

**THIS IS THE TITLE**

by

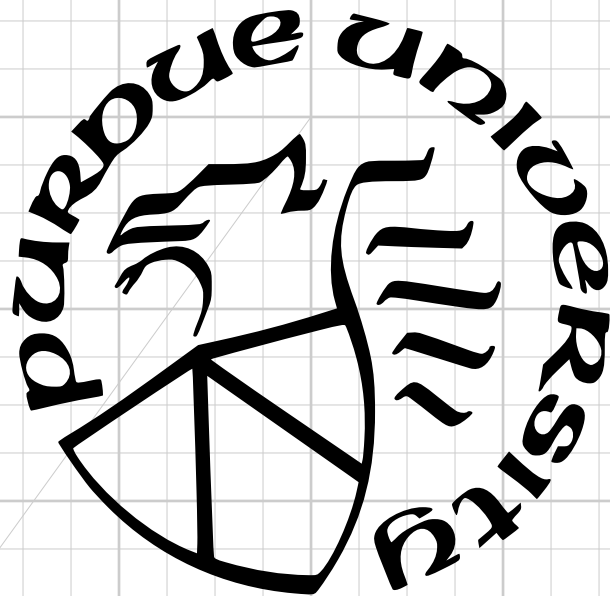
**Mark Senn**

**A Dissertation**

*Submitted to the Faculty of Purdue University*

*In Partial Fulfillment of the Requirements for the degree of*

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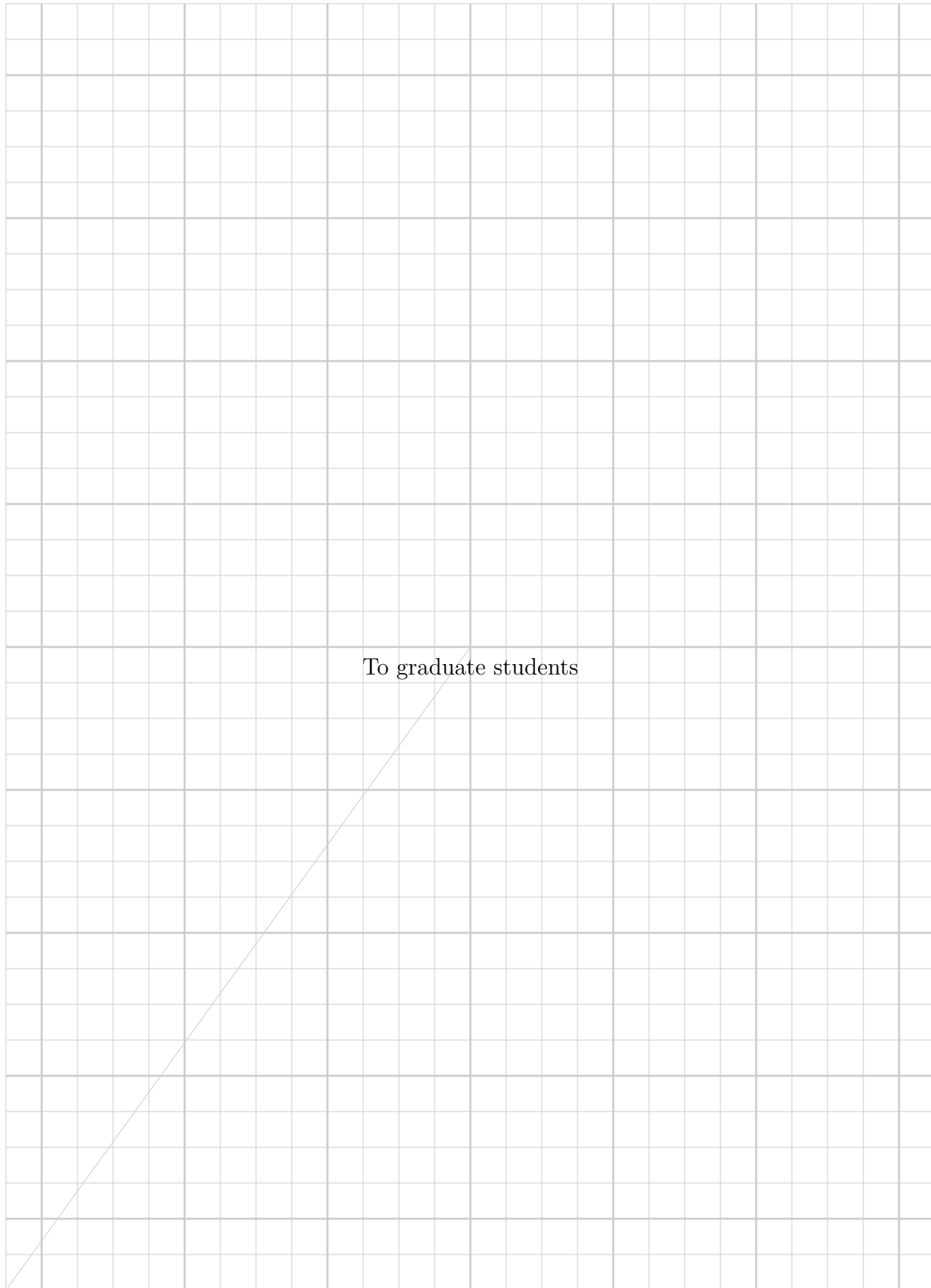
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# PREFACE

This is the preface.

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## LIST OF SYMBOLS

$m$  mass

$v$  velocity

## ABBREVIATIONS

abbr abbreviation

bcf billion cubic feet

BMOC big man on campus

## NOMENCLATURE

alanine	2-Aminopropanoic acid
gasoline	a transparent, petroleum-derived flammable liquid that is used primarily as a fuel in most spark-ignited internal combustion engines [1]
valine	2-Amino-3-methylbutanoic acid
Valvoline	Valvoline Inc. is an American manufacturer and distributor of Valvoline-brand automotive oil, additives, and lubricants. It also owns the Valvoline Instant Oil Change and Valvoline Express Care chains of car repair centers. As of 2016, it is the second largest oil change service provider in the United States with 10% market share and 1,050 locations. [2]

you can divide these into categories if you want

### Biology

alanine	2-Aminopropanoic acid
valine	2-Amino-3-methylbutanoic acid

### Transportation

gasoline	a transparent, petroleum-derived flammable liquid that is used primarily as a fuel in most spark-ignited internal combustion engines [1]
Valvoline	Valvoline Inc. is an American manufacturer and distributor of Valvoline-brand automotive oil, additives, and lubricants. It also owns the Valvoline Instant Oil Change and Valvoline Express Care chains of car repair centers. As of 2016, it is the second largest oil change service provider in the United States with 10% market share and 1,050 locations. [2]

## GLOSSARY

philtrum	the groove between the nose and upper lip
septem	the cartilage in the nose that separates the nostrils
supercalifragilisticexpialidocious	a nonsense word, originally used esp. by children, and typically expressing excited approbation: fantastic, fabulousextraordinarily good [3]
test entry	This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence. This is a a long test sentence.

test entry		This is a a long test sentence. This is a a long test sen-
		tence. This is a a long test sentence. This is a a long test
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## ABSTRACT

PurdueThesis is a  $\LaTeX$  document class used for master's bypass reports, master's theses, PhD dissertations, and PhD preliminary reports. This template demonstrates how to use PurdueThesis.

## 1. INTRODUCTION

$\text{T}_{\text{E}}\text{X}$  is a typesetting system for the creation of beautiful books—and especially for books that contain lots of mathematics [4, page v].

$\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$  is a software system for typesetting documents [5, back cover]. It extends  $\text{T}_{\text{E}}\text{X}$  with more natural chapter, section, etc. commands that are easier to use.  $\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$  has document classes for articles, books, reports, etc.

*PurdueThesis* (*PuTh* for short—rhymes with tooth) is a  $\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$  document class used for Purdue theses, dissertations, master’s bypass reports, and PhD preliminary reports. This template demonstrates how to use *PurdueThesis*. *PurdueThesis* supports all Purdue campuses, programs, and graduate degrees.

The Thesis and Dissertation Office wrote a manual [6] and Microsoft Word templates [7].

Draizelle Sexon [8] recommends using these chapter names:

- Problem and Its Background
- Review of Related Literature and Studies
- Methodology of the Study
- Presentation, Analysis and Interpretation of Data
- Summary, Conclusions, and Recommendations

Mantian Xue’s [9] thesis contained these chapters:

- Introduction
- Device Technology
- Graphene-based Biosensors
- Graphene-based Ion Sensing
- MoS<sub>2</sub>-based Sensors
- Conclusion and Future Work

Think about the structure of your thesis and use appropriate chapter names.

### 1.1 Typographic Conventions

The following typographic conventions are used in this document. These conventions were influenced by [10]–[12]. There are no quotes in the typographic conventions.

D. Sexon. “The thesis.” (Sep. 18, 2012), [Online]. Available: [https://www.slideshare.net/draizelle\\_sexon/the-thesis-and-its-parts](https://www.slideshare.net/draizelle_sexon/the-thesis-and-its-parts).’ gets printed for this reference. The URL contains a `_`, the URL is invisible in the bibliography but copy/paste shows it.

Change to, for example, [10–12] here and everywhere.



### *Emphasis, First Use, and Title*

Emphasis: You *must* do this.

First Use: The sensor was installed in an *ekayak*. An ekayak is an electric kayak.

Title: He read *The Grapes of Wrath* and watched *Citizen Kane*.

### Keyboard Keys

`Control` + `A` means press the Control key and A key at the same time. `A` `B`  
means press key A and then press key B.

### Literal Elements

Literal elements include checkboxes, code, environment variables, file names, function names,  $\LaTeX$  input, output, variable names, and verbatim input (except for commands typed on the command line).  is used to indicate a space if it is not clear where spaces are.

### Menu $\gg$ Item

To make sure smooth scrolling is on go to `Edit`  $\gg$  `Settings` and make sure the `Use smooth scrolling` checkbox is checked.

### Placeholders

Placeholders need to be replaced with real input.

### shell commands

Commands typed on the command line by the user.

## 1.2 Writing in English Information

### 1.2.1 Logical punctuation

I use logical punctuation [13]:

The sign said “Buses Only”.

instead of

The sign said “Buses Only.”

so quoted material, and only quoted material, is inside quotes. This is relatively new and not many people use it. Your major professor may not like this style. Check with them before you decide to use this.

## 1.2.2 Serial comma

, (comma)  $\Rightarrow$  comma  $\Rightarrow$  serial comma

I use the serial comma:

apple, berry, and cherry

instead of

apple, berry and cherry

because I find it easier to see the list items when they are separated by commas. The serial comma is also known as the Oxford comma, Harvard comma, or series comma.

## 1.3 L<sup>A</sup>T<sub>E</sub>X-related information

### 1.3.1 Input reading rules

L<sup>A</sup>T<sub>E</sub>X uses the following rules when reading input:

- the end of a line is equivalent to a space
- spaces at the beginning of a line are ignored
- a blank line ends a paragraph

### 1.3.2 Input preparation conventions

In L<sup>A</sup>T<sub>E</sub>X typing

As  $h$  approaches 0 in the limit, the last fraction can be shown to go to zero. This is true because the area of the red portion of excess region is less than or equal to the area of the tiny black-bordered rectangle. More precisely,  $\left| \left| f(x) - \frac{A(x+h)-A(x)}{h} \right| - \frac{\left| \text{Red Excess} \right|}{h} \right| \leq \frac{h \cdot \max(|f(x+h_1)-f(x+h_2)|)}{h} = \max(|f(x+h_1)-f(x+h_2)|)$  where  $(x+h_1)$  and  $(x+h_2)$  are points where  $f$  reaches its maximum and its minimum, respectively, in the interval  $[x, x+h]$ .

gives exactly the same output as

As  $h$  approaches 0 in the limit, the last fraction can be shown to go to zero. This is true because the area of the red portion of excess region

is less than or equal to the area of the tiny black-bordered rectangle.

More precisely,

$$\begin{aligned} & \left[ \right. \\ & \quad \left| \right. \\ & \quad \quad f(x) \\ & \quad \quad - \\ & \quad \quad \left. \frac{A(x+h)-A(x)}{h} \right. \\ & \quad \left. \right| \\ & \quad - \\ & \quad \left. \frac{\left| \left| \text{Red Excess} \right| \right|}{h} \right. \\ & \quad \left. \leq \right. \\ & \quad \left. \frac{h \big( f(x+h_1) - f(x+h_2) \big)}{h} \right. \\ & \quad = \\ & \quad \left. \frac{f(x+h_1) - f(x+h_2)}{h} \right. \\ & \quad \left. \right] \end{aligned}$$

where  $(x+h_1)$   
and  $(x+h_2)$  are points where  $(f)$  reaches its maximum and its minimum,  
respectively,  
in the interval  $[x, x + h]$ .

I've used L<sup>A</sup>T<sub>E</sub>X over 30 years and use these personal conventions to prepare input. Using these conventions leads to many short lines, but I find those easier to read and edit. Do whatever works best for you.

start input lines with

the first word of a sentence

(

and

but

from

or

to

end input lines with

sentence-ending periods

phrase-ending commas

phrase-ending colons  
 phrase-ending semicolons  
 )  
 \\  
 \\[*dimension*]

put these on a line of their own

`\begin{environment name}`  
`\end{environment name}`  
 short parenthetical remark

## 1.4 Filenames

filenames

There are several different name styles for file names:

camelCase ⇒ kebab-case ⇒ PascalCase ⇒ snake\_case

Name	Why it's called that
camelCase	C is taller than surrounding characters, looks like camel's hump
kebab-case	letters appear to be slid on shish-kebab skewer, no <code>Shift</code> needed
PascalCase	popular in the Pascal programming language
snake_case	looks like a snake, is kebab-case except - is changed to _

**I recommend you only use** kebab-case file names that consist of only lowercase letters, zero or more - characters (but no consecutive - characters), and a single period.

**Do not put spaces in your file names.** It makes it easier to run your thesis on other computers.

I like to start all chapter file names with `ch-`. Chapter names are everything from the beginning of the thesis through the last chapter. Chapters include all front matter in addition to all chapters.

Appendix names start with `ap-` and are everything after the last chapter including any bibliography, colophon, indices, and vita.

Graphics files specific to your thesis start with `gr-` and go in the graphics folder. Non-thesis graphics files retain their normal names and go in the graphics folder.

L<sup>A</sup>T<sub>E</sub>X package files specific to your thesis start with pa- and go in the packages folder.

Non-thesis packages retain their normal names and go in the packages folder.

### 1.5 Special input characters

These input characters are special:

	#	\$	%	&	\	^	_	{	}	~
Type	\#	\\$	\%	\&	\backslash\$	\char'136	\_	\{	\}	\char'176

to get this output

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

### 1.6 Spacing after periods

One or more <sup>uppercase</sup><sub>lowercase</sub> letters followed by a period is treated like <sup>a middle initial</sup><sub>the end of a sentence</sub>

with approximately <sup>one</sup><sub>two</sub> space(s) following the period.

. (period)

Input	Output	Comment
Dr. Smith	Dr. Smith	too much space after abbreviation
Dr.\ Smith	Dr. Smith	correct, Dr. and Smith can be on different lines
Dr.~Smith	Dr. Smith	correct, Dr. and Smith will be on same line, I recommend using this
at NASA. The	at NASA. The	not enough space after sentence ending period
at NASA\@. The	at NASA. The	correct

### 1.7 Four kinds of dashes

There are four kinds of dashes

dash

**hyphen** The hyphen is a punctuation mark used to join words and to separate syllables of a single word. [14].

dash ⇒ hyphen ⇒ dash!hyphen

Input	Output	Comment
- (one hyphen)	-	
son-in-law	son-in-law	used to join words
gas-oline	gas-oline	used to separate syllables, L <sup>A</sup> T <sub>E</sub> X hyphenates words automatically so you may not ever use this

**endash** | The endash [15] is used for

dash ⇒ endash ⇒ dash!endash

Input	Output	Comment
-- (two hyphens)	-	
The Purdue--IU game	The Purdue–IU game	conflict
Perth--Dubai--Boston	Perth–Dubai–Boston	connection
Teal Road runs East--West	Teal Road runs East–West	direction
ages 21--65	ages 21–65	age range
June--July 1967	June–July 1967	month range
pages 38--55	pages 38–55	page range
1:15--2:15 p.m.	1:15–2:15 p.m.	time range
Purdue beat IU 35--28	Purdue beat IU 35–28	scores

**emdash** | The emdash [16] is used for

dash ⇒ emdash ⇒ dash!emdash

---	(three hyphens)	—
<b>Input</b>	the usual suspects---	Larry, Moe, and Curly
<b>Output</b>	the usual suspects—	Larry, Moe, and Curly
<b>Comment</b>	— acts like colon	
<b>Input</b>	Larry, Moe, and Curly---	the usual suspects
<b>Output</b>	Larry, Moe, and Curly—	the usual suspects
<b>Comment</b>	inverse function of colon	
<b>Input</b>	three people---	Larry, Moe, and Curly--%
<b>Output</b>	three people—	Larry, Moe, and Curly—are the usual suspects
<b>Comment</b>	first — acts as (, second — acts as )	
<b>Input</b>	I believe I shall---	no, I'm going to do it.
<b>Output</b>	I believe I shall—	no, I'm going to do it.
<b>Comment</b>	use — when a thought evolves on the fly	

Emdashes should be used sparingly in formal writing.

**figure dash** | The figure dash (input: `\FigureDash`) is used to separate digits—it's the same

dash ⇒ figure dash ⇒ dash!figure dash

width as a digit and is used in identification numbers, part numbers, phone numbers, etc. Type, for example, `Q6759\FigureDash 18100` to get “Q6759-18100”.

**minus sign** `\`Used for negative numbers or subtraction in math mode.

dash  $\Rightarrow$  minus sign  $\Rightarrow$  dash!minus sign

Input	Output	Comment
<code>-</code>	<code>-</code>	(one hyphen in text or display math mode)
<code>\(-a + b\)</code>	$-a + b$	negative $a$
<code>\(a - b\)</code>	$a - b$	subtraction

## 2. SUMMARY

This is the summary chapter.

### 2.1 First Section

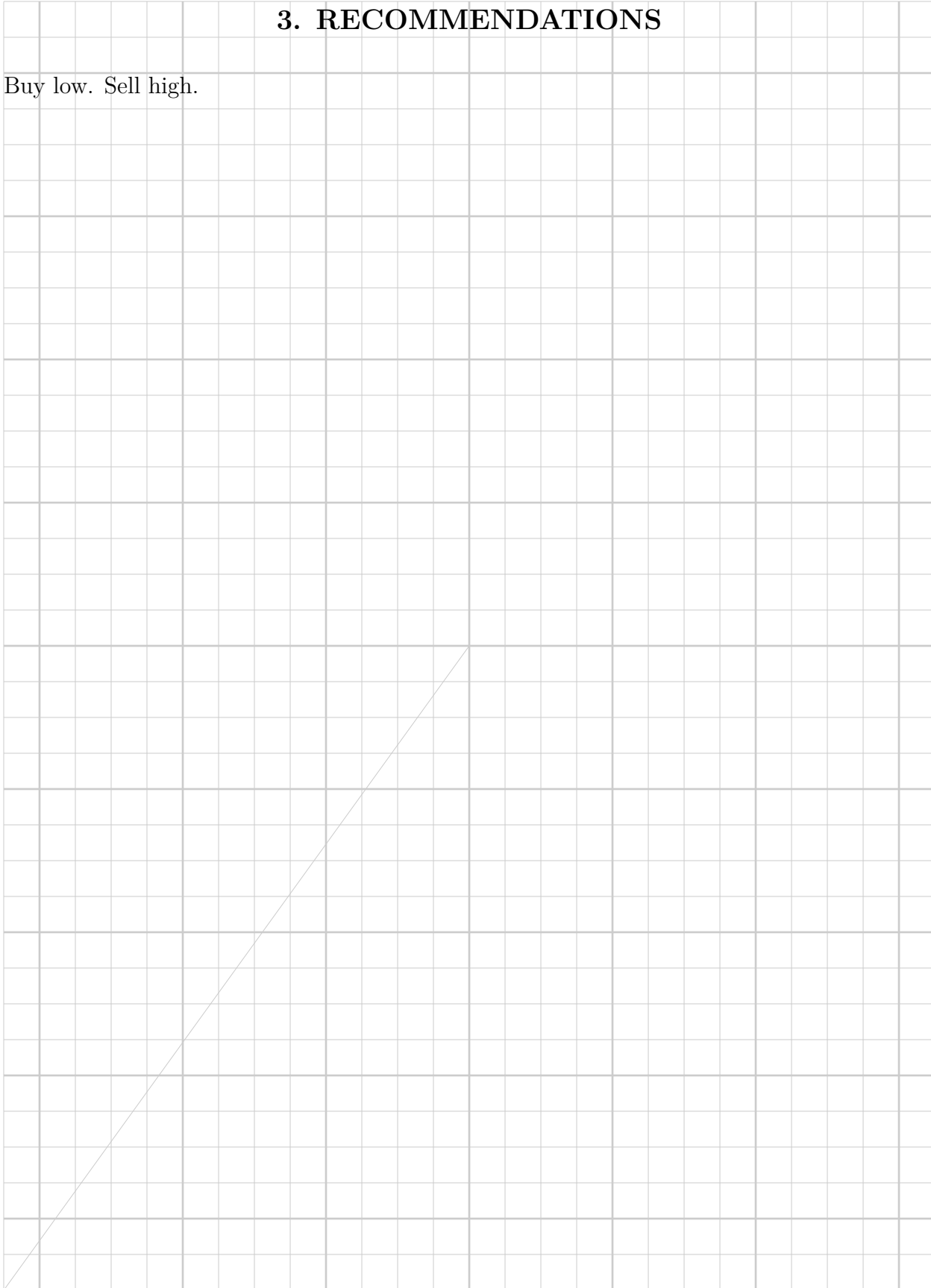
This is the first section of the summary chapter.

```
1 \chapter{SUMMARY}
2
3 This is the summary chapter.
4
5
6 \section{First Section}
7
8 This is the first section of the summary chapter.
```



### 3. RECOMMENDATIONS

Buy low. Sell high.



## 4. TEST

`\cite[page v]{knuth2012}` gives “[1, page v]”.

`\cite[back cover]{lamport1994}` gives “[2, back cover]”.

`\cite{thesis2017}` gives “[3]”.

`\cite{thesis2020}` gives “[4]”.

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## A. ABOUT THE APPENDICES

~~These appendices are single-spaced to save space. Your thesis should use the default 1.5 line spacing.~~

There are two groups of appendices. The first group are general appendices; the second group are domain-specific appendices.

These appendices are a series of examples. They are a work in progress.

Each example consists of some  $\LaTeX$  output followed by the corresponding input lines. Some  $\LaTeX$  input lines only define things and don't produce any output. Each chunk in the input file begins with `\begin{VerbatimOut}{z.out}` then has the  $\LaTeX$  input for the example, and ends with `\end{VerbatimOut}`, followed by a blank line, followed by a line that begins with `\My`.

```

1 \chapter{ABOUT THE APPENDICES}
2
3 % Use single spacing in the appendices from now on to save space.
4 \ZZbaselinestretch{1}
5
6 \textcolor{red}{%
7   \textbf{%
8     These appendices are single-spaced to save space.
9     Your thesis should use the default-1.5 line spacing.%
10  }}%
11 }
12
13 There are two groups of appendices.
14 The first group are general appendices;
15 the second group are domain-specific appendices.
16
17 These appendices are a series of examples.
18 They are a work in progress.
19
20 Each example consists of some \LaTeX\ output
21 followed by the corresponding input lines.
22 Some \LaTeX\ input lines only define things
23 and don't produce any output.
24 Each chunk in the input file begins with
25 \verb+\begin{VerbatimOut}{z.out}+
26 then has the \LaTeX\ input for the example,
27 % Don't literally end VerbatimOut on next line.
28 and ends with {\tt \char'134 end\char'173 VerbatimOut\char'175},
29 followed by a blank line,
30 followed by a line that begins with
31 \verb+\My+.
32

```

### A.1 Paragraphs

This is the first paragraph. Paragraphs are separated by blank lines.

This is the second paragraph.

## A.2 Section Heading

This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

### A.2.1 Subsection heading

This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

#### Subsubsection heading

This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2
3 \section{Paragraphs}
4
5 This is the first paragraph.
6 Paragraphs are separated by blank lines.
7
8 This is the second paragraph.
9
10
11 \section{Section Heading}
12
13 This is a sentence.
14 This is a sentence.
15 This is a sentence.
16 This is a sentence.
17 This is a sentence.
18
19
20 \subsection{Subsection heading}
21
22 This is a sentence.
23 This is a sentence.
24 This is a sentence.
25 This is a sentence.
26 This is a sentence.
27
28
29 \subsubsection{Subsubsection heading}
30
31 This is a sentence.
32 This is a sentence.
33 This is a sentence.
34 This is a sentence.
35 This is a sentence.
```

### A.3 Text math

If items in a list are narrow like these Greek characters,

$\alpha$ ,  $\beta$ , and  $\gamma$

I'd input the line like this

$\alpha$ ,  $\beta$ , and  $\gamma$

where the  $\sim$  is a tie that ties together what's before and after it on the same line of the output [4, page 92].

This text is the correct length to show what happens with and without ties:  $\alpha$ ,  $\beta$ , and  $\gamma$ . See how the line gets split and the  $\gamma$  is at the beginning of the line?

This text is the correct length to show what happens with and without ties:  $\alpha$ ,  $\beta$ , and  $\gamma$ . See how the line gets compressed a little bit so the  $\gamma$  is not at the beginning of the line?

```

1
2
3 \section{Text math}
4
5 If items in a list are narrow like these Greek characters,\
6 \I2 \verb+\alpha$, \beta$, and \gamma$+\
7 I'd input the line like this\
8 \I2 \verb+\alpha$,~\beta$, and~\gamma$+\
9 where the \verb+~+ is a tie
10 that ties together what's before and after it on the same line of the output
11 \cite[page~92]{knuth2012}.
12
13 This text is the correct length to show what happens with and without ties:
14 \alpha$,
15 \beta$,
16 and \gamma$.
17 See how the line gets split
18 and the~\gamma$ is at the beginning of the line?
19
20 This text is the correct length to show what happens with and without ties:
21 \alpha$,~\beta$,
22 and~\gamma$.
23 See how the line gets compressed a little bit so the~\gamma$
24 is not at the beginning of the line?

```



## B. BUGS

See ap-bugs.tex file for L<sup>A</sup>T<sub>E</sub>X input.

### B.1 These problems need to be fixed

Allow manual line break in `\title`. (Mark Senn <mark@purdue.edu>.)

Allow comma in `\title`. (Mark Senn <mark@purdue.edu>.)

Table of Contents uses double-spaced instead of 1½ spacing. Tighten up section and less significant heading spacing? (Anita Adams Sale <aasale@iupui.edu>, 2021-03-17, 11:16.)

List of Figures indented  $\approx 1/4$  inch more than List of Tables. (Anita Adams Sale <aasale@iupui.edu>, 2021-03-17, 11:16.)

Left reference section margin is ok if a person has 10–99 references. Figure out how to adjusting margin for 1–9 or over 99 references. (Mark Senn <mark@purdue.edu>.)

Change citation, e.g., “[6], [71]” to “[6,71]”. (Mark Senn <mark@purdue.edu>, 2021-04-07, 11:55.)

Change citation, e.g., “[6], [7], [8]” to “[6-8]”. (Mark Senn <mark@purdue.edu>, 2021-04-07, 11:55.)

APA reference style indents references too far on left. (Mark Senn <mark@purdue.edu>, 2021-04-08, 21:42.)

Use “Last Accessed: dd/mm/yy.” `urldate` in bibliography. (Priyank Kalgaonkar <pkalgaon@iupui.edu>, 2021-04-06, 15:58.)

Use “Last Accessed: yyyy-mm-dd.” `urldate` in bibliography. (Mark Senn <mark@purdue.edu>, 2021-04-19, 17:05.)

Check that `@{}` is before the left column and after the right column in all tables. (Mark Senn <mark@purdue.edu>, 2021-04-19, 21:32.)

Add DTECH degree.

### B.2 These issues have been reported

Bibliography change. Change, for example, “Acoustical Science and Technology, vol. 23, no. 1” to “Acoustical Science and Technology **23 (1)**”. (Daniel Joesph Carr <djcarr@purdue.edu>, 2021-06-16, 09:33.)

Bibliography change. Change, for example, “M. Abramowitz and I.A. Stegun, Eds.,” to “M. Abramowitz and I.A. Stegun, editors,” (Daniel Joesph Carr <djcarr@purdue.edu>, 2021-06-16, 09:33.)

Section headings containing a SmallCaps font do not work. (Javad (Nima) Darivandpour” <jdarivan@purdue.edu>, 2021-06-29, 10:25. See [N.5](#))

### B.3 These problems are waiting on a reply

— `linktoc = section` does not work with captions with `\frac`. (Mark Senn <mark@purdue.edu>, 2021-05-27, 13:09. In the short-term check with Ashlee Messersmith <amiley@purdue.edu> if `linktoc = page` can be used. If that’s ok make the change and look into changing captions from my code to L<sup>A</sup>T<sub>E</sub>X’s code.) **Waiting on Ashlee.**

### B.4 These problems have been fixed

— Non-nested description environments have bold items. Nested description environments have non-bold items. How come? Are the indentations correct? (Mark Senn <mark@purdue.edu>, 2021-04-09, 16:49.) **Checked ok on 2021-05-31.**





## D. CITATIONS AND REFERENCES

```
1 \chapter{CITATIONS AND REFERENCES}
```

This chapter contains information about citations and references—how to cite a reference in the text and the fine points of defining a bibliography (also called “References”) entry.

```
1 This chapter contains information about citations
2 and references---how to cite a reference in the text
3 and the fine points of defining a bibliography
4 (also called ``References'')
5 entry.
```

### D.1 Citations

```
1 \section{Citations}
```

For L<sup>A</sup>T<sub>E</sub>X answers I refer to [5] and then to [17] or [18]. [18] is an update to [19] (the 1995 edition).

```
1 For \LaTeX\ answers I refer to
2 \cite{lampport1994}
3 and then to
4 \cite{goossens1994}
5 or
6 \cite{kopka1999}.
7 \cite{kopka1999}
8 is an update to \cite{kopka1995} (the 1995 edition).
```

Here is an example .bib file entry:

```
@miscexample2020, address = Imaginaryville, Indiana, author = Andrew Anteater and
Bertha Bear and Charles Cheetah and Davida Deer and Ethan Eagle, date = 2020-10-27, doi
= 00.0000/000-0-000-00000-0, editor = Mark Senn, edition = 2, isbn = 000-0-000-00000-0,
publisher = Bogus International Publishing Company, title = An Imaginary Document Not
About Mark Senn or NASA, url = https://bogus.com/bogus.html, urldate = 2020-10-27,
version = 1.0,
```

```
1 @misc{example2020,
2   address   = {Imaginaryville, Indiana},
3   author    = {Andrew Anteater and Bertha Bear and Charles Cheetah and Davida Deer and Ethan Eagle},
4   date      = {2020-10-27},
5   doi       = {00.0000/000-0-000-00000-0},
6   editor    = {Mark Senn},
7   edition   = {2},
8   isbn      = {{000\FigureDash 0\FigureDash 000\FigureDash 00000\FigureDash 0}},
9   publisher = {Bogus International Publishing Company},
10  title     = {An Imaginary Document Not About {Mark Senn} or {NASA}},
11  url       = {https://bogus.com/bogus.html},
12  urldate   = {2020-10-27},
13  version   = {1.0},
14 }
```

Here are some example BibLaTeX citations. Depending on the style being used these will produce different results.

Input	Output
<code>\cite{example2020}</code>	[20]
<code>\cite*{example2020}</code>	[20]
<code>\citeauthor{example2020}</code>	Anteater, Bear, Cheetah, <i>et al.</i>
<code>\citeauthor*{example2020}</code>	Anteater <i>et al.</i>
<code>\citedate{example2020}</code>	Oct. 27, 2020
<code>\citetitle{example2020}</code>	<i>An Imaginary Document Not About Mark Senn or NASA</i>
<code>\citetitle*{example2020}</code>	<i>An Imaginary Document Not About Mark Senn or NASA</i>
<code>\citeurl{example2020}</code>	<a href="https://bogus.com/bogus.html">https://bogus.com/bogus.html</a>
<code>\citeyear{example2020}</code>	2020
<code>\parencite{example2020}</code>	[20]
<code>\textcite{example2020}</code>	Anteater, Bear, Cheetah, <i>et al.</i> [20]

## D.2 References

```
1 \section{References}
```

Emily Spreen wrote that the following URLs are invisible in the PDF file. They worked fine for me on 2021-04-08. See [21], [22], and [23] in the REFERENCES.

```
@misc{hambleton,
  key = {Deep Space Gateway},
  title = {{Deep Space Gateway to Open Opportunities for Distant Destinations}},
  note = {Editor: Kathryn Hambleton},
  year = {2018},
  month = {August 24,},
  howpublished = {\url{https://www.nasa.gov/feature/deep-space-gateway-to-open-...}},
  organization = {NASA},
}
```

```
@misc{gerstenmaier,
  author = {William H. Gerstenmaier},
  title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
  month = {March},
  year = {2017},
  howpublished = {\url{https://www.nasa.gov/sites/default/files/atoms/files/...}},
  organization = {NASA},
}
```

I suggest using the following (added a ‘2’ to the key so they’d have separate entries in the references.).

```
@misc{gerstenmaier2,
  author = {William H. Gerstenmaier},
  date = {2017-03},
  title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
  url = {https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf},
  organization = {NASA},
}
```

1	Emily Spreen wrote that the following URLs are invisible in the PDF file.
2	They worked fine for me on 2021-04-08.
3	See \cite{hambleton}, \cite{gerstenmaier}, and \cite{gerstenmaier2} in the REFERENCES.
4	
5	{\footnotesize
6	\begin{verbatim}
7	@misc{hambleton,
8	key = {Deep Space Gateway},
9	title = {{Deep Space Gateway to Open Opportunities for Distant Destinations}},
10	note = {Editor: Kathryn Hambleton},
11	year = {2018},
12	month = {August 24,},
13	howpublished = {\url{https://www.nasa.gov/feature/deep-space-gateway-to-open-...}},
14	organization = {NASA},
15	}
16	\end{verbatim}
17	}
18	
19	{\footnotesize
20	\begin{verbatim}
21	@misc{gerstenmaier,
22	author = {William H. Gerstenmaier},
23	title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
24	month = {March},
25	year = {2017},
26	howpublished = {\url{https://www.nasa.gov/sites/default/files/atoms/files/...}},
27	organization = {NASA},
28	}
29	\end{verbatim}
30	}
31	
32	I suggest using the following
33	(added a `2' to the key so they'd have separate entries in the references.).
34	{\footnotesize
35	\begin{verbatim}
36	@misc{gerstenmaier2,
37	author = {William H. Gerstenmaier},
38	date = {2017-03},
39	title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
40	url = {https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf},
41	organization = {NASA},
42	}
43	\end{verbatim}
44	}

## E. COMMON MISTAKES

The following Headings, Mathematics, and Text sections describe some common mistakes.

### E.1 Headings

Farkas [24, page 289] wrote

The practice of stacking headings is routinely condemned by style manuals and other authorities. Here is a typical statement, taken from Houghton Mifflin's guidelines for authors.

Avoid “stacking” heads, or placing two levels of headings together without intervening text. A heading cannot substitute for the transitional or introductory paragraphs that guide the reader through a chapter. Remember too that a chapter opening looks better in type when one or more paragraphs of text precede the first heading.

