using Small Caps}, use \texttt{\textsc{}}.
    \paragraph{}\underline{You should almost never underline text}!
    If you choose to do so, use \texttt{\underline{}}.
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:** As with much else in  $\text{\LaTeX 2}_{\epsilon}$ , there are multiple ways to italicize or bold-face text. Can you find other ways?

## 2.8 Basic fontsizes

- tiny
- scriptsize
- footnotesize
- small
- normalsize
- large
- Large
- LARGE
- huge
- Huge

L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> has several different ways to alter the size of the font. Perhaps the simplest way is to create a *size environment*. You do this by using one of the commands listed above, and this controls the size of all text until it is changed by another command. You would typically use this for sections of text that need to be made smaller, such as tables, block quotes, technical sections not germane to the main discussion, and similar.

This paragraph has a normalsize font size.

This paragraph has a tiny font size.

This paragraph has a scriptsize font size.

This paragraph has a footnotesize font size.

This paragraph has a small font size.

This paragraph has a normalsize font size.

This paragraph has a large font size.

This paragraph has a Large font size.

This paragraph has a LARGE font size.

This paragraph has a huge font size.

This paragraph has a Huge font size.

This paragraph has a normalsize font size.

```
\documentclass{article}
  \title{Font Sizes}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
```

```

\label{Body}
\normalsize{}\paragraph{}This paragraph has a normalsize font size.
\tiny{}\paragraph{}This paragraph has a tiny font size.
\scriptsize{}\paragraph{}This paragraph has a scriptsize font size.
\footnotesize{}\paragraph{}This paragraph has a footnotesize font size.
\small{}\paragraph{}This paragraph has a small font size.
\normalsize{}\paragraph{}This paragraph has a normalsize font size.
\large{}\paragraph{}This paragraph has a large font size.
\Large{}\paragraph{}This paragraph has a Large font size.
\LARGE{}\paragraph{}This paragraph has a LARGE font size.
\huge{}\paragraph{}This paragraph has a huge font size.
\Huge{}\paragraph{}This paragraph has a Huge font size.
\normalsize{}\paragraph{}This paragraph has a normalsize font size.
\section{Conclusion}
\label{Conclusion}
\end{document}

```

**Exercise:** The issues of font, font size, and font decoration, are difficult, complicated, and subject to internecine wars. You may want to postpone your exploration of these issues until you have created and compiled several hundred `.tex` documents. If you want, and have discretionary time available and nothing else to do, you may want to delve into the complex and divisive world of fonts, font sizes, and font decorations.

## **L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> is *Professional***

L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> is flexible to an extreme. You can customize every part of your document. However, its authors have spent much time and effort to ensure that it gives a professional appearance “out of the box.” This short tutorial does not cover customization. After you have created and compiled several dozen `.tex` files, you will begin to see the need for customization.<sup>4</sup> Unless you have special requirements, such as page margins, paragraph spacing, and page numbers, and you are happy with the appearance of your document, you do not need to think about customization.

---

<sup>4</sup>The first thing you may want to do is to change the page margins. An easy way to change page margins is to use the `geometry` package.

## 3 Math and Symbols

Both  $\text{\TeX}$  and  $\text{\LaTeX}$  shine when it comes to math. In fact, Donald Knuth originally wrote  $\text{\TeX}$  just so he could typeset math. In this section, we will dip our toes into math and symbols. This will not be difficult. If you have need for more advanced mathematics, you will know how to find what you need to render your equations.

### 3.1 Special characters

Most characters are not special. An  $a$  is just an  $a$ , a  $Z$  is just a  $Z$ , and a  $7$  is just a  $7$ . Sometimes, this isn't the case — an  $\&$  is not just an ampersand.  $\text{\LaTeX}$  has ten special characters. They are listed below.

$\backslash, \%, \{, \}, \$, ^, _ , \sim, \#, \&$

You already know four of them. “ $\backslash$ ” indicates the beginning of a command, “ $\%$ ” indicates a comment, and the “ $\{ \dots \}$ ” pair (usually) indicates the argument to a command. You will learn about three more in this section, “ $\$$ ”, “ $_$ ”, and “ $^$ ”. It's worthwhile to stare at these ten characters long enough to become familiar with them. When your document misbehaves, often these characters are the culprit.

Sometimes you will find characters that wish they were special, but are not. These include the cedilla ( $\text{\c}$ ), the degree ( $^\circ$ ), and diphthongs ( $\text{\ae}$ ). All these are represented by  $\text{\LaTeX}$  commands, you will use the command for the character.

**Exercise:** Scott Pakin has published the booklet *The Comprehensive  $\text{\LaTeX}$  Symbol List*. You can find this online in PDF format. Search for it and just look at it. It contains over 300 pages of symbols. You'll be amazed!

### 3.2 Inline math

- $\$$
  - plus or  $+$
  - $-$  (dash or subtraction)
  - times or  $\ast$
  - $\text{frac}$  or  $\text{div}$
  - $\text{sqrt}$
  - $^$  (caret or circumflex)
  - $_$  (underscore)

This is an example of inline math. Use the dollar symbol ( $\$$ ) to set the math. Here is how it works. Addition:  $4 + 5 = 9$ . Subtraction:  $4 - 5 = -1$ . Multiplication:

$4 \times 5 = 20$ . Multiplication:  $4 * 5 = 20$ . Division:  $\frac{4}{5} = 0.8$ . Division:  $4 \div 5 = 0.8$ .  
 Square root:  $\sqrt{2} = 1.41421$ . Exponents:  $2^8 = 256$ . Subscripts:  $x_0, x_1, x_2$ .

```
\documentclass{article}
  \title{Inline Math}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
This is an example of inline math. Use the dollar symbol (\$) to set the math.
Here is how it works.
  Addition: $4 + 5 = 9$.
  Subtraction: $4 - 5 = -1$.
  Multiplication: $4 \times 5 = 20$.
  Multiplication: $4 \ast 5 = 20$.
  Division: $\frac{4}{5} = 0.8$.
  Division: $4 \div 5 = 0.8$.
  Square root: $\sqrt{2} = 1.41421$.
  Exponents: $2^8 = 256$.
Subscripts: $x_0, x_1, x_2$
\end{document}
```

**Exercise:** You can find the *User's Guide for the amsmath Package* in PDF format online. Search for it and start reading through it.