```

1  \chapter{COMMON MISTAKES}
2
3  The following Headings, Mathematics, and Text
4  sections describe some common mistakes.
5
6
7  \section{Headings}
8
9  \ifthen{\equal{\bibprocessor}{biblatex}}
10 {\textcite[page=289]{farkas2011} }%
11 \ifthen{\equal{\bibprocessor}{bibtex}}
12 {\cite{farkas2011} }%
13 wrote
14
15 \begin{quotation}
16   The practice of stacking headings
17   is routinely condemned by style manuals
18   and other authorities.
19   Here is a typical statement,
20   taken from Houghton Mifflin's guidelines for authors.
21 \begin{quotation}
22   Avoid ``stacking'' heads,
23   or placing two levels
24   of headings together without intervening text.
25   A heading cannot substitute
26   for the transitional
27   or introductory paragraphs
28   that guide the reader through a chapter.
29   Remember too that a chapter opening looks better in type
30   when one
31   or more paragraphs
32   of text precede the first heading.
33 \end{quotation}
34 \end{quotation}

```



## E.2 Mathematics

### E.2.1 Put a little extra horizontal space before dx.

```

1
2
3 \section{Mathematics}
4
5 \subsection{Put a little extra horizontal space before dx.}

```

## E.3 Text

```

1
2
3 \section{Text}

```

### E.3.1 e.g.,

“e.g.” should always be followed by a comma.

e.g.

```

1
2 \subsection{e.g.,}
3 \ix{e.g.}
4
5 ``e.g.'' should always be followed by a comma.

```

### E.3.2 “et al.” is an abbreviation

et al.

The phrase “et al.” is an abbreviation and should always be followed by a period. It should be in the normal font for your document—do not italicize or underline it.

Example:

input	Thun et al.~used data from Santa Claus.
output	Thun et al. used data from Santa Claus.
comment	my recommendation
input	Thun et al. used data from Santa Claus.
output	Thun et al. used data from Santa Claus.
comment	too much space after period—L <sup>A</sup> T <sub>E</sub> X thinks period is end of sentence
input	Thun et al\@. used data from Santa Claus.
output	Thun et al. used data from Santa Claus.
comment	spacing is right but the “et al.” could occur at end of a line

```

1
2 \subsection{``et al.'' is an abbreviation}
3 \ix{et al.}
4
5 The phrase ``et al.''
6 is an abbreviation
7 and should always be followed by a period.
8 It should be in the normal font for your document---%

```

```

9 do not italicize or underline it.
10
11 Example:\\[6pt]
12 \\indent\\indent
13 \\begin{tabular}{@{}l@{}}
14   input& \\verb+Thun et al.~used data from Santa Claus.+\\
15   output& Thun et al.~used data from Santa Claus.\\
16   comment& my recommendation\\[6pt]
17   input& \\verb+Thun et al. used data from Santa Claus.+\\
18   output& Thun et al. used data from Santa Claus.\\
19   comment& too much space after period---\\LaTeX\\ thinks period is end of sentence\\[6pt]
20   input& \\verb+Thun et al\\@. used data from Santa Claus.+\\
21   output& Thun et al\\@. used data from Santa Claus.\\
22   comment& spacing is right but the ``et al.'' could occur at end of a line\\
23 \\end{tabular}

```

### E.3.3 i.e.,

i.e.

“i.e.” should always be followed by a comma.

```

1 \\subsection{i.e.,}
2 \\ix{i.e.}
3
4
5 ``i.e.' should always be followed by a comma.

```

## F. DEFINING COMMANDS

The next paragraph demonstrates how to define and use a command.

Editors recommend that a chapter title should never be followed by a section heading without some intervening text. I suggest writing for readers. Break the rules if necessary.

```
1 \chapter{DEFINING COMMANDS}
2
3 The next paragraph demonstrates how to define and use a command.
4
5 \renewcommand{\t}[2]
6 {%
7   Editors recommend that a #1 should never be
8   followed by a #2 without some intervening text.
9 }
10
11 \t{chapter title}{section heading}
12 I suggest writing for readers.
13 Break the rules if necessary.
14
```

## G. CHAPTER APPENDICES

Using `\chapterappendix` or `\chapterappendices` in the first chapter will number sections, for example, 1.1, 1.2, 1.A.

Using `\chapterappendix` or `\chapterappendices` in the first appendix will number sections, for example, A.1, A.2, A.A.

Only use `\chapterappendix` or `\chapterappendices` in chapters. Using them in appendices is too confusing.

### G.1 This is a section headings

This is a paragraph.

Use `\chapterappendix` or `chapterappendices` to make sections until the end of the next chapter be appendices.

### G.A This is a chapter appendix

This is a paragraph.

```

1 \chapter{CHAPTER APPENDICES}
2
3 Using \verb+\chapterappendix+ or \verb+\chapterappendices+
4 in the first chapter will number sections, for example,
5 1.1, 1.2, 1.A.
6
7 Using \verb+\chapterappendix+ or \verb+\chapterappendices+
8 in the first appendix will number sections, for example,
9 A.1, A.2, A.A.
10
11 Only use \verb+\chapterappendix+ or \verb+\chapterappendices+
12 in chapters.
13 Using them in appendices is too confusing.
14
15 \section{This is a section headings}
16
17 This is a paragraph.
18
19 Use \verb+\chapterappendix+ or \verb+chapterappendices+
20 to make sections until the end of the next chapter
21 be appendices.
22
23 \chapterappendix
24
25 \section{This is a chapter appendix}
26
27 This is a paragraph.
```





## I. FIGURES

```
1 \chapter{FIGURES}
2
```

The `h` specifier used in all the examples below tells  $\text{\LaTeX}$  to put the figure “here” instead of trying to find a good spot at the top or bottom of a page. Specifiers can be combined, for example, “`\begin{figure}[htbp!]`”.

```
1
2 The
3 \verb+h+
4 specifier used in all the examples below
5 tells \LaTeX\ to put the figure
6 ``here''
7 instead of trying
8 to find a good spot
9 at the top or bottom of a page.
10 Specifiers can be combined,
11 for example,
12 ``\verb+\begin{figure}[htbp!]+''.
```

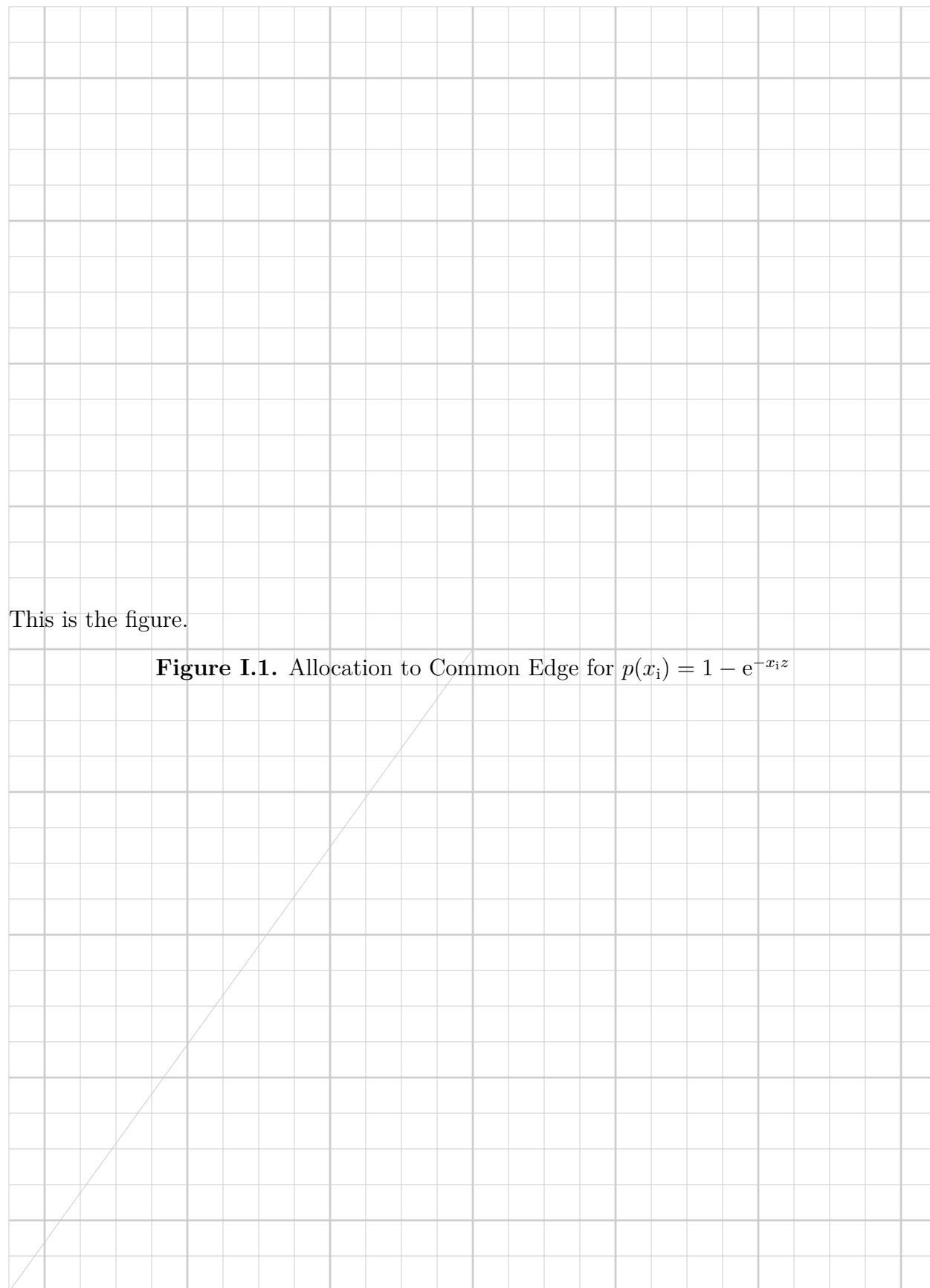
The complete list of specifiers:

Specifier	Description
<code>b</code>	bottom of page
<code>h</code>	here on page
<code>p</code>	on separate page of figures
<code>t</code>	top of page
<code>!</code>	try hard to put figure as early as possible

```
1
2 The complete list of specifiers:
3 \vspace*{6pt}
4 \begin{center}
5 \begin{tabular}{@{}l@{}}
6 \toprule
7 \bf Specifier& \bf Description\\
8 \midrule
9 \noalign{\vspace*{2pt}}
10 \tt b& bottom of page\\
11 \tt h& here on page\\
12 \tt p& on separate page of figures\\
13 \tt t& top of page\\
14 \tt !& try hard to put figure as early as possible\\
15 \bottomrule
16 \end{tabular}
17 \end{center}
```

This is the first paragraph. This is the first paragraph. This is the first paragraph. This is the first paragraph. This is the first paragraph.

```
1
2 % MyRepeat is defined in MyRepeat.sty.
3 \MyRepeat{This is the first paragraph. }{5}
```



This is the figure.

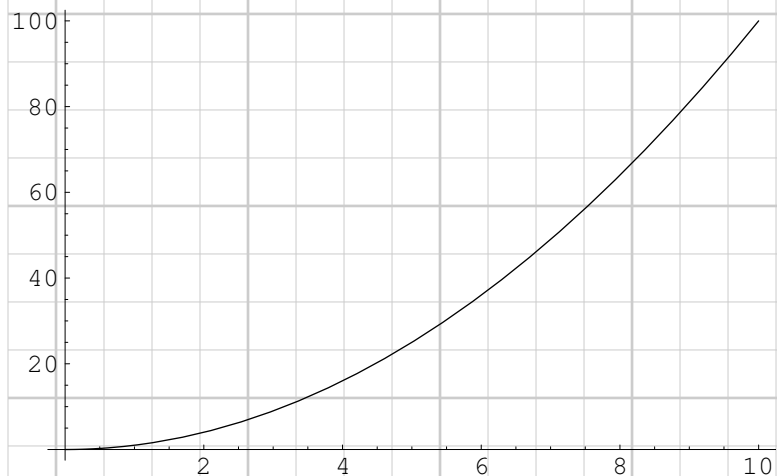
**Figure I.1.** Allocation to Common Edge for  $p(x_i) = 1 - e^{-x_i z}$



```

1
2 \begin{figure}
3   This is the figure.
4   \caption{%
5     Allocation to Common Edge for
6     \(\rho(x_i) = 1 - e^{-x_i z}\) \(\frac{-x_i}{z}\)
7   }
8 \end{figure}

```



**Figure I.2.** By default figures are not centered. This is a long caption to demonstrate that captions are single spaced. This is a long caption to demonstrate that captions are single spaced.

```

1
2 \begin{figure}[ht]
3   \includegraphics{gr-plot.pdf}
4   \caption
5   {%
6     By default figures are not centered.
7     This is a long caption to demonstrate that captions are single spaced.
8     This is a long caption to demonstrate that captions are single spaced.%
9   }
10  \label{fi:not-centered}
11 \end{figure}

```

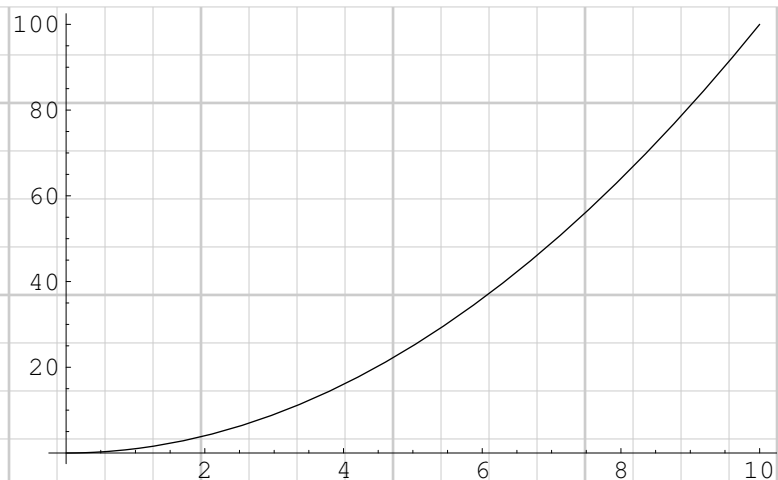
This is the second paragraph. This is the second paragraph. This is the second paragraph.  
 This is the second paragraph. This is the second paragraph. This is the second paragraph.  
 This is the second paragraph. This is the second paragraph. This is the second paragraph.  
 This is the second paragraph.

```

1
2 \MyRepeat{This is the second paragraph. }{10}

1
2 \begin{figure}[ht]
3   \centering
4   \includegraphics{gr-plot.pdf}
5   \caption{Use {\tt \char'134centering\} to center figures.}
6   \label{fi:centered}
7 \end{figure}

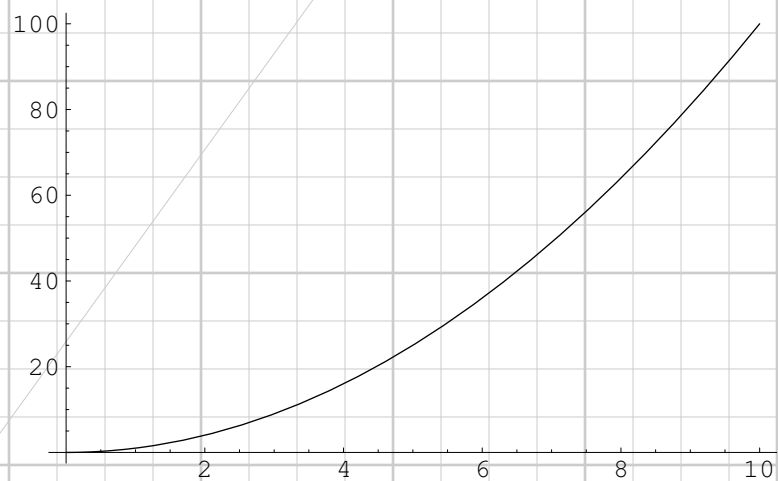
```



**Figure I.3.** Use `\centering` to center figures.

This is the third paragraph. This is the third paragraph. This is the third paragraph.  
 This is the third paragraph. This is the third paragraph. This is the third paragraph. This  
 is the third paragraph. This is the third paragraph. This is the third paragraph. This is the  
 third paragraph. This is the third paragraph. This is the third paragraph. This is the third  
 paragraph. This is the third paragraph. This is the third paragraph. This is the third  
 paragraph. This is the third paragraph. This is the third paragraph.

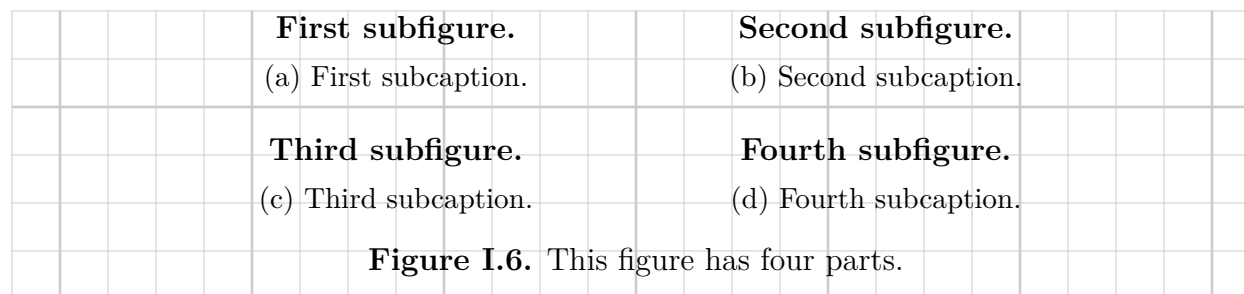
```
1
2 \MyRepeat{This is the third paragraph. }{15}
```



**Figure I.4.** This is another figure.

```
1
2 \begin{figure}[ht]
3 \centering
4 \includegraphics{gr-plot.pdf}
```

5	<code>\caption{This is another figure.}</code>
6	<code>\label{fi:another}</code>
7	<code>\end{figure}</code>
	<p>This is the fourth paragraph. This is the fourth paragraph. This is the fourth paragraph.  This is the fourth paragraph. This is the fourth paragraph. This is the fourth paragraph.  This is the fourth paragraph. This is the fourth paragraph. This is the fourth paragraph.  This is the fourth paragraph.</p>
1	
2	<code>\MyRepeat{This is the fourth paragraph. }{10}</code>
	<p><b>First subfigure.</b>                      <b>Second subfigure.</b></p> <p>(a) First subcaption.                      (b) Second subcaption.</p>
	<p><b>Figure I.5.</b> This figure has two parts.</p>
1	
2	<code>% See pages 4--5 of</code>
3	<code>% <a href="http://mirrors.ibiblio.org/CTAN/macros/latex/contrib/caption/subcaption.pdf">http://mirrors.ibiblio.org/CTAN/macros/latex/contrib/caption/subcaption.pdf</a></code>
4	<code>% for how to use \subcaptionbox.</code>
5	<code>\begin{figure}[ht]</code>
6	<code>% Center the entire figure (containing the two subfigures).</code>
7	<code>\centering</code>
8	<code>% The \subcaptionbox for the first subfigure.</code>
9	<code>\subcaptionbox</code>
10	<code>% The first subcaption with a \label.</code>
11	<code>% Use \ref{sf:two-parts-a} to print the subcaption number.</code>
12	<code>{First subcaption.\label{sf:two-parts-a}}%</code>
13	<code>% The first subfigure is this wide.</code>
14	<code>[2in]%</code>
15	<code>% This is the first subfigure.</code>
16	<code>% You'll usually use an \includegraphics{filename}</code>
17	<code>% inside the braces on the next line.</code>
18	<code>{\bfseries First subfigure.}%</code>
19	<code>% Put 0.5 inches of blank space between the subfigures.</code>
20	<code>\hskip 0.5truein</code>
21	<code>\subcaptionbox</code>
22	<code>{Second subcaption.\label{sf:two-parts-b}}%</code>
23	<code>[2in]%</code>
24	<code>{\bfseries Second subfigure.}%</code>
25	<code>% The caption for the entire figure (containing two subfigures).</code>
26	<code>\caption{This figure has two parts.}</code>
27	<code>% The label for the entire figure.</code>
28	<code>\label{fi:two-parts}</code>
29	<code>\end{figure}</code>
	<p>This is the fifth paragraph. This is the fifth paragraph. This is the fifth paragraph. This  is the fifth paragraph. This is the fifth paragraph. This is the fifth paragraph. This is the  fifth paragraph. This is the fifth paragraph. This is the fifth paragraph. This is the fifth  paragraph.</p>
1	
2	<code>\MyRepeat{This is the fifth paragraph. }{10}</code>



```

1
2 \newpage
3
4 \begin{figure}[ht]
5   \centering
6     \subcaptionbox
7       {First subcaption.\label{sf:four-parts-a}}
8       [2in]%
9       {\bfseries First subfigure.}%
10    \hskip 0.5truein
11    \subcaptionbox
12      {Second subcaption.\label{sf:four-parts-b}}
13      [2in]%
14      {\bfseries Second subfigure.}%
15    \vspace*{\baselineskip}
16    \subcaptionbox
17      {Third subcaption.\label{sf:four-parts-c}}
18      [2in]%
19      {\bfseries Third subfigure.}%
20    \hskip 0.5truein
21    \subcaptionbox
22      {Fourth subcaption.\label{sf:four-parts-d}}
23      [2in]%
24      {\bfseries Fourth subfigure.}%
25    \caption{This figure has four parts.}
26    \label{fi:four-parts}
27 \end{figure}

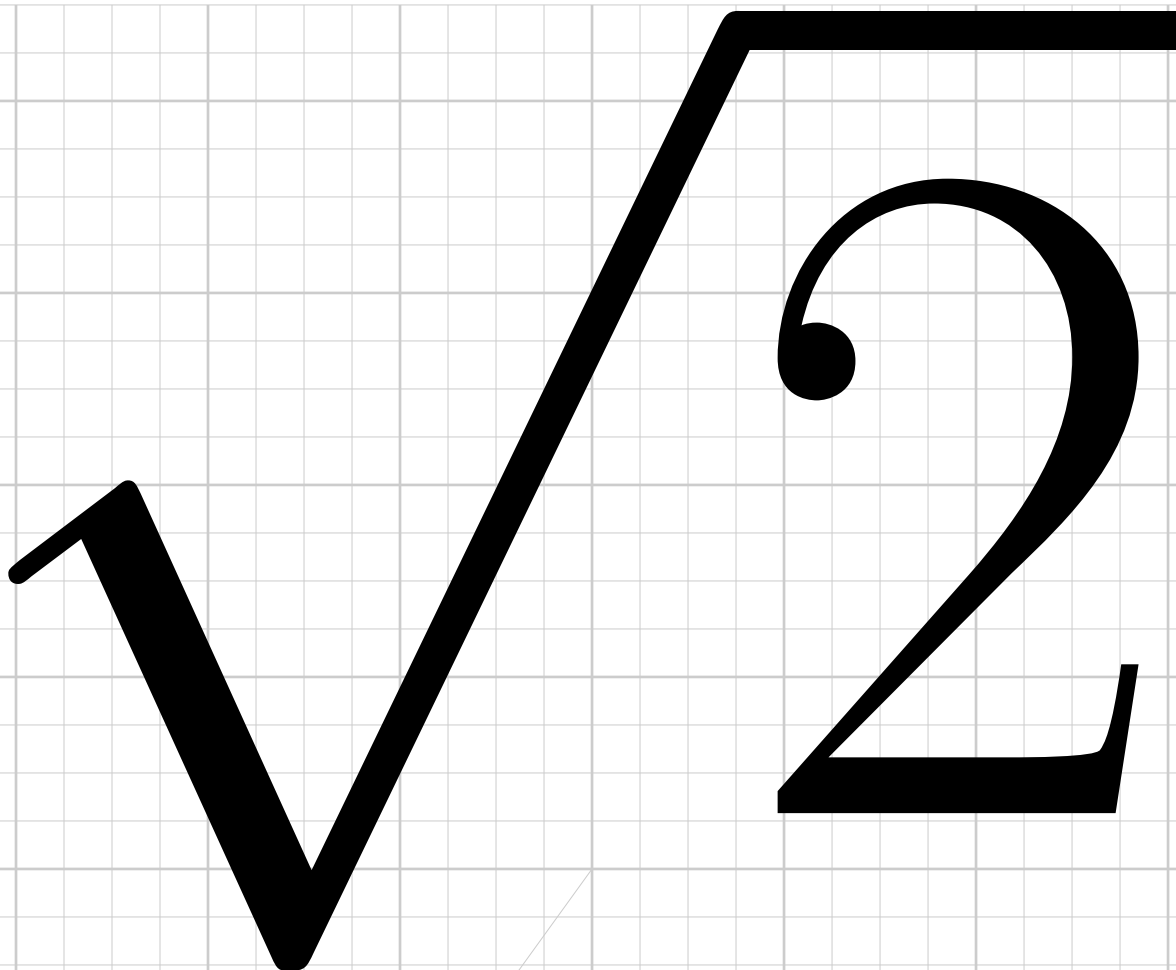
```

This is the sixth paragraph. This is the sixth paragraph. This is the sixth paragraph.  
 This is the sixth paragraph. This is the sixth paragraph. This is the sixth paragraph. This  
 is the sixth paragraph. This is the sixth paragraph. This is the sixth paragraph. This is the  
 sixth paragraph.

```

1
2 \MyRepeat{This is the sixth paragraph. }{10}

```

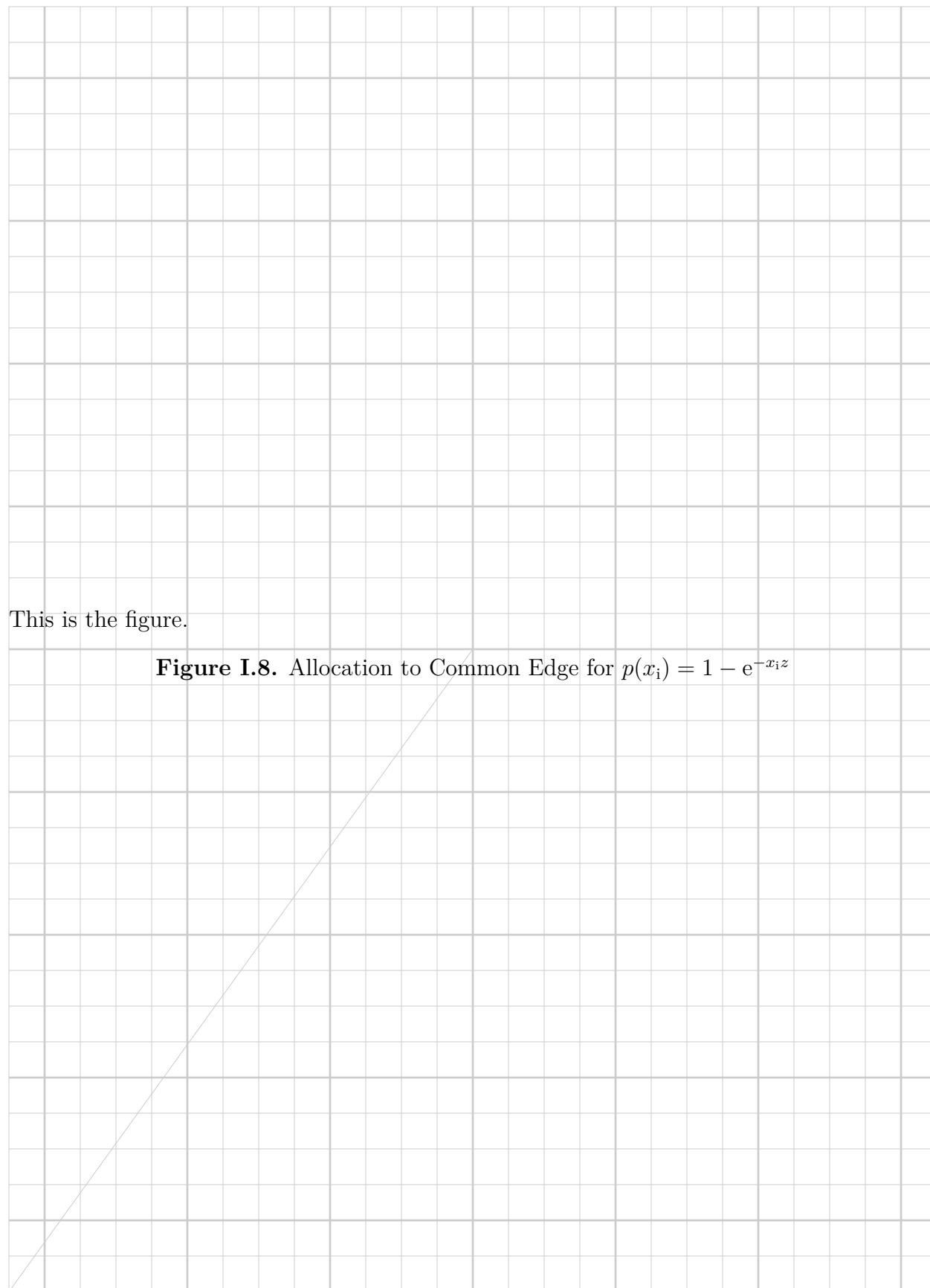


**Figure I.7.** A big “ $\sqrt{2}$ ”. L<sup>A</sup>T<sub>E</sub>X can make output big enough for T-shirts or posters. Square roots are printed with space before them, I put some negative horizontal space before this one to center it.

```

1
2 \newpage
3
4 \begin{figure}[ht]
5   \centering
6   % Use a 5" font.
7   {\fontsize{5in}{5in}\selectfont{\hspace*{-0.07em}\sqrt 2\}}
8   \caption{%
9     A big ``\(\sqrt 2\)''.
10    \LaTeX can make output big enough for T-shirts or posters.
11    Square roots are printed with space before them,
12    I put some negative horizontal space before this one to center it.%
13   }
14 \end{figure}

```



This is the figure.

**Figure I.8.** Allocation to Common Edge for  $p(x_i) = 1 - e^{-x_i z}$

The remainder of this file tests having lots of figures. There are 20 figures in this test.



**Figure I.9.** Test figure 1 of 20.



**Figure I.10.** Test figure 2 of 20.



**Figure I.11.** Test figure 3 of 20.



**Figure I.12.** Test figure 4 of 20.



**Figure I.13.** Test figure 5 of 20.



**Figure I.14.** Test figure 6 of 20.

```
1
2 \newpage
3
4 The remainder of this file tests having lots of figures.
5 There are 20 figures in this test.
6
7 \begin{figure}[ht]
8   \centering
9   \includegraphics[scale=0.5]{gr-tally-01.pdf}
10  \caption{Test figure 1 of 20.}
11  \label{fi:1of20}
12 \end{figure}
13
14 \begin{figure}[ht]
15  \centering
```



Figure I.15. Test figure 7 of 20.



Figure I.16. Test figure 8 of 20.



Figure I.17. Test figure 9 of 20.



Figure I.18. Test figure 10 of 20.



Figure I.19. Test figure 11 of 20.



Figure I.20. Test figure 12 of 20.



Figure I.21. Test figure 13 of 20.



Figure I.22. Test figure 14 of 20.

```
16 \includegraphics[scale=0.5]{gr-tally-02.pdf}
17 \caption{Test figure 2 of 20.}
18 \label{fi:2of20}
19 \end{figure}
20
21 \begin{figure}[ht]
22 \centering
23 \includegraphics[scale=0.5]{gr-tally-03.pdf}
24 \caption{Test figure 3 of 20.}
25 \label{fi:3of20}
26 \end{figure}
27
28 \begin{figure}[ht]
29 \centering
```





Figure I.23. Test figure 15 of 20.



Figure I.24. Test figure 16 of 20.

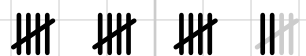


Figure I.25. Test figure 17 of 20.

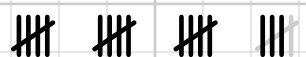


Figure I.26. Test figure 18 of 20.

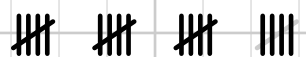


Figure I.27. Test figure 19 of 20.

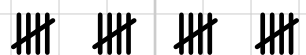


Figure I.28. Test figure 20 of 20.

```

30 \includegraphics[scale=0.5]{gr-tally-04.pdf}
31 \caption{Test figure 4 of 20.}
32 \label{fi:4of20}
33 \end{figure}
34
35 \begin{figure}[ht]
36 \centering
37 \includegraphics[scale=0.5]{gr-tally-05.pdf}
38 \caption{Test figure 5 of 20.}
39 \label{fi:5of20}
40 \end{figure}
41
42 \begin{figure}[ht]
43 \centering
44 \includegraphics[scale=0.5]{gr-tally-06.pdf}
45 \caption{Test figure 6 of 20.}
46 \label{fi:6of20}
47 \end{figure}
48
49 \begin{figure}[ht]
50 \centering
51 \includegraphics[scale=0.5]{gr-tally-07.pdf}
52 \caption{Test figure 7 of 20.}
53 \label{fi:7of20centered7}
54 \end{figure}
55

```

```
56 \begin{figure}[ht]
57   \centering
58   \includegraphics[scale=0.5]{gr-tally-08.pdf}
59   \caption{Test figure 8 of 20.}
60   \label{fi:8of20}
61 \end{figure}
62
63 \begin{figure}[ht]
64   \centering
65   \includegraphics[scale=0.5]{gr-tally-09.pdf}
66   \caption{Test figure 9 of 20.}
67   \label{fi:9of20}
68 \end{figure}
69
70 \begin{figure}[ht]
71   \centering
72   \includegraphics[scale=0.5]{gr-tally-10.pdf}
73   \caption{Test figure 10 of 20.}
74   \label{fi:10of20}
75 \end{figure}
76
77 \begin{figure}[ht]
78   \centering
79   \includegraphics[scale=0.5]{gr-tally-11.pdf}
80   \caption{Test figure 11 of 20.}
81   \label{fi:11of20}
82 \end{figure}
83
84 \begin{figure}[ht]
85   \centering
86   \includegraphics[scale=0.5]{gr-tally-12.pdf}
87   \caption{Test figure 12 of 20.}
88   \label{fi:12of20}
89 \end{figure}
90
91 \begin{figure}[ht]
92   \centering
93   \includegraphics[scale=0.5]{gr-tally-13.pdf}
94   \caption{Test figure 13 of 20.}
95   \label{fi:13of20}
96 \end{figure}
97
98 \begin{figure}[ht]
99   \centering
100  \includegraphics[scale=0.5]{gr-tally-14.pdf}
101  \caption{Test figure 14 of 20.}
102  \label{fi:14of20}
103 \end{figure}
104
105 \begin{figure}[ht]
106   \centering
107   \includegraphics[scale=0.5]{gr-tally-15.pdf}
108   \caption{Test figure 15 of 20.}
109   \label{fi:15of20}
110 \end{figure}
111
112 \begin{figure}[ht]
113   \centering
114   \includegraphics[scale=0.5]{gr-tally-16.pdf}
115   \caption{Test figure 16 of 20.}
116   \label{fi:16of20}
117 \end{figure}
118
119 \begin{figure}[ht]
```

```
120 \centering
121 \includegraphics[scale=0.5]{gr-tally-17.pdf}
122 \caption{Test figure 17 of 20.}
123 \label{fi:17of20}
124 \end{figure}
125
126 \begin{figure}[ht]
127 \centering
128 \includegraphics[scale=0.5]{gr-tally-18.pdf}
129 \caption{Test figure 18 of 20.}
130 \label{fi:18of20}
131 \end{figure}
132
133 \begin{figure}[ht]
134 \centering
135 \includegraphics[scale=0.5]{gr-tally-19.pdf}
136 \caption{Test figure 19 of 20.}
137 \label{fi:19of20}
138 \end{figure}
139
140 \begin{figure}[ht]
141 \centering
142 \includegraphics[scale=0.5]{gr-tally-20.pdf}
143 \caption{Test figure 20 of 20.}
144 \label{fi:20of20}
145 \end{figure}
```

## J. GRAPHICS

There are many ways to make graphics for  $\text{\LaTeX}$ . I like to use a system that uses  $\text{\LaTeX}$  fonts so the appearance of the output is more professional.