### 3.3 Equations

- amsmath
- equation
- equation\*

L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> provides the *equation* environment for writing block equations with the *amsmath* package. First, import the package with `\usepackage{amsmath}`. Equations are numbered and can be referenced by means of their labels. The starred version omits the equation from the numbered equations. Here are some examples. Equation 1 is the formula for a straight line. Equation 2 is the formula for the slope of a straight line. The third, unnumbered equation is the formula for a straight line with multiple parameters.

$$y = \beta_0 + \beta_1 x_1 \tag{1}$$

$$m = \frac{y_1 - y_0}{x_1 - x_0} \tag{2}$$

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$$

```
\documentclass{article}
\usepackage{amsmath}
```

```

\title{Equations}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
This is an example of equations.
\begin{equation}
\label{line}
y = \beta_0 + \beta_1 x_1
\end{equation}
\begin{equation}
\label{slope}
m = \frac{y_1 - y_0}{x_1 - x_0}
\end{equation}
\begin{equation*}
y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3
\end{equation*}
\end{document}

```

**Exercise:** Continue reading through the *User's Guide for the amsmath Package*.

### 3.4 Multiline equations

- align
- gather
- multiline

How do I place several equations together in one equation environment, aligned on a particular character, such as an equal sign (=)? Use the *align* environment, with the ampersand (&) as the tab character, and end each line with two backslashes (\\).

$$y = \beta_0 + \beta_1 x_1 \tag{3}$$

$$slope = \frac{y_1 - y_0}{x_1 - x_0} \tag{4}$$

$$predictedvalue = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \tag{5}$$

How do I center the equations? Use the *gather* environment, with no tab character but ending each line with two backslashes (\\).

$$y = \beta_0 + \beta_1 x_1 \tag{6}$$

$$slope = \frac{y_1 - y_0}{x_1 - x_0} \tag{7}$$

$$predictedvalue = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \tag{8}$$



What if I have a very long equation that won't fit on one line? Use the *multline* environment, breaking with two backslashes (\\)

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 \quad (9)$$

```
\documentclass{article}
\usepackage{amsmath}
\title{Multiline Equations}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
This is an example of align.
\begin{align}
y&= \backslash\beta\_0 + \backslash\beta\_1 x\_1\\
slope&= \frac{y\_1 - y\_0}{x\_1 - x\_0}\\
predictedvalue&= \backslash\beta\_0 + \backslash\beta\_1 x\_1 + \backslash\beta\_2 x\_2 + \backslash\beta\_3 x\_3
\end{align}
This is an example of gather.
\begin{gather}
y = \backslash\beta\_0 + \backslash\beta\_1 x\_1\\
slope = \frac{y\_1 - y\_0}{x\_1 - x\_0}\\
predictedvalue = \backslash\beta\_0 + \backslash\beta\_1 x\_1 + \backslash\beta\_2 x\_2 + \backslash\beta\_3 x\_3
\end{gather}
This is an example of multiline.
\begin{multline}
y = \backslash\beta\_0 + \backslash\beta\_1 x\_1 + \backslash\beta\_2 x\_2 + \backslash\beta\_3 x\_3 +\\
\backslash\beta\_4 x\_4 + \backslash\beta\_5 x\_5 + \backslash\beta\_6 x\_6 +\\
\backslash\beta\_7 x\_7 + \backslash\beta\_8 x\_8 + \backslash\beta\_9 x\_9
\end{multline}
\end{document}
```

### 3.5 Higher math

- sums
- products
- limits
- derivatives
- integrals

Equation 10 states the shorthand for the sum of a series of integers 1 through  $n$ . Equation 11 states the shorthand for the product of a series of integers 1 through

$n$ . Equation 12 demonstrates the notation for limits. Equation 13 demonstrates the notation for derivatives. Equation 14 demonstrates the notation for integrals.

$$\sum_{i=1}^{i=n} i = 1 + 2 + 3 + \cdots + n \quad (10)$$

$$\prod_{i=1}^{i=n} i = 1 \times 2 \times 3 \times \cdots \times n \quad (11)$$

$$\lim_{x \rightarrow \infty} f(x) \quad (12)$$

$$\frac{d}{dx} [e^{\frac{x}{2}} \sin(ax)] \quad (13)$$

$$\int_a^b x^2 dx \quad (14)$$

```
\documentclass{article}
  \title{Higher Math}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
\begin{gather}
\sum_{i=1}^{i=n} i = 1 + 2 + 3 + \dots{} + n \\
\prod_{i=1}^{i=n} i = 1 \times 2 \times 3 \times \dots{} \times n \\
\lim_{x \to \infty} f(x) \label{higher:lim} \\
\frac{d}{dx} \left[ e^{\frac{x}{2}} \sin(ax) \right] \\
\int_a^b x^2 dx
\end{gather}
\end{document}
```

**Exercise:** Continue reading through the *User's Guide for the amsmath Package*.

### 3.6 Matrices

- vmatrix
- pmatrix
- bmatrix
- Bmatrix
- Vmatrix

Matrices are contained within a math environment, either an equation block or inline math pairs ( $\dots$ ). They are entered by row. Each row ends with two backslash symbols ( $\backslash\backslash$ ). Each element on a row is separated by an ampersand ( $\&$ ).

The different variations create different surrounding brackets. `\vmatrix` uses vertical bars ( $|\dots|$ ). `\pmatrix` uses parentheses ( $(\dots)$ ). `\bmatrix` uses square brackets ( $[\dots]$ ). `\Bmatrix` uses curly braces ( $\{\dots\}$ ). `\Vmatrix` uses double vertical bars ( $\| \dots \|$ ).

$$\begin{vmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{vmatrix} \times \begin{vmatrix} 7 & -3 & -3 \\ -1 & 1 & 0 \\ -1 & 0 & 1 \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

```
\documentclass{article}
\title{Matrices}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
$ \begin{vmatrix}
1 & 3 & 3 \\
1 & 4 & 3 \\
1 & 3 & 4
\end{vmatrix}
\times
\begin{vmatrix}
7 & -3 & -3 \\
-1 & 1 & 0 \\
-1 & 0 & 1
\end{vmatrix}
=
\begin{vmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{vmatrix} $
\end{document}
```

**Exercise:** Continue reading through the *User's Guide for the amsmath Package*.

### 3.7 Greek letters

Here are the Greek letters commonly used in mathematical and scientific applications, table 3.7 on page 20. The  $\text{\LaTeX} 2_{\epsilon}$  commands for the Greek letters are in inline math mode, so you *must* surround the command by a pair of dollar signs ( $\dots$ ). You must also use the `amsmath` package.

```
\documentclass{article}
\usepackage{amsmath}
\title{Greek Letters}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle
\begin{tabular}{|| 1 || 1 | 1 || 1 | 1 ||}
\hline
Alpha & Alpha & $\alpha$ & & alpha & $\alpha$ \\
\end{tabular}
```

Alpha	Alpha	$A$	alpha	$\alpha$
Beta	B	$B$	beta	$\beta$
Gamma	Gamma	$\Gamma$	gamma	$\gamma$
Delta	Delta	$\Delta$	delta	$\delta$
Epsilon	E	$E$	epsilon	$\epsilon$
Zeta	Z	$Z$	zeta	$\zeta$
Eta	H	$H$	eta	$\eta$
Theta	Theta	$\Theta$	theta	$\theta$
Iota	I	$I$	iota	$\iota$
Kappa	K	$K$	kappa	$\kappa$
Lambda	Lambda	$\Lambda$	lambda	$\lambda$
Mu	M	$M$	mu	$\mu$
Nu	N	$N$	nu	$\nu$
Xi	Xi	$\Xi$	xi	$\xi$
Omicron	O	$O$	o	$o$
Pi	Pi	$\Pi$	pi	$\pi$
Rho	R	$R$	rho	$\rho$
Sigma	S	$S$	sigma	$\sigma$
Tau	T	$T$	tau	$\tau$
Upsilon	Y	$Y$	upsilon	$\upsilon$
Phi	Phi	$\Phi$	phi	$\phi$
Chi	X	$X$	chi	$\chi$
Psi	Psi	$\Psi$	psi	$\psi$
Omega	Omega	$\Omega$	omega	$\omega$

Table 1: Greek letters

```

\hline
Beta & B &  $B$  & beta &  $\beta$  \\
\hline
Gamma & Gamma &  $\Gamma$  & gamma &  $\gamma$  \\
\hline
Delta & Delta &  $\Delta$  & delta &  $\delta$  \\
\hline
Epsilon & E &  $E$  & epsilon &  $\epsilon$  \\
\hline
Zeta & Z &  $Z$  & zeta &  $\zeta$  \\
\hline
Eta & H &  $H$  & eta &  $\eta$  \\
\hline
Theta & Theta &  $\Theta$  & theta &  $\theta$  \\
\hline
Iota & I &  $I$  & iota &  $\iota$  \\
\hline
Kappa & K &  $K$  & kappa &  $\kappa$  \\
\hline
Lamba & Lambda &  $\Lambda$  & lambda &  $\lambda$  \\
\hline
Mu & M &  $M$  & mu &  $\mu$  \\
\hline

```

```

Nu & N & $N$      & nu & $\nu$ \\
\hline
Xi & Xi & $\Xi$      & xi & $\xi$ \\
\hline
Omicron & O & $O$      & o & $o$ \\
\hline
Pi & Pi & $\Pi$      & pi & $\pi$ \\
\hline
Rho & R & $R$      & rho & $\rho$ \\
\hline
Sigma & S & $S$      & sigma & $\sigma$ \\
\hline
Tau & T & $T$      & tau & $\tau$ \\
\hline
Upsilon & Y & $Y$      & upsilon & $\upsilon$ \\
\hline
Phi & Phi & $\Phi$      & phi & $\phi$ \\
\hline
Chi & X & $X$      & chi & $\chi$ \\
\hline
Psi & Psi & $\Psi$      & psi & $\psi$ \\
\hline
Omega & Omega & $\Omega$      & omega & $\omega$ \\
\hline
\end{tabular}
\end{document}

```

**Exercise:** Mathematics uses a large number of non-Latin characters. For example, search for the Hebrew character Aleph ( $\aleph$ ) and the symbol for infinity ( $\infty$ ).

$\text{\LaTeX}$  2 $_{\epsilon}$  is *Well Documented*

## 4 References

In scientific and research writing, one of the most critical aspects is references. Think about it: can you imagine a research paper without a single reference? These include footnotes, endnotes, marginal notes, and especially citations to sources. References have two components, a target and a source, or a label and a reference to that label. We have used labels before, but now we will explicitly consider them.

### 4.1 Text references

- label
- ref
- pageref

TEXT HERE

add text

```
\documentclass{article}
  \title{Footnotes and References}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  TEXT HERE
\end{document}
```

**Exercise:** Read the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> documentation on footnotes.

### 4.2 Footnotes

- footnote
- label
- ref
- pageref

To insert a footnote, just use the command `footnote`.<sup>5</sup> If you label the footnote, you can refer to the footnote by number and page in the text of the document. Please be sure to read footnote 5 on page 23.

---

<sup>5</sup>Don't forget to put the `\` before the `footnote` command.

```

\documentclass{article}
  \title{Footnotes and References}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  To insert a footnote, just use the command \text{footnote}.
  \footnote{\label{references:fn} Don't forget to put the
    \textbackslash{} before the \texttt{footnote} command.}
  If you label the footnote, you can refer to the footnote
  by number and page in the text of the document. Please
  be sure to read footnote \ref{references:fn} on page
  \pageref{references:fn}.
\end{document}

```

**Exercise:** Read the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> documentation on footnotes.

### 4.3 Endnotes

- package endnotes
- endnote
- theendnotes
- addcontentsline

Endnotes are a little more complicated than footnotes, but not much.<sup>1</sup> Here is an endnote.<sup>2</sup> In order to actually print the endnotes, use the **theendnotes** command. In order to create an entry for the endnotes in the table of contents, you must use the **addcontentsline**.<sup>3</sup> Please see endnote 3 on page 61 for the details.

```

\documentclass{article}
  \usepackage{endnotes}
  \title{Endnotes}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \tableofcontents{}
  \section{Text}
  Endnotes are a little more complicated than footnotes, but not much.
  \endnote{The difference between footnotes and endnotes is that
    footnotes go at the foot of the page where they appear, while
    endnotes appear at the end of the document.} Here is an
    endnote.\endnote{This is an endnote.} In order to actually print
    the endnotes, use the \texttt{theendnotes} command. In order to
    create an entry for the endnotes in the table of contents, you

```



```

must use the \texttt{addcontentsline}. \endnote{\label{references:en}
The addcontentsline takes three parameters, where the line should be
written, usually \textit{toc}, the formatting to be used, usually
\textit{section}, and the name to be given to the entry, perhaps
\textit{Endnotes}.) Please see endnote \ref{references:en} on
page \pageref{references:en} for the details.
\theendnotes{}
\addcontentsline{toc}{section}{Endnotes}
\end{document}

```

**Exercise:** Find and read through the documentation of the Endnotes package.

## 4.4 Margin notes

- marginpar
- reversemarginpar
- normalmarginpar
- raggedright

Marginal notes are really useful to call attention to very important points. They can also be useful in drafting documents to note future edits, insertions, or deletions. Use `marginpar` to create a marginal note. To delete marginal notes during the drafting process, just comment them out. The text remains as a reminder of the modifications in the document.