```

1 \chapter{GRAPHICS}
2
3 There are many ways to make graphics for \LaTeX.
4 I like to use a system that uses \LaTeX fonts
5 so the appearance of the output is more professional.
```

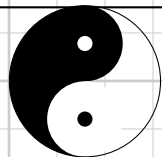
### J.1 $\text{\LaTeX}$ TikZ package

```

1
2
3 \section{\LaTeX\ TikZLogo\ package}
4 \index{TikZ@TikZLogo}
```

#### J.1.1 Yin and yang

This Yin and yang example was done by Thomas G. Kristensen [25]. This is the “traditional Taijitu symbol from Chinese philosophy”.



Kristensen, Thomas G.  $\Rightarrow$  Taijitu symbol  $\Rightarrow$  Yin and yang symbol

```

1
2
3 \subsection{Yin and yang}
4
5 This Yin and yang example was done by Thomas G. Kristensen \cite{kristensen}.
6 This is the ``traditional Taijitu symbol from Chinese philosophy''.\
7 \ix{Kristensen, Thomas G.//Taijitu symbol//Yin and yang symbol}
8
9 \index{TikZ@TikZLogo}
10 \begin{tikzpicture}
11 % Yin and yang
12 % Author: Thomas G. Kristensen
13
14 % color one half of a unit circle
15 \begin{scope}
16 \clip (0,0) circle (1cm);
17 \fill[black] (0cm,1cm) rectangle (-1cm, -1cm);
18 \end{scope}
19
20 % fill heads
21 \fill[black] (0,0.5) circle (0.5cm);
22 \fill[white] (0,-0.5) circle (0.5cm);
23
24 % fill eyes
25 \fill[white] (0,0.5) circle (0.1cm);
26 \fill[black] (0,-0.5) circle (0.1cm);
27
28 % outer line
```

```
29 \draw (0,0) circle (1cm);
30
31 \end{tikzpicture}
```

## J.2 Mathematica (which uses Wolfram Language)

Mathematica

```
1
2 \section{Mathematica (which uses Wolfram Language)}
3 \ix{Mathematica}
```

## J.3 MATLAB

MATLAB

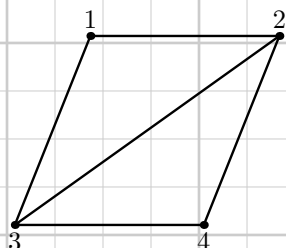
```
1
2 \section{MATLAB}
3 \ix{MATLAB}
```

## J.4 METAPOST (uses L<sup>A</sup>T<sub>E</sub>X fonts)

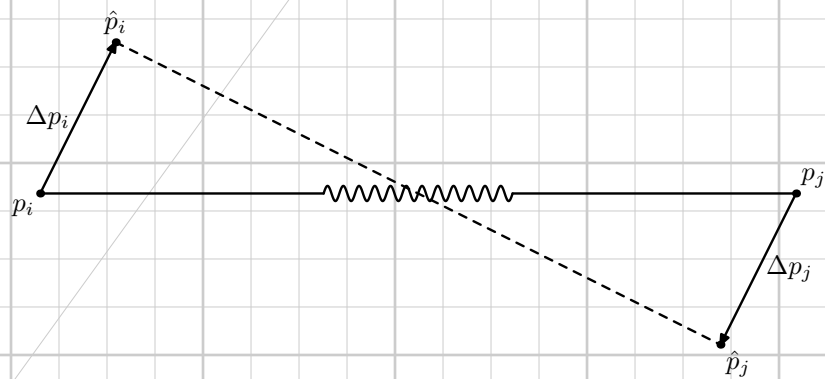
I did these METAPOST [26] examples for Yanghyun Kim [27].

Kim, Yanghyun

```
1
2 \section{\protect\METAPOSTLogo\ (uses \LaTeX\ fonts)}
3 \index{METAPOST@METAPOSTLogo}
4
5 I did these \METAPOSTLogo\ \cite{metapost} examples
6 for Yanghyun Kim \cite{kim2009}.
7 \ix{Kim, Yanghyun}
```



need source code



need source code

```

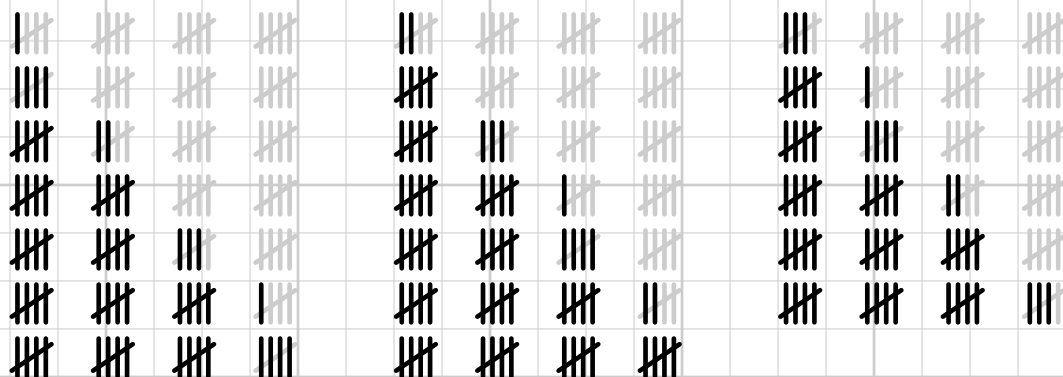
1
2 \includegraphics{gr-kim1.pdf}
3 \todoerror{need source code}
4
5 \vspace{0.1truein}
6
7 \includegraphics{gr-kim2.pdf}
8 \todoerror{need source code}

```

#### J.4.1 METAPOST Tally Example

Whenever I use files with numbers in them I like to put leading zeros in the names so they will be listed in order in the directory.

These 20 graphics (gr-tally-01.pdf through gr-tally-20.pdf)



were produced by

```

1 %
2 % tally.mp 2021-08-14 Mark Senn http://engineering.purdue.edu/~mark
3 %
4 % Make 20 .pdf files for the tally mark representations for 1 to 20.
5 %
6 % Whenever I use files with numbers in them I like to put leading zeros
7 % in the names so they will be listed in order in the directory.
8 %
9 % Do these commands:
10 % mpost tally
11 % epspdf gr-tally-1.mps; mv gr-tally-1.pdf gr-tally-01.pdf
12 % epspdf gr-tally-2.mps; mv gr-tally-2.pdf gr-tally-02.pdf
13 % ...
14 % epspdf gr-tally-9.mps; mv gr-tally-9.pdf gr-tally-09.pdf
15 % epspdf gr-tally-10.mps
16 % epspdf gr-tally-11.mps
17 % ...
18 % epspdf gr-tally-20.mps
19 %
20 % If you use bash you can do
21 % for i in $(seq 1 20); \
22 % do epspdf gr-tally-$i.mps ; printf -v var "%02d" "$i"; mv gr-tally-$i.pdf gr-tally-$var.pdf; \
23 % done
24 % to do all the lines that start with epspdf.
25 %
26
27 prologues := 3;
28 outputtemplate := "gr-%j-%c.mps";
29 outputformat := "eps";

```

```

30
31 % Define dimensions.
32 adjust = 0.15cm; % x and y adjustment
33 dx     = 0.25cm; % delta x
34 h     = 1cm;    % tally height
35 s     = 1cm;    % spacing between groups of tally marks
36
37 % Define number of tally marks.
38 n = 20; % number of marks
39
40 % Compute the tally mark paths.
41 path p[];
42 x := 0; xstart := x;
43 for i = 1 upto n:
44     if (i mod 5 = 1):
45         p[i] = ((x,0)--(x,h)); x := x + dx;
46     fi;
47     if (i mod 5 = 2):
48         p[i] = ((x,0)--(x,h)); x := x + dx;
49     fi;
50     if (i mod 5 = 3):
51         p[i] = ((x,0)--(x,h)); x := x + dx;
52     fi;
53     if (i mod 5 = 4):
54         p[i] = ((x,0)--(x,h));
55     fi;
56     if (i mod 5 = 0):
57         p[i] = ((xstart-adjust,adjust)--(x+adjust,h-adjust));
58         x := x + dx + adjust + s; xstart := x;
59     fi;
60 endfor;
61 show p[1];
62
63 %
64 % Write the tally-*.mps files
65 %
66
67 for i = 1 upto n:
68
69     beginfig(i);
70
71     % Define pen---this must go between beginfig and endfig.
72     pen mypen;
73     mypen = pencircle scaled 3.5;
74     pickup mypen;
75
76     % Draw gray tally marks.
77     for j = i+1 upto n:
78         draw p[j] withcolor 0.8white;
79     endfor;
80
81     % Draw black tally marks.
82     % Do this last so the dark tally marks
83     % will be on top of the light tally marks.
84     for j = 1 upto i:
85         draw p[j] withcolor black;
86     endfor;
87
88     endfig;
89
90 endfor;
91
92 end.

```

```

1
2 \subsection{\METAPOSTLogo\ Tally Example}
3 \label{ss:tally-example}
4
5 Whenever I use files with numbers in them I like to put leading zeros
6 in the names so they will be listed in order in the directory.
7
8 These 20 graphics (gr-tally-01.pdf through gr-tally-20.pdf)
9
10 \vspace*{6pt}
11
12 {%
13 % Let * represent zero or more spaces!
14 % Method 1: \def\g#1{ requires using \g*{10} for 10.
15 %     Two shifted characters, { and } are needed.
16 % Method 2: \def\g#1/{ requires using \g*10/ for 10.
17 %     One unshifted character, / is needed.
18 \def\g#1/{\includegraphics[scale=0.5]{gr-tally-#1.pdf}}%
19
20 % Note that tabular* instead of tabular is used below.
21 %   The {\textwidth} makes the total width of the table the width
22 % of the printed area of the page.
23 %   The @{\kern2\parindent} puts blank space the width of two
24 % paragraph indents before the first column.
25 %   The @{\extracolsep{\fill}} adds \fill space between all subsequent
26 % columns.
27 %   The lll left justifies the next three columns.
28 % after the column.
29 %   The @{\kern2\parindent} puts blank space the width of two
30 % paragraph indents before the first column.
31 \begin{tabular*}{\textwidth}{@{\kern2\parindent}@{\extracolsep{\fill}}lll@{\kern2\parindent}}%
32   \g 01/& \g 02/& \g 03/\
33   \g 04/& \g 05/& \g 06/\
34   \g 07/& \g 08/& \g 09/\
35   \g 10/& \g 11/& \g 12/\
36   \g 13/& \g 14/& \g 15/\
37   \g 16/& \g 17/& \g 18/\
38   \g 19/& \g 20/\
39 \end{tabular*}%
40 }
41 \noindent were produced by
42
43 \MyI{misc/tally.mp}
44

```

## J.5 R

R

```

1
2 \section{R}
3 \ix{R}

```

## J.6 TikZ and PGF (uses L<sup>A</sup>T<sub>E</sub>X fonts)

PGF

```

1
2 \section{\TikZLogo\ and PGF (uses \LaTeX\ fonts)}
3 \index{\TikZ@\TikZLogo}
4 \ix{PGF}

```

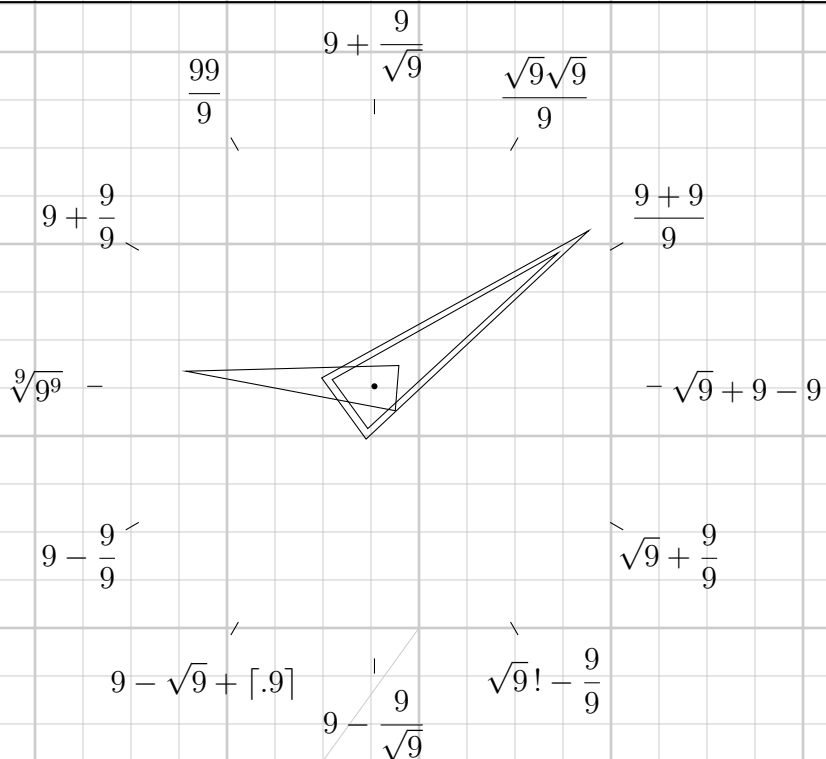


### J.6.1 Clock

```
1
2 \subsection{Clock}
```

The idea for this clock was originally from a Google+ posting by Afamefuna “Ferdy” Ibeabuchia.

Ibeabuchia, Afamefuna “Ferdy” ⇒ PGF



```
1
2 The idea for this clock was originally
3 from a Google+ posting by
4 Afamefuna ``Ferdy'' Ibeabuchia. \ix{Ibeabuchia, Afamefuna ``Ferdy''//PGF}
5 \index{TikZ@TikZLogo}
6
7 \hbox to\textwidth{%
8   \hfil
9   \begin{tikzpicture}
10    \def\CenterRadius{0.04cm}
11    \def\InnerTickRadius{3.6cm}
12    \def\OuterTickRadius{3.8cm}
13    % Make \LR be an abbreviation for \LabelRadius so the
14    % lines below will fit within the width of the page.
15    \def\LabelRadius{4.5cm} \let\LR=\LabelRadius
16    \def\HourHandRadius{2.5cm} \def\HourHandBase{0.3cm}
17    \def\MinuteHandRadius{3cm} \def\MinuteHandBase{0.4cm}
18    \def\SecondHandRadius{3.5cm} \def\SecondHandBase{0.5cm}
19    \def\DS{\displaystyle}
20    \fill (0,0) circle (\CenterRadius);
21    \foreach \i in {0,30,...,330}
22    \draw (\i:\InnerTickRadius)--(\i:\OuterTickRadius);
23    \node at ( 0:\LR) {$\DS \quad \sqrt{9 + 9 - 9}$}; % 3
24    \node at ( 30:\LR) {$\DS \frac{9+9}{9}$}; % 2
25    \node at ( 60:\LR) {$\DS \frac{\sqrt{9}\sqrt{9}}{9}$}; % 1
```

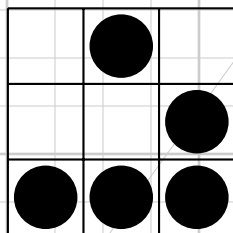
```

26 \node at ( 90:\LR) {\DS 9 + \frac{9{\sqrt{9}}$}; % 12
27 \node at (120:\LR) {\DS \frac{99}{9}$}; % 11
28 \node at (150:\LR) {\DS 9 + \frac{99}{9}$}; % 10
29 \node at (180:\LR) {\DS \sqrt[\scriptstyle 9]{9^9}$}; % 9
30 \node at (210:\LR) {\DS 9 - \frac{99}{9}$}; % 8
31 \node at (240:\LR) {\DS 9 - \sqrt{9 + \lceil.9\rceil}$}; % 7
32 \node at (270:\LR) {\DS 9 - \frac{9{\sqrt{9}}$}; % 6
33 \node at (300:\LR) {\DS \sqrt{9},! - \frac{99}{9}$}; % 5
34 \node at (330:\LR) {\DS \sqrt{9 + \frac{99}{9}$}; % 4
35 % In the following
36 % ABBREVIATION DESCRIPTION
37 % deg degrees
38 % min minutes
39 % sec seconds
40 % for second hand:
41 % (9 sec/60 sec) * 360 deg = 54 deg;
42 % 90 deg - 54 deg = 36 deg
43 \draw[rotate around={36:(0,0)}]
44 (-\SecondHandBase,\SecondHandBase) -- (\SecondHandRadius,0)
45 -- (-\SecondHandBase,-\SecondHandBase) -- cycle;
46 % for minute hand:
47 % (9 min/60 min) * 360 deg = 54 deg;
48 % 90 deg - 54 deg = 36 deg
49 \draw[rotate around={36:(0,0)}]
50 (-\MinuteHandBase,\MinuteHandBase) -- (\MinuteHandRadius,0)
51 -- (-\MinuteHandBase,-\MinuteHandBase) -- cycle;
52 % for hour hand:
53 % (9 min * (60 sec/1 min)) + 9 sec / 3600 sec
54 % = 549 sec / 3600 sec = 0.1525
55 % The hour hand is 0.1525 of the way from 9:00 to 10:00.
56 % Each hour is 30 degrees on the clock, so the hour hand
57 % position is
58 % 30 deg * 0.1525 = 4.575 deg past 9:00
59 % 180 deg - 4.575 deg = 175.425 deg
60 \draw[rotate around={175.425:(0,0)}]
61 (-\HourHandBase,\HourHandBase) -- (\HourHandRadius,0)
62 -- (-\HourHandBase,-\HourHandBase) -- cycle;
63 \end{tikzpicture}
64 \hfil
65 }

```

### J.6.2 Glider

The glider is a pattern from the Game of Life, and it's used as an emblem representing the hacker community.



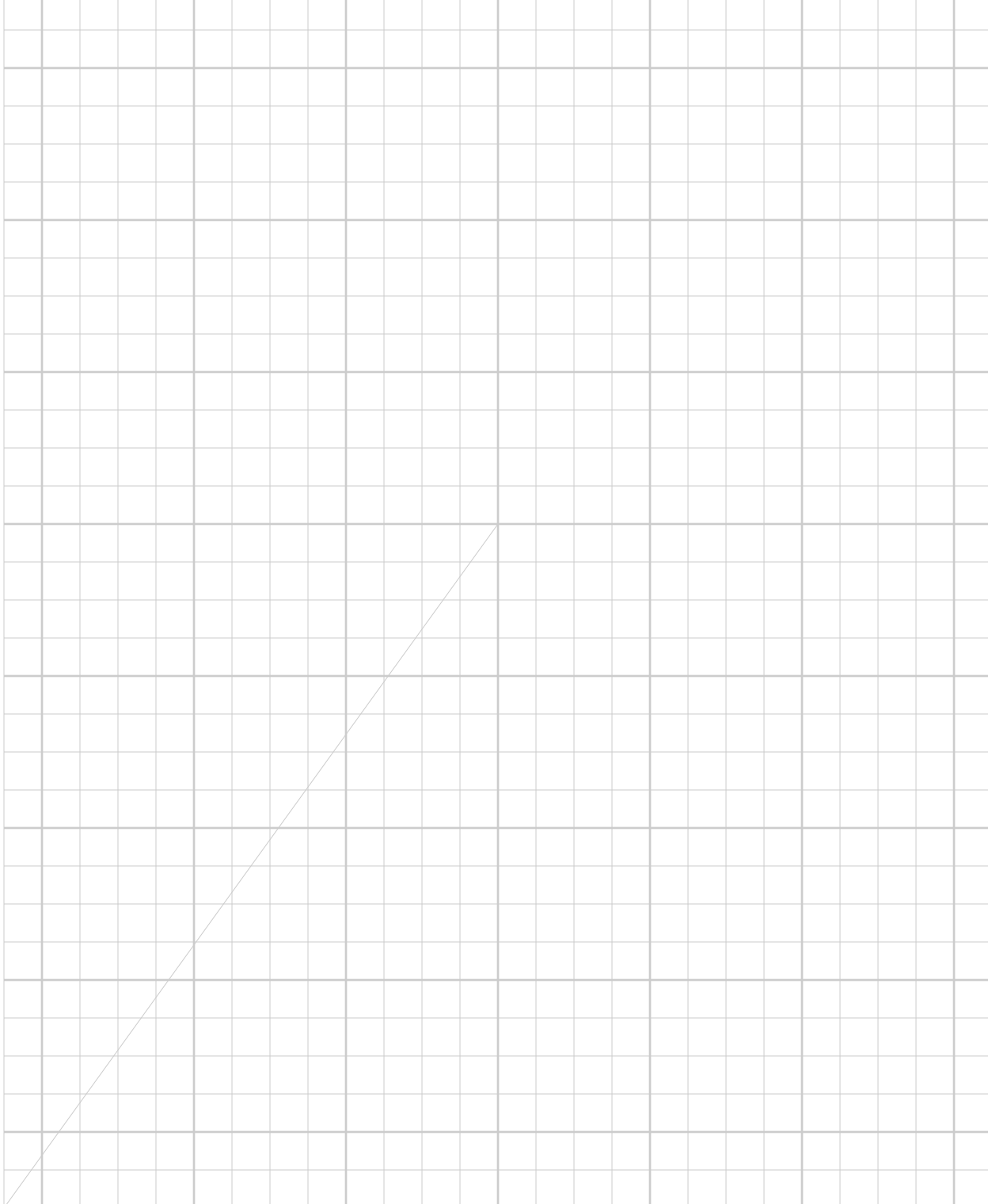
Hirzel, Alex ⇒ Glider emblem representing the hacker community

```

1
2 \subsection{Glider}
3 \ix{Hirzel, Alex//Glider emblem representing the hacker community}
4
5 The glider
6 is a pattern from the Game of Life,

```

```
7 and it's used as an emblem representing the hacker community.  
8  
9 \begin{tikzpicture}[thick]  
10 \draw (0,0) grid (3,3);  
11 \foreach \c in {(0,0), (1,0), (2,0), (2,1), (1,2)}  
12 \fill \c + (0.5,0.5) circle (0.42);  
13 \end{tikzpicture}
```



## K. NUMBERS AND UNITS

```
1 \chapter{NUMBERS AND UNITS}
```

Note to self: scientific prefixes, scientific suffixes, tables.

The puthesis 2.0 and after documentclass uses the siunitx package with some extra definitions in the puthesis.cls file to do numbers and units.

```
1
2 Note to self: scientific prefixes, scientific suffixes, tables.
3
4 The puthesis 2.0 and after documentclass uses the siunitx
5 package with some extra definitions in the puthesis.cls
6 file to do numbers and units.
```

### K.1 Number Examples

```
1
2 \section{Number Examples}
```

Input	Output	Comment
<code>\num{-0.12345}</code>	-0.123 45	note the small space after the “3”
<code>\num{-0.1234}</code>	-0.1234	note no space between the “3” and “4”
<code>\num{-.123}</code>	-0.123	the “0.” is inserted automatically
<code>\num{123}</code>	123	
<code>\num{1234}</code>	1234	
<code>\num{12345}</code>	12345	note the small space after the “2”
<code>\num{2e4}</code>	$2 \times 10^4$	
<code>\num{e5}</code>	$1 \times 10^5$	
<code>\num{2.34567e6}</code>	$2.345\ 67 \times 10^6$	note the small space after the “5”

```
1 \noindent\begin{tabular}{@{}l|l|l@{}}
2 \bfseries Input& \bfseries Output& \bfseries Comment\\
3 \tabularspace
4 \verb+\num{-0.12345}+& \num{-0.12345}& note the small space after the ``3''\\
5 \verb+\num{-0.1234}+& \num{-0.1234}&
6 \num{-0.1234}&
7 note no space between the ``3'' and ``4''\\
8 \verb+\num{-.123}+& \num{-.123}& the ``0.'' is inserted automatically\\
9 \verb+\num{123}+& \num{123}\\
10 \verb+\num{1234}+& \num{1234}\\
11 \verb+\num{12345}+& \num{12345}& note the small space after the ``2''\\
12 \verb+\num{2e4}+& \num{2e4}\\
13 \verb+\num{e5}+& \num{e5}\\
14 \verb+\num{2.34567e6}+& \num{2.34567e6}&
15 \num{2.34567e6}&
16 note the small space after the ``5''\\
17 \end{tabular}
```

### K.2 Unit Examples

```
1
2 \section{Unit Examples}
```

See page 89 for the complete list of units defined by PurdueThesis.

Input	Output	Comment
<code>\si{\kg}</code>	kg	kilogram
<code>\si{\m}</code>	m	meter
<code>\si{\kg\per\m\squared}</code>	$\text{kg m}^{-2}$	= kg/m <sup>2</sup>

```

1
2 See page-\pageref{se:Complete-List-of-Units}
3 for the complete list
4 of units defined by \PurdueThesisLogo.
5
6 \noindent\begin{tabular}{@{}l}
7 \bfseries Input& \bfseries Output& \bfseries Comment\\
8 \tabularspace
9 \verb+\si{\kg}+& \si{\kg}& kilogram\\
10 \verb+\si{\m}+& \si{\m}& meter\\
11 \verb+\si{\kg\per\m\squared}+&
12 \si{\kg\per\m\squared}&
13 \ (= \si{\kg}/\si{\m\squared})\\
14 \end{tabular}

```

### K.3 Combined Number and Unit Examples

```

1
2 \section{Combined Number and Unit Examples}

```

Input	Output	Comment
<code>\SI{12}{\kg}</code>	12 kg	12 kilograms
<code>\SI{34}{\m}</code>	34 m	34 meters
<code>\SI{4.5e3}{\kg\per\m\squared}</code>	$4.5 \times 10^3 \text{ kg m}^{-2}$	= $4.5 \times 10^3 \text{ kg/m}^2$

```

1 \begin{tabular}{@{}l}
2 \bfseries Input& \bfseries Output& \bfseries Comment\\
3 \tabularspace
4 \verb+\SI{12}{\kg}+& \SI{12}{\kg}& 12 kilograms\\
5 \verb+\SI{34}{\m}+& \SI{34}{\m}& 34 meters\\
6 % The next input line is too wide for the margins
7 % so I'm splitting it into pieces.
8 \verb+\SI{4.5e3}{\kg\per\m\squared}+&
9 \SI{4.5e3}{\kg\per\m\squared}&
10 \ (= \num{4.5e3}\, \si{\kg}/\si{\m\squared})\\
11 \end{tabular}

```

How many seconds are in a non-leap year that does not have any leap seconds?

$$\begin{aligned}
 \frac{365 \cancel{\text{d}}}{\text{y}} \times \frac{24 \cancel{\text{h}}}{\cancel{\text{d}}} \times \frac{60 \cancel{\text{min}}}{\cancel{\text{h}}} \times \frac{60 \text{ s}}{\cancel{\text{min}}} &= 31\,536\,000 \frac{\text{s}}{\text{y}} \\
 &= 31\,536\,000 \text{ s y}^{-1} \\
 &\approx 3 \times 10^7 \text{ s y}^{-1} \\
 &\approx 30 \text{ million s y}^{-1}
 \end{aligned}$$

```

1
2 How many seconds are in a non-leap year that does not have any leap seconds?
3 % I tried several things and could not get \cancel to work with \per.
4 % Mark Senn 2019-12-29
5 \begin{align*}
6     \frac{\SI{365}{\cancel{d}}{\si{y}}
7     \times \frac{\SI{24}{\cancel{h}}{\si{\cancel{d}}}
8     \times \frac{\SI{60}{\cancel{min}}{\si{\cancel{h}}}
9     \times \frac{\SI{60}{\s}}{\si{\cancel{min}}}
10    % From http://www.emerson.emory.edu/services/latex/latex_119.html
11    % Spacing in Math Mode
12    % In a math environment, LaTeX ignores the spaces you type
13    % and puts in the spacing that it thinks is best. LaTeX formats
14    % mathematics the way it's done in mathematics texts. If you
15    % want different spacing, LaTeX provides the following four
16    % commands for use in math mode:
17    % \; - a thick space
18    % \: - a medium space
19    % \, - a thin space
20    % \! - a negative thin space
21    & = \num{31536000}\; \frac{\si{s}}{\si{y}} \\
22    & = \SI{31536000}{\s\per y} \\
23    & \approx \SI{3e7}{\s\per y} \\
24    & \approx \text{30 million}\, \si{\s\per y} \\
25 \end{align*}

```

## K.4 Binary Prefixes

```

1
2 \section{Binary Prefixes}

```

The `\kibi ... \yobi` commands are defined immediately after the `\usepackage{siunitx}` command in the `PurdueThesis.cls` file.

```

1
2 The \verb+\kibi+ \ldots \verb+\yobi+
3 commands are defined immediately after the \verb+\usepackage{siunitx}+
4 in the PurdueThesis.cls file.

```

Power	Prefix	Symbol	Command	Comment
10	kibi	Ki	<code>\si{\kibi}</code>	2 <sup>10</sup> bytes is a KB, 10 <sup>3</sup> bytes is a KiB
20	mebi	Mi	<code>\si{\mebi}</code>	2 <sup>20</sup> bytes is a MB, 10 <sup>6</sup> bytes is a MiB
30	gibi	Gi	<code>\si{\gibi}</code>	2 <sup>30</sup> bytes is a GB, 10 <sup>9</sup> bytes is a GiB
40	tebi	Ti	<code>\si{\tebi}</code>	2 <sup>40</sup> bytes is a TB, 10 <sup>12</sup> bytes is a TiB
50	pebi	Pi	<code>\si{\pebi}</code>	2 <sup>50</sup> bytes is a PB, 10 <sup>15</sup> bytes is a PiB
60	exbi	Ei	<code>\si{\exbi}</code>	2 <sup>60</sup> bytes is a EB, 10 <sup>18</sup> bytes is a EiB
70	zebi	Zi	<code>\si{\zebi}</code>	2 <sup>70</sup> bytes is a ZB, 10 <sup>21</sup> bytes is a ZiB
80	yobi	Yi	<code>\si{\yobi}</code>	2 <sup>80</sup> bytes is a YB, 10 <sup>24</sup> bytes is a YiB

```

1
2 \newcolumntype{m}{>{\$}r<{\$}} % math mode version of "r" column type
3 \renewcommand{\t}[4]{\({}^{#1}\) bytes is a #2, \({}^{#3}\) bytes is a #4}
4 \begin{tabular}{@{}mlll@{}}
5     \multicolumn{1}{l}{\bfseries Power}&
6     \bfseries Prefix&
7     \bfseries Symbol&

```

```

8      \bfseries Command&
9      \bfseries Comment\\
10     \tabularspace
11     10& kibi& \unit{\kibi\nounit}& \verb+\si{\kibi}+& \t{10}{KB}{3}{KiB}\\
12     20& mebi& \unit{\mebi\nounit}& \verb+\si{\mebi}+& \t{20}{MB}{6}{MiB}\\
13     30& gibi& \unit{\gibi\nounit}& \verb+\si{\gibi}+& \t{30}{GB}{9}{GiB}\\
14     40& tebi& \unit{\tebi\nounit}& \verb+\si{\tebi}+& \t{40}{TB}{12}{TiB}\\
15     50& pebi& \unit{\pebi\nounit}& \verb+\si{\pebi}+& \t{50}{PB}{15}{PiB}\\
16     60& exbi& \unit{\exbi\nounit}& \verb+\si{\exbi}+& \t{60}{EB}{18}{EiB}\\
17     70& zebi& \unit{\zebi\nounit}& \verb+\si{\zebi}+& \t{70}{ZB}{21}{ZiB}\\
18     80& yobi& \unit{\yobi\nounit}& \verb+\si{\yobi}+& \t{80}{YB}{24}{YiB}\\
19     \end{tabular}

```

## K.5 Decimal Prefixes

```

1
2 \section{Decimal Prefixes}



| Power | Prefix | Symbol | Command     | Comment            |
|-------|--------|--------|-------------|--------------------|
| -24   | yocto  | y      | \si{\yocto} |                    |
| -21   | zepto  | z      | \si{\zepto} |                    |
| -18   | atto   | a      | \si{\atto}  |                    |
| -15   | femto  | f      | \si{\femto} |                    |
| -12   | pico   | p      | \si{\pico}  |                    |
| -9    | nano   | n      | \si{\nano}  |                    |
| -6    | micro  | μ      | \si{\micro} |                    |
| -3    | milli  | m      | \si{\milla} |                    |
| -2    | centi  | c      | \si{\centi} |                    |
| -1    | deci   | d      | \si{\deci}  |                    |
| 1     | deca   | da     | \si{\deca}  |                    |
| 1     | deka   | da     | \si{\deka}  | same as \si{\deca} |
| 2     | hecto  | h      | \si{\hecto} |                    |
| 3     | kilo   | k      | \si{\kilo}  |                    |
| 6     | mega   | M      | \si{\mega}  |                    |
| 9     | giga   | G      | \si{\giga}  |                    |
| 12    | tera   | T      | \si{\tera}  |                    |
| 15    | peta   | P      | \si{\peta}  |                    |
| 18    | exa    | E      | \si{\exa}   |                    |
| 21    | zetta  | Z      | \si{\zetta} |                    |
| 24    | yotta  | Y      | \si{\yotta} |                    |



1
2 \newcolumnntype{m}{>{\$}r<{\$}} % math mode version of "r" column type
3 \begin{tabular}{@{}mllll@{}}
4     \multicolumn{1}{l}{\bfseries Power}&
5     \bfseries Prefix&
6     \bfseries Symbol&
7     \bfseries Command&
8     \bfseries Comment\\
9 \tabularspace
10 -24& yocto& \unit{\yocto\nounit}& \verb+\si{\yocto}+\\
11 -21& zepto& \unit{\zepto\nounit}& \verb+\si{\zepto}+

```

```

12 -18& atto& \unit{\atto\nounit}& \verb+\si{\atto}+\\
13 -15& femto& \unit{\femto\nounit}& \verb+\si{\femto}+\\
14 -12& pico& \unit{\pico\nounit}& \verb+\si{\pico}+\\
15 -9& nano& \unit{\nano\nounit}& \verb+\si{\nano}+\\
16 -6& micro& \unit{\micro\nounit}& \verb+\si{\micro}+\\
17 -3& milli& \unit{\milli\nounit}& \verb+\si{\milli}+\\
18 -2& centi& \unit{\centi\nounit}& \verb+\si{\centi}+\\
19 -1& deci& \unit{\deci\nounit}& \verb+\si{\deci}+\\
20 1& deca& \unit{\deca\nounit}& \verb+\si{\deca}+\\
21 1& deka& \unit{\deka\nounit}& \verb+\si{\deka}+& same as \verb+\si{\deca}+\\
22 2& hecto& \unit{\hecto\nounit}& \verb+\si{\hecto}+\\
23 3& kilo& \unit{\kilo\nounit}& \verb+\si{\kilo}+\\
24 6& mega& \unit{\mega\nounit}& \verb+\si{\mega}+\\
25 9& giga& \unit{\giga\nounit}& \verb+\si{\giga}+\\
26 12& tera& \unit{\tera\nounit}& \verb+\si{\tera}+\\
27 15& peta& \unit{\peta\nounit}& \verb+\si{\peta}+\\
28 18& exa& \unit{\exa\nounit}& \verb+\si{\exa}+\\
29 21& zetta& \unit{\zetta\nounit}& \verb+\si{\zetta}+\\
30 24& yotta& \unit{\yotta\nounit}& \verb+\si{\yotta}+\\
31 \end{tabular}

```

## K.6 SI Units

```

1
2 \section{SI Units}

```

The International System of Units (SI) is the modern form of the metric system. There are seven SI base units:

Name	Unit Of	Symbol
ampere	electrical current	A
candela	luminous intensity	cd
kelvin	thermodynamic temperature	K
kg	mass	kg
meter	length	m
mole	amount of substance	mol
second	time	s

```

1
2 The International System of Units
3 (SI)
4 % !!! Doing
5 % !!! \include{tipa}
6 % !!! in thesis.tex so \textprimstress works
7 % !!! apparently causes problems with math commands.
8 % !!! Figure out why the following doesn't work later.
9 % (%)
10 % SI,
11 % abbreviated from the French Syst\`eme International
12 % (d\textprimstress unit\`es)%
13 % )
14 is the modern form of the metric system.
15 There are seven SI base units:
16
17 \hspace{40pt}
18 \begin{tabular}{@{}l|l|l@{}}
19 \tabularspace
20 \bfseries Name& \bfseries Unit Of& \bfseries Symbol\\

```



21	<code>\tabularspace</code>		
22	<code>ampere&amp;</code>	electrical current&	<code>\si{\ampere}\</code>
23	<code>candela&amp;</code>	luminous intensity&	<code>\si{\candela}\</code>
24	<code>kelvin&amp;</code>	thermodynamic temperature&	<code>\si{\kelvin}\</code>
25	<code>kg&amp;</code>	mass&	<code>\si{\kilogram}\</code>
26	<code>meter&amp;</code>	length&	<code>\si{\meter}\</code>
27	<code>mole&amp;</code>	amount of substance&	<code>\si{\mole}\</code>
28	<code>second&amp;</code>	time&	<code>\si{\second}\</code>
29	<code>\end{tabular}</code>		

## K.7 Complete List of Units

1	
2	<code>\section{Complete List of Units}</code>
3	<code>\label{se:Complete-List-of-Units}</code>

**Table K.1.** Units and Corresponding Symbols

Name	Unit Of	Symbol	Command	Is equal to
ampere	electrical current	A	<code>\si{\A}</code>	(SI base unit)
picoampere	"	pA	<code>\si{\pA}</code>	$1 \times 10^{-12}$ A
nanoampere	"	nA	<code>\si{\nA}</code>	$1 \times 10^{-9}$ A
microampere	"	$\mu$ A	<code>\si{\uA}</code>	$1 \times 10^{-6}$ A
milliampere	"	mA	<code>\si{\mA}</code>	$1 \times 10^{-3}$ A
kiloampere	"	kA	<code>\si{\kA}</code>	$1 \times 10^3$ A
arcminute	plane angle	'	<code>\si{\arcmin}</code>	$1/60^\circ$
arcsecond	plane angle	"	<code>\si{\arcsec}</code>	$1/60'$
astronomical unit	length	au	<code>\si{\au}</code>	mean earth to sun distance
bar	pressure	bar	<code>\si{\bar}</code>	$1 \times 10^{-5}$ Pa
millibar	"	mbar	<code>\si{\mbar}</code>	$1 \times 10^{-3}$ bar
barn	area	b	<code>\si{\b}</code>	$1 \times 10^{-28}$ m <sup>2</sup>
becquerel	radioactivity	Bq	<code>\si{\Bq}</code>	one radioactive decay per second
bel	sound intensity	B	<code>\si{\B}</code>	10 decibels

*continued on next page*

Table K.1. <i>continued</i>				
Name	Unit Of	Symbol	Command	Is equal to
decibel	"	dB	<code>\si{\dB}</code>	$1 \times 10^{-1} \text{ B}$
bohr	length	$a_0$	<code>\si{\bohr}</code>	distance between nucleus and electron in hydrogen atom
bushel	quantity	bu	<code>\si{\bu}</code>	see [28]
candela	luminous intensity	cd	<code>\si{\cd}</code>	(SI base unit)
coulomb	electrical charge	C	<code>\si{\C}</code>	$\text{A s}^{-1}$
dalton	mass	Da	<code>\si{\Da}</code>	another name for atomic mass unit
day	time	d	<code>\si{\d}</code>	86 400 s
degree	plane angle	°	<code>\si{\degree}</code>	1/360 of a cycle
degree Celsius	temperature	°C	<code>\si{\celsius}</code>	xxx
electron mass	mass	$m_e$	<code>\si{\em}</code>	xxx
electronvolt	energy	eV	<code>\si{\eV}</code>	xxx
millielectronvolt	"	meV	<code>\si{\meV}</code>	$1 \times 10^{-3} \text{ eV}$
kiloelectronvolt	"	keV	<code>\si{\keV}</code>	$1 \times 10^3 \text{ eV}$
megaelectronvolt	"	MeV	<code>\si{\MeV}</code>	$1 \times 10^6 \text{ eV}$
gigaelectronvolt	"	GeV	<code>\si{\GeV}</code>	$1 \times 10^9 \text{ eV}$
teraelectronvolt	"	TeV	<code>\si{\TeV}</code>	$1 \times 10^{12} \text{ eV}$
elementary charge	electrical charge	e	<code>\si{\ec}</code>	$\approx 1.6 \times 10^{19} \text{ C}$
farad	electrical capacitance	F	<code>\si{\F}</code>	$\text{s}^4 \text{ A}^2 \text{ m}^{-2} \text{ kg}^{-1}$
femtofarad	"	fF	<code>\si{\fF}</code>	$1 \times 10^{-15} \text{ F}$
<i>continued on next page</i>				

Table K.1. <i>continued</i>				
Name	Unit Of	Symbol	Command	Is equal to
picofarad	"	pF	<code>\si{\pF}</code>	$1 \times 10^{-12} \text{ F}$
foot	length	ft	<code>\si{\ft}</code>	0.3048 m
gray	absorbed dose of ionizing radiation	Gy	<code>\si{\Gy}</code>	$\text{J kg}^{-1}$
hartree	energy used in molecular orbital calculations	$E_h$	<code>\si{\hartree}</code>	xxx
hectare	area	ha	<code>\si{\ha}</code>	$1 \times 10^4 \text{ m}^2$
henry	electrical inductance	H	<code>\si{\H}</code>	$\text{kg m}^2 \text{ s}^{-2} \text{ A}^{-2}$
hertz	frequency	Hz	<code>\si{\Hz}</code>	$\text{s}^{-1}$
millihertz	"	mHz	<code>\si{\mHz}</code>	$1 \times 10^{-3} \text{ Hz}$
kilohertz	"	kHz	<code>\si{\kHz}</code>	$1 \times 10^3 \text{ Hz}$
megahertz	"	MHz	<code>\si{\MHz}</code>	$1 \times 10^6 \text{ Hz}$
gigahertz	"	GHz	<code>\si{\GHz}</code>	$1 \times 10^9 \text{ Hz}$
terahertz	"	THz	<code>\si{\THz}</code>	$1 \times 10^{12} \text{ Hz}$
horsepower	power	hp	<code>\si{\hp}</code>	$\approx 745.7 \text{ W}$ , <b>IMPORTANT:</b> see <a href="#">Horsepower</a>
hour	time	h	<code>\si{\h}</code>	3600 s
inch	length	in	<code>\si{\in}</code>	25.4 mm
joule	work or energy	J	<code>\si{\J}</code>	$\text{kg m}^2 \text{ s}^{-2}$
microjoule	"	$\mu\text{J}$	<code>\si{\uJ}</code>	$1 \times 10^{-6} \text{ J}$
millijoule	"	mJ	<code>\si{\mJ}</code>	$1 \times 10^{-3} \text{ J}$
kilojoule	"	kJ	<code>\si{\kJ}</code>	$1 \times 10^3 \text{ J}$
megajoule	"	MJ	<code>\si{\MJ}</code>	$1 \times 10^6 \text{ J}$
katal	catalytic activity	kat	<code>\si{\kat}</code>	$\text{mol s}^{-1}$
kelvin	thermody- namic temperature	K	<code>\si{\K}</code>	(SI base unit)
kilogram	mass	kg	<code>\si{\kg}</code>	(SI base unit)

*continued on next page*

Table K.1. <i>continued</i>				
Name	Unit Of	Symbol	Command	Is equal to
femtogram	"	fg	<code>\si{\fg}</code>	$1 \times 10^{-15} \text{ g}$
picogram	"	pg	<code>\si{\pg}</code>	$1 \times 10^{-12} \text{ g}$
nanogram	"	ng	<code>\si{\ng}</code>	$1 \times 10^{-9} \text{ g}$
microgram	"	$\mu\text{g}$	<code>\si{\ug}</code>	$1 \times 10^{-6} \text{ g}$
milligram	"	mg	<code>\si{\mg}</code>	$1 \times 10^{-3} \text{ g}$
gram	"	g	<code>\si{\g}</code>	$1 \times 10^{-3} \text{ kg}$
kilowatt hour	electrical energy	kWh	<code>\si{\kWh}</code>	kW h
knot	speed	kn	<code>\si{\kn}</code>	$\text{M h}^{-1}$
liter	volume	L	<code>\si{\L}</code>	$1 \times 10^{-3} \text{ m}^3$
microliter	"	$\mu\text{L}$	<code>\si{\uL}</code>	$1 \times 10^{-6} \text{ L}$
milliliter	"	mL	<code>\si{\mL}</code>	$1 \times 10^{-3} \text{ L}$
hectoliter	"	hL	<code>\si{\hL}</code>	$1 \times 10^2 \text{ L}$
lumen	luminous flux	lm	<code>\si{\lm}</code>	cd sr
lux	illumination	lx	<code>\si{\lx}</code>	$\text{lm m}^{-2}$
meter	length	m	<code>\si{\m}</code>	(SI base unit)
picometer	"	pm	<code>\si{\pm}</code>	$1 \times 10^{-12} \text{ m}$
nanometer	"	nm	<code>\si{\nm}</code>	$1 \times 10^{-9} \text{ m}$
micrometer	"	$\mu\text{m}$	<code>\si{\um}</code>	$1 \times 10^{-6} \text{ m}$
millimeter	"	mm	<code>\si{\mm}</code>	$1 \times 10^{-3} \text{ m}$
centimeter	"	cm	<code>\si{\cm}</code>	$1 \times 10^{-2} \text{ m}$
decimeter	"	dm	<code>\si{\dm}</code>	$1 \times 10^{-1} \text{ m}$
kilometer	"	km	<code>\si{\km}</code>	$1 \times 10^3 \text{ m}$
millimeter of mercury	pressure	mmHg	<code>\si{\mmHg}</code>	$\approx 133 \text{ Pa}$
minute	time	min	<code>\si{\min}</code>	60 s
mole	amount of substance	mol	<code>\si{\mol}</code>	(SI base unit)
femtomole	"	fmol	<code>\si{\fmol}</code>	$1 \times 10^{-15} \text{ mol}$
picomole	"	pmol	<code>\si{\pmol}</code>	$1 \times 10^{-12} \text{ mol}$
nanomole	"	nmol	<code>\si{\nmol}</code>	$1 \times 10^{-9} \text{ mol}$
micromole	"	$\mu\text{mol}$	<code>\si{\umol}</code>	$1 \times 10^{-6} \text{ mol}$
millimole	"	mmol	<code>\si{\mmol}</code>	$1 \times 10^{-3} \text{ mol}$
<i>continued on next page</i>				

Table K.1. <i>continued</i>				
Name	Unit Of	Symbol	Command	Is equal to
kilomole	"	kmol	<code>\si{\kmol}</code>	$1 \times 10^3 \text{ mol}$
nautical mile	distance	M	<code>\si{\M}</code>	1852 m
neper	gain, loss, and relative values	Np	<code>\si{\Np}</code>	1
newton	force	N	<code>\si{\N}</code>	$\text{kg m s}^{-2}$
millinewton	"	mN	<code>\si{\mN}</code>	$1 \times 10^{-3} \text{ N}$
kilonewton	"	kN	<code>\si{\kN}</code>	$1 \times 10^3 \text{ N}$
meganewton	"	MN	<code>\si{\MN}</code>	$1 \times 10^6 \text{ N}$
ohm	electrical resistance	$\Omega$	<code>\si{\ohm}</code>	$\text{kg m}^2 \text{ s}^{-3} \text{ A}^{-2}$
milliohm	"	m $\Omega$	<code>\si{\mohm}</code>	$1 \times 10^{-3} \text{ ohm}$
kiloohm	"	k $\Omega$	<code>\si{\kohm}</code>	$1 \times 10^3 \text{ ohm}$
megaohm	"	M $\Omega$	<code>\si{\Mohm}</code>	$1 \times 10^6 \text{ ohm}$
pascal	pressure	Pa	<code>\si{\Pa}</code>	$\text{kg m}^{-1} \text{ s}^{-2}$
kilopascal	"	kPa	<code>\si{\kPa}</code>	$1 \times 10^3 \text{ Pa}$
megapascal	"	MPa	<code>\si{\MPa}</code>	$1 \times 10^6 \text{ Pa}$
gigapascal	"	GPa	<code>\si{\GPa}</code>	$1 \times 10^9 \text{ Pa}$
percent	hundredths	%	<code>\si{\percent}</code>	$1 \times 10^{-2}$
pound	weight	lb	<code>\si{\lb}</code>	0.453 592 37 kg
radian	plane angular measurement	rad	<code>\si{\rad}</code>	$180/\pi^\circ$
reduced Planck constant	angular momentum	$\hbar$	<code>\si{\planckbar}</code>	$\approx 1.05 \times 10^{-34} \text{ J s}$
second	time	s	<code>\si{\s}</code>	(SI base unit)
attosecond	"	as	<code>\si{\as}</code>	$1 \times 10^{-18} \text{ s}$
femtosecond	"	fs	<code>\si{\fs}</code>	$1 \times 10^{-15} \text{ s}$
picosecond	"	ps	<code>\si{\ps}</code>	$1 \times 10^{-12} \text{ s}$
nanosecond	"	ns	<code>\si{\ns}</code>	$1 \times 10^{-9} \text{ s}$
microsecond	"	$\mu\text{s}$	<code>\si{\us}</code>	$1 \times 10^{-6} \text{ s}$
<i>continued on next page</i>				

Table K.1. <i>continued</i>				
Name	Unit Of	Symbol	Command	Is equal to
millisecond	"	ms	<code>\si{\ms}</code>	$1 \times 10^{-3} \text{ s}$
siemens	conductance	S	<code>\si{\S}</code>	$\text{kg}^{-1} \text{ m}^{-2} \text{ s}^3 \text{ A}^2$
sievert	dosage of ionizing radiation	Sv	<code>\si{\Sv}</code>	$\text{m}^2 \text{ s}^{-2}$
speed of light	speed	$c_0$	<code>\si{\clight}</code>	$299\,792\,458 \text{ m s}^{-1}$
standard deviation	amount of variation	SD	<code>\si{\SD}</code>	$\sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}$
steradian	measure of solid angles	sr	<code>\si{\sr}</code>	$1 \text{ m}^2 \text{ m}^{-2}$
tesla	magnetic flux density	T	<code>\si{\T}</code>	$\text{kg s}^{-2} \text{ A}^{-1}$
metric ton	mass	t	<code>\si{\t}</code>	$1 \times 10^3 \text{ kg}$
volt	electrical potential difference	V	<code>\si{\V}</code>	$\text{kg m}^2 \text{ s}^{-3} \text{ A}^{-1}$
picovolt	"	pV	<code>\si{\pV}</code>	$1 \times 10^{-12} \text{ V}$
nanovolt	"	nV	<code>\si{\nV}</code>	$1 \times 10^{-9} \text{ V}$
microvolt	"	$\mu\text{V}$	<code>\si{\uV}</code>	$1 \times 10^{-6} \text{ V}$
millivolt	"	mV	<code>\si{\mV}</code>	$1 \times 10^{-3} \text{ V}$
kilovolt	"	kV	<code>\si{\kV}</code>	$1 \times 10^3 \text{ V}$
watt	power	W	<code>\si{\W}</code>	$\text{kg m}^2 \text{ s}^{-3}$
microwatt	"	$\mu\text{W}$	<code>\si{\uW}</code>	$1 \times 10^{-6} \text{ W}$
milliwatt	"	mW	<code>\si{\mW}</code>	$1 \times 10^{-3} \text{ W}$
kilowatt	"	kW	<code>\si{\kW}</code>	$1 \times 10^3 \text{ W}$
megawatt	"	MW	<code>\si{\MW}</code>	$1 \times 10^6 \text{ W}$
gigawatt	"	GW	<code>\si{\GW}</code>	$1 \times 10^9 \text{ W}$
weber	magnetic flux	Wb	<code>\si{\Wb}</code>	$\text{kg m}^2 \text{ s}^{-2} \text{ A}^{-1}$
yard	length	yd	<code>\si{\yd}</code>	$0.9144 \text{ m}$
year	time	y	<code>\si{\y}</code>	$\approx 365.25 \text{ d}$
1				
2	<code>{%</code>			
3	<code>\ZZbaselinestretch{1}</code>			
4	<code>\newcommand\vsp{\noalign{\vspace*{6pt}}}</code>			
5	<code>% From</code>			
6	<code>% <a href="https://tex.stackexchange.com/questions/31508/flushleft-with-p-option-in-tabular">https://tex.stackexchange.com/questions/31508/flushleft-with-p-option-in-tabular</a></code>			
7	<code>% It's necessary to use the \arraybackslash in the last column,</code>			

```

8 % otherwise \\ would not end the table row. You can use \newline
9 % to end lines in the last column cells (and the regular \\ in
10 % the other column cells).
11 % ...
12 % If you need it often, consider defining a new column type using
13 % array features, as I did here:
14 % \newcolumntype{P}[1]{>{\raggedright\arraybackslash}p{#1}}
15 \newcolumntype{P}[1]{>{\raggedright\arraybackslash}p{#1}}%
16 % \begin{longtable}{@{}P{1.4in}P{1in}lP{1.8in}@{}}
17 % \begin{longtable}{@{}P{1in}P{1in}lP{1.8in}@{}}
18 % \begin{longtable}{@{}P{1.2in}P{1in}lP{1.8in}@{}}
19 % \begin{longtable}{@{}P{90.72pt}P{1in}lP{1.8in}@{}} % 1.2in (86.72pt) + 4pt = 90.72pt
20 \begin{longtable}{@{}P{1.4in}P{1in}lP{1.8in}@{}}% 1.2in (86.72pt) + 4pt = 90.72pt
21 \caption{Units and Corresponding Symbols}\\
22 \bfseries Name&
23 \bfseries Unit Of&
24 \bfseries Symbol&
25 \bfseries Command&
26 \bfseries Is equal to\\
27 \vsp
28 \endfirsthead
29 \caption[{\emph{continued}}]\\
30 \bfseries Name&
31 \bfseries Unit Of&
32 \bfseries Symbol&
33 \bfseries Command&
34 \bfseries Is equal to\\
35 \vsp
36 \endhead
37 \vsp
38 % I don't know why the \hspace*{-7.5mm} was
39 % needed to center this horizontally.
40 \multicolumn{5}{@{}c@{}}{\hspace*{-7.5mm}\emph{continued on next page}}%
41 \endfoot
42 \endlastfoot
43 ampere&
44 electrical current&
45 \si{A}&
46 \verb+\si{A}+&
47 (SI base unit)\\
48 \quad picoampere&
49 \ditto&
50 \si{pA}&
51 \verb+\si{pA}+&
52 \SI{e-12}{A}\\
53 \quad nanoampere&
54 \ditto&
55 \si{nA}&
56 \verb+\si{nA}+&
57 \SI{e-9}{A}\\
58 \quad microampere&
59 \ditto&
60 \si{uA}&
61 \verb+\si{uA}+&
62 \SI{e-6}{A}\\
63 \quad milliampere&
64 \ditto&
65 \si{mA}&
66 \verb+\si{mA}+&
67 \SI{e-3}{A}\\
68 \quad kiloampere&
69 \ditto&
70 \si{kA}&
71 \verb+\si{kA}+&

```

72	<code>\SI{e3}{\A}\</code>
73	<code>\vsp</code>
74	<code>% \aa ngstr\om&amp;</code>
75	<code>% length&amp;</code>
76	<code>% \si{AA}&amp;</code>
77	<code>% \verb+\si{AA}+&amp;</code>
78	<code>% \SI{e-10}{\m}\</code>
79	<code>\vsp</code>
80	<code>arcminute&amp;</code>
81	<code>plane angle&amp;</code>
82	<code>\si{\arcmin}&amp;</code>
83	<code>\verb+\si{\arcmin}+&amp;</code>
84	<code>% Changed</code>
85	<code>% \SI{1/60}{\degree}\</code>
86	<code>% to</code>
87	<code>1/60\unit{\degree\nunit}\</code>
88	<code>arcsecond&amp;</code>
89	<code>plane angle&amp;</code>
90	<code>\si{\arcsec}&amp;</code>
91	<code>\verb+\si{\arcsec}+&amp;</code>
92	<code>% Changed</code>
93	<code>% \SI{1/60}{\arcmin}\</code>
94	<code>% to</code>
95	<code>1/60\unit{\arcmin\nunit}\</code>
96	<code>\vsp</code>
97	<code>astronomical unit&amp;</code>
98	<code>length&amp;</code>
99	<code>\si{\au}&amp;</code>
100	<code>\verb+\si{\au}+&amp;</code>
101	<code>mean earth to\newline sun distance\</code>
102	<code>\vsp</code>
103	<code>% From</code>
104	<code>% siunitx - A comprehensive (SI) units package</code>
105	<code>% Joseph Wright</code>
106	<code>% Released 2021-08-04</code>
107	<code>% (this describes v3.0.24, last revised 2021-08-04)</code>
108	<code>% <a href="https://mirror.las.iastate.edu/tex-archive/macros/latex/contrib/siunitx/siunitx.pdf">https://mirror.las.iastate.edu/tex-archive/macros/latex/contrib/siunitx/siunitx.pdf</a></code>
109	<code>% page 51:</code>
110	<code>% ...the unit \atomicmassunit has similar deprecated status:</code>
111	<code>% this was listed as with experimentally-determined units</code>
112	<code>% in the 8th Edition of the si Brochure but is equivalent</code>
113	<code>% to the dalton, a unit which remains accepted.</code>
114	<code>% atomic mass unit&amp;</code>
115	<code>% mass&amp;</code>
116	<code>% \si{\amu}&amp;</code>
117	<code>% \verb+\si{\amu}+&amp;</code>
118	<code>% \((1/12)\) mass of\newline carbon-12 atom\</code>
119	<code>% \vsp</code>
120	<code>bar&amp;</code>
121	<code>pressure&amp;</code>
122	<code>\si{\bar}&amp;</code>
123	<code>\verb+\si{\bar}+&amp;</code>
124	<code>\SI{e-5}{\Pa}\</code>
125	<code>\quad millibar&amp;</code>
126	<code>\ditto&amp;</code>
127	<code>\si{\mbar}&amp;</code>
128	<code>\verb+\si{\mbar}+&amp;</code>
129	<code>\SI{e-3}{\bar}\</code>
130	<code>\vsp</code>
131	<code>barn&amp;</code>
132	<code>area&amp;</code>
133	<code>\si{\b}&amp;</code>
134	<code>\verb+\si{\b}+&amp;</code>
135	<code>\SI{e-28}{\m\squared}\</code>



```

136 \vsp
137 becquerel&
138 radioactivity&
139 \si{\Bq}&
140 \verb+\si{\Bq}+&
141 one radioactive\newline decay per second\\
142 \vsp
143 bel&
144 sound intensity&
145 \si{\B}&
146 \verb+\si{\B}+&
147 10 decibels\\
148 \quad decibel&
149 \ditto&
150 \si{\dB}&
151 \verb+\si{\dB}+&
152 \SI{e-1}{\B}\\
153 \vsp
154 bohr&
155 length&
156 \si{\bohr}&
157 \verb+\si{\bohr}+&
158 distance between\newline nucleus and electron\newline in hydrogen atom\\
159 \vsp
160 bushel&
161 quantity&
162 \si{\bu}&
163 \verb+\si{\bu}+&
164 see \cite{wikipedia-bushel}\\
165 \vsp
166 candela&
167 luminous intensity&
168 \si{\cd}&
169 \verb+\si{\cd}+&
170 (SI base unit)\\
171 \vsp
172 coulomb&
173 electrical charge&
174 \si{\C}&
175 \verb+\si{\C}+&
176 \si{\A\per\s}\\
177 \vsp
178 dalton&
179 mass&
180 \si{\Da}&
181 \verb+\si{\Da}+&
182 another name for\newline atomic mass unit\\
183 \vsp
184 day&
185 time&
186 \si{\d}&
187 \verb+\si{\d}+&
188 \SI{86400}{\s}\\
189 \vsp
190 degree&
191 plane angle&
192 \si{\degree}&
193 \verb+\si{\degree}+&
194 1/360 of a cicle\\
195 \vsp
196 degree Celsius&
197 temperature&
198 \si{\celsius}&
199 \verb+\si{\celsius}+&

```

200	xxx\\
201	\vsp
202	electron mass&
203	mass&
204	\si{\em}&
205	\verb+\si{\em}+&
206	xxx\\
207	\vsp
208	electronvolt&
209	energy&
210	\si{\eV}&
211	\verb+\si{\eV}+&
212	xxx\\
213	\quad millielectronvolt&
214	\ditto&
215	\si{\meV}&
216	\verb+\si{\meV}+&
217	\SI{e-3}{\eV}\\
218	\quad kiloelectronvolt&
219	\ditto&
220	\si{\keV}&
221	\verb+\si{\keV}+&
222	\SI{e3}{\eV}\\
223	\quad megaelectronvolt&
224	\ditto&
225	\si{\MeV}&
226	\verb+\si{\MeV}+&
227	\SI{e6}{\eV}\\
228	\quad gigaelectronvolt&
229	\ditto&
230	\si{\GeV}&
231	\verb+\si{\GeV}+&
232	\SI{e9}{\eV}\\
233	\quad teraelectronvolt&
234	\ditto&
235	\si{\TeV}&
236	\verb+\si{\TeV}+&
237	\SI{e12}{\eV}\\
238	\vsp
239	elementary charge&
240	electrical charge&
241	\si{\ec}&
242	\verb+\si{\ec}+&
243	\href{https://en.wikipedia.org/wiki/Elementary_charge}{\SI{\approx 1.6e19}{\C}}\\
244	\vsp
245	farad&
246	electrical capacitance&
247	\si{\F}&
248	\verb+\si{\F}+&
249	\si{\s\tothe{4}\A\squared\per\m\squared\per\kg}\\
250	\quad femtofarad&
251	\ditto&
252	\si{\fF}&
253	\verb+\si{\fF}+&
254	\SI{e-15}{\F}\\
255	\quad picofarad&
256	\ditto&
257	\si{\pF}&
258	\verb+\si{\pF}+&
259	\SI{e-12}{\F}\\
260	\vsp
261	foot&
262	length&
263	\si{\ft}&

264	<code>\verb+\si{ft}+&amp;</code>
265	<code>\SI{0.3048}{m}\ \ % not an SI unit</code>
266	<code>\vsp</code>
267	<code>% gauss: The gauss, symbol G, sometimes Gs, is the cgs unit of measurement of magnetic flux.</code>
268	<code>gray&amp;</code>
269	<code>absorbed dose of ionizing radiation&amp;</code>
270	<code>\si{Gy}&amp;</code>
271	<code>\verb+\si{Gy}+&amp;</code>
272	<code>\si{J\per\kg}\ \</code>
273	<code>\vsp</code>
274	<code>hartree&amp;</code>
275	<code>energy used in molecular orbital calculations&amp;</code>
276	<code>\si{hartree}&amp;</code>
277	<code>\verb+\si{hartree}+&amp;</code>
278	<code>xxx\ \</code>
279	<code>\vsp</code>
280	<code>hectare&amp;</code>
281	<code>area&amp;</code>
282	<code>\si{ha}&amp;</code>
283	<code>\verb+\si{ha}+&amp;</code>
284	<code>\SI{e4}{m\squared}\ \</code>
285	<code>\vsp</code>
286	<code>henry&amp;</code>
287	<code>electrical inductance&amp;</code>
288	<code>\si{H}&amp;</code>
289	<code>\verb+\si{H}+&amp;</code>
290	<code>\si{kg\m\squared\per\s\squared\per\A\squared}\ \</code>
291	<code>\vsp</code>
292	<code>hertz&amp;</code>
293	<code>frequency&amp;</code>
294	<code>\si{Hz}&amp;</code>
295	<code>\verb+\si{Hz}+&amp;</code>
296	<code>\si{\per\s}\ \</code>
297	<code>\quad millihertz&amp;</code>
298	<code>\ditto&amp;</code>
299	<code>\si{mHz}&amp;</code>
300	<code>\verb+\si{mHz}+&amp;</code>
301	<code>\SI{e-3}{Hz}\ \</code>
302	<code>\quad kilohertz&amp;</code>
303	<code>\ditto&amp;</code>
304	<code>\si{kHz}&amp;</code>
305	<code>\verb+\si{kHz}+&amp;</code>
306	<code>\SI{e3}{Hz}\ \</code>
307	<code>\quad megahertz&amp;</code>
308	<code>\ditto&amp;</code>
309	<code>\si{MHz}&amp;</code>
310	<code>\verb+\si{MHz}+&amp;</code>
311	<code>\SI{e6}{Hz}\ \</code>
312	<code>\quad gigahertz&amp;</code>
313	<code>\ditto&amp;</code>
314	<code>\si{GHz}&amp;</code>
315	<code>\verb+\si{GHz}+&amp;</code>
316	<code>\SI{e9}{Hz}\ \</code>
317	<code>\quad terahertz&amp;</code>
318	<code>\ditto&amp;</code>
319	<code>\si{THz}&amp;</code>
320	<code>\verb+\si{THz}+&amp;</code>
321	<code>\SI{e12}{Hz}\ \</code>
322	<code>\vsp</code>
323	<code>horsepower&amp;</code>
324	<code>power&amp;</code>
325	<code>\si{hp}&amp;</code>
326	<code>\verb+\si{hp}+&amp;</code>
327	<code>\SI{\approx 745.7}{W}, {\bfseries IMPORTANT:\newline</code>

328	see \href{https://en.wikipedia.org/wiki/Horsepower#Mechanical_horsepower}{Horsepower}}\\
329	% not an SI unit
330	\vsp
331	hour&
332	time&
333	\si{\h}&
334	\verb+\si{\h}+&
335	\SI{3600}{\s}\\
336	\vsp
337	inch&
338	length&
339	\si{\in}&
340	\verb+\si{\in}+&
341	\SI{25.4}{\mm}\\ % not an SI unit
342	\vsp
343	joule&
344	work or energy&
345	\si{\J}&
346	\verb+\si{\J}+&
347	\si{\kg\m\squared\per\s\squared}\\
348	\quad microjoule&
349	\ditto&
350	\si{\uJ}&
351	\verb+\si{\uJ}+&
352	\SI{e-6}{\J}\\
353	\quad millijoule&
354	\ditto&
355	\si{\mJ}&
356	\verb+\si{\mJ}+&
357	\SI{e-3}{\J}\\
358	\quad kilojoule&
359	\ditto&
360	\si{\kJ}&
361	\verb+\si{\kJ}+&
362	\SI{e3}{\J}\\
363	\quad megajoule&
364	\ditto&
365	\si{\MJ}&
366	\verb+\si{\MJ}+&
367	\SI{e6}{\J}\\
368	\vsp
369	katal&
370	catalytic activity&
371	\si{\kat}&
372	\verb+\si{\kat}+&
373	\si{\mol\per\s}\\
374	\vsp
375	kelvin&
376	thermodynamic temperature&
377	\si{\K}&
378	\verb+\si{\K}+&
379	(SI base unit)\\
380	\vsp
381	kilogram&
382	mass&
383	\si{\kg}&
384	\verb+\si{\kg}+&
385	(SI base unit)\\
386	\quad femtogram&
387	\ditto&
388	\si{\fg}&
389	\verb+\si{\fg}+&
390	\SI{e-15}{\g}\\
391	\quad picogram&

392	\ditto&
393	\si{\pg}&
394	\verb+\si{\pg}+&
395	\SI{e-12}{\g}\
396	\quad nanogram&
397	\ditto&
398	\si{\ng}&
399	\verb+\si{\ng}+&
400	\SI{e-9}{\g}\
401	\quad microgram&
402	\ditto&
403	\si{\ug}&
404	\verb+\si{\ug}+&
405	\SI{e-6}{\g}\
406	\quad milligram&
407	\ditto&
408	\si{\mg}&
409	\verb+\si{\mg}+&
410	\SI{e-3}{\g}\
411	\quad gram&
412	\ditto&
413	\si{\g}&
414	\verb+\si{\g}+&
415	\SI{e-3}{\kg}\
416	\vsp
417	kilowatt hour&
418	electrical energy&
419	\si{\kWh}&
420	\verb+\si{\kWh}+&
421	\si{\kW\h}\
422	\vsp
423	knot&
424	speed&
425	\si{\kn}&
426	\verb+\si{\kn}+&
427	\si{M\per\h}\
428	\vsp
429	liter&
430	volume&
431	\si{\L}&
432	\verb+\si{\L}+&
433	\SI{e-3}{m\cubed}\
434	\quad microliter&
435	\ditto&
436	\si{\uL}&
437	\verb+\si{\uL}+&
438	\SI{e-6}{\L}\
439	\quad milliliter&
440	\ditto&
441	\si{\mL}&
442	\verb+\si{\mL}+&
443	\SI{e-3}{\L}\
444	\quad hectoliter&
445	\ditto&
446	\si{\hL}&
447	\verb+\si{\hL}+&
448	\SI{e2}{\L}\
449	\vsp
450	lumen&
451	luminous flux&
452	\si{\lm}&
453	\verb+\si{\lm}+&
454	\si{\cd\sr}\
455	\vsp

456	lux&
457	illumination&
458	\si{\lx}&
459	\verb+\si{\lx}+&
460	\si{\lm\per\m\squared}\
461	\vsp
462	meter&
463	length&
464	\si{\m}&
465	\verb+\si{\m}+&
466	(SI base unit)\
467	\quad picometer&
468	\ditto&
469	\si{\pm}&
470	\verb+\si{\pm}+&
471	\SI{e-12}{\m}\
472	\quad nanometer&
473	\ditto&
474	\si{\nm}&
475	\verb+\si{\nm}+&
476	\SI{e-9}{\m}\
477	\quad micrometer&
478	\ditto&
479	\si{\um}&
480	\verb+\si{\um}+&
481	\SI{e-6}{\m}\
482	\quad millimeter&
483	\ditto&
484	\si{\mm}&
485	\verb+\si{\mm}+&
486	\SI{e-3}{\m}\
487	\quad centimeter&
488	\ditto&
489	\si{\cm}&
490	\verb+\si{\cm}+&
491	\SI{e-2}{\m}\
492	\quad decimeter&
493	\ditto&
494	\si{\dm}&
495	\verb+\si{\dm}+&
496	\SI{e-1}{\m}\
497	\quad kilometer&
498	\ditto&
499	\si{\km}&
500	\verb+\si{\km}+&
501	\SI{e3}{\m}\
502	\vsp
503	% mile: not an SI unit
504	millimeter of mercury&
505	pressure&
506	\si{\mmHg}&
507	\verb+\si{\mmHg}+&
508	\href{https://en.wikipedia.org/wiki/Millimetre_of_mercury}{\SI{\approx 133}{\Pa}}\
509	\vsp
510	minute&
511	time&
512	\si{\min}&
513	\verb+\si{\min}+&
514	\SI{60}{\s}\
515	\vsp
516	mole&
517	amount of substance&
518	\si{\mol}&
519	\verb+\si{\mol}+&