Important  
point!

This is re-  
versed text

To permanently reverse the page sides, use `reversemarginpar`. To reverse the reverse page margins, use `normalmarginpar`. To change the paragraph alignment from the default justified text, use the command `raggedright` in a block.

This is in  
the correct  
margin

```

\documentclass{article}
\title{Margin Notes}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
\marginpar{Important point!}
Marginal notes are really useful to call attention to very important
points. They can also be useful in drafting documents to note
future edits, insertions, or deletions. Use \texttt{marginpar}
to create a marginal note. To delete marginal notes during the
drafting process, just comment them out. The text remains as a
reminder of the modifications in the document.
{\raggedright\reversemarginpar{\marginpar{This is reversed text}}}
To permanently reverse the page sides, use \texttt{reversemarginpar}.
To reverse the reverse page margins, use \texttt{normalmarginpar}.
{\raggedright\normalmarginpar\marginpar{This is in the correct margin}}

```

`\end{document}`

**Exercise:** If you really need to create sophisticated marginal notes, you will need both the `geometry` and `marginnote` packages. The former is very useful, and you may need to use it in every paper. The latter is useful for marginal notes when you need something more than the default  $\text{\LaTeX} 2_{\epsilon}$  commands.

## 4.5 Bibliography

- creating an external BibTeX database

Needless to say, every research paper requires a bibliography.  $\text{\LaTeX} 2_{\epsilon}$  has multiple ways to include bibliographies. I have chosen to use a method called BibTeX. There are three reasons for this choice. First, it's simple enough to include in a simple tutorial. Second, it gives good results using its default settings. Third, it's complex enough to be configured for almost any application (given an author's time and patience).

BibTeX uses an external file as a bibliographical database. This means that management of the sources is separate from writing and editing the original document. The data from the external database is merged into the original document with a series of commands. We will cover the basics of the external database in this lesson. In the following lesson, we will see how to merge the two files.

The external BibTeX database is merely a plain text file with entries in a prescribed format. It *must* have the `.bib` extension for the filename. The following file includes four books and three online sources. The BibTeX format file contains specifications for a large number of types of sources, and you should become familiar with the various types of documents and the format for each.

Create a document with the following content. Name it `tut.bib` and place it in the same directory with your original source document, where you compile your PDF output. Each entry has a type identifier preceded by the at symbol (`@`) and followed by a curly brace pair (`{...}`), within which are contained various fields separated by commas. The first field is the identifier you will use to access the entry. The subsequent fields are “key”=“value” pairs, giving the title, author, date etc.

```
\\tut.bib
@book{
  goossens04,
  author    = "Frank Mittelbach and Michel Goossens and
              Johannes Braams and David Carlisle and
              Chris Rowley",
  title     = "The \LaTeX{} Companion (Tools and
              'Techniques for Computer Typesetting)",
  year      = "2004",
  edition   = "2nd",
  publisher = "Addison-Wesley",
  address   = "Reading, MA",
```

```

        ISBN      = "978-0201362992"
    }
    @book{
        kottwitz11,
        author      = "Stefan Kottwitz ",
        title       = "\LaTeX{} Beginner's Guide",
        year        = "2011",
        publisher    = "Packt Publishing",
        address     = "Birmingham, UK",
        ISBN        = "978-1847199867"
    }
    @book{
        kottwitz15,
        author      = "Stefan Kottwitz ",
        title       = "\LaTeX{} Cookbook",
        year        = "2015",
        publisher    = "Packt Publishing",
        address     = "Birmingham, UK",
        ISBN        = " 978-1784395148"
    }
    @book{
        gratzer14,
        author      = "George Gratzer",
        title       = "Practical \LaTeX{}",
        year        = "2014",
        publisher    = "Springer",
        address     = "New York, NY",
        ISBN        = "978-1847199867"
    }
    @electronic{
        oetiker15,
        author      = "Tobias Oetiker and Hubert Partl and Irene Hyna and Elisabeth Schlegl",
        title       = "The Not So Short Introduction to {LaTeX2e}",
        url         = "http://tug.ctan.org/info/lshort/english/lshort.pdf",
        year        = "2015",
        note        = "accessed August 2, 2016"
    }
    @electronic{
        pakin15,
        author      = "Scott Pakin",
        title       = "The Comprehensive {LATEX} Symbol List",
        url         = "http://tug.ctan.org/info/symbols/comprehensive/symbols-letter.pdf",
        year        = "2015",
        note        = "accessed August 2, 2016"
    }
    @electronic{
        carter16,
        author      = "Charles Carter",
        title       = "Another Short Tutorial to {LaTeX2e}",
        url         = "https://github.com/cc31807/latex-short-intro",
        year        = "2016",
    }

```

```

    note = "accessed August 2, 2016"
}

```

**Exercise:** Search for the Bib<sub>T</sub><sub>E</sub>X format specification. Name four different kinds of source documents and identifies the required elements for each.

## 4.6 Citations

- cite
- nocite
- bibliographystyle
- bibliography
- addcontentsline
- bibtex

Preparing the bibliographic database is fairly straightforward and easy. Unfortunately, the details of including the citations in your document is not as straightforward.<sup>6</sup> To cite to a reference, use the `cite` command, passing the citation reference as an argument. By default, the printed bibliography includes only cited references — to include a particular uncited reference, use the `nocite` command, passing the citation reference as an argument. To include all uncited references, use the command `nocite{*}`. (The asterisk is a typeglob that means “everything”).