```

520 (SI base unit)\
521 \quad femtomole&
522 \ditto&
523 \si{fmol}&
524 \verb+\si{fmol}+&
525 \SI{e-15}{mol}\
526 \quad picomole&
527 \ditto&
528 \si{pmol}&
529 \verb+\si{pmol}+&
530 \SI{e-12}{mol}\
531 \quad nanomole&
532 \ditto&
533 \si{nmol}&
534 \verb+\si{nmol}+&
535 \SI{e-9}{mol}\
536 \quad micromole&
537 \ditto&
538 \si{umol}&
539 \verb+\si{umol}+&
540 \SI{e-6}{mol}\
541 \quad millimole&
542 \ditto&
543 \si{mmol}&
544 \verb+\si{mmol}+&
545 \SI{e-3}{mol}\
546 \quad kilomole&
547 \ditto&
548 \si{kmol}&
549 \verb+\si{kmol}+&
550 \SI{e3}{mol}\
551 \vsp
552 nautical mile&
553 distance&
554 \si{M}&
555 \verb+\si{M}+&
556 \SI{1852}{m}\
557 \vsp
558 neper&
559 gain, loss, and relative values&
560 \si{Np}&
561 \verb+\si{Np}+&
562 1\
563 \vsp
564 newton&
565 force&
566 \si{N}&
567 \verb+\si{N}+&
568 \si{kg\m\per\s\squared}\
569 \quad millinewton&
570 \ditto&
571 \si{mN}&
572 \verb+\si{mN}+&
573 \SI{e-3}{N}\
574 \quad kilonewton&
575 \ditto&
576 \si{kN}&
577 \verb+\si{kN}+&
578 \SI{e3}{N}\
579 \quad meganewton&
580 \ditto&
581 \si{MN}&
582 \verb+\si{MN}+&
583 \SI{e6}{N}\

```

584	\vsp
585	ohm&
586	electrical resistance&
587	\si{\ohm}&
588	\verb+\si{\ohm}+&
589	\si{\kg\m\squared\per\s\cubed\per\A\squared}\\
590	\quad milliohm&
591	\ditto&
592	\si{\mohm}&
593	\verb+\si{\mohm}+&
594	\SI{e-3}{ohm}\\
595	\quad kiloohm&
596	\ditto&
597	\si{\kohm}&
598	\verb+\si{\kohm}+&
599	\SI{e3}{ohm}\\
600	\quad megaohm&
601	\ditto&
602	\si{\Mohm}&
603	\verb+\si{\Mohm}+&
604	\SI{e6}{ohm}\\
605	\vsp
606	pascal&
607	pressure&
608	\si{\Pa}&
609	\verb+\si{\Pa}+&
610	\si{\kg\per\m\per\s\squared}\\
611	\quad kilopascal&
612	\ditto&
613	\si{\kPa}&
614	\verb+\si{\kPa}+&
615	\SI{e3}{\Pa}\\
616	\quad megapascal&
617	\ditto&
618	\si{\MPa}&
619	\verb+\si{\MPa}+&
620	\SI{e6}{\Pa}\\
621	\quad gigapascal&
622	\ditto&
623	\si{\GPa}&
624	\verb+\si{\GPa}+&
625	\SI{e9}{\Pa}\\
626	\vsp
627	percent&
628	hundredths&
629	\si{\percent}&
630	\verb+\si{\percent}+&
631	\SI{e-2}{}\\
632	\vsp
633	pound&
634	weight&
635	\si{\lb}&
636	\verb+\si{\lb}+&
637	\SI{.45359237}{\kg}\\ % not an SI unit
638	\vsp
639	radian&
640	plane angular measurement&
641	\si{\rad}&
642	\verb+\si{\rad}+&
643	\(180/\pi\) \unit{\degree\nounit}\\
644	\vsp
645	reduced Planck constant&
646	angular momentum&
647	\si{\planckbar}&



648	<code>\verb+\si{\planckbar}+&amp;</code>
649	<code>\(\approx \SI{1.05e-34}{\J\}\)\</code>
650	<code>\vsp</code>
651	<code>second&amp;</code>
652	<code>time&amp;</code>
653	<code>\si{\s}&amp;</code>
654	<code>\verb+\si{\s}+&amp;</code>
655	<code>(SI base unit)\</code>
656	<code>\quad attosecond&amp;</code>
657	<code>\ditto&amp;</code>
658	<code>\si{\as}&amp;</code>
659	<code>\verb+\si{\as}+&amp;</code>
660	<code>\SI{e-18}{\s}\</code>
661	<code>\quad femtosecond&amp;</code>
662	<code>\ditto&amp;</code>
663	<code>\si{\fs}&amp;</code>
664	<code>\verb+\si{\fs}+&amp;</code>
665	<code>\SI{e-15}{\s}\</code>
666	<code>\quad picosecond&amp;</code>
667	<code>\ditto&amp;</code>
668	<code>\si{\ps}&amp;</code>
669	<code>\verb+\si{\ps}+&amp;</code>
670	<code>\SI{e-12}{\s}\</code>
671	<code>\quad nanosecond&amp;</code>
672	<code>\ditto&amp;</code>
673	<code>\si{\ns}&amp;</code>
674	<code>\verb+\si{\ns}+&amp;</code>
675	<code>\SI{e-9}{\s}\</code>
676	<code>\quad microsecond&amp;</code>
677	<code>\ditto&amp;</code>
678	<code>\si{\us}&amp;</code>
679	<code>\verb+\si{\us}+&amp;</code>
680	<code>\SI{e-6}{\s}\</code>
681	<code>\quad millisecond&amp;</code>
682	<code>\ditto&amp;</code>
683	<code>\si{\ms}&amp;</code>
684	<code>\verb+\si{\ms}+&amp;</code>
685	<code>\SI{e-3}{\s}\</code>
686	<code>\vsp</code>
687	<code>siemens&amp;</code>
688	<code>conductance&amp;</code>
689	<code>\si{\S}&amp;</code>
690	<code>\verb+\si{\S}+&amp;</code>
691	<code>\si{\per\kg\per\m\squared\s\cubed\A\squared}\</code>
692	<code>\vsp</code>
693	<code>sievert&amp;</code>
694	<code>dosage of ionizing radiation&amp;</code>
695	<code>\si{\Sv}&amp;</code>
696	<code>\verb+\si{\Sv}+&amp;</code>
697	<code>\si{\m\squared\per\s\squared}\</code>
698	<code>\vsp</code>
699	<code>speed of light&amp;</code>
700	<code>speed&amp;</code>
701	<code>\si{\clight}&amp;</code>
702	<code>\verb+\si{\clight}+&amp;</code>
703	<code>\SI{299792458}{\m\per\s}\</code>
704	<code>\vsp</code>
705	<code>standard deviation&amp;</code>
706	<code>amount of variation&amp;</code>
707	<code>\si{\SD}&amp;</code>
708	<code>\verb+\si{\SD}+&amp;</code>
709	<code><math>\displaystyle \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}</math></code>
710	<code>\vsp</code>
711	<code>steradian&amp;</code>

712	measure of solid angles&
713	\si{\sr}&
714	\verb+\si{\sr}+&
715	\SI{1}{\m\squared\per\m\squared}\
716	\vsp
717	tesla&
718	magnetic flux density&
719	\si{\T}&
720	\verb+\si{\T}+&
721	\si{\kg\per\s\squared\per\A}\
722	\vsp
723	metric ton&
724	mass&
725	\si{\t}&
726	\verb+\si{\t}+&
727	\SI{e3}{\kg}\
728	\vsp
729	volt&
730	electrical potential difference&
731	\si{\V}&
732	\verb+\si{\V}+&
733	\si{\kg\m\squared\per\s\cubed\per\A}\
734	\quad picovolt&
735	\ditto&
736	\si{\pV}&
737	\verb+\si{\pV}+&
738	\SI{e-12}{\V}\
739	\quad nanovolt&
740	\ditto&
741	\si{\nV}&
742	\verb+\si{\nV}+&
743	\SI{e-9}{\V}\
744	\quad microvolt&
745	\ditto&
746	\si{\uV}&
747	\verb+\si{\uV}+&
748	\SI{e-6}{\V}\
749	\quad millivolt&
750	\ditto&
751	\si{\mV}&
752	\verb+\si{\mV}+&
753	\SI{e-3}{\V}\
754	\quad kilovolt&
755	\ditto&
756	\si{\kV}&
757	\verb+\si{\kV}+&
758	\SI{e3}{\V}\
759	\vsp
760	watt&
761	power&
762	\si{\W}&
763	\verb+\si{\W}+&
764	\si{\kg\m\squared\per\s\cubed}\
765	\quad microwatt&
766	\ditto&
767	\si{\uW}&
768	\verb+\si{\uW}+&
769	\SI{e-6}{\W}\
770	\quad milliwatt&
771	\ditto&
772	\si{\mW}&
773	\verb+\si{\mW}+&
774	\SI{e-3}{\W}\
775	\quad kilowatt&

```

776     \ditto&
777     \si{\kW}&
778     \verb+\si{\kW}+&
779     \SI{e3}{\W}\
780     \quad megawatt&
781     \ditto&
782     \si{\MW}&
783     \verb+\si{\MW}+&
784     \SI{e6}{\W}\
785     \quad gigawatt&
786     \ditto&
787     \si{\GW}&
788     \verb+\si{\GW}+&
789     \SI{e9}{\W}\
790     \vsp
791     weber&
792     magnetic flux&
793     \si{\Wb}&
794     \verb+\si{\Wb}+&
795     \si{\kg\m\squared\per\s\squared\per\A}\
796     \vsp
797     yard&
798     length&
799     \si{\yd}&
800     \verb+\si{\yd}+&
801     \SI{.9144}{\m}\ % not an SI unit
802     \vsp
803     year&
804     time&
805     \si{\y}&
806     \verb+\si{\y}+&
807     \SI{\approx 365.25}{\d}\ % not an SI unit
808 \end{longtable}
809 }

```

## L. RESOURCES

From the IEEE Author Center [29]:

- The IEEE Editorial Style Manual for Authors [30] contains a formal set of editorial guidelines.
- Editing Mathematics [31] illustrates how to do mathematics.
- The IEEE Reference Guide [32] outlines how to cite references.

```

1 \chapter{RESOURCES}
2
3 From the
4 IEEE Author Center \cite{ieee-author-center}:
5 \begin{itemize}
6   \item
7     The
8     IEEE Editorial Style Manual for Authors \cite{ieee-editorial-style-manual-for-authors}
9     contains a formal set of editorial guidelines.
10  \item
11    Editing Mathematics \cite{editing-mathematics}
12    illustrates how to do mathematics.
13  \item
14    The
15    IEEE Reference Guide \cite{ieee-reference-guide}
16    outlines how to cite references.
17 \end{itemize}
18

```

## M. TABLES

table

```
1 \chapter{TABLES}
2 \ix{table}
```

Here is a really simple table. I was greatly influenced by Herbert Voss' following ideas on typesetting tables [33]: Use `\toprule`, `\midrule`, and `\bottomrule`. Don't have blank horizontal space to left or right of body of table.

Voss, Herbert

**Table M.1.** The first three American Presidents.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

table

```
1
2 Here is a really simple table.
3 I was greatly influenced by Herbert Voss' following ideas on typesetting tables \cite{voss2011}:
4 Use |\toprule|, |\midrule|, and |\bottomrule|.
5 \index{\verb+\toprule+}
6 \index{\verb+\midrule+}
7 \index{\verb+\bottomrule+}
8 Don't have blank horizontal space to left or right of body of table.
9 \ix{Voss, Herbert}
10
11 % "h" means put table "here"---don't let it float to top or bottom of page
12 \begin{table}[ht]
13   \caption{The first three American Presidents.}
14   \vspace*{6pt}
15   \centering
16   % Table format:
17   %   WHAT   DESCRIPTION
18   %   @{}   don't put extra space before first column
19   %   r     right justify first column
20   %   l     left justify second column
21   %   @{}   don't put extra space after second column
22   \begin{tabular}{@{}rl@{}}
23     \toprule
24     \bf Number& \bf Name\\
25     \midrule
26     1& George Washington\\
27     2& John Adams\\
28     3& Thomas Jefferson\\
29     \bottomrule
30   \end{tabular}
31   \label{ta:first-three-american-presidents}
32 \end{table}
33 \ix{table}
34 \index{\verb+\begin{table}+}
```

Here is the same table with a longer caption.

**Table M.2.** The first three American Presidents. This caption is much, much, much, much, much, much, much, much, much, much longer.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

```

1
2 \newpage
3
4 Here is the same table with a longer caption.
5
6 % "h" means put table "here"---don't let it float to top or bottom of page
7 \begin{table}[ht]
8 \caption{%
9 The first three American Presidents.
10 This caption is
11 much, much, much, much, much, much,
12 much, much, much, much, much, much
13 longer.%
14 }
15 \vspace*{6pt}
16 \centering
17 % Table format:
18 % WHAT DESCRIPTION
19 % @{} don't put extra space before first column
20 % r right justify first column
21 % l left justify second column
22 % @{} don't put extra space after second column
23 \begin{tabular}{@{}rl@{}}
24 \toprule
25 \bf Number& \bf Name\\
26 \midrule
27 1& George Washington\\
28 2& John Adams\\
29 3& Thomas Jefferson\\
30 \bottomrule
31 \end{tabular}
32 \label{ta:first-three-american-presidents-longer-caption}
33 \end{table}

```

$\LaTeX$  can print horizontal and vertical rules in tables. I don't like the way this looks and suggest you do not use tables with lots of horizontal and vertical lines.

**Table M.3.** The first three American Presidents with horizontal and vertical lines

#	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

```

1
2 \newpage
3
4 \LaTeX\ can print horizontal
5 and vertical rules in tables.
6 I don't like the way this looks
7 and suggest you do not use tables
8 with lots of horizontal and vertical lines.
9 \begin{table}[ht]
10 \caption{The first three American Presidents with horizontal and vertical lines}
11 \vspace*{6pt}
12 \centering
13 % Table format:
14 % WHAT DESCRIPTION
15 % @{} don't put any space left of first column
16 % | print a vertical rule
17 % c center column
18 % | print a vertical rule
19 % l left justify column
20 % | print a vertical rule
21 % @{} don't put any space right of last column
22 \begin{tabular}{@{}|c|l|@{}}
23 % "\hline" prints a horizontal rule
24 \hline
25 \bf \#\& \bf Name\\
26 \hline
27 1& George Washington\\
28 \hline
29 2& John Adams\\
30 \hline
31 3& Thomas Jefferson\\
32 \hline
33 \end{tabular}
34 \label{ta:American-Presidents-with-horizontal}
35 \end{table}

```

Here is a more complicated table.

**Table M.4. C Bitwise Operators**

A	B	A B	A&B
0	0	0	0
0	1	1	0
1	0	1	0
1	1	1	1

```

1
2 \newpage
3
4 Here is a more complicated table.
5
6 {
7   \UndefineShortVerb{\|}
8   \begin{table}[ht]
9     \caption{C Bitwise Operators}
10    \vspace*{6pt}
11    \centering
12    % Table format:
13    %   WHAT   DESCRIPTION
14    %   @{}   don't put extra space before first column
15    %   c     first column is centered
16    %   c     second column is centered
17    %   c     third column is centered
18    %   c     fourth column is centered
19    %   @{}   don't put extra space after fourth column
20    \begin{tabular}{@{}cccc@{}}
21      \toprule
22      \bf A& \bf B& \bf A(|)B& \bf A&B\\[2pt]
23      \midrule
24      0& 0& 0& 0\\
25      0& 1& 1& 0\\
26      1& 0& 1& 0\\
27      1& 1& 1& 1\\
28      \bottomrule
29    \end{tabular}
30    \label{ta:C-Bitwise}
31  \end{table}
32 }

```

```

1 \begin{table}[ht]
2   \caption{Participant descriptors for twelve practitioners engaged in co-creation activities}
3   \label{tab:22participants}
4   \centering
5   \begin{tabular}{@{}c|l|S@{}}
6     \toprule
7     \multicolumn{1}{@{}l}{\textbf{Pseudonym}}&
8     \textbf{Disciplinary Role}&
9     \textbf{Company Type}&
10    \multicolumn{1}{l}{\textbf{\# Years of Experience}}\\
11    \midrule
12    \multicolumn{4}{@{}l@{}}%

```



**Table M.5.** Participant descriptors for twelve practitioners engaged in co-creation activities

Pseudonym	Disciplinary Role	Company Type	# Years of Experience
<b>Sequence 1:</b> A1.1 → B2.1: Overlapping dilemma cards to strengthen and represent ethical complexity through practitioner’s current ecological complexity model			
1P1	UX Designer	Enterprise (B2C)	1.5
1P2	Product Manager	Enterprise (B2B)	5
1P3	Data Scientist	Agency or Consultancy	1
<b>Sequence 2:</b> B2.1 → A1.1: Building and tracing complexity based on Dilemmas Cards to reconstruct and reflect on their experience			
2P1	UX Designer	Agency or Consultancy	8
2P2	Product Manager	Agency or Consultancy	2
2P3	Software Engineer	Enterprise (B2B)	2

```

13  {%
14  \textbf{Sequence 1:} $\text{A1.1}\to\text{B2.1}$:
15  Overlapping dilemma cards to strengthen and represent%
16  }\\
17  \multicolumn{4}{@{}l}{ethical complexity
18  through practitioner's current ecological complexity model}\\
19  1P1& UX Designer& Enterprise (B2C)& 1.5\\
20  1P2& Product Manager& Enterprise (B2B)& 5\\
21  1P3& Data Scientist& Agency or Consultancy& 1\\
22  \noalign{\vspace{8pt}}
23  \multicolumn{4}{@{}l}{%
24  {%
25  \textbf{Sequence 2:} $\text{B2.1}\to\text{A1.1}$:
26  Building and tracing complexity based on Dilemmas Cards%
27  }\\
28  \multicolumn{4}{@{}l}{to reconstruct and reflect on their experience}\\
29  2P1& UX Designer& Agency or Consultancy& 8\\
30  2P2& Product Manager& Agency or Consultancy& 2\\
31  2P3& Software Engineer& Enterprise (B2B)& 2\\
32  \bottomrule
33  \end{tabular}
34  \end{table}

```

Here is a table that is too long to fit on one page.

**Table M.6.** State Abbreviations

<b>State</b>	<b>Abbreviation</b>
Alabama	AL
Alaska	AK
American Samoa	AS
Arizona	AZ
Arkansas	AR
Armed Forces Europe	AE
Armed Forces Pacific	AP
Armed Forces the Americas	AA
California	CA
Colorado	CO
Connecticut	CT
Delaware	DE
District of Columbia	DC
Federated States of Micronesia	FM
Florida	FL
Georgia	GA
Guam	GU
Hawaii	HI
Idaho	ID
Illinois	IL
Indiana	IN
Iowa	IA
Kansas	KS
Kentucky	KY
Louisiana	LA
Maine	ME
Marshall Islands	MH
Maryland	MD
Massachusetts	MA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
Montana	MT
Nebraska	NE
Nevada	NV
New Hampshire	NH
New Jersey	NJ
New Mexico	NM

*continued on next page*





34	Connecticut& CT\\
35	Delaware& DE\\
36	District of Columbia& DC\\
37	Federated States of Micronesia& FM\\
38	Florida& FL\\
39	Georgia& GA\\
40	Guam& GU\\
41	Hawaii& HI\\
42	Idaho& ID\\
43	Illinois& IL\\
44	Indiana& IN\\
45	Iowa& IA\\
46	Kansas& KS\\
47	Kentucky& KY\\
48	Louisiana& LA\\
49	Maine& ME\\
50	Marshall Islands& MH\\
51	Maryland& MD\\
52	Massachusetts& MA\\
53	Michigan& MI\\
54	Minnesota& MN\\
55	Mississippi& MS\\
56	Missouri& MO\\
57	Montana& MT\\
58	Nebraska& NE\\
59	Nevada& NV\\
60	New Hampshire& NH\\
61	New Jersey& NJ\\
62	New Mexico& NM\\
63	New York& NY\\
64	North Carolina& NC\\
65	North Dakota& ND\\
66	Northern Mariana Islands& MP\\
67	Ohio& OH\\
68	Oklahoma& OK\\
69	Oregon& OR\\
70	Pennsylvania& PA\\
71	Puerto Rico& PR\\
72	Rhode Island& RI\\
73	South Carolina& SC\\
74	South Dakota& SD\\
75	Tennessee& TN\\
76	Texas& TX\\
77	Utah& UT\\
78	Vermont& VT\\
79	Virgin Islands& VI\\
80	Virginia& VA\\
81	Washington& WA\\
82	West Virginia& WV\\
83	Wisconsin& WI\\
84	Wyoming& WY\\
85	\\multicolumn{2}{c}{make this three pages long}\\
86	\\multicolumn{2}{c}{make this three pages long}\\
87	\\multicolumn{2}{c}{make this three pages long}\\
88	\\multicolumn{2}{c}{make this three pages long}\\
89	\\multicolumn{2}{c}{make this three pages long}\\
90	\\multicolumn{2}{c}{make this three pages long}\\
91	\\multicolumn{2}{c}{make this three pages long}\\
92	\\multicolumn{2}{c}{make this three pages long}\\
93	\\multicolumn{2}{c}{make this three pages long}\\
94	\\multicolumn{2}{c}{make this three pages long}\\
95	\\multicolumn{2}{c}{make this three pages long}\\
96	\\multicolumn{2}{c}{make this three pages long}\\
97	\\multicolumn{2}{c}{make this three pages long}\\

```
98  \multicolumn{2}{c}{make this three pages long}\\
99  \multicolumn{2}{c}{make this three pages long}\\
100 \multicolumn{2}{c}{make this three pages long}\\
101 \multicolumn{2}{c}{make this three pages long}\\
102 \multicolumn{2}{c}{make this three pages long}\\
103 \multicolumn{2}{c}{make this three pages long}\\
104 \multicolumn{2}{c}{make this three pages long}\\
105 \multicolumn{2}{c}{make this three pages long}\\
106 \multicolumn{2}{c}{make this three pages long}\\
107 \multicolumn{2}{c}{make this three pages long}\\
108 \multicolumn{2}{c}{make this three pages long}\\
109 \multicolumn{2}{c}{make this three pages long}\\
110 \multicolumn{2}{c}{make this three pages long}\\
111 \multicolumn{2}{c}{make this three pages long}\\
112 \multicolumn{2}{c}{make this three pages long}\\
113 \multicolumn{2}{c}{make this three pages long}\\
114 \multicolumn{2}{c}{make this three pages long}\\
115 \multicolumn{2}{c}{make this three pages long}\\
116 \multicolumn{2}{c}{make this three pages long}\\
117 \multicolumn{2}{c}{make this three pages long}\\
118 \multicolumn{2}{c}{make this three pages long}\\
119 \multicolumn{2}{c}{make this three pages long}\\
120 \end{longtable}
```

```

1
2 % The table is on the next page.
3
4 \newpage
5
6 % Set \LTcapwidth (the longtable caption width)
7 % to \textwidth minus 4 paragraph indent widths.
8 \setlength{\LTcapwidth}{\textwidth}
9 \addtolength{\LTcapwidth}{-4\parindent}
10
11 \newlength{\twidth}
12 \newlength{\theight}
13
14 \setlength{\twidth}{\textwidth}
15 \setlength{\theight}{\textheight}
16
17 \begin{sidewaystable}
18 % The following two lines compensate for what I think is a bug.
19 \setlength{\textwidth}{\theight}
20 \setlength{\textheight}{\twidth}
21 \caption{Sidewaystable of the first three American Presidents.}
22 \vspace*{6pt}
23 \centering
24 \begin{tabular}{@{}rl@{}}
25 \toprule
26 \bf Number& \bf Name\\
27 \midrule
28 1& George Washington\\
29 2& John Adams\\
30 3& Thomas Jefferson\\
31 \bottomrule
32 \end{tabular}
33 \end{sidewaystable}

```

**Table M.7.** Sidewaystable of the first three American Presidents.

<b>Number</b>	<b>Name</b>
1	George Washington
2	John Adams
3	Thomas Jefferson



```

1 \begin{sidewaystable}
2 % The following two lines compensate for what I think is a bug.
3 \setlength{\textwidth}{\theight}
4 \setlength{\textheight}{\twidth}
5 \caption{Two tables can be placed vertically in a sidewaysstable environment.}
6 \vspace*{6pt}
7 \centering
8 \begin{tabular}{@{}rl@{}}
9 \toprule
10 \bf Number& \bf Name\\
11 \midrule
12 1& George Washington\\
13 2& John Adams\\
14 3& Thomas Jefferson\\
15 \bottomrule
16 \end{tabular}
17 \vspace*{2\baselineskip}
18 \caption{This is the second table in the sideways environment.}
19 \vspace*{6pt}
20 \begin{tabular}{@{}rl@{}}
21 \toprule
22 \bf Number& \bf Name\\
23 \midrule
24 1& George Washington\\
25 2& John Adams\\
26 3& Thomas Jefferson\\
27 \bottomrule
28 \end{tabular}
29 \end{sidewaystable}

```

**Table M.8.** Two tables can be placed vertically in a sidewaysstable environment.

<b>Number</b>	<b>Name</b>
1	George Washington
2	John Adams
3	Thomas Jefferson

**Table M.9.** This is the second table in the sideways environment.

<b>Number</b>	<b>Name</b>
1	George Washington
2	John Adams
3	Thomas Jefferson

```

1 \begin{sidewaystable}[ht]%
2 % The following two lines compensate for what I think is a bug.
3 \setlength{\textwidth}{\theight}%
4 \setlength{\textheight}{\textwidth}%
5 \caption{Live Guitar Open String Testing Data - Pitch (\textit{f\textsubscript{0}})}
6 \vspace*{6pt}%
7 \label{ta:live-guitar}%
8 % Define "Live Guitar Test" column.
9 \def\lgt#1{\bf Live Guitar Test #1}
10 % Define "Note", "Computed", "Measured", "%", and "Accuracy" column headings.
11 \def\note{\bf Note}
12 \def\cal{\bf Computed}
13 \def\mea{\bf Measured}
14 \def\per{\bf \%}
15 \def\acc{\bf Accuracy}
16 % Define "Name", "f_0 (Hz)", "Error", and "Range (\textcent)" column headings.
17 \def\name{\bf Name}
18 \def\fsz{\bf \textit{f\textsubscript{0}} (Hz)}
19 \def\err{\bf Error}
20 \def\ran{\bf Range (\textcent)}
21 % Make "!" be an invisible character the width of a digit.
22 % (All digits in the normal font are the same width.)
23 \catcode`\!=\active \def!\{\hphantom 1}
24 \hbox to \textwidth
25 {%
26 \hss
27 % From http://zerocapcable.com/?page_id=225
28 % The units of tuning accuracy are cents. A cent is one hundredth
29 % of a semitone. Since there are 12 semitones in an octave, there
30 % are 1200 cents in an octave.
31 % The default \tabcolsep is 6.0pt.
32 \setlength{\tabcolsep}{5pt}%
33 \begin{tabular}{@{}cc|ccc|ccc|ccc@{}}
34 \hline
35 \multicolumn{2}{c|}{ }&
36 \multicolumn{3}{c|}{\lgt1}&
37 \multicolumn{3}{c|}{\lgt2}&
38 \multicolumn{3}{c}{\lgt3}\\
39 \cline{3-11}
40 \note& \cal& \mea& \per& \acc& \mea& \per& \acc& \mea& \per& \acc\\
41 \name& \fsz& \fsz& \err& \ran& \fsz& \err& \ran& \fsz& \err& \ran\\
42 \hline
43 E\textsubscript 2& !82.407& !82.333& 0.0897& $+2$& !82.616& 0.2538& $+6$& !82.474& 0.0814& $+2$\\
44 A\textsubscript 2& 110.000& 110.092& 0.0836& $+2$& 110.092& 0.0836& $+2$& 110.092& 0.0836& $+2$\\
45 D\textsubscript 3& 146.832& 146.789& 0.0295& $-2$& 146.789& 0.0295& $-2$& 147.239& 0.2769& $+6$\\
46 G\textsubscript 3& 195.998& 196.721& 0.3690& $+8$& 195.918& 0.0407& $+2$& 196.721& 0.3690& $+8$\\
47 B\textsubscript 3& 246.942& 247.423& 0.1949& $+4$& 246.517& 0.1720& $-4$& 247.423& 0.1949& $+4$\\
48 E\textsubscript 4& 329.628& 331.034& 0.4267& $+8$& 331.034& 0.4267& $+8$& 331.034& 0.4267& $+8$\\
49 \hline
50 \multicolumn{11}{@{}l}{Thanks to Kathryn Schmidt for donating this table.}\\
51 \end{tabular}
52 \hss
53 }
54 \end{sidewaystable}

```

Table M.10. Live Guitar Open String Testing Data - Pitch ( $f_0$ )

Note Name	Computed $f_0$ (Hz)	Live Guitar Test 1			Live Guitar Test 2			Live Guitar Test 3		
		Measured $f_0$ (Hz)	% Error	Accuracy Range (¢)	Measured $f_0$ (Hz)	% Error	Accuracy Range (¢)	Measured $f_0$ (Hz)	% Error	Accuracy Range (¢)
E <sub>2</sub>	82.407	82.333	0.0897	+2	82.616	0.2538	+6	82.474	0.0814	+2
A <sub>2</sub>	110.000	110.092	0.0836	+2	110.092	0.0836	+2	110.092	0.0836	+2
D <sub>3</sub>	146.832	146.789	0.0295	-2	146.789	0.0295	-2	147.239	0.2769	+6
G <sub>3</sub>	195.998	196.721	0.3690	+8	195.918	0.0407	+2	196.721	0.3690	+8
B <sub>3</sub>	246.942	247.423	0.1949	+4	246.517	0.1720	-4	247.423	0.1949	+4
E <sub>4</sub>	329.628	331.034	0.4267	+8	331.034	0.4267	+8	331.034	0.4267	+8



Thanks to Kathryn Schmidt for donating this table.

```

1 % Define a control sequence to save typing.
2 % Let * represent zero or more spaces!
3 % Method 1: \def\g#1{ requires using \g*{10} for 10.
4 %           Two shifted characters, { and } are needed.
5 % Method 2: \def\g#1/{ requires using \g*10/ for 10.
6 %           One unshifted character, / is needed.
7 % Method 2 requires less work than Method 1.
8 \def\g#1/{\includegraphics[scale=0.5]{gr-tally-#1.pdf}}%
9
10 % Define a length for use later.
11 \newlength{\tlen}
12 \setlength{\tlen}{2\parindent}

```

**Table M.11.** First tally table. Use this method. I think it is the simplest.

			
---	---	---	---

```

1 \begin{table}[h]%
2 \label{ta:first-tally-table}
3 \caption
4 [%
5 First tally table. Use this method.%
6 ]%
7 {%
8 First tally table. Use this method. I think it is the simplest.
9 }
10 \vspace*{6pt}
11 % Note that tabular* instead of tabular is used below.
12 % The {\textwidth} makes the total width of the table the width
13 % of the printed area of the page.
14 % The @{\kern\tlen} puts blank space the width of two paragraph indents
15 % before the first column.
16 % The @{\extracolsep{\fill}} adds \fill space between all subsequent
17 % columns.
18 % The lll left justifies the next three columns.
19 % after the column.
20 % The @{\kern\tlen} puts blank space the width of two
21 % paragraph indents before the first column.
22 \begin{tabular*}{\textwidth}{@{\kern\tlen}@{\extracolsep{\fill}}lll@{\kern\tlen}}%
23 \g 01/& \g 02/& \g 03/\
24 \g 04/& \g 05/\
25 \end{tabular*}%
26 \end{table}

```

**Table M.12.** Second tally table. Don't use this method. The method used in the first tally table is easier to understand.

			
---	---	---	---

```

1 \begin{table}[h]
2 \caption{%
3   Second tally table.
4   Don't use this method.
5   The method used in the first tally table
6   is easier to understand.%
7 }%
8 \vspace*{6pt}
9 % Note that tabularx instead of tabular is used below.
10 % The {\textwidth} makes the total width of the table the width
11 % of the printed area on the page.
12 % The @{\kern\tlen} puts blank space the width of two paragraph indents
13 % before the first column.
14 % The XX makes the first two columns the same width including the space
15 % after the column.
16 % The l left justifies the last column.
17 % The @{\kern\tlen} puts blank space the width of two paragraph indents
18 % after the last column.
19 \begin{tabularx}{\textwidth}{@{\kern\tlen}XXl@{\kern\tlen}}%
20 \g 01/& \g 02/& \g 03/\
21 \g 04/& \g 05/\
22 \end{tabularx}%
23 \end{table}

```

**Table M.13.** Third tally table. Don't use this method. The method used in the first tally table is easier to understand.



```

1 \begin{table}[h!]
2 \caption{
3   Third tally table.
4   Don't use this method.
5   The method used in the first tally table
6   is easier to understand.%
7 }%
8 \vspace*{6pt}
9 \def\t #1/#2/#3/%
10 {%
11 \hbox to\textwidth{%
12 \kern\tlen \g #1/\hfil \g #2/\hfil \g #3/\kern\tlen
13 }%
14 }%
15 \vbox{
16 \t 01/02/03/
17 \hbox to\textwidth{%
18 \kern\tlen \g 04/\hfil \g 05/\hfil \phantom{\g 05/}\kern\tlen
19 }%
20 }
21 \end{table}

```

```

1
2
3 % Process all unprocessed floats.
4 % None of the current floats will be after the \FloatBarrier.
5 \FloatBarrier

```

# N. TESTING (THIS APPENDIX IS USED FOR TESTING, DOES THIS VERY, VERY, VERY, VERY, VERY, VERY, VERY, VERY, VERY, VERY, VERY, VERY, LONG TITLE LOOK OK?)

Testing chapter

METAPOST

Input	Output	Comment
PurdueThesis	PurdueThesis	just ordinary text
\PurdueThesisLogo	PurdueThesis	PurdueThesis logo, less space between P and u, e and T, and T and h
\PuThLogo	PuTh	PuTh abbreviation logo

alpha ⇒ beta ⇒ gamma ⇒ delta ⇒ epsilon ⇒ zeta ⇒ eta ⇒ theta ⇒ iota ⇒ kappa ⇒ lambda ⇒ mu ⇒ nu ⇒ xi ⇒ omicron ⇒ pi ⇒ rho ⇒ sigma ⇒ tau ⇒ upsilon ⇒ phi ⇒ chi ⇒ psi ⇒ omega

## N.1 Figure Captions

This is the figure.

**Figure N.1.** This is the caption. This is the caption. This is the caption.  
This is the caption. This is the caption. This is the caption.

```

1
2 \begin{figure}[h]
3   This is the figure.
4   \caption
5   [%
6     This is the caption. This is the caption. This is the caption.
7     This is the caption. This is the caption. This is the caption.%
8   ]%
9   {%
10    This is the caption. This is the caption. This is the caption.
11    This is the caption. This is the caption. This is the caption.%
12  }
13 \end{figure}

```

## N.2 Apostrophes

Test apostrophes in text mode: f', f'', and f'''.

Test apostrophes in math mode:  $f'$ ,  $f''$ , and  $f'''$ .

```

1
2
3 \section{Apostrophes}
4
5 Test apostrophes in text mode: f', f'', and f'''.
6
7 Test apostrophes in math mode: \{f',\ f'',\text{ and }f'''\}.

```

### N.3 Citations

Do a bunch of citations to make bibliography over 100 items:

[34]–[43]  
 [44]–[53]  
 [54]–[63]  
 [64]–[73]  
 [74]–[83]  
 [84]–[93]  
 [94]–[103]  
 [104]–[113]  
 [114]–[123]  
 [124]–[133].

```

1
2
3 \section{Citations}
4
5 Do a bunch of citations to make bibliography over 100 items:\\
6 \cite{t001,t002,t003,t004,t005,t006,t007,t008,t009,t010}\\
7 \cite{t011,t012,t013,t014,t015,t016,t017,t018,t019,t020}\\
8 \cite{t021,t022,t023,t024,t025,t026,t027,t028,t029,t030}\\
9 \cite{t031,t032,t033,t034,t035,t036,t037,t038,t039,t040}\\
10 \cite{t041,t042,t043,t044,t045,t046,t047,t048,t049,t050}\\
11 \cite{t051,t052,t053,t054,t055,t056,t057,t058,t059,t060}\\
12 \cite{t061,t062,t063,t064,t065,t066,t067,t068,t069,t070}\\
13 \cite{t071,t072,t073,t074,t075,t076,t077,t078,t079,t080}\\
14 \cite{t081,t082,t083,t084,t085,t086,t087,t088,t089,t090}\\
15 \cite{t091,t092,t093,t094,t095,t096,t097,t098,t099,t100}.
    
```

### N.4 Footnote

This is a footnote<sup>1</sup>

footnote

```

1
2
3 \section{Footnote}
4
5 This is a footnote\footnote{This is a footnote.}%
6 \index{\verb+\footnote+}%
7 \ix{footnote}
    
```

### N.5 Section heading in SmallCaps font

Section headings with `{\protect\scshape SmallCaps}` don't work.

Section headings with SMALLCAPS don't work.

This does not work:

Putting this section in a VerbatimOut environment caused a “! LaTeX Error: Float(s) lost.” error.

```
\section{Section heading in {\protect\scshape SmallCaps} font}
```

<sup>1</sup>↑This is a footnote.



use

`\section`

[Section heading with `{\protect\scshape SmallCaps}]%`  
`{Section heading with S{\protect\scriptsize MALL}C{\protect\scriptsize APS}}`

instead.

## N.6 To-do notes

Make a todo comment.

The Purdue football game is at noon tomorrow.

$$\sum_1^n = 1, 2, \dots, n - 1$$

Some people use “to-do”, but I want to be consistent with command names.

Leave at 10:00—the traffic will be terrible.

$n - 1$  should be  $n$ .

```

1
2
3 \section{To-do notes}
4
5 Make a todo comment.%
6 \todocomment{Some people use ``to-do'',
7   but I want to be consistent with command names.}
8
9 The Purdue football game is at noon tomorrow.%
10 \todowarn{Leave at 10:00---the traffic will be terrible.}
11
12 \[
13   \sum_1^n = 1, 2, \ldots, n - 1
14 \]%
15 \todoerror{$n-1$ should be $n$.
```

Cite a reference with a very, very, very, ...long title [134].

```

1 Cite a reference with a very, very, very, \ldots long title
2 \cite{test-long-title}.
```

@misc{gerstenmaier, key = Deep Space Gateway, title = Deep Space Gateway to Open Opportunities for Distant Destinations, note = Editor: Kathryn Hambleton, year = 2018, month = August 24,, howpublished = <https://www.nasa.gov/feature/deep-space-gateway-to-open-opportunities-for-distant-destinations>, organization = NASA

Emily Spreen wrote that the following URLs are invisible in the PDF file.

```

@misc{gerstenmaier,
  author = {William H. Gerstenmaier},
  title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
  month = {March},
  year = {2017},
  howpublished = {\url{https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf}},
  organization = {NASA}
}
```

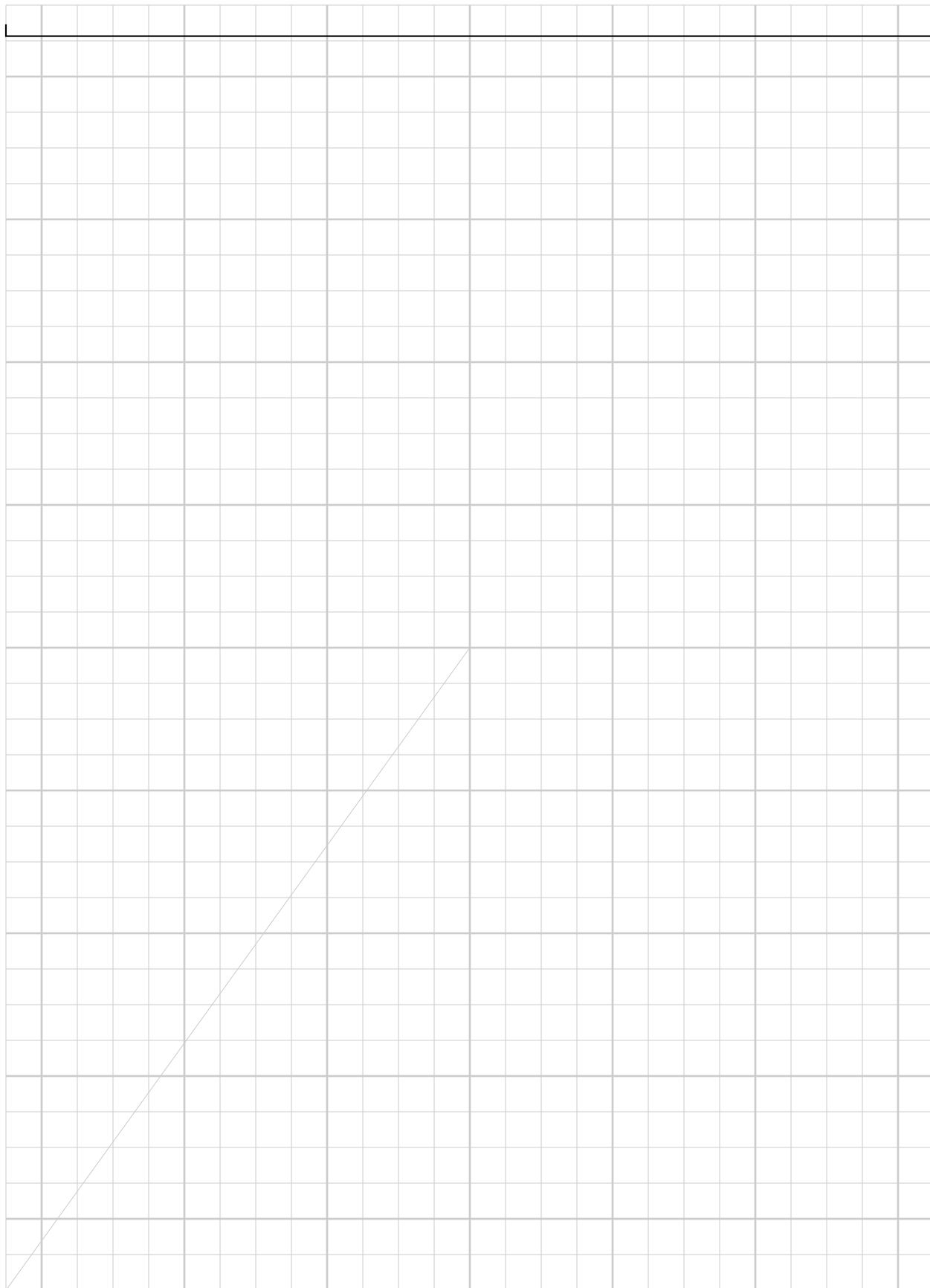
I suggest using the following (added a '2' to the key so they'd have separate entries in the references.).

```
@misc{gerstenmaier2,
  author = {William H. Gerstenmaier},
  title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
  date = {2017-03},
  url = {https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf},
  organization = {NASA}
}
```

See [22] and [23] in the REFERENCES.

```
1 Emily Spreen wrote that the following URLs are invisible in the PDF file.
2
3 \begin{verbatim}
4 @misc{gerstenmaier,
5   author = {William H. Gerstenmaier},
6   title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
7   month = {March},
8   year = {2017},
9   howpublished = {\url{https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf}},
10  organization = {NASA}
11 }
12 \end{verbatim}
13
14 I suggest using the following
15 (added a `2' to the key so they'd have separate entries in the references.).
16 \begin{verbatim}
17 @misc{gerstenmaier2,
18   author = {William H. Gerstenmaier},
19   title = {{Progress in Defining the Deep Space Gateway and Transport Plan}},
20   date = {2017-03},
21   url = {https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf},
22   organization = {NASA}
23 }
24 \end{verbatim}
25
26 See \cite{gerstenmaier} and \cite{gerstenmaier2} in the REFERENCES.
```

description environment  $\Rightarrow$  enumerate environment  
 $\Rightarrow$  itemize environment



## O. TEXT

Text

### O.1 Description, enumerate, and itemize environments

description environment ⇒ enumerate environment  
⇒ itemize environment

The first example:

**elephant** This is the elephant item of a description environment. This is the elephant item of a description environment. This is the elephant item of a description environment.

**frog** This is the frog item of a description environment. This is the frog item of a description environment. This is the frog item of a description environment.

1. This is the first item of an enumerate environment. This is the first item of an enumerate environment. This is the first item of an enumerate environment.

2. This is the second item of an enumerate environment. This is the second item of an enumerate environment. This is the second item of an enumerate environment.

- This is the first item of an itemize environment. This is the first item of an itemize environment. This is the first item of an itemize environment.

- This is the second item of an itemize environment. This is the second item of an itemize environment. This is the second item of an itemize environment.

```

1  \chapter{TEXT}
2
3  \ix{Text}
4
5  \newcommand\sentence[1]{\MyRepeat{This is a sentence. }{#1}}
6
7  \section{Description, enumerate, and itemize environments}
8  \ix{description environment//enumerate environment//itemize environment}
9  \index{\verb+\begin{description}+}
10 \index{\verb+\begin{enumerate}+}
11 \index{\verb+\begin{itemize}+}
12
13 The first example:
14
15 \begin{description}
16   \item[elephant]
17     \MyRepeat{This is the elephant item of a description environment. }{3}
18   \item[frog]
19     \MyRepeat{This is the frog item of a description environment. }{3}
20 \end{description}
21
22 \begin{enumerate}
23   \item
24     \MyRepeat{This is the first item of an enumerate environment. }{3}
25   \item
26     \MyRepeat{This is the second item of an enumerate environment. }{3}
27 \end{enumerate}
28
29 \begin{itemize}
30   \item

```

```

31   \MyRepeat{This is the first item of an itemize environment. }{3}
32   \item
33   \MyRepeat{This is the second item of an itemize environment. }{3}
34   \end{itemize}

```

The second example:

**elephant** This is the elephant item of a level zero description environment. This is the elephant item of a level zero description environment.

1. This is the first item of a level one enumerate environment. This is the first item of a level one enumerate environment.
  - This is the first item of a level two itemize environment. This is the first item of a level two itemize environment.
  - This is the first item of a level two itemize environment. This is the first item of a level two itemize environment.
2. This is the second item of a level one enumerate environment. This is the second item of a level one enumerate environment.

**frog** This is the frog item of a level zero description environment. This is the frog item of a level zero description environment.

```

1   The second example:
2
3   \begin{description}
4     \item[elephant]
5       \MyRepeat{This is the elephant item of a level zero description environment. }{2}
6       \begin{enumerate}
7         \item
8           \MyRepeat{This is the first item of a level one enumerate environment. }{2}
9         \begin{itemize}
10          \item
11            \MyRepeat{This is the first item of a level two itemize environment. }{2}
12          \item
13            \MyRepeat{This is the first item of a level two itemize environment. }{2}
14          \end{itemize}
15          \item
16            \MyRepeat{This is the second item of a level one enumerate environment. }{2}
17        \end{enumerate}
18      \item[frog]
19        \MyRepeat{This is the frog item of a level zero description environment. }{2}
20    \end{description}

```

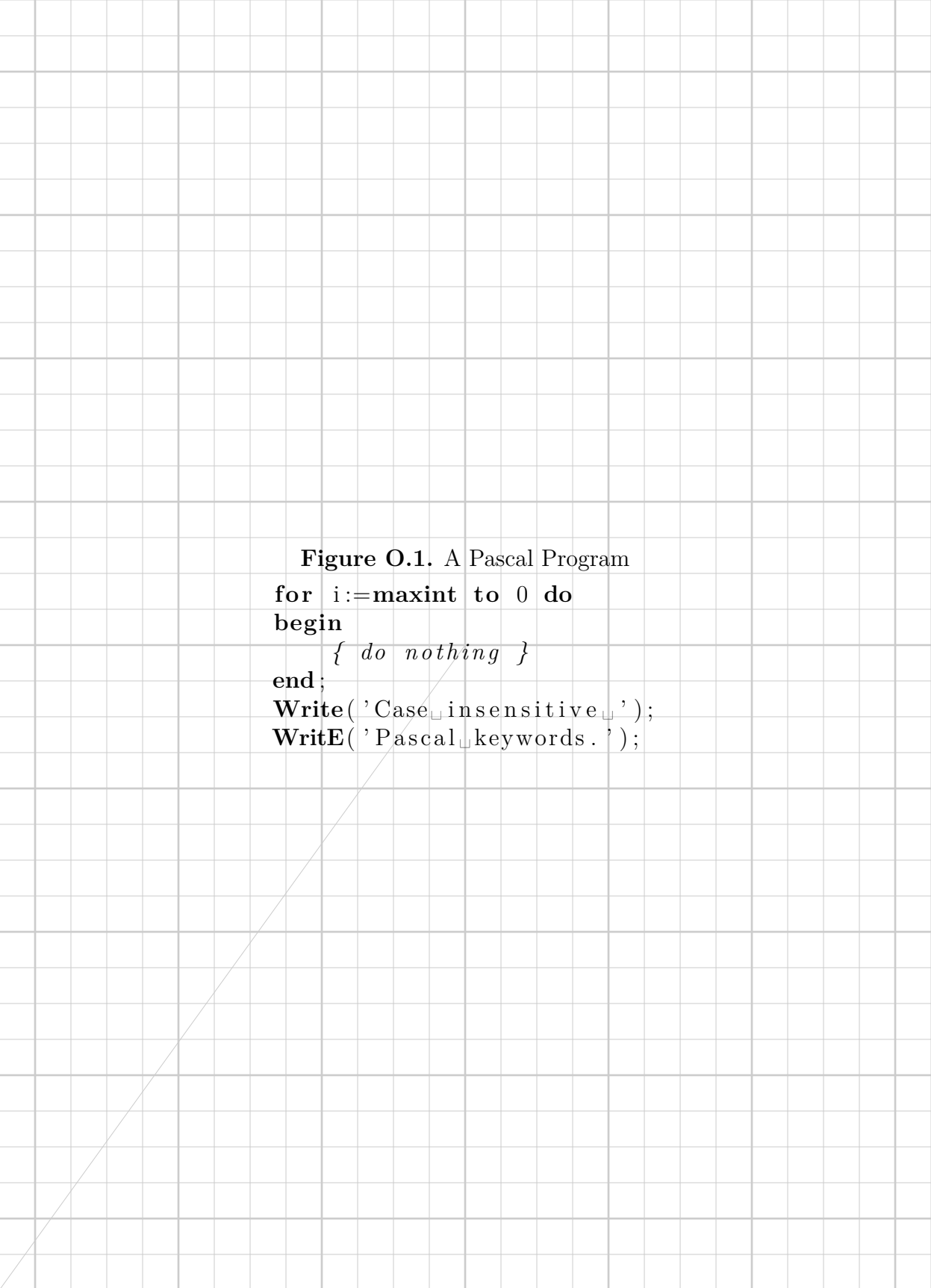
## O.2 Computer program listings

See the  $\text{\LaTeX}$  input in `ap-text.tex` to see how to do typeset computer programs.

```

1   \section{Computer program listings}
2
3   See the \LaTeX\ input in ap-text.tex
4   to see how to do typeset computer programs.
5
6   \lstset{language=Pascal}
7

```



**Figure O.1.** A Pascal Program  
**for**  $i := \text{maxint}$  **to** 0 **do**  
**begin**  
    { *do nothing* }  
**end**;  
**Write**('Case\_ insensitive\_ ');  
**WriteE**('Pascal\_ keywords. ');

```

8 \begin{figure}
9 \caption{A Pascal Program}
10 \begin{CenteredBox}
11 \begin{lstlisting}
12 for i:=maxint to 0 do
13 begin
14 { do nothing }
15 end;
16 Write('Case insensitive ');
17 Write('Pascal keywords. ');
18 \end{lstlisting}
19 \end{CenteredBox}
20 \end{figure}

```

### O.3 Frenchspacing

frenchspacing ⇒ nonfrenchspacing

The `\frenchspacing` command puts approximately <sup>one</sup>/<sub>two</sub> spaces after sentences. The default is `\nonfrenchspacing`.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nam cursus. Morbi ut mi. Nullam enim leo, egestas id, condimentum at, laoreet mattis, massa. Sed eleifend nonummy diam. Praesent mauris ante, elementum et, bibendum at, posuere sit amet, nibh. Duis tincidunt lectus quis dui viverra vestibulum. Suspendisse vulputate aliquam dui. Nulla elementum dui ut augue. Aliquam vehicula mi at mauris. Maecenas placerat, nisl at consequat rhoncus, sem nunc gravida justo, quis eleifend arcu velit quis lacus. Morbi magna magna, tincidunt a, mattis non, imperdiet vitae, tellus. Sed odio est, auctor ac, sollicitudin in, consequat vitae, orci. Fusce id felis. Vivamus sollicitudin metus eget eros.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nam cursus. Morbi ut mi. Nullam enim leo, egestas id, condimentum at, laoreet mattis, massa. Sed eleifend nonummy diam. Praesent mauris ante, elementum et, bibendum at, posuere sit amet, nibh. Duis tincidunt lectus quis dui viverra vestibulum. Suspendisse vulputate aliquam dui. Nulla elementum dui ut augue. Aliquam vehicula mi at mauris. Maecenas placerat, nisl at consequat rhoncus, sem nunc gravida justo, quis eleifend arcu velit quis lacus. Morbi magna magna, tincidunt a, mattis non, imperdiet vitae, tellus. Sed odio est, auctor ac, sollicitudin in, consequat vitae, orci. Fusce id felis. Vivamus sollicitudin metus eget eros.

```

1
2
3 \section{Frenchspacing}%
4 \ix{frenchspacing//nonfrenchspacing}
5 \index{\verb+\frenchspacing+}
6 \index{\verb+\nonfrenchspacing+}
7
8 The
9 \def\t{\tt\char'134 frenchspacing}
10 \def\u{\tt\char'134 nonfrenchspacing}
11 \raise6pt\hbox{\rlap\t}}%
12 \lower6pt\hbox{\u}
13 command puts approximately
14 \raise6pt\hbox{\rlap{one}}%
15 \lower6pt\hbox{two}
16 spaces after sentences.
17 The\[\!3pt]
18 default is |\nonfrenchspacing|.

```

```

19
20 {\frenchspacing
21 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nam
22 cursus. Morbi ut mi. Nullam enim leo, egestas id, condimentum at,
23 laoreet mattis, massa. Sed eleifend nonummy diam. Praesent mauris
24 ante, elementum et, bibendum at, posuere sit amet, nibh. Duis
25 tincidunt lectus quis dui viverra vestibulum. Suspendisse
26 vulputate aliquam dui. Nulla elementum dui ut augue. Aliquam
27 vehicula mi at mauris. Maecenas placerat, nisl at consequat
28 rhoncus, sem nunc gravida justo, quis eleifend arcu velit quis
29 lacus. Morbi magna magna, tincidunt a, mattis non, imperdiet
30 vitae, tellus. Sed odio est, auctor ac, sollicitudin in,
31 consequat vitae, orci. Fusce id felis. Vivamus sollicitudin metus
32 eget eros.\endgraf
33 }
34
35 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nam
36 cursus. Morbi ut mi. Nullam enim leo, egestas id, condimentum at,
37 laoreet mattis, massa. Sed eleifend nonummy diam. Praesent mauris
38 ante, elementum et, bibendum at, posuere sit amet, nibh. Duis
39 tincidunt lectus quis dui viverra vestibulum. Suspendisse
40 vulputate aliquam dui. Nulla elementum dui ut augue. Aliquam
41 vehicula mi at mauris. Maecenas placerat, nisl at consequat
42 rhoncus, sem nunc gravida justo, quis eleifend arcu velit quis
43 lacus. Morbi magna magna, tincidunt a, mattis non, imperdiet
44 vitae, tellus. Sed odio est, auctor ac, sollicitudin in,
45 consequat vitae, orci. Fusce id felis. Vivamus sollicitudin metus
46 eget eros.

```

## O.4 Multiple Columns

Depending on what version of L<sup>A</sup>T<sub>E</sub>X you're running the `multicols` package may or may not do what you want.

This is one columnThis is one column. This is one column. This is one column. This is one column. This is one column. This is one column. This is one column. This is one column. This is one column. This is one column.

This is two columns. This is two columns. | This is two columns. This is two columns. This is two columns. This is two columns. | This is two columns. This is two columns. This is two columns. This is two columns.

This is three columns. | three columns. This is | three columns. This is  
This is three columns. This | three columns. This is | three columns. This is three  
is three columns. This is | three columns. This is | columns.

This is four | columns. This is four | columns. This is four | columns. This is four  
columns. This is four | columns. This is four | columns. This is four | columns.  
columns. This is four | columns. This is four | columns. This is four |

This is five | This is five | This is five | This is five | This is five  
columns. This is | columns. This is | columns. This is | columns. This is  
five | columns. | five | columns. | five | columns. | five | columns. | five columns.



```

1 \section{Multiple Columns}
2
3 Depending on what version of \LaTeX\ you're running
4 the \verb+multicols+ package may or may not do what
5 you want.
6
7 % The multicols package must be loaded for this to work.
8 % To load the multicols package put
9 % \usepackage{multicols}
10 % between the "\documentclass" and "\begin{document}" commands.
11
12 % Put this amount of space between the columns.
13 % Let's use the default column separation to see what happens.
14 % \setlength{\columnsep}{0.5truein}
15
16 % Separate the columns with a vertical rule this wide.
17 % Make the column three times the default width.
18 \setlength{\columnseprule}{1.2pt}
19
20 This is one column\MyRepeat{This is one column. }{10}
21
22 \begin{multicols}{2}
23 \MyRepeat{This is two columns. }{12}
24 \end{multicols}
25
26 \begin{multicols}{3}
27 \MyRepeat{This is three columns. }{9}
28 \end{multicols}
29
30 \begin{multicols}{4}
31 \MyRepeat{This is four columns. }{10}
32 \end{multicols}
33
34 \begin{multicols}{5}
35 \MyRepeat{This is five columns. }{10}
36 \end{multicols}

```

## O.5 Words

**irregardless** is a nonstandard word that means regardless. Use *regardless* instead [135].

**out of date / out-of-date** means “outmoded, obsolete”. [136].

When it comes after the noun, the compound adjective usually doesn’t get a hyphen. So we say an easy-to-remember number, but the number is easy to remember. Same goes for up to date—if it’s before a noun it needs a hyphen. A document is up to date but it’s an up-to-date document [137]. Also see [138].

In the context of writing about out-of-date software you may want to use “deprecated” [139] instead.

**start-up / start-up company** means a fledgling business enterprise [140]. I would use the more modern *startup* and only use *company* if not clear from the context.

**peace out** means “goodbye” [141]

3	<code>\section{Words}</code>
4	
5	<code>\newenvironment{entry}</code>
6	<code>{%</code>
7	<code>\bigskip</code>
8	<code>% Start a \vbox here.</code>
9	<code>% Everything in a \vbox is guaranteed to be on the same page.</code>
10	<code>\vbox\bgroup</code>
11	<code>\noindent</code>
12	<code>}</code>
13	<code>{%</code>
14	<code>% End the \vbox here.</code>
15	<code>\egroup</code>
16	<code>}</code>
17	
18	<code>\begin{entry}</code>
19	<code>{\bfseries irregardless}\quad</code>
20	<code>is a nonstandard word that means regardless.</code>
21	<code>Use \emph{regardless} instead</code>
22	<code>\cite{merriam-webster-irregardless}.</code>
23	<code>\end{entry}</code>
24	
25	<code>\begin{entry}</code>
26	<code>{\bfseries out of date / out-of-date}\quad</code>
27	<code>means ``outmoded, obsolete''.</code>
28	<code>\cite{merriam-webster-out-of-date}.</code>
29	
30	<code>When it comes after the noun,</code>
31	<code>the compound adjective usually doesn't get a hyphen.</code>
32	<code>So we say an easy-to-remember number,</code>
33	<code>but the number is easy to remember.</code>
34	<code>Same goes for up to date---if it's before a noun it needs a hyphen.</code>
35	<code>A document is up to date but it's an up-to-date document</code>
36	<code>\cite{thewriter-to-hyphenate-or-not-to-hyphenate}.</code>
37	<code>Also see</code>
38	<code>\cite{oed-out-of-date}.</code>
39	
40	<code>In the context of writing about out-of-date software you may want to</code>
41	<code>use ``deprecated'' \cite{merriam-webster-deprecated} instead.</code>
42	<code>\end{entry}</code>
43	
44	<code>\begin{entry}</code>
45	<code>{\bfseries start-up / start-up company}\quad</code>
46	<code>means a fledgling business enterprise</code>
47	<code>\cite{wikipedia-startup-company}.</code>
48	<code>I would use the more modern \emph{startup}</code>
49	<code>and only use \emph{company} if not clear from the context.</code>
50	<code>\end{entry}</code>
51	
52	<code>\begin{entry}</code>
53	<code>{\bfseries peace out}\quad</code>
54	<code>means</code>
55	<code>``goodbye''</code>
56	<code>\cite{online-slang-dictionary-peace-out}</code>
57	<code>\end{entry}</code>

## P. ASTRONOMY

astronomy ⇒ Astronomy appendix

astronomy

```
1 \chapter{ASTRONOMY}
2 \ix{astronomy//Astronomy appendix}
3
4 \ix{astronomy}
5
```

## Q. BIOLOGY

Biology chapter

```
1 \chapter{BIOLOGY}
2
3 \ix{Biology chapter}
```

## R. CHEMISTRY

chemistry

Chemistry appendix

```

1 \chapter{CHEMISTRY}
2 \label{ch:chemistry}
3
4 \ix{chemistry}
5 \ix{Chemistry appendix}
6

```

### R.1 Chemical Diagrams

The chemplants package [142] extends the [TikZ](#) package to draw chemical process units.

```

1
2
3 \section{Chemical Diagrams}
4
5 The chemplants package \cite{feffin2019}
6 extends the
7 \href{http://ctan.math.washington.edu/tex-archive/graphics/pgf/base/doc/pgfmanual.pdf}{\TikZLogo} package
8 to draw chemical process units.

```

### R.2 Chemical Equations

The mhchem Bundle [143] contains mhchem v4.08 (chemical equations), hpstatement v1.02 (official hazard and precautionary statements), and rsphrase v3.11 (official risk and safety phrases).

```

1
2
3 \section{Chemical Equations}
4
5 The mhchem Bundle \cite{hensel2018}
6 contains mhchem v4.08 (chemical equations),
7 hpstatement v1.02 (official hazard and precautionary statements),
8 and rsphrase v3.11 (official risk and safety phrases).

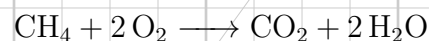
```

Defined in thesis.tex: NO<sub>3</sub><sup>-</sup>.

```

1
2 Defined in thesis.tex: \nitrate.

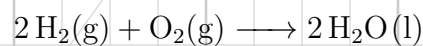
```



```

1
2 % See page 1 of
3 % https://www.thoughtco.com/what-is-a-chemical-equation-604026
4 \ce{CH4 + 2O2 -> CO2 + 2H2O}

```



```

1
2 % See page 1 of
3 % https://www.thoughtco.com/what-is-a-chemical-equation-604026
4 \ce{2H2(g) + O2(g) -> 2H2O(l)}

```

$\text{Ag}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \longrightarrow \text{AgCl}(\text{s}) + \text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$  is an ionic equation of the chemical reaction:  $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \longrightarrow \text{AgCl}(\text{s}) + \text{NaNO}_3(\text{aq})$

```

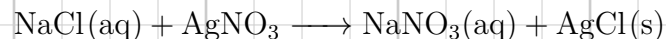
1
2 % See page 1 of
3 % https://www.thoughtco.com/definition-of-ionic-equation-605262
4 \ce{Ag+(aq) + NO3-(aq) + Na+(aq) + Cl-(aq) -> AgCl(s) + Na+(aq) + NO3-(aq)}
5 is an ionic equation of the chemical reaction:
6 \ce{AgNO3(aq) + NaCl(aq) -> AgCl(s) + NaNO3(aq)}
```



```

1
2 % See page 1 of
3 % https://www.thoughtco.com/definition-of-balanced-equation-and-examples-604380
4 \ce{Fe2O3 + C -> Fe + CO2}
```

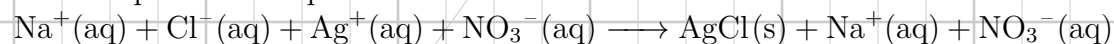
For example, in the reaction between sodium chloride ( $\text{NaCl}$ ) and silver nitrate ( $\text{AgNO}_3$ ), the molecular reaction is:



```

1
2 % From page 1 of
3 % https://www.thoughtco.com/definition-of-molecular-equation-605366
4
5 For example, in the reaction between sodium chloride
6 (\ce{NaCl})
7 and silver nitrate
8 (\ce{AgNO3}),
9 the molecular reaction is:
10
11 \ce{NaCl(aq) + AgNO3 -> NaNO3(aq) + AgCl(s)}
```

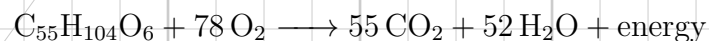
The complete ionic equation is:



```

1
2 The complete ionic equation is:
3
4 \ce{Na+(aq) + Cl-(aq) + Ag+(aq) + NO3-(aq) -> AgCl(s) + Na+(aq) + NO3-(aq)}
```

Ruben Meerman [144, starting at 5:25] claims this equation



describes weight loss.

```

1
2 Ruben Meerman \cite[starting at 5:25]{meerman} claims this equation
3 \begin{center}
4 \ce{C55H104O6 + 78O2 -> 55CO2 + 52H2O + energy}\endgraf
5 \end{center}
6 describes weight loss.
```

And with better annotation:



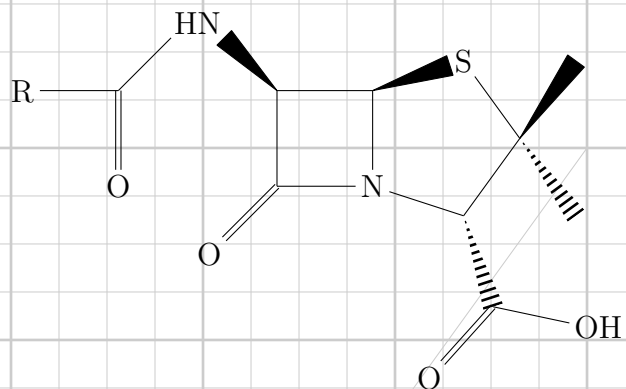
```

33 & \ce{55CO2} % 5.
34 & \ce{+} % 6.
35 & \ce{52H2O} % 7.
36 & \ce{+} % 8.
37 & energy\\ % 9.
38 %
39 \Fs human fat& % 1.
40 & % 2.
41 \Fs oxygen& % 3.
42 & % 4.
43 \Fs carbon dioxide& % 5.
44 & % 6.
45 \Fs water& % 7.
46 & % 8.
47 \Fs body heat, moving, thinking, growing\\ % 9.
48 \end{tabular}
49 \end{center}

```

### R.3 Chemical Figures

Below is an example of how to use the chemfig package [145].  
 Here is the chemical figure for Penicillin [145, pages 72–73]:



```

1
2
3 \section{Chemical Figures}
4
5 Below is an example of how to use the chemfig package \cite{tellechea2021}.
6
7 % Chicago Manual of Style Online, 17 edition, section 9.61 states
8 % that 72--73, not 72--3, should be used.
9 Here is the chemical figure
10 for Penicillin \cite[pages~72--73]{tellechea2021}:\
11
12 \chemfig{
13 [-:90]HN(-[:45](-[:45]R)=[:45]O)>[:45]*4(- (=O)-N*5(- (<[:60]O)
14 -[:60]OH)-(<[:0])(<[:108])S>--))
15 }

```



## R.4 Chemical Schemes

Below are some examples of how to do schemes.

**Scheme R.1.** This is the first scheme caption.

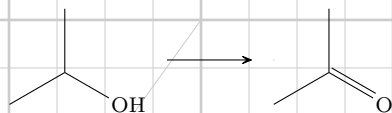
This is the first scheme.