To specify a citation style, use the command `bibliographystyle`. As you will see when you study the different styles, there are many of them. Adding to the amount of effort of work potentially involved, you can write your own style specification if you don’t want to use any that are available. In the example below, I have used the *IEEEtranS* style. This will probably not meet your needs. You will have to find an appropriate style for your requirements.

To include the bibliography itself, use the command `bibliography`. To add your references to the table of contents, use the command `addcontentsline`. To compile your bibliography using the command line interface, see appendix C on page 60.<sup>7</sup>

```

\documentclass{article}
  \title{Bibliography}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \tableofcontents{}

```

<sup>6</sup>Again, you must pay attention to the reference types and required fields. This is probably the most onerous part of including a bibliography.

<sup>7</sup>If you compile your document using the command line, you must use the `bibtex <document name>` command in order to produce the bibliography itself.

```

\section{Introduction}
\label{inTroduction}
This section cites \cite{goossens04} and \cite{oetiker15}.
\section{Body}
\label{Body}
This section cites \cite{kottwitz15} and \cite{pakin15}.
\section{Conclusion}
This section contains no citations.
\label{Conclusion}
\bibliographystyle{IEEEtranS}
\bibliography{tut}
\addcontentsline{toc}{section}{References}
\nocite{*}
\end{document}

```

**Exercise:** BibTeX provides many different kinds of styles. Research three of them.

**Exercise:** Every style has required fields and optional fields. For the three styles you researched, list the required fields and the optional fields.

## 4.7 Indices

- package imakeidx
- makeindex
- index
- printindex
- addcontentsline

Any paper of a reasonable size should have an index. Fortunately, indices in L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> are easy if a bit tedious. The tedious part comes from marking all the words to be indexed. The rest is pretty easy.

First, in the preamble, you use an indexing package, the current version of which is **imakeidx** (perhaps for *improved* makeidx) followed by the **makeindex** command. At the end of your paper, include the **printindex** command, optionally followed by the **addcontentsline** if you wish to have an entry in our table of contents for the index.

Then, for every term you wish to index, you must make a reference using the **index** command. L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> produces the index automatically.<sup>8</sup>

```

\documentclass{article}
\usepackage{imakeidx}
\makeindex{}

```

---

<sup>8</sup>If you compile your document using the command line, you must use the **makeindex <document name>** command in order to produce the index itself.

```

\title{Indices}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
\tableofcontents{}
\section{Introduction}
\label{inTroduction}
This section contains the indexed word introduction.\index{introduction}
\section{Body}
\label{Body}
\paragraph{}This paper concerns the structure\index{structure} of a paper.
\paragraph{}Papers generally consist of an introduction\index{introduction},
    body\index{body|}, and conclusion\index{conclusion}.
\paragraph{}This is the body\index{body} of a paper.
\section{Conclusion}
This section contains the conclusion\index{conclusion}.
\label{Conclusion}
\printindex{}
\addcontentsline{toc}{section}{Index}
\end{document}

```

**Exercise:** Find the documentation to the `imakeidx` package and read through it.

**Exercise:** How can you generate multiple indices, perhaps one for people and one for commands?

$\text{\LaTeX } 2_{\varepsilon}$  is *Stable*

## 5 Lists

### 5.1 Verbatim

- verbatim environment
- verbatim

Perhaps the simplest and easiest way to make a list is by using the `verbatim` environment. Everything in the environment is printed as is, that is,  $\text{\LaTeX} 2_{\epsilon}$  commands are not evaluated.

```
\documentclass{article}
  \title{Verbtim Environment}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Verbatim Environment}
  \begin{verbatim}
    \texttt{one}
    \textit{two}
    \textsf{three}
    \huge{aye}
    \tiny{bee}
    \section{see}
  \end{verbatim}
\end{document}
```

**Exercise:** The only command not permitted in the `verbatim` environment is the `\end{verbatim}` command. The reason is that this command ends the verbatim environment. If you examine the source of this tutorial, you will see that I resorted to a trick to include this command. As an exercise, can you figure out the trick?

### 5.2 Unnnmbered Lists

- itemize
- item

$\text{\LaTeX} 2_{\epsilon}$  unnumbered lists are very easy. Simply enclose the list in the `itemize` environment, and place each list item as an argument to the `item` command.

- Green



- Eggs
- and
- Ham

```
\documentclass{article}
  \title{Unnumbered List}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \begin{itemize}
    \item{Green}
    \item{Eggs}
    \item{and}
    \item{Ham}
  \end{itemize}
\end{document}
```

**Exercise:** Make your own unnumbered list.

### 5.3 Numbered Lists

- enumerate
  - item

L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> numbered lists are very easy. Simply enclose the list in the `enumerate` environment, and place each list item as an argument to the `item` command.

1. Washington
2. Adams
3. Jefferson
4. Madison

```
\documentclass{article}
  \title{Unnumbered List}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \begin{enumerate}
    \item{Washington}
    \item{Adams}
    \item{Jefferson}
```

```

        \item{Madison}
    \end{enumerate}
\end{document}

```

**Exercise:** Make your own numbered list.

## 5.4 Dictionary Lists

- description
- item

$\text{\LaTeX} 2_{\epsilon}$  dictionary lists are very easy. Simply enclose the list in the **description** environment, place the term in square brackets ( $[]$ ), and place each list item as an argument to the **item** command.

**C** a procedural language

**Java** an object oriented language

**Lisp** a functional language

**JavaScript** an event driven language

**Erlang** a concurrent language

```

\documentclass{article}
  \title{Unnumbered List}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \item[C]{a procedural language}
  \item[Java]{an object oriented language}
  \item[Lisp]{a functional language}
  \item[JavaScript]{an event driven language}
  \item[Erlang]{a concurrent language}
\end{document}

```

**Exercise:** Make your own dictionary list.

## 5.5 Nested Lists

And of course,  $\text{\LaTeX} 2_{\epsilon}$  lists can be nested. Notice how “smart” the numbered lists are — the number style depends on the heading level.