```

1 \newpage
2 \section{Chemical Schemes}
3
4 Below are some examples of how to do schemes.
5
6 \begin{scheme}[ht]
7   \caption{This is the first scheme caption.}
8   \vspace*{6pt}
9   \begin{center}
10    This is the first scheme.
11   \end{center}
12 \end{scheme}

```

**Scheme R.2.** This is the second scheme caption.

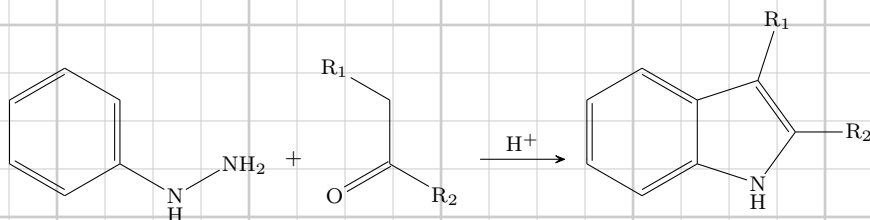


```

1 \begin{scheme}[ht]
2   \caption{This is the second scheme caption.}
3   \vspace*{6pt}
4   \begin{center}
5     % Next line was added to make scheme a little smaller.
6     \scriptsize\setchemfig{bond offset=1pt,atom sep=3em,compound sep=6em}
7     \schemestart
8       \chemfig{-[:30](-[2])-[:-30]OH}
9       \arrow
10      \chemfig{-[:30](-[2])=^[:-30]O}
11     \schemestop
12   \end{center}
13 \end{scheme}

```

**Scheme R.3.** The Fischer indole synthesis [145, pages 74–75].

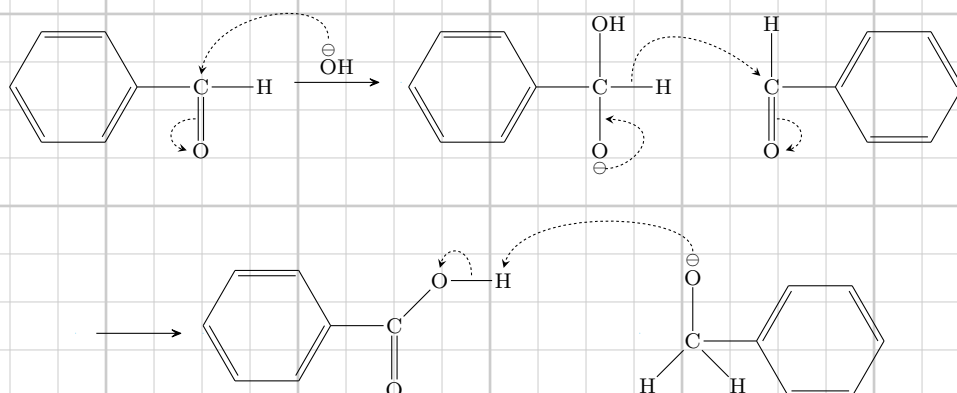


```

1 \newpage
2 \begin{scheme}[ht]
3 \caption{%
4 The Fischer indole synthesis
5 \cite[pages=74--75]{tellechea2021}.%
6 }
7 \vspace*{6pt}
8 \begin{center}
9 % Next line was added to make scheme a little smaller.
10 \scriptsize\setchemfig{bond offset=1pt,atom sep=3em,compound sep=6em}
11 \schemestart
12 \chemfig{*6(=*6(-\chembelow{N}{H}-NH_2)=-=)}
13 \+
14 \chemfig{([:-150]O)(-[:-30]R_2)-[2]-[:150]R_1}
15 \arrow(.mid east--.mid west){->[\chemfig{H^+}]}
16 \chemfig{*6(=*5(-\chembelow{N}{H}-(-R_2)=(-R_1)-)=-=)}
17 \schemestop
18 \end{center}
19 \end{scheme}

```

Scheme R.4. The Cannizzaro reaction [145, pages 77–78].



```

1 \newpage
2 \begin{scheme}[ht]
3 \caption{%
4   The Cannizzaro reaction
5   \cite[pages=77--78]{tellechea2021}.%
6 }
7 \vspace*{12pt}
8 \begin{center}
9   % Next line was added to make scheme a little smaller.
10  \scriptsize\setchemfig{bond offset=1pt,atom sep=3em,compound sep=6em}
11  \schemestart
12  \chemfig{[:30]*6(=--(-@{atoc}C([6]=[@{db}]@{atoo1}O)-H)-==)}
13  \arrow{start.mid east--.mid west}{->[\chemfig{@{atoo2}\chemabove{0}{\scriptstyle\ominus}}H]}
14  \chemmove[-stealth,shorten >=2pt,dash pattern=on 1pt off 1pt,thin]{
15    \draw[shorten <=8pt](atoo2) ..controls +(up:10mm) and +(up:10mm)..(atoc);
16    \draw[shorten <=2pt](db) ..controls +(left:5mm) and +(west:5mm)..(atoo1);}
17  \chemfig{[:30]*6(=--(-C([6]-[O]{sb1}]@{atoo1}\chembelow{0}{\scriptstyle\ominus})
18    ([2]-OH)-[O]{sb2}H)-==)}
19  \hspace{1cm}
20  \chemfig{[:30]*6((-@{atoc}C([6]=[@{db}]@{atoo2}O)-[2]H)-==)}
21  \chemmove[-stealth,shorten <=2pt,shorten >=2pt,dash pattern=on 1pt off 1pt,thin]{
22    \draw([yshift=-4pt]atoo1.270) ..controls +(0:5mm) and +(right:10mm)..(sb1);
23    \draw(sb2) ..controls +(up:10mm) and +(north west:10mm)..(atoc);
24    \draw(db) ..controls +(right:5mm) and +(east:5mm)..(atoo2);}
25  \arrow{@start.base west--}{0}[-75,2]
26  {}
27  \arrow
28  \chemfig{[:30]*6(=--(-C([1]-@{atoo2}O-[O]{sb}0]@{atoh}H)([6]=O))-==)}
29  \arrow{0}
30  \chemfig{[:30]*6((-C(-[5]H)(-[7]H)-[2]@{atoo1}\chemabove{0}{\scriptstyle\ominus})-==)}
31  \chemmove[-stealth,shorten >=2pt,dash pattern=on 1pt off 1pt,thin]{
32    \draw[shorten <=7pt](atoo1.90) ..controls +(90:8mm) and +(up:10mm)..(atoh);
33    \draw[shorten <=2pt](sb) ..controls +(up:5mm) and +(up:5mm)..(atoo2);}
34  \schemestop
35  \end{center}
36  \end{scheme}

```

## S. COMPUTER SCIENCE

computer science ⇒ Computer Science appendix

The cryptocode package [146] is used to typeset pseudocode, algorithms, and protocols.

cryptocode ⇒ pseudocode ⇒ algorithm ⇒ protocol

```

1 \chapter{COMPUTER SCIENCE}
2 \ix{computer science//Computer Science appendix}
3
4 The cryptocode package \cite{mittelbach2020}
5 \ix{cryptocode//pseudocode//algorithm//protocol}
6 is used to typeset pseudocode,
7 algorithms,
8 and protocols.
```

### S.1 Protocol examples

**Protocol S.1.** This is the first protocol caption.

This is the first protocol.

**Protocol S.2.** This is the second protocol caption.

**Alice**                      **Bob**  
 $b \leftarrow \{0, 1\}$   
 $\xrightarrow{\text{send over } b}$   
do something

```

1
2
3 \section{Protocol examples}
4
5 \begin{protocol}[ht]
6   \caption{This is the first protocol caption.}
7   This is the first protocol.
8 \end{protocol}
9
10 \begin{protocol}[ht]
11   \caption{This is the second protocol caption.}
12   \pseudocodeblock
13   {
14     \textbf{Alice} \> \> \textbf{Bob} \\
15     b \sample \bin -> -> \\
16     \> \xrightarrow{\text{send over } b} \> \\
17     \> \> \text{do something}
18   }
19 \end{protocol}
```

## T. ELECTRICAL ENGINEERING

electrical engineering ⇒ Electrical Engineering appendix

```
1 \chapter{ELECTRICAL ENGINEERING}
2 \ix{electrical engineering//Electrical Engineering appendix}
```

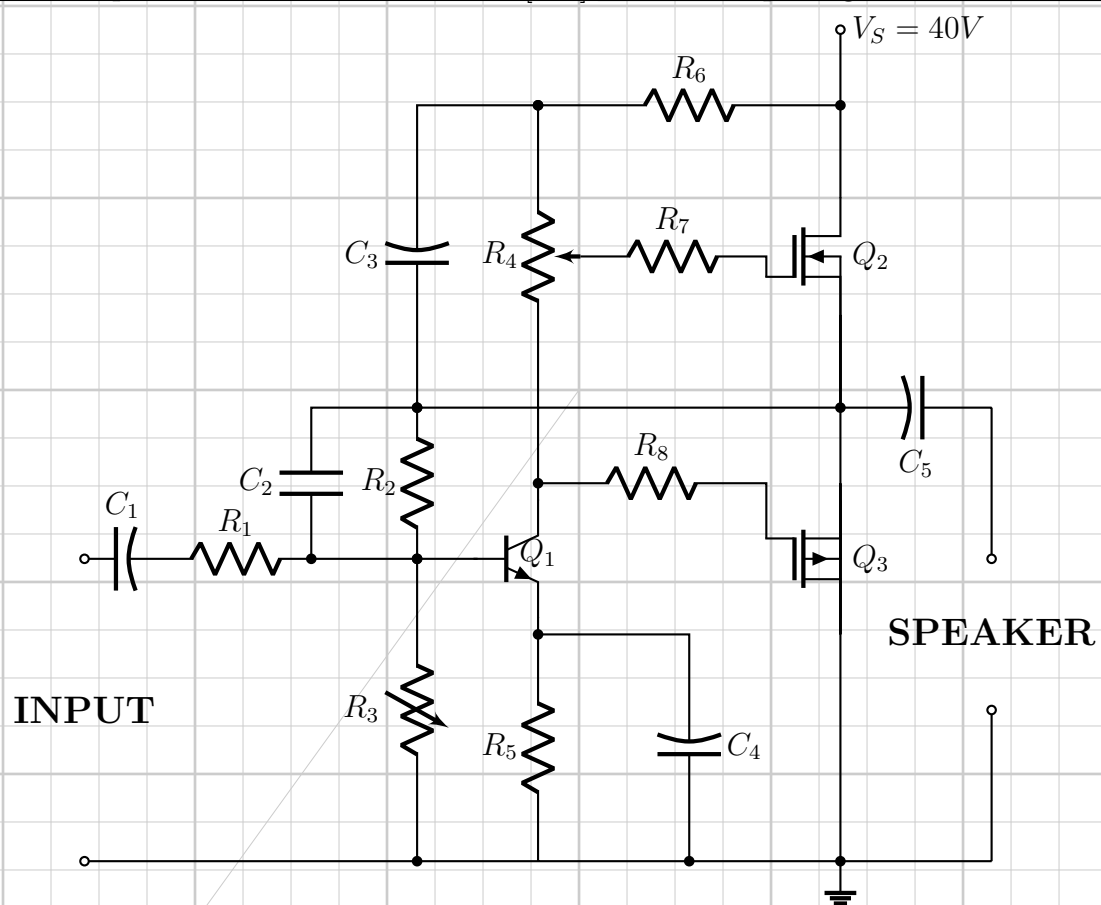
### T.1 Amplifiers

```
1
2
3 \section{Amplifiers}
```

This 18 W MOSFET amplifier with npn transistor was done by Ramón Jaramillo [147]. This example make uses the CircuiTikZ [148] and siunitx packages.

Jaramillo, Ramón

Redaelli, Massimo A.



```
1 This \qty{18}{W} MOSFET amplifier
2 with npn transistor was done by Ram'on Jaramillo
3 \cite{jaramillo}.
4 \ix{Jaramillo, Ram'on}
5 This example make uses the \CircuiTikZLogo\index{\CircuiTikZLogo}
6 \cite{redaelli2021}
7 \ix{Redaelli, Massimo A.}%
8 and siunitx packages.
```

```
9
10 \begin{tikzpicture}[scale=2]
11 \draw[color=black, thick]
```

```

12 (0,0) to [short,o-] (6,0){} % Baseline for connection to ground
13 % Input and ground
14 (0,1) node[{}]{\large{\textbf{INPUT}}}
15 % Connection of passive components
16 (5,0) node[ground]{} node[circ] (4.5,0){}
17 (0,2) to [cC, l=$C_1$, o-] (0.5,2)
18 to [R,l=$R_1$,] (1.5,2)
19 to node[short]{} (2.6,2)
20 (1.5,2) to [C, l=$C_2$, *-] (1.5,3) -| (5,3)
21 (2.2,2) to [R, l=$R_2$, *-] (2.2,3)
22 (2.2,3) to [cC, l=$C_3$, *-] (2.2,5) -| (3,5)
23 % Transistor Bipolar Q1
24 (3,0) to [R,l=$R_5$,-*] (3,1.5)
25 to [Tnpn,n=npn1] (3,2.5)
26 (npn1.E) node[right=3mm, above=5mm]{$Q_1$} % Labelling the NPN transistor
27 (4,0) to [cC, l_=$C_4$, *-] (4, 1.5)--(3,1.5)
28 (2.2,0) to [vR, l=$R_3$, *-] (2.2,2)
29 (3,2.5) to node[short]{} (3,3)
30 (3,5) to [pR, n=pot1, l_=$R_4$, *-] (3,3)
31 (3,5) to [R, l=$R_6$, *-] (5,5)
32 to [short,*-o] (5,5.5) node[right]{$V_S=40$ V}
33 % Mosfet Transistors
34 (5,3) to [Tnigfetd,n=mos1] (5,5)
35 (mos1.B) node[anchor=west]{$Q_2$} % Labelling MOSFET Q2 Transistor
36 (pot1.wiper) to [R, l=$R_7$,] (4.5,4) -| (mos1.G)
37 (5,1.5) to [Tpigfetd,n=mos2] (5,2.5)
38 (5,0) to (mos2.S)
39 (3,2.5) to [R, l=$R_8$, *-] (4.5,2.5)
40 -| (mos2.G)
41 (mos2.B) node[anchor=west]{$Q_3$} % Labelling MOSFET Q3 Transistor
42 % Output
43 (6,3) to [cC, l=$C_5$,-*] (5,3)
44 (6,3) to [short,-o] (6,2){}
45 (mos1.S)--(mos2.D)
46 (6,0) to [short,-o] (6,1){} node[above=7mm]{}{\large{\textbf{SPEAKER}}}
47 ;
48 \end{tikzpicture}

```

## T.2 Kalman Filter System Model

This Kalman filter system model was done by Burkart Lingner [149].

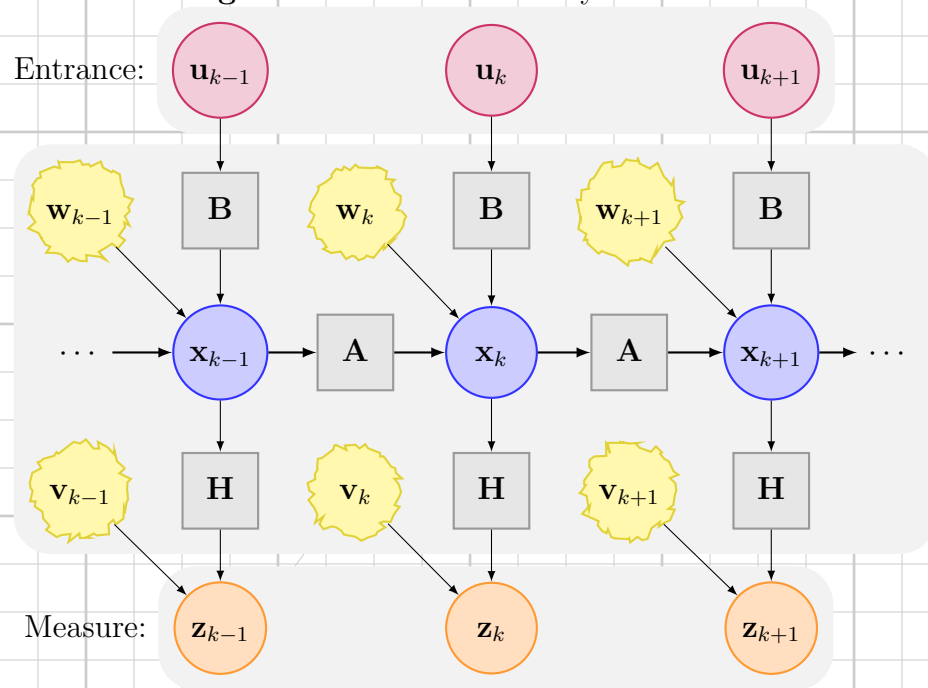
Lingner, Burkart

```

1
2
3 \section{Kalman Filter System Model}
4
5 This Kalman filter system model was done by Burkart Lingner
6 \cite{lingner2010}.
7 \ix{Lingner, Burkart}
8
9 % An example using TikZ/PGF 2.00
10 %
11 % Features: Decorations, Fit, Layers, Matrices, Styles
12 % Tags: Block diagrams, Diagrams
13 % Technical area: Electrical engineering
14
15 %%% \documentclass[a4paper,10pt]{article}
16 %%%
17 %%% \usepackage[english]{babel}
18 %%% \usepackage[T1]{fontenc}
19 %%% \usepackage[ansinew]{inputenc}

```

Figure T.1. Kalman filter system model



```

20 %%%
21 %%% \usepackage{lmodern} % font definition
22 %%% \usepackage{amsmath} % math fonts
23 %%% \usepackage{amsthm}
24 %%% \usepackage{amsfonts}
25 %%%
26 %%% \usepackage{tikz}
27 %%%
28 %%% %%%<
29 %%% \usepackage{verbatim}
30 %%% \usepackage[active,tightpage]{preview}
31 %%% \PreviewEnvironment{tikzpicture}
32 %%% \setlength\PreviewBorder{5pt}%
33 %%% %%%>
34 %%%
35 %%% \begin{comment}
36 %%% :Title: Kalman Filter System Model
37 %%% :Slug: kalman-filter
38 %%% :Author: Burkart Lingner
39 %%%
40 %%% This is the system model of the (linear) Kalman filter.
41 %%%
42 %%% \end{comment}
43 %%%
44 %%%
45
46 \begin{figure}[htbp]
47 \caption{Kalman filter system model}
48 \centering
49 % The state vector is represented by a blue circle.
50 % "minimum size" makes sure all circles have the same size
51 % independently of their contents.
52 \tikzstyle{state}=[circle,
53                    thick,
54                    minimum size=1.2cm,
55                    draw=blue!80,
56                    fill=blue!20]
57
58 % The measurement vector is represented by an orange circle.
59 \tikzstyle{measurement}=[circle,
60                           thick,
61                           minimum size=1.2cm,
62                           draw=orange!80,
63                           fill=orange!25]
64
65 % The control input vector is represented by a purple circle.
66 \tikzstyle{input}=[circle,
67                   thick,
68                   minimum size=1.2cm,
69                   draw=purple!80,
70                   fill=purple!20]
71
72 % The input, state transition, and measurement matrices
73 % are represented by gray squares.
74 % They have a smaller minimal size for aesthetic reasons.
75 \tikzstyle{matrx}=[rectangle,
76                   thick,
77                   minimum size=1cm,
78                   draw=gray!80,
79                   fill=gray!20]
80
81 % The system and measurement noise are represented by yellow
82 % circles with a "noisy" uneven circumference.
83 % This requires the TikZ library "decorations.pathmorphing".

```



```

84 \tikzstyle{noise}=[circle,
85
86
87
88
89
90
91
92
93
94 % Everything is drawn on underlying gray rectangles with
95 % rounded corners.
96 \tikzstyle{background}=[rectangle,
97
98
99
100
101 \begin{tikzpicture}[>=latex,text height=1.5ex,text depth=0.25ex]
102 % "text height" and "text depth" are required to vertically
103 % align the labels with and without indices.
104
105 % The various elements are conveniently placed using a matrix:
106 \matrix[row sep=0.5cm,column sep=0.5cm] {
107 % First line: Control input
108 &
109 \node (u_{k-1}) [input] {$\mathbf{u}_{k-1}$}; &
110 &
111 \node (u_k) [input] {$\mathbf{u}_k$}; &
112 &
113 \node (u_{k+1}) [input] {$\mathbf{u}_{k+1}$}; &
114 \\
115 % Second line: System noise & input matrix
116 \node (w_{k-1}) [noise] {$\mathbf{w}_{k-1}$}; &
117 \node (B_{k-1}) [matrix] {$\mathbf{B}$}; &
118 \node (w_k) [noise] {$\mathbf{w}_k$}; &
119 \node (B_k) [matrix] {$\mathbf{B}$}; &
120 \node (w_{k+1}) [noise] {$\mathbf{w}_{k+1}$}; &
121 \node (B_{k+1}) [matrix] {$\mathbf{B}$}; &
122 \\
123 % Third line: State & state transition matrix
124 \node (A_{k-2}) {$\cdots$}; &
125 \node (x_{k-1}) [state] {$\mathbf{x}_{k-1}$}; &
126 \node (A_{k-1}) [matrix] {$\mathbf{A}$}; &
127 \node (x_k) [state] {$\mathbf{x}_k$}; &
128 \node (A_k) [matrix] {$\mathbf{A}$}; &
129 \node (x_{k+1}) [state] {$\mathbf{x}_{k+1}$}; &
130 \node (A_{k+1}) {$\cdots$}; & \\
131 % Fourth line: Measurement noise & measurement matrix
132 \node (v_{k-1}) [noise] {$\mathbf{v}_{k-1}$}; &
133 \node (H_{k-1}) [matrix] {$\mathbf{H}$}; &
134 \node (v_k) [noise] {$\mathbf{v}_k$}; &
135 \node (H_k) [matrix] {$\mathbf{H}$}; &
136 \node (v_{k+1}) [noise] {$\mathbf{v}_{k+1}$}; &
137 \node (H_{k+1}) [matrix] {$\mathbf{H}$}; &
138 \\
139 % Fifth line: Measurement
140 &
141 \node (z_{k-1}) [measurement] {$\mathbf{z}_{k-1}$}; &
142 &
143 \node (z_k) [measurement] {$\mathbf{z}_k$}; &
144 &
145 \node (z_{k+1}) [measurement] {$\mathbf{z}_{k+1}$}; &
146 \\
147 };

```

```

148
149 % The diagram elements are now connected through arrows:
150 \path[->]
151     (A_k-2) edge[thick] (x_k-1) % The main path between the
152     (x_k-1) edge[thick] (A_k-1) % states via the state
153     (A_k-1) edge[thick] (x_k) % transition matrices is
154     (x_k) edge[thick] (A_k) % accentuated.
155     (A_k) edge[thick] (x_k+1) % x -> A -> x -> A -> ...
156     (x_k+1) edge[thick] (A_k+1)
157
158     (x_k-1) edge (H_k-1) % Output path x -> H -> z
159     (H_k-1) edge (z_k-1)
160     (x_k) edge (H_k)
161     (H_k) edge (z_k)
162     (x_k+1) edge (H_k+1)
163     (H_k+1) edge (z_k+1)
164
165     (v_k-1) edge (z_k-1) % Output noise v -> z
166     (v_k) edge (z_k)
167     (v_k+1) edge (z_k+1)
168
169     (w_k-1) edge (x_k-1) % System noise w -> x
170     (w_k) edge (x_k)
171     (w_k+1) edge (x_k+1)
172
173     (u_k-1) edge (B_k-1) % Input path u -> B -> x
174     (B_k-1) edge (x_k-1)
175     (u_k) edge (B_k)
176     (B_k) edge (x_k)
177     (u_k+1) edge (B_k+1)
178     (B_k+1) edge (x_k+1)
179 ;
180
181 % Now that the diagram has been drawn, background rectangles
182 % can be fitted to its elements. This requires the TikZ
183 % libraries "fit" and "background".
184 % Control input and measurement are labeled. These labels have
185 % not been translated to English as "Measurement" instead of
186 % "Messung" would not look good due to it being too long a word.
187 \begin{pgfonlayer}{background}
188     \node [background,
189           fit=(u_k-1) (u_k+1),
190           label=left:Entrance:] {};
191     \node [background,
192           fit=(w_k-1) (v_k-1) (A_k+1)] {};
193     \node [background,
194           fit=(z_k-1) (z_k+1),
195           label=left:Measure:] {};
196 \end{pgfonlayer}
197 \end{tikzpicture}
198
199 \end{figure}

```

## U. LINGUISTICS

linguistics ⇒ Linguistics appendix

See WIKIBOOKS  $\LaTeX$ /Linguistics [150] or google for the information you need.

The doulossil font [151] is a TrueType font. Version 0.1 on September 21, 2020 claimed “it has characters that are not in other TeX IPA fonts”.

```

1 \chapter{LINGUISTICS}
2 \ix{linguistics//Linguistics appendix}
3
4 See WIKIBOOKS \LaTeX/Linguistics \cite{wikibooks-latex-linguistics}
5 or google for the information you need.
6
7 The doulossil font \cite{tambe2020}
8 is a TrueType font.
9 Version 0.1 on September 21, 2020 claimed
10 ``it has characters that are not in other TeX IPA fonts''.

```

## V. MATHEMATICS

mathematics  $\Rightarrow$  Mathematics appendix

PurdueThesis loads the AMSmath package [152] to do mathematics.

```

1 \chapter{MATHEMATICS}
2 \ix{mathematics//Mathematics appendix}
3
4 \PurdueThesisLogo\ loads the \AMSMathLogo\ package \cite{amslatex3project2019}
5 to do mathematics.
```

There are two types of mathematics in  $\LaTeX$ . Text math is math that that is interspersed with text. For example, this is text math:  $a = b + c$ . This is display math:

$$a = b + c \tag{V.1}$$

```

1 There are two types of mathematics in \LaTeX.
2 Text math is math that that is interspersed with text.
3 For example, this is text math: \(\a = b + c\).
4 This is display math:
5 \begin{equation}
6   \a = b + c
7 \end{equation}
```

## V.1 Standard Functions

Standard functions should be in a roman font. Like this:  $\cos \theta$ . Here is a list of standard function commands:

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

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

```

1  \newpage
2
3  \section{Standard Functions}
4
5  Standard functions should be in a roman font.
6  Like this:  $\cos \theta$ .
7  Here is a list of standard function commands:\\
8
9  % The "@{\hspace*{\parindent}}" indents the table
10 % the same amount as a paragraph.
11 \begin{tabular}{@{\hspace*{\parindent}}llll@{}}
12 \verb+\arccos+& \verb+\csc+& \verb+\ker+& \verb+\min+\\
13 \verb+\arcsin+& \verb+\deg+& \verb+\lg+& \verb+\Pr+\\
14 \verb+\arctan+& \verb+\det+& \verb+\lim+& \verb+\sec+\\
15 \verb+\arg+& \verb+\dim+& \verb+\liminf+& \verb+\sin+\\
16 \verb+\cos+& \verb+\exp+& \verb+\limsup+& \verb+\sinh+\\
17 \verb+\cosh+& \verb+\gcd+& \verb+\ln+& \verb+\sup+\\
18 \verb+\cot+& \verb+\hom+& \verb+\log+& \verb+\tan+\\
19 \verb+\coth+& \verb+\inf+& \verb+\max+& \verb+\tanh+\\
20 \end{tabular}
21 \ix
22 {%
23   arccos//arcsin//arctan//arg//cos//cosh//cot//coth%
24   //csc//deg//det//dim//exp//gcd//hom//inf%
25   //ker//lg//lim//liminf//limsup//ln//log//max%
26   //min//Pr//sec//sin//sinh//sup//tan//tanh%
27 }
28 \index{\verb+\arccos+} \index{\verb+\arcsin+} \index{\verb+\arctan+} \index{\verb+\arg+}
29 \index{\verb+\cos+} \index{\verb+\cosh+} \index{\verb+\cot+} \index{\verb+\coth+}
30 \index{\verb+\csc+} \index{\verb+\deg+} \index{\verb+\det+} \index{\verb+\dim+}
31 \index{\verb+\exp+} \index{\verb+\gcd+} \index{\verb+\hom+} \index{\verb+\inf+}
32 \index{\verb+\ker+} \index{\verb+\lg+} \index{\verb+\lim+} \index{\verb+\liminf+}
33 \index{\verb+\limsup+} \index{\verb+\ln+} \index{\verb+\log+} \index{\verb+\max+}
34 \index{\verb+\min+} \index{\verb+\Pr+} \index{\verb+\sec+} \index{\verb+\sin+}
35 \index{\verb+\sinh+} \index{\verb+\sup+} \index{\verb+\tan+} \index{\verb+\tanh+}

```

## V.2 English Words in Math

English words in math should be in a roman font like this:

Let the maximum value of  $a$  be  $a_{\max}$ .

$a_{\max} \geq a_{\min}$  should always be true.

The temperature in the attic is  $t_{\text{attic}}$ .

```

1 \newpage
2
3 \section{English Words in Math}
4
5 English words in math should be in a roman font like this:\
6 Let the maximum value of \(\a\) be \(\a_{\text{max}}\).\
7 \(\a_{\text{max}} \geq a_{\text{min}}\) should always be true.\
8 The temperature in the attic is \(\t_{\text{attic}}\).
```

## V.3 Text Math

Use  $\text{\(}$  to start text math and  $\text{\)}$  to end text math. Some people use  $\text{\$}$  to start and end text math—I don't recommend that because  $\text{\LaTeX}$  can give better error messages if you use  $\text{\(}$  and  $\text{\)}$ .

```

1 \section{Text Math}
2
3 Use \verb+\(+ to start text math and \verb+\)+ to end text math.
4 Some people use \verb+\$+ to start and end text math---I don't
5 recommend that because \LaTeX\ can give better error messages
6 if you use \verb+\(+ and \verb+\)+.
```

## V.4 Displayed Equations

Do not use  $\text{\$\$}$  to start or end displayed math like  $\text{\TeX}$  uses [153].

The  $\text{\AMSMath}$  package provides a number of additional displayed equation structures beyond the ones provided in basic  $\text{\LaTeX}$ . The augmented set includes [154]:

Environment	Used for
<code>equation</code>	used for single equations
<code>multline</code>	split single equations over multiple lines
<code>gather</code>	collect but do not align multiple equations
<code>align</code>	align multiple equations
<code>alignat</code>	aligns multiple equations at multiple places
<code>flalign</code>	aligns multiple equations at multiple places on full length lines
<code>split</code>	split a single equation over multiple lines

All but `split` can be followed by `*` to not number equations.

```

1 \section{Displayed Equations}
2
3 Do not use \verb+\$\$+ to start or end displayed math like \TeX\ uses
4 \cite{gratzer2016}.
5
```

```

6 The \AMSMathLogo\ package provides a number
7 of additional displayed equation structures
8 beyond the ones provided in basic \LaTeX.
9 The augmented set includes \cite{amslatex3project2019b}:
10
11 \hbox to\hsize{%
12   \hss
13   \begin{tabular}{@{}l@{}}
14     \toprule
15     \bseries Environment & \bseries Used for\\
16     \midrule
17     \tt equation & used for single equations\\
18     \tt multline & split single equations over multiple lines\\
19     \tt gather & collect but do not align multiple equations\\
20     \tt align & align multiple equations\\
21     \tt alignat & aligns multiple equations at multiple places\\
22     \tt flalign & aligns multiple equations at multiple places on full length lines\\
23     \tt split & split a single equation over multiple lines\\
24     \bottomrule
25   \end{tabular}%
26   \hss
27 }
28
29 All but \verb+split+ can be followed by \verb+*+ to not number equations.

```

### V.4.1 equation environment

The equation environment is used for single equations.

$$E = mc^2 \tag{V.2}$$

```

1
2 \subsection{\texttt{equation} environment}
3
4 The \verb+equation+ environment is used for single equations.
5
6 \begin{equation}
7   E = mc^2
8 \end{equation}

```

The equation\* environment does single, unnumbered equations.

$$a = b_0c + \frac{1}{2}de^2 + \frac{1}{2}fg^2 + h_1 + h_2 + \dots + h_n \quad \text{for } c \neq d \text{ and } g < \infty$$

```

1
2 The \verb+equation*+ environment does single, unnumbered equations.
3
4 \begin{equation*}
5   a = b_0c + \frac{1}{2}de^2 + \text{\textstyle \frac{1}{2}} fg^2
6     + h_1 + h_2 + \cdots + h_n
7   \quad \text{\text{for } (c \neq d) \text{ and } (g < \infty)}
8 \end{equation*}

```

Greene [155] wrote For #PiDay, one of the coolest formulae for today's honoree:

$$\frac{1}{\pi} = \frac{\sqrt{8}}{9801} \sum_{n=0}^{\infty} \frac{(4n!)(1103 + 26390n)}{(n!)^4 396^{4n}}$$

```

1
2 \textcite{greene-2021-03-14} wrote
3 % \begin{quotation}
4 For
5 \href{https://twitter.com/hashtag/PiDay?src=hashtag\_click\#PiDay}{\#PiDay},
6 one of the coolest formulae for today's honoree:
7 \[
8 \frac{1}{\pi}
9 =
10 \frac{\sqrt{8}}{9801}
11 \sum_{n=0}^{\infty}
12 \frac{(4n!) (1103+26390n)}{(n!)^4 396^{4n}}
13 \]
14 % \end{quotation}

```

International standard ISO 80000-2:2019 [156] states that  $e$ ,  $i$ ,  $j$ , and  $\pi$  should appear as  $e$ ,  $i$ ,  $j$  and  $\pi$  because they are constants. This is done automatically by the `pa-mismath` package that is loaded by `thesis.tex`. See `thesis.tex` for more information, including what to do if you're not using those as constants.

Euler's identity is

$$e^{i\pi} + 1 = 0.$$

```

1
2 International standard ISO 80000-2:2019 \cite{iso8000022019}
3 states that  $e$ ,  $i$ ,  $j$ ,
4 and  $\pi$  should appear as
5  $e$ ,  $i$ ,  $j$ 
6 and  $\pi$  because they are constants.
7 This is done automatically by the pa-mismath package
8 that is loaded by thesis.tex.
9 See thesis.tex for more information,
10 including what to do if you're not using those as constants.
11
12 Euler's identity is
13 \begin{equation*}
14 e^{i\pi} + 1 = 0.
15 \end{equation*}

```

Here's a simple formula relating  $e$ ,  $i$ ,  $\pi$ , and  $\phi$ , the golden ratio

$$e^{i\pi} + 2\phi = \sqrt{5}. \tag{V.3}$$

I didn't notice anything on the web about putting the symbol for the golden ratio in a special font even though it is a constant.