1. 17th century

- (a) Thirty Years War
    - Gustavus Adolphus** Sweden
    - Wallenstein** Hapsburg Austria
    - Turenne** France
  - (b) War of the Grand Alliance
    - William III** Dutch Republic
    - Eugene** Hapsburg Austria
    - Vauban** France
2. 18th century
- (a) War of the Spanish Succession
    - Eugene** Hapsburg Austria
    - Malbrough** England
    - Villeroi** France
    - Maximilian II** Bavaria
  - (b) Seven Years War
    - Frederick II** Prussia
    - Daun** Hapsburg Austria
    - Maximilian III** Bavaria
    - Clive** Great Britain
3. 19th century
- (a) War of the Sixth Coalition
    - Napoleon I** France
    - Blucher** Prussia
    - Bennigsen** Russia
    - Schwarzenberg** Austria
  - (b) Franco-Prussian War
    - Napoleon III** France
    - Moltke** Prussia
4. 20th century
- (a) World War 1
    - Haig** United Kingdom
    - Foch** France
    - Hindenburg** Germany
    - Pershing** United States
  - (b) World War 2
    - McArthur** United States
    - Montgomery** United Kingdom
    - Manstein** Germany
    - Rossokovsky** Soviet Union

```

\documentclass{article}
  \title{Unnumbered List}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \begin{enumerate}
    \item{17th century}
    \begin{enumerate}
      \item{Thirty Years War}
      \begin{description}
        \item[Gustavus Adolphus]{Sweden}
        \item[Wallenstein]{Hapsburg Austria}
        \item[Turenne]{France}
      \end{description}
      \item{War of the Grand Alliance}
      \begin{description}
        \item[William III]{Dutch Republic}
        \item[Eugene]{Hapsburg Austria}
        \item[Vauban]{France}
      \end{description}
    \end{enumerate}
    \item{18th century}
    \begin{enumerate}
      \item{War of the Spanish Succession}
      \begin{description}
        \item[Eugene]{Hapsburg Austria}
        \item[Malbourough]{England}
        \item[Villeroi]{France}
        \item[Maximilian II]{Bavaria}
      \end{description}
      \item{Seven Years War}
      \begin{description}
        \item[Frederick II]{Prussia}
        \item[Daun]{Hapsburg Austria}
        \item[Maximilian III]{Bavaria}
        \item[Clive]{Great Britain}
      \end{description}
    \end{enumerate}
    \item{19th century}
    \begin{enumerate}
      \item{War of the Sixth Coalition}
      \begin{description}
        \item[Napoleon I]{}
        \item[Blucher]{Prussia}
        \item[Bennigsen]{Russia}
        \item[Schwarenborg]{Austria}
      \end{description}
      \item{Franco-Prussian War}
      \begin{description}
        \item[Napoleon III]{}France
      \end{description}
    \end{enumerate}
  \end{enumerate}

```

```

        \item[Moltke]{Prussia}
    \end{description}
\end{enumerate}
\item{20th century}
\begin{enumerate}
    \item{World War 1}
    \begin{description}
        \item[Haig]{United Kingdom}
        \item[Foch]{France}
    \item[Hindenburg]{Germany}
        \item[Pershing]{United States}
    \end{description}
    \item{World War 2}
    \begin{description}
        \item[McArthur]{United States}
        \item[Montgomery]{United Kingdom}
        \item[Manstein]{Germany}
        \item[Rossokovsky]{Soviet Union}
    \end{description}
    \end{enumerate}
\end{enumerate}
\end{document}

```

**Exercise:** Make your own nested list to at least two levels.

## 5.6 Listings Package

- listings package
- lstset
- lstlisting

If you really want to customize your listing, use the `listings` package. Import the package as usual in the preamble with `\usepackage{listings}`. Use `lstset` to specify your list settings. This can be either in the preamble or (if you have various lists with different settings) in the body of the document just prior to the list. Use `lstlisting` to set the list. See section 5.7 on page 38 and section 5.8 on page 40 for examples.

Here are some of the parameters allowed for `lstset`.

```

\lstset{ %
backgroundcolor=\color{white},    % choose the background color;
    you must add \usepackage{color} or \usepackage{xcolor}
basicstyle=\footnotesize,        % the size of the fonts that are used for the code
breakatwhitespace=false,         % sets if automatic breaks should only happen at whitespace
breaklines=true,                 % sets automatic line breaking
captionpos=b,                   % sets the caption-position to bottom
frame=single,                   % adds a frame around the code
keepspace=true,                 % keeps spaces in text, useful for keeping indentation
}

```

```

of code (possibly needs columns=flexible)
keywordstyle=\color{blue},      % keyword style
language=Octave,                % the language of the code
numbers=left,                   % where to put the line-numbers;
    possible values are (none, left, right)
numbersep=5pt,                  % how far the line-numbers are from the code
numberstyle=\tiny\color{gray},  % the style that is used for the line-numbers
rulecolor=\color{black},        % if not set, the frame-color may be changed on line-breaks
    within not-black text (e.g. comments (green here))
showspaces=false,               % show spaces everywhere adding particular underscores;
    it overrides 'showstringspaces'
showstringspaces=false,         % underline spaces within strings only
showtabs=false,                 % show tabs within strings adding particular underscores
tabsize=2,                      % sets default tabsize to 2 spaces
}

```

**Exercise:** Find the documentation for the listings package and look through it.

## 5.7 Listings Version 1

The programming language Lisp was created in the late 1950s as a LISP Processing language — it might not be inappropriate to use Lisp to illustrate lists. Here is the listing.

```

1  ;;; add-test.lisp
2  (print "This is add-lisp. Evaluate (start-test) to start the test
   .")
3
4  (defun start-test ()
5    (defparameter number-of-questions 10)
6    (defparameter number-correct 0)
7    (defparameter question-counter 1)
8    (format t "Starting the addition test, you have ~a questions.~%"
   " number-of-questions)
9    (run-test))
10
11 (defun addition-problem ()
12   (let* ((a (random 11))
13         (b (random 11))
14         (c (+ a b))
15         (d (read (format t "What is ~a + ~a? " a b))))
16     (cond ((= c d)
17            (format t "Correct~%")
18            1)
19           (t (format t "The answer is ~a~%" c)
20              0))))
21
22 (defun run-test ()
23   (cond
24     ((zerop number-of-questions)
25      (format t "You got ~a correct and made a ~a.~%"
26              number-correct (* 100 (/ number-correct 10.0))))
27     (t (format t "Question ~a. " question-counter)
28         (decf number-of-questions)
29         (incf number-correct (addition-problem))
30         (incf question-counter)
31         (run-test))))

```

Here is the code.

```

\documentclass{article}
  \title{Lists, Version 1}
  \author{Charles Carter}
  \date{\today{}}
  \usepackage{listings}
  \usepackage{xcolor}
\begin{document}
  \maketitle{}
\lstset{language=Lisp,numbers=left,keepspaces=true,
  basicstyle=\small,numberstyle=\tiny,
  showstringspaces=false,breaklines=true}
\begin{lstlisting}
;;;add-test.lisp
(print "This is add-lisp. Evaluate (start-test) to start the test.")

(defun start-test ()
  (defparameter number-of-questions 10)
  (defparameter number-correct 0)
  (defparameter question-counter 1)
  (format t "Starting the addition test, you have ~a questions.~%"
    number-of-questions)
  (run-test))

(defun addition-problem ()
  (let* ((a (random 11))
        (b (random 11))
        (c (+ a b))
        (d (read (format t "What is ~a + ~a? " a b)))))
    (cond ((= c d)
      (format t "Correct~%"
        1)
      (t (format t "The answer is ~a~%" c)
        0))))))

(defun run-test ()
  (cond
    ((zerop number-of-questions)
      (format t "You got ~a correct and made a ~a.~%"
        number-correct (* 100 (/ number-correct 10.0))))
    (t (format t "Question ~a. " question-counter)
      (decf number-of-questions)
      (incf number-correct (addition-problem))
      (incf question-counter)
      (run-test))))
\end{lstlisting}
\end{document}

```

**Exercise:** What programming languages does the listings package know about?

## 5.8 Listings Version 2

Here is a listing you have see before. To create this, use this code. The language is set to “TeX”, the dialect is “LaTeX”. The line numbers are on the right. Keywords are blue bolded. Comments are colored teal. Note the use of packate *xcolor*, which I will cover in section 7.6 on page 53.

```
\lstset{
  language=[LaTeX]TeX
  numbers=right
  keywordstyle=\color{blue}\textbf
  keepspaces=true
  basicstyle=\footnotesize
  numberstyle=\scriptsize
  showstringspaces=false
  breaklines=true
  commentstyle=\color{teal}}
\begin{lstlisting}
  %code goes here
\end{lstlisting}
```

Here is what the listing looks like with these settings.

```
\documentclass{article} 1
  %this is the preamble 2
  %author and title information 3
  \usepackage{xcolor} 4
  \usepackage{listings} 5
  \title{Font Sizes} 6
  \author{Charles Carter} 7
  \date{\today{}} 8
\begin{document} 9
  %create the title 10
  \maketitle{} 11
  %create the table of contents 12
  \tableofcontents{} 13
  \section{Introduction} 14
  \label{Introduction} 15
  \section{Body} 16
  \label{Body} 17
  %start with a normal sized font 18
  \normalsize{}\paragraph{}This paragraph has a normalsize font size 19
  .
  %font sizes in forder from smallest to largest 20
  \tiny{}\paragraph{}This paragraph has a tiny font size. 21
  \scriptsize{}\paragraph{}This paragraph has a scriptsize font size 22
  .
  \footnotesize{}\paragraph{}This paragraph has a footnotesize font 23
  size.
  \small{}\paragraph{}This paragraph has a small font size. 24
  \normalsize{}\paragraph{}This paragraph has a normalsize font size 25
  .
  \large{}\paragraph{}This paragraph has a large font size. 26
  \Large{}\paragraph{}This paragraph has a Large font size. 27
  \LARGE{}\paragraph{}This paragraph has a LARGE font size. 28
  \huge{}\paragraph{}This paragraph has a huge font size. 29
  \Huge{}\paragraph{}This paragraph has a Huge font size. 30
  %end with a normal sized font 31
  \normalsize{}\paragraph{}This paragraph has a normalsize font size 32
  .
```



<code>\section{Conclusion}</code>	33
<code>\label{Conclusion}</code>	34
<code>\end{document}</code>	35

Here is the code for the listing.

```
\documentclass{article}
%this is the preamble
%author and title information
\usepackage{xcolor}
\usepackage{listings}
\lstset{language=[LaTeX]TeX,numbers=right,keywordstyle=\color{blue}\textbf,
        keepspaces=true,basicstyle=\footnotesize,numberstyle=\scriptsize,
        kshowstringspaces=false,breaklines=true,commentstyle=\color{teal}}
\title{Font Sizes}
\author{Charles Carter}
\date{\today{}}
\begin{document}
%create the title
\maketitle{}
%create the table of contents
\tableofcontents{}
\section{Introduction}
\label{Introduction}
\section{Body}
\label{Body}
\begin{lstlisting}
%start with a normal sized font
\normalsize{}\paragraph{}This paragraph has a normalsize font size.
%font sizes in forder from smallest to largest
\tiny{}\paragraph{}This paragraph has a tiny font size.
\scriptsize{}\paragraph{}This paragraph has a scriptsize font size.
\footnotesize{}\paragraph{}This paragraph has a footnotesize font size.
\small{}\paragraph{}This paragraph has a small font size.
\normalsize{}\paragraph{}This paragraph has a normalsize font size.
\large{}\paragraph{}This paragraph has a large font size.
\Large{}\paragraph{}This paragraph has a Large font size.
\LARGE{}\paragraph{}This paragraph has a LARGE font size.
\huge{}\paragraph{}This paragraph has a huge font size.
\Huge{}\paragraph{}This paragraph has a Huge font size.
%end with a normal sized font
\normalsize{}\paragraph{}This paragraph has a normalsize font size.
\end{lstlisting}
\section{Conclusion}
\label{Conclusion}
\end{document}
```

**Exercise:** Try listing your own favorite programming language.

$\text{\LaTeX}$  2 $_{\epsilon}$  is *Easy*

## 6 Tables

Unfortunately, tables in L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> tend to be a bit cumbersome. Tables are specified row by row, and require meticulous attention to detail. If sufficient care is taken, composing tables is not very difficult. Fortunately, simple tables are not too hard.

### 6.1 Verbatim table

- verbatim
- verbatim environment

As with lists, the simplest, most brain-dead way to make a table is by using the `verbatim` environment.

Abigail	Derek	Gladiola
Brenda	Edgar	Hibiscus
Claudia	Frank	Impatiens

```
\documentclass{article}
  \title{Verbatim Tables}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \begin{verbatim}
Abigail      Derek      Gladiola
Brenda       Edgar      Hibiscus
Claudia     Frank       Impatiens
  \end{verbatim}
\end{document}
```

**Exercise:** Create your own verbatim table.

### 6.2 Simple table

- tabular environment
- l (column specifier)
- c (column specifier)
- r (column specifier)
- \\ (row terminator)
- & (cell separator)

A simple L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> table is created within a `tabular` environment. The column specifications are passed as a parameter to the environment — r (right), c (center), l (left). Table rows are terminated by two backslashes (`\\`). Cells are separated by an ampersand (`&`).

Abigail	Derek	Gladiola
Brenda	Edgar	Hibiscus
Claudia	Frank	Impatiens

```
\documentclass{article}
\title{Simple Tables}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
\begin{tabular}{lcr}
Abigail & Derek & Gladiola \\
Brenda & Edgar & Hibiscus \\
Claudia & Frank & Impatiens \\
\end{tabular}
\end{document}
```

**Exercise:** Make your own simple table.

### 6.3 Row and column lines

- |
- \hline

Table rules are specified by the vertical bar (`|`) and by `\hline`. Column rules are set in the parameter of the column specifications based to the `tabular` environment. Row rules are created by the `\hline` command. Both of these can be doubled to produce double rules.

Girls	Boys	Flowers	Animals
Abigail	Derek	Gladiola	Jackel
Brenda	Edgar	Hibiscus	Koala
Claudia	Frank	Impatiens	Lynx

```
\documentclass{article}
\title{Table Rules}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
\hline
Girls & Boys & Flowers & Animals\\
\hline
```

```

\hline
Abigail & Derek & Gladiola & Jackel \\
\hline
Brenda & Edgar & Hibiscus & Koala \\
\hline
Claudia & Frank & Impatiens & Lynx \\
\hline

```

**Exercise:** Create your own simple table with vertical and horizontal rules.

## 6.4 Column spacing

- p (column specifier)

The column specifiers l (left), c (center), and r (right) mostly do what you want, but their capacity is limited and frequently you need to use the column specifier p (paragraph) to make the content of the cells behave. p takes as a parameter a length recognized by L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>, frequently a common English measure expressed in inches, for example, p{2in}.

```

\documentclass{article}
\title{This is My Title}
\author{Charles Carter}
\date{\today{}}
\begin{document}
\maketitle{}
\begin{tabular}{p{1in} p{4in}}
\hline{}
C & C is a general-purpose, imperative computer programming
language, supporting structured programming, lexical variable
scope and recursion, while a static type system prevents many
unintended operations. \\
Java & Java is a general-purpose computer programming language
that is concurrent, class-based, object-oriented, and
specifically designed to have as few implementation
dependencies as possible. It is intended to let application
developers "write once, run anywhere" meaning that compiled
Java code can run on all platforms that support Java without
the need for recompilation. \\
Common Lisp & Common Lisp (historically, LISP) is a family
of computer programming languages with a long history and a
distinctive, fully parenthesized prefix notation. Originally
specified in 1958, Lisp is the second-oldest high-level
programming language in widespread use today. Only Fortran
is older, by one year. \\
JavaScript & JavaScript is a high-level, dynamic, untyped,

```

C	C is a general-purpose, imperative computer programming language, supporting structured programming, lexical variable scope and recursion, while a static type system prevents many unintended operations.
Java	Java is a general-purpose computer programming language that is concurrent, class-based, object-oriented, and specifically designed to have as few implementation dependencies as possible. It is intended to let application developers “write once, run anywhere” meaning that compiled Java code can run on all platforms that support Java without the need for recompilation.
Common Lisp	Common Lisp (historically, LISP) is a family of computer programming languages with a long history and a distinctive, fully parenthesized prefix notation. Originally specified in 1958, Lisp is the second-oldest high-level programming language in widespread use today. Only Fortran is older, by one year.
JavaScript	JavaScript is a high-level, dynamic, untyped, and interpreted programming language. It has been standardized in the ECMAScript language specification.
Erlang	Erlang is a programming language designed for developing robust systems of programs that can be distributed among different computers in a network. Named for the Danish mathematician Agner Krarup Erlang, the language was developed by the Ericsson Computer Sciences Lab to build software for its own telecommunication products.

Table 2: P columns

```

and interpreted programming language. It has been
standardized in the ECMAScript language specification. \\
Erlang & Erlang is a programming language designed for
developing robust systems of programs that can be
distributed among different computers in a network.
Named for the Danish mathematician Agner Krarup Erlang,
the language was developed by the Ericsson Computer
Sciences Lab to build software for its own tele
communication products.  \\
\hline{}
\end{tabular}
\end{document}

```

**Exercise:** Create your own table with paragraph spacing.

## 6.5 Captions and labels

- table environment

- caption
- label
- listoftables

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:** You can refer to a table, and the page number of the table, by using the `ref` and `pageref` commands. See section 4.1 on page 23.

**Exercise:** How would you center a table horizontally on the page?

## 6.6 Table placement

- 

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

Exercise:

## 6.7 Long tables

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

Exercise:

Exercise:

## 6.8 Nested tables

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

Exercise:



**Exercise:**

$\text{\LaTeX 2}_{\epsilon}$  is *Free*

## 7 Images

### 7.1 Image types

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

### 7.2 Including graphics

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

Exercise:

### 7.3 Image manipulation

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

Exercise:

Exercise:

### 7.4

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

Exercise:

**Exercise:**

## 7.5 Captions and labels

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

## 7.6 Colors

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

## 8 Advanced Topics

### 8.1 New commands

- 

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

### 8.2 Templates

- 

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

### 8.3 Source listing

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

### 8.4 Presentations

•

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**



**Exercise:**

## 8.5 Books

- 

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

## 8.6 Geometry

- 

```
\documentclass{article}
  \title{This is My Title}
  \author{Charles Carter}
  \date{\today{}}
\begin{document}
  \maketitle{}
  \section{Introduction}
  \label{Introduction}
  \section{Body}
  \label{Body}
  \section{Conclusion}
  \label{Conclusion}
\end{document}
```

**Exercise:**

**Exercise:**

## 9 Conclusion

- A Installing  $\text{\LaTeX}$  2 $\epsilon$
- B Development Environments
- C Command Line Execution

## Notes

<sup>1</sup>The difference between footnotes and endnotes is that footnotes go at the foot of the page where they appear, while endnotes appear at the end of the document.

<sup>2</sup>This is an endnote.

<sup>3</sup>The `addcontentsline` takes three parameters, where the line should be written, usually *toc*, the formatting to be used, usually *section*, and the name to be given to the entry, perhaps *Endnotes*.

## References

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