```

1
2 Here's a simple formula relating  $e$ ,  $i$ ,  $\pi$ , and  $\phi$ ,
3 the golden ratio
4 \begin{equation*}
5 e^{i\pi} + 2\phi = \sqrt{5}.
6 \end{equation*}
7 I didn't notice anything on the web about putting the symbol for
8 the golden ratio in a special font even though it is a constant.

```

International standard ISO 80000-2:2019 [156] states that the “ $d$ ” in math differentials should be typeset as “ $d$ ”. So,

use  $\int x dx$  instead of  $\int x d x$



```

1
2 International standard ISO 80000-2:2019 \cite{iso8000022019}
3 states that the ``$d/$'' in math differentials
4 should be typeset as ``$di$''.
5 So,
6 \begin{equation*}
7 \text{\textit{use }} \int x \, dx \quad \quad \text{\textit{instead of }} \int x \, dx
8 \end{equation*}

```

The formula for Bekenstein-Hawking entropy:

$$S_{\text{BH}} = \frac{A}{4L_P^2} = \frac{c^3 A}{4G\hbar}$$

```

1
2 The formula for Bekenstein-Hawking entropy:
3
4 \begin{equation*}
5 S_{\text{BH}}
6 =
7 \frac{A}{4L_P^2}
8 = \frac{c^3 A}{4G\hbar}
9 \end{equation*}

```

Type in the math and let  $\LaTeX$  worry about the spacing. You only need to do fine tuning by hand if it looks bad.

Another `equation*` environment, note the spacing before the large close parenthesis:

$$\frac{a}{b} = ab^{-1} = \left(\sqrt{\frac{a}{b}}\right)^2 = \left(\sqrt{\frac{a}{b}}\right)^2 = \left(\sqrt{\frac{a}{b}}\right)^2 = \left(\sqrt{\frac{a}{b}}\right)^2 = \left(\sqrt{\frac{a}{b}}\right)^2$$

```

1
2 Type in the math and let \LaTeX\ worry about the spacing.
3 You only need to do fine tuning by hand if it looks bad.
4
5 Another \verb+equation*+ environment,
6 note the spacing before the large close parenthesis:
7
8 \begin{equation*}
9 \frac{a}{b}
10 = ab^{-1}
11 % Parens are the wrong size.
12 = (\sqrt{\frac{a}{b}})^2
13 % Parens are the right size but closing paren is too close to radical.
14 = \left(\sqrt{\frac{a}{b}}\right)^2
15 % Parens are right size but a negative thin space puts closing paren on top of radical.
16 = \left(\sqrt{\frac{a}{b}}\right)^2
17 % Parens are right size but a thin space puts closing paren too close to radical.
18 = \left(\sqrt{\frac{a}{b}}\right)^2
19 % Parens are right size but a medium space puts closing paren too close to radical.
20 = \left(\sqrt{\frac{a}{b}}\right)^2
21 % Parens are right size and I think a thick space looks the best.
22 = \left(\sqrt{\frac{a}{b}}\right)^2
23 \end{equation*}

```

$$(\cos x)^2 + (\sin x)^2 = \cos^2 x + \sin^2 x = 1$$

```

1
2 \begin{equation*}
3 (\cos x)^2 + (\sin x)^2 = \cos^2 x + \sin^2 x = 1
4 \end{equation*}

```

$$x \bmod 2 = \begin{cases} 0 & \text{if } x \text{ is even} \\ 1 & \text{if } x \text{ is odd} \end{cases} \quad (\text{V.4})$$

```

1
2 \begin{equation}
3 x \bmod 2 =
4 \begin{cases}
5 0 & \text{\text{if } $x$ is even}\} \\
6 1 & \text{\text{if } $x$ is odd}\} \\
7 \end{cases}
8 \end{equation}

```

The first six derivatives of distance are velocity, acceleration, jerk, snap, crackle, and pop [157].

$$\text{distance derivatives} = \begin{cases} x = \text{distance} & = vt \\ v = \text{velocity} & = \frac{dx}{dt} \\ a = \text{acceleration} & = \frac{dv}{dt} = \frac{d^2x}{dt^2} \\ j = \text{jerk} & = \frac{da}{dt} = \frac{d^2v}{dt^2} = \frac{d^3x}{dt^3} \\ s = \text{snap} & = \frac{dj}{dt} = \frac{d^2a}{dt^2} = \frac{d^3v}{dt^3} = \frac{d^4x}{dt^4} \\ c = \text{crackle} & = \frac{ds}{dt} = \frac{d^2j}{dt^2} = \frac{d^3a}{dt^3} = \frac{d^4v}{dt^4} = \frac{d^5x}{dt^5} \\ p = \text{pop} & = \frac{dc}{dt} = \frac{d^2s}{dt^2} = \frac{d^3j}{dt^3} = \frac{d^4a}{dt^4} = \frac{d^5v}{dt^5} = \frac{d^6x}{dt^6} \end{cases} \quad (\text{V.5})$$

```

1
2 The first six derivatives of distance are velocity, acceleration, jerk, snap, crackle,
3 and pop \cite{reid2013}.
4
5 \begin{equation}
6 % Every array element should be in \displaystyle (a big font).
7 \AtBeginEnvironment{array}{\everymath{\displaystyle}}
8 % Set space between columns to zero, use {} = ... to add a little space before the = "by hand".
9 \arraycolsep = 0pt
10 \text{distance derivatives} = \left\{ \begin{array}{l}
11 \begin{array}{llllll}
12 % I'm formatting the first 4 lines different from the last 3 so this will fit on one page.
13 x & {} = \text{distance} & {} = vt \\
14 v & {} = \text{velocity} & {} = \frac{dx}{dt} \\
15 a & {} = \text{acceleration} & {} = \frac{dv}{dt} & {} = \frac{d^2x}{dt^2} \\
16 \mit j & {} = \text{jerk} & {} = \frac{da}{dt} & {} = \frac{d^2v}{dt^2} \\
17 {} & {} = \frac{d^3x}{dt^3} \\
18 s

```

```

19 & {}=\text{snap}
20 & {}=\frac{\di \mit j}{\di t}
21 & {}=\frac{\di^2a}{\di t^2}
22 & {}=\frac{\di^3v}{\di t^3}
23 & {}=\frac{\di^4x}{\di t^4}\!\!\! [9pt]
24 c
25 & {}=\text{crackle}
26 & {}=\frac{\di s}{\di t}
27 & {}=\frac{\di^2\mit j}{\di t^2}
28 & {}=\frac{\di^3a}{\di t^3}
29 & {}=\frac{\di^4v}{\di t^4}
30 & {}=\frac{\di^5x}{\di t^5}\!\!\! [9pt]
31 p
32 & {}=\text{pop}
33 & {}=\frac{\di c}{\di t}
34 & {}=\frac{\di^2s}{\di t^2}
35 & {}=\frac{\di^3\mit j}{\di t^3}
36 & {}=\frac{\di^4a}{\di t^4}
37 & {}=\frac{\di^5v}{\di t^5}
38 & {}=\frac{\di^6x}{\di t^6}
39 \end{array}
40 \right.
41 \end{equation}

```

#### V.4.2 multiline environment

The `multiline` environment is used to split single equations over multiple lines.

$$\begin{aligned}
 S = a + b + c + d + e + f + g + h + i + j \\
 \quad \quad \quad + k + l + m + n + o + p \\
 \quad \quad \quad \quad \quad + q + r + s + t + u + v + w + x + y + z \quad (V.6)
 \end{aligned}$$

```

1 \subsection{\texttt{multiline} environment}
2
3 The \verb+multiline+ environment is used
4 to split single equations over multiple lines.
5
6
7 \begin{multiline}
8 S = a + b + c + d + e + f + g + h + i + j\!
9 + k + l + m + n + o + p\!
10 + q + r + s + t + u + v + w + x + y + z
11 \end{multiline}

```

$$\begin{aligned}
 S = a + b + c + d + e \\
 \quad \quad \quad + f + g + h + i + j \\
 \quad \quad \quad + k + l + m + n + o \\
 \quad \quad \quad + p + q + r + s + t \\
 \quad \quad \quad + u + v + w + x + y \\
 \quad \quad \quad \quad \quad + z \quad (V.7)
 \end{aligned}$$

```

1
2 \begin{multline}
3   S = a + b + c + d + e\\
4   + f + g + h + i + j\\
5   + k + l + m + n + o\\
6   + p + q + r + s + t\\
7   + u + v + w + x + y\\
8   + z
9 \end{multline}

```

$$\begin{aligned}
 S = a + b + c + d + e \\
 \quad + f + g + h + i + j \\
 \quad \quad + k + l + m + n + o \\
 \quad \quad \quad + p + q + r + s + t \\
 \quad \quad \quad \quad + u + v + w + x + y \\
 \quad \quad \quad \quad \quad + z \quad (V.8)
 \end{aligned}$$

```

1
2 % Calculate width of space before equation plus equation number.
3 % (All digits are the same width.)
4 \newdimen{\tdimen}
5 \settowidth{\tdimen}{\kern\multlinetaggap (L.5)}
6 \begin{multline}
7   S = a + b + c + d + e\\
8   \makebox[\textwidth]{\hfill $+ f + g + h + i + j$\hfill\hfill\hfill\hfill\kern\tdimen}\\
9   \makebox[\textwidth]{\hfill\hfill$\{ + k + l + m + n + o$\hfill\hfill\hfill\kern\tdimen}\\
10  \makebox[\textwidth]{\hfill\hfill\hfill$\{ + p + q + r + s + t$\hfill\hfill\kern\tdimen}\\
11  \makebox[\textwidth]{\hfill\hfill\hfill\hfill$\{ + u + v + w + x + y$\hfill\kern\tdimen}\\
12  + z
13 \end{multline}

```

### V.4.3 gather environment

The `gather` environment collects but does not align multiple equations.

$$\begin{aligned}
 a = b + c + d + e + f + g + h + i + j + k + l & \quad (V.9) \\
 m = n + o + p + q + r + s + t + u + v + w + x + y + z & \quad (V.10)
 \end{aligned}$$

```

1
2 \subsection{\texttt{gather} environment}
3
4 The \verb+gather+ environment collects but does not align multiple equations.
5
6 \begin{gather}
7   a = b + c + d + e + f + g + h + i + j + k + l\\
8   m = n + o + p + q + r + s + t + u + v + w + x + y + z
9 \end{gather}

```

$$\begin{aligned} a &= b + c + d + e + f + g + h + i + j + k + l \\ m &= n + o + p + q + r + s + t + u + v + w + x + y + z \end{aligned} \tag{V.11}$$

```

1
2 \begin{gather}
3   a = b + c + d + e + f + g + h + i + j + k + l\notag\
4   m = n + o + p + q + r + s + t + u + v + w + x + y + z
5 \end{gather}

```

$$\begin{aligned} \alpha &= \beta + \gamma + \delta + \eta \\ \theta &= \iota + \kappa + \lambda + \mu + \nu + \rho + \tau \end{aligned}$$

```

1
2 \begin{gather*}
3   \alpha = \beta + \gamma + \delta + \eta\
4   \theta = \iota + \kappa + \lambda + \mu + \nu + \rho + \tau
5 \end{gather*}

```

$$x_{\min} + x_{\max} \leq \sum_{i=1}^n x_i \tag{V.12}$$

$$x_{\min} + x_{\max} = \sum_{i=1}^n x_i - \sum_{i=2}^{n-1} x_i \quad \text{if } x \text{ is sorted} \tag{V.13}$$

$$x_{\min} \leq \left( \sum_{i=1}^n x_i \right) / n \tag{V.14}$$

```

1
2 \begin{gather}
3   x_{\text{\text{min}}} + x_{\text{\text{max}}} \le \sum_{i=1}^n x_i\
4   x_{\text{\text{min}}} + x_{\text{\text{max}}}
5   = \sum_{i=1}^n x_i - \sum_{i=2}^{n-1} x_i\quad\text{\text{if } $x$ is sorted}\
6   x_{\text{\text{min}}} \le \left( \sum_{i=1}^n x_i \right) / n
7 \end{gather}

```

#### V.4.4 align environment

The align environment aligns multiple equations.

$$a = b + c + d \tag{V.15}$$

$$e = f + g + h + i + j \tag{V.16}$$

```

1
2 \subsection{\texttt{align} environment}
3
4 The \verb+align+ environment aligns multiple equations.

```

```

5
6 \begin{align}
7 a &= b + c + d \\
8 e &= f + g + h + i + j
9 \end{align}

```

align environment

thin space

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (\text{V.17})$$

```

1
2 \begin{align}
3 x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} \notag \\
4 % Put a thin space before the b^2 to improve the appearance.
5 x = \frac{-b \pm \sqrt{\,b^2-4ac}}{2a} \\
6 \end{align}

```

Quadratic formula proof [158]:

quadratic formula

$$ax^2 + bx + c = 0 \quad (\text{V.18})$$

$$ax^2 + bx = -c$$

$$x^2 + \frac{b}{a}x = -\frac{c}{a}$$

$$x^2 + \frac{b}{a}x + \frac{b^2}{4a^2} = \frac{b^2}{4a^2} - \frac{c}{a}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{c}{a}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{4ac}{4a^2}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2 - 4ac}{4a^2}$$

$$\sqrt{\left(x + \frac{b}{2a}\right)^2} = \sqrt{\left(\frac{b^2 - 4ac}{4a^2}\right)}$$

$$x + \frac{b}{2a} = \pm \frac{\sqrt{b^2 - 4ac}}{\sqrt{4a^2}}$$

$$x + \frac{b}{2a} = \pm \frac{\sqrt{b^2 - 4ac}}{2a}$$

$$x = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (\text{V.19})$$

```

1
2 Quadratic formula proof \cite{khan}:
3 \ix{quadratic formula}
4
5 % The align environment requires the amsmath package.
6 % Use \addtolength{\jot}{6pt} to increase the space between rows in an amsmath multi-line math formula.
7 % That's not done here so everything will fit on one page.
8 \begin{align}
9   ax^2 + bx + c &= 0 \\
10  ax^2 + bx &= -c \notag \\
11  % The "\", " adds a thinspace of horizontal space.
12  x^2 + \frac{ba}{x} &= -\frac{ca}{\notag} \\
13  x^2 + \frac{ba}{x} + \frac{b^2}{4a^2} &= \frac{b^2}{4a^2} - \frac{ca}{\notag} \\
14  \left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{ca}{\notag} \\
15  \left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{4ac}{4a^2} \notag \\
16  \left(x + \frac{b}{2a}\right)^2 &= \frac{b^2-4ac}{4a^2} \notag \\
17  \sqrt{\left(x + \frac{b}{2a}\right)^2} & \\
18  &= \sqrt{\left(\frac{b^2-4ac}{4a^2}\right)} \notag \\
19  x + \frac{b}{2a} &= \pm \frac{\sqrt{b^2-4ac}}{\sqrt{4a^2}} \notag \\
20  x + \frac{b}{2a} &= \pm \frac{\sqrt{b^2-4ac}}{2a} \notag \\
21  x &= -\frac{b}{2a} \pm \frac{\sqrt{b^2-4ac}}{2a} \notag \\
22  x &= \frac{-b \pm \sqrt{b^2-4ac}}{2a} \\
23 \end{align}

```

#### V.4.5 alignat environment

alignat environment

The alignat environment aligns multiple equations at multiple places.

$$a = b \qquad \text{set } a \qquad (V.20)$$

$$c = d \qquad \text{you guessed it, set } c$$

$$g = h \qquad \text{and finally, set } g \qquad (V.21)$$

alignat environment

I like to align input columns on the input if possible and will sometimes use windows over 250 characters wide to do so. If that won't work I sometimes do, for example,

$$a = b \qquad \text{set } a \qquad (V.22)$$

$$c = d \qquad \text{you guessed it, set } c$$

$$g = h \qquad \text{and finally, set } g \qquad (V.23)$$

alignat environment

Do whatever works best for you.

```

1
2 \subsection{\texttt{alignat} environment}
3 \index{\verb+\begin{alignat}+\@{\verb+\begin{alignat}+}
4 \ix{alignat environment}
5
6 The \verb+alignat+ environment aligns multiple equations at multiple places.
7 \begin{alignat}{2}
8   a &= b & \quad & \text{set } a \\
9   c &= d & & \text{you guessed it, set } c \\
10  g &= h & & \text{and finally, set } g \\
11 \end{alignat}

```

```

12 \index{\verb+\begin{aligo}+\@verb+\begin{alignat}+}
13 \ix{alignat environment}
14
15 I like to align input columns on the input if possible
16 and will sometimes use windows over-250 characters wide to do so.
17 If that won't work I sometimes do,
18 for example,
19 \begin{alignat}{2}
20   a
21   &= b
22   & \quad\quad
23   & \text{set } \$a\$\\
24   c
25   &= d
26   &
27   & \text{you guessed it, set } \$c\$ \notag\\
28   g
29   &= h
30   &
31   & \text{and finally, set } \$g\$}
32 \end{alignat}
33 \index{\verb+\begin{aligo}+\@verb+\begin{alignat}+}
34 \ix{alignat environment}
35
36 Do whatever works best for you.
37

```

Quadratic formula proof [\[158\]](#):



$$ax^2 + bx + c = 0 \quad \text{subtract } c \quad (\text{V.24})$$

$$ax^2 + bx = -c \quad \text{divide by } a$$

$$x^2 + \frac{b}{a}x = -\frac{c}{a} \quad \text{add } \frac{b^2}{4a^2}$$

$$x^2 + \frac{b}{a}x + \frac{b^2}{4a^2} = \frac{b^2}{4a^2} - \frac{c}{a} \quad \text{factor left hand side}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{c}{a} \quad \text{multiply right-most term by } \frac{4a}{4a}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{4ac}{4a^2} \quad \text{use common denominator}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2 - 4ac}{4a^2} \quad \text{take square root of each side}$$

$$\sqrt{\left(x + \frac{b}{2a}\right)^2} = \sqrt{\left(\frac{b^2 - 4ac}{4a^2}\right)} \quad \text{compute square root of each side}$$

$$x + \frac{b}{2a} = \pm \frac{\sqrt{b^2 - 4ac}}{\sqrt{4a^2}} \quad \text{simplify right hand denominator}$$

$$x + \frac{b}{2a} = \pm \frac{\sqrt{b^2 - 4ac}}{2a} \quad \text{subtract } \frac{b}{2a} \text{ from each side}$$

$$x = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} \quad \text{use common denominator}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (\text{V.25})$$

```

1
2 Quadratic formula proof \cite{khan}:
3
4 % Make changes to \jot be local to the group that starts on the next line.
5 {
6   % Increase distance between lines by 6pt.
7   \addtolength{\jot}{6pt}
8   \begin{alignat}{2}
9     ax^2 + bx + c
10    &= 0
11    &
12    &\text{\text{subtract } \$c\$}\backslash
13    ax^2 + bx
14    &= -c
15    &

```

```

16      &\text{divide by $a$}\notag\\
17      % The "\", " adds a thinspace of horizontal space.
18      x^2 + \frac ba,x
19      &= -\frac ca
20      &
21      &\text{add $\displaystyle\frac{b^2}{4a^2}$}\notag\\
22      x^2+\frac ba,x+\frac{b^2}{4a^2}
23      &= \frac{b^2}{4a^2}-\frac ca
24      &
25      &\text{factor left hand side}\notag\\
26      \left(x+\frac b{2a}\right)^2
27      &= \frac{b^2}{4a^2}-\frac ca
28      &
29      &\text{multiply right-most term by $\displaystyle\frac{4a}{4a}$}\notag\\
30      \left(x + \frac b{2a}\right)^2
31      &= \frac{b^2}{4a^2}-\frac{4ac}{4a^2}
32      &
33      &\text{use common denominator}\notag\\
34      \left(x + \frac b{2a}\right)^2
35      &= \frac{b^2-4ac}{4a^2}
36      &
37      &\text{take square root of each side}\notag\\
38      \sqrt{\left(x + \frac b{2a}\right)^2}
39      &= \sqrt{\left(\frac{b^2-4ac}{4a^2}\right)}
40      &
41      &\text{compute square root of each side}\notag\\
42      x + \frac b{2a}
43      &= \pm \frac{\sqrt{b^2-4ac}}{\sqrt{4a^2}}
44      &
45      &\text{simplify right hand denominator}\notag\\
46      x + \frac b{2a}
47      &= \pm \frac{\sqrt{b^2-4ac}}{2a}
48      &
49      &\text{subtract $\displaystyle\frac b{2a}$ from each side}\notag\\
50      x
51      &= -\frac b{2a} \pm \frac{\sqrt{b^2-4ac}}{2a}
52      &\quad
53      &\text{use common denominator}\notag\\
54      x
55      &= \frac{-b \pm \sqrt{b^2-4ac}}{2a}
56      \end{alignat}
57      }

```

Verb+Begin-Ocurly-flalign-Ccurly+

falign environment

### V.4.6 flalign environment

The flalign environment aligns multiple equations at multiple places on full length lines.

$$\begin{array}{lcl}
 a = b & & u = v \quad (\text{V.26}) \\
 c = d & m = n & w = x \\
 g = h & & y = z \quad (\text{V.27})
 \end{array}$$

```

1
2 \index{\verb+\begin{flalign}+}
3 \todoindex{Verb+Begin-Ocurly-flalign-Ccurly+}
4 \ix{falign environment}

```

```

5 \subsection{\texttt{flalign} environment}
6
7 The \verb+flalign+ environment aligns multiple equations at multiple places
8 on full length lines.
9
10 \begin{flalign}
11   a &= b& & & u &= v\\
12   c &= d& m & = & n& w & = x\notag\\
13   g &= h& & & & y & = z
14 \end{flalign}

```

Verb+Begin-Ocurly-split-Ccurly+

split environment

### V.4.7 split environment

The split environment ???.

```

1
2 \index{\verb+\begin{split}+}
3 \todoindex{Verb+Begin-Ocurly-split-Ccurly+}
4 \ix{split environment}
5 \subsection{\texttt{split} environment}
6
7 The \verb+split+ environment ???.
```

Verb+Begin-Ocurly-split-Ccurly+

split environment

### V.5 Theorem-like environments

These theorem-like environments are defined in the amsthm package or in PurdueThesis.cls.

```

1 \section{Theorem-like environments}
2
3 These theorem-like environments are defined
4 in the amsthm package or in\ % break line here so we don't go past right margin
5 \verb+PurdueThesis.cls+.
```

Verb+Begin-Ocurly-definition-Ccurly+

definition environment

**Definition V.5.1.** *This is an example definition.*

Verb+Begin-Ocurly-observation-Ccurly+

observation environment

**Observation V.5.1.** *This is an example observation.*

*Proof.* This is an example proof. If  $a = b$  and  $b = c$  then  $a = c$ . □

Verb+Begin-Ocurly-proof-Ccurly+

proof environment

**Proposition V.5.1.** *This is an example proposition.*

Verb+Begin-Ocurly-proposition-Ccurly+

proposition environment

**Theorem V.5.1.** *This is an example theorem.*

Verb+Begin-Ocurly-theorem-Ccurly+

theorem environment

```

1
2 \index{\verb+\begin{definition}+}
3 \todoindex{Verb+Begin-Ocurly-definition-Ccurly+}
4 \ix{definition environment}
5 \begin{definition}
6   This is an example definition.
7 \end{definition}
8
9 \index{\verb+\begin{observation}+}
10 \todoindex{Verb+Begin-Ocurly-observation-Ccurly+}
11 \ix{observation environment}
12 \begin{observation}
13   This is an example observation.
14 \end{observation}
15
16 \index{\verb+\begin{proof}+}
17 \todoindex{Verb+Begin-Ocurly-proof-Ccurly+}
18 \ix{proof environment}
19 \begin{proof}
20   This is an example proof.
21   If \((a = b)\) and \((b = c)\) then \((a = c)\).
22 \end{proof}
23
24 \index{\verb+\begin{proposition}+}
25 \todoindex{Verb+Begin-Ocurly-proposition-Ccurly+}
26 \ix{proposition environment}
27 \begin{proposition}
28   This is an example proposition.
29 \end{proposition}
30
31 \index{\verb+\begin{theorem}+}
32 \todoindex{Verb+Begin-Ocurly-theorem-Ccurly+}
33 \ix{theorem environment}
34 \begin{theorem}
35   This is an example theorem.
36 \end{theorem}

```

## V.6 Examples

### V.6.1 Bayes' Theorem

Bayes' Theorem

Bayes' Theorem [159]:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

```

1
2
3 \section{Examples}
4
5 \subsection{Bayes' Theorem}
6 \ix{Bayes' Theorem}
7
8 Bayes' Theorem \cite{bayes}:
9 {
10   \UndefineShortVerb{\|}
11 \[
12   \text{P}(\text{A}|\text{B})
13   % The "\," puts a thin horizontal space there, 1/6 of an "em".

```

```

14 % An "em" is roughly the width of a lowercase "m".
15 = \frac{\text P(\text B|\text A)\,\text P(\text A)}{\text P(\text B)}
16 \]
17 }

```

### V.6.2 Nicomachus's theorem

Nicomachus's theorem

Nicomachus's theorem [160] states that the sum of the first  $n$  cubes is the square of the  $n$ th triangular number. That is,

$$1^3 + 2^3 + 3^3 + \dots + n^3 = (1 + 2 + 3 + \dots + n)^2.$$

The same equation may be written more compactly using the mathematical notation for summation:

$$\sum_{k=1}^n k^3 = \left( \sum_{k=1}^n k \right)^2.$$

Also see the diagram on that web page.

```

1
2 \subsection{Nicomachus's theorem}
3 \ix{Nicomachus's theorem}
4
5 Nicomachus's theorem \cite{wikipedia-nicomachus} states that
6 the sum of the first-$n$ cubes is the square of the-$n$th triangular number.
7 That is,
8 \[
9 1^3 + 2^3 + 3^3 + \cdots + n^3 = (1 + 2 + 3 + \cdots + n)^2.
10 \]
11 The same equation may be written more compactly using the mathematical notation for summation:
12 \[
13 \sum_{k=1}^n k^3 = \left( \sum_{k=1}^n k \right)^2.
14 \]
15 Also see the diagram on that web page.

```

### V.6.3 Prime Number Theorem

Prime Number Theorem

Li [161] suggested using a functional equation from the Prime Number Theorem proof as an example:

$$\int_1^x \sum_{p \leq u} \left[ \frac{\log u}{\log p} \right] \log p \, du = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} \frac{x^{s+1}}{s(s+1)} \left( -\frac{\zeta'(s)}{\zeta(s)} \right) ds \quad (\text{V.28})$$

```

1
2 \subsection{Prime Number Theorem}
3 \ix{Prime Number Theorem}
4
5 \textcite{li2013} suggested using a functional equation
6 from the Prime Number Theorem proof
7 as an example:
8 \begin{equation}
9 \int_1^x \sum_{p \leq u}
10 \left[ \frac{\log u}{\log p} \right] \log p \, du = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} \frac{x^{s+1}}{s(s+1)} \left( -\frac{\zeta'(s)}{\zeta(s)} \right) ds
11 \end{equation}

```

```

12 \log p
13 \,\text{d}u
14 =
15 \frac{1}{2\pi i}
16 \int_{c-i\infty}^{c+i\infty}
17 \frac{x^{s+1}}{s(s+1)}
18 \left(-\frac{\zeta'(s)}{\zeta(s)}\right)
19 \text{d}s
20 \end{equation}

```

## V.6.4 Quantum Mechanics

Quantum Mechanics

Greene [162] wrote

Greene, Brian Randolph

Quantum Mechanics in a nutshell: A particle goes from here to there by sampling every possible trajectory from here to there.

$$\langle x_f, t_f | x, t_i \rangle = \sum_{p \in \text{paths}} e^{iS(p)/\hbar}$$

```

1 \subsection{Quantum Mechanics}
2 \ix{Quantum Mechanics}
3
4
5 \textcite{greene-2021-04-04} wrote
6 \ix{Greene, Brian Randolph}
7 \begin{quotation}
8   Quantum Mechanics in a nutshell:
9   A particle goes from here to there
10  by sampling every possible trajectory from here to there.
11
12  \[
13    \langle x_f, t_f | x, t_{\mathit{i}} \rangle
14    =
15    \sum_{p \in \text{paths}} e^{iS(p)/\hbar}
16  \]
17 \end{quotation}

```

## V.6.5 Question in String Theory / Mass of States / Number Operator

yourlazyphysicist [163] wrote “I have the following definition of the space-time coordinates”:

$$\text{closed string: } \begin{cases} X_R^\mu = \frac{1}{2}x^\mu + \frac{1}{4\pi T}(\tau - \sigma)p^\mu + \frac{i}{\sqrt{4\pi T}} \sum_{n \neq 0} \frac{1}{n} \alpha_n^\mu e^{-in(\tau - \sigma)}, \\ X_L^\mu = \frac{1}{2}x^\mu + \frac{1}{4\pi T}(\tau + \sigma)p^\mu + \frac{i}{\sqrt{4\pi T}} \sum_{n \neq 0} \frac{1}{n} \tilde{\alpha}_n^\mu e^{-in(\tau + \sigma)}. \end{cases} \quad (\text{V.29})$$

$$\text{open string: } \begin{cases} X_N^\mu = x^\mu + \frac{1}{\pi T}p^\mu\tau + \frac{i}{\sqrt{\pi T}} \sum_{n \neq 0} \frac{1}{n} \alpha_n^\mu e^{-in\tau} \cos(n\sigma), \\ X_D^\mu = x^\mu + \frac{i}{\sqrt{\pi T}} \sum_{n \neq 0} \frac{1}{n} \alpha_n^\mu e^{-in\tau} \sin(n\sigma). \end{cases} \quad (\text{V.30})$$

```

1 \subsection{Question in String Theory / Mass of States / Number Operator}
2
3
4 \textcite{yourlazyphysicist2017} wrote
5 ``I have the following definition of the space-time coordinates'':
6
7 \newcommand{\fpt}{4\pi T}
8 \newcommand{\oh}{\frac{1}{2}}
9 \newcommand{\snnz}{\sum_{n \neq 0}}
10 \newcommand{\tms}{\tau - \sigma}
11 \newcommand{\tps}{\tau + \sigma}
12 \begin{align}
13 \text{\text{closed string: }} &
14 \begin{cases}
15 \displaystyle
16 X^{\mu}_R
17 = \oh x^{\mu}
18 + \frac{1}{\fpt} (\tms) p^{\mu}
19 + \frac{i}{\sqrt{\fpt}} \snnz \frac{1}{n} \alpha_n^{\mu} e^{-in(\tms)}, \\
20 \displaystyle
21 X^{\mu}_L
22 = \oh x^{\mu}
23 + \frac{1}{\fpt} (\tps) p^{\mu}
24 + \frac{i}{\sqrt{\fpt}} \snnz \frac{1}{n} \tilde{\alpha}_n^{\mu} e^{-in(\tps)}.
25 \end{cases} \\
26 \text{\text{open string: }} &
27 \begin{cases}
28 \displaystyle
29 X^{\mu}_N
30 = x^{\mu}
31 + \frac{1}{\pi T} p^{\mu} \tau
32 + \frac{i}{\sqrt{\pi T}} \snnz \frac{1}{n} \alpha_n^{\mu} e^{-in\tau} \cos(n\sigma), \\
33 \displaystyle
34 X^{\mu}_D
35 = x^{\mu}
36 + \frac{i}{\sqrt{\pi T}} \snnz \frac{1}{n} \alpha_n^{\mu} e^{-in\tau} \sin(n\sigma).
37 \end{cases}
38 \end{align}

```

## W. MUSIC

music ⇒ Music appendix

To get the following printed music score I did the following steps.

- Get the “Example of LilyPond input file” from the Wikipedia LilyPond page [164] and put it in a `fib.ly` file.
- Ran `lilypond fib.ly` and got the following `fib.pdf` file:

LilyPond music typesetting software

### Excerpt from *fibonacci*

Patrick McCarty

Slow and steady (♩ = 60)

Music engraving by LilyPond 2.22.0—[www.lilypond.org](http://www.lilypond.org)

```

1 \chapter{MUSIC}
2 \ix{music//Music appendix}
3
4 To get the following printed music score I did the following steps.
5 \begin{itemize}
6   \item
7     Get the ``Example of LilyPond input file''
8     from the Wikipedia LilyPond page \cite{wikipedia-lilypond}
9     and put it in a \verb+fib.ly+ file.
10  \item
11    Ran \verb+lilypond fib.ly+ and got the following \verb+fib.pdf+ file:
12  \end{itemize}
13 \ix{LilyPond music typesetting software}
14
15 \noindent \includegraphics[scale=0.77]{gr-fib.pdf}

```



## X. PHYSICS

physics ⇒ Physics appendix

Feynman diagrams show what happens when elementary particles collide [165]. The Feynman diagrams below are from the *TikZ-Feynman: Feynman diagrams with TikZ* documentation [166]. You must use `lualatex` instead of `pdflatex` to process documents that use the `tikz-feynman` package.

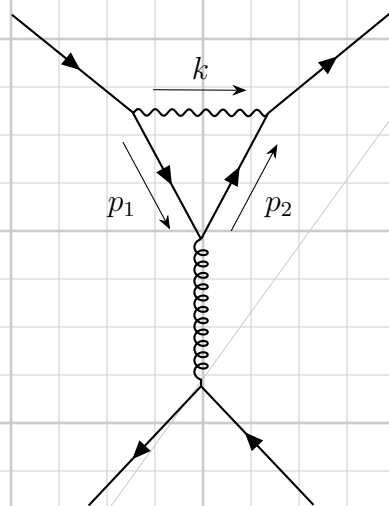
Feynman diagram

The input in the documentation is different than here because a different random number generator is used [167]. I expect this to be corrected. In the meantime try replacing `vertical` with `vertical'` and/or switch some `fermion` to `anti fermion` lines [168].

```

1 \chapter{PHYSICS}
2 \ix{physics//Physics appendix}
3
4 Feynman diagrams\ix{Feynman diagram}
5 show what happens
6 when elementary particles collide
7 \cite{feynman-diagram}.
8 The Feynman diagrams below are from the
9 \citetitle{ellis2016} documentation \cite{ellis2016}.
10 \textbf{%
11   You must use \texttt{lualatex} instead
12   of \texttt{pdflatex}
13   to process documents that use the \texttt{tikz-feynman} package.%
14 }
15
16 The input
17 in the documentation
18 is different than here because a different random number generator
19 is used \cite{menke2019}.
20 I expect this to be corrected.
21 In the meantime try replacing \texttt{vertical}
22 with \texttt{vertical'}
23 and/or switch some \texttt{fermion}
24 to \texttt{anti} \texttt{fermion} lines \cite{ellis2017}.

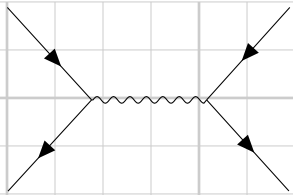
```



```

1 \feynmandiagram [large, vertical='e to f] {
2   a -- [fermion] b -- [photon, momentum=(k)] c -- [fermion] d,
3   b -- [fermion, momentum=(p_1)] e -- [fermion, momentum=(p_2)] c,
4   e -- [gluon] f,
5   h -- [anti fermion] f -- [anti fermion] i,
6 };

```



```
1 \feynmandiagram [horizontal=a to b] {  
2   i1 -- [anti fermion] a -- [anti fermion] i2,  
3   a -- [photon] b,  
4   f1 -- [fermion] b -- [fermion] f2,  
5 };
```

## Y. FREQUENTLY ASKED QUESTIONS

### PART OF THESIS WITH PROBLEM

frequently asked questions ⇒ Frequently Asked Questions appendix

#### Entire Thesis

**Q:** What  $\LaTeX$  comand should I use to compile my thesis?

**A:** The  $\text{Lua}\LaTeX$  program in the  $\text{TeX}$  Live software distribution. Overleaf [169] (run  $\LaTeX$  over the web) uses  $\text{TeX}$  Live—in Overleaf click **Menu** key in upper left corner of window and set **Compiler** to  $\text{LuaLaTeX}$  to run  $\text{Lua}\LaTeX$ .)  $\text{TeX}$  Live runs on Linux, MacOS, Unix, and Windows.

$\text{LuaLaTeX}$  ⇒ lualatex

$\text{TeX}$  Live

Linux

MacOS

Unix

Windows

#### References

**Q:** URLs are not getting printed. What should I do?

**A:** Make sure you are processing your document with  $\text{Lua}\LaTeX$ .

```

1 \chapter{FREQUENTLY ASKED QUESTIONS}
2 \ix{frequently asked questions//Frequently Asked Questions appendix}
3
4 {\bfseries PART OF THESIS WITH PROBLEM}
5
6 {
7   \def\part#1%
8   {
9     \vspace*{\baselineskip}
10    {\bfseries #1}
11   }
12
13   \def\qa#1#2%
14   {
15     \vspace*{\baselineskip}
16     {\small\bfseries Q}: #1\endgraf
17     \vspace*{0.5\baselineskip}
18     {\small\bfseries A}: #2\endgraf
19   }
20
21
22 \part{Entire Thesis}
23
24 \qa
25 {What \LaTeX\ comand should I use to compile my thesis?}
26 {%
27   The \LuaLaTeXLogo%
28   \ix{LuaLaTeX//lualatex}%
29   \index{\LuaLaTeXLogo}
30   program in the \TeXLiveLogo%
31   \index{\TeXLiveLogo}%
32   \ix{TeX Live}
33   software distribution.
34   Overleaf \cite{overleaf}
35   (run \LaTeX%
36   \index{\LaTeX}
37   over the web)
38   uses \TeXLiveLogo---%
39   in Overleaf click {\tt Menu\} key in upper left corner of window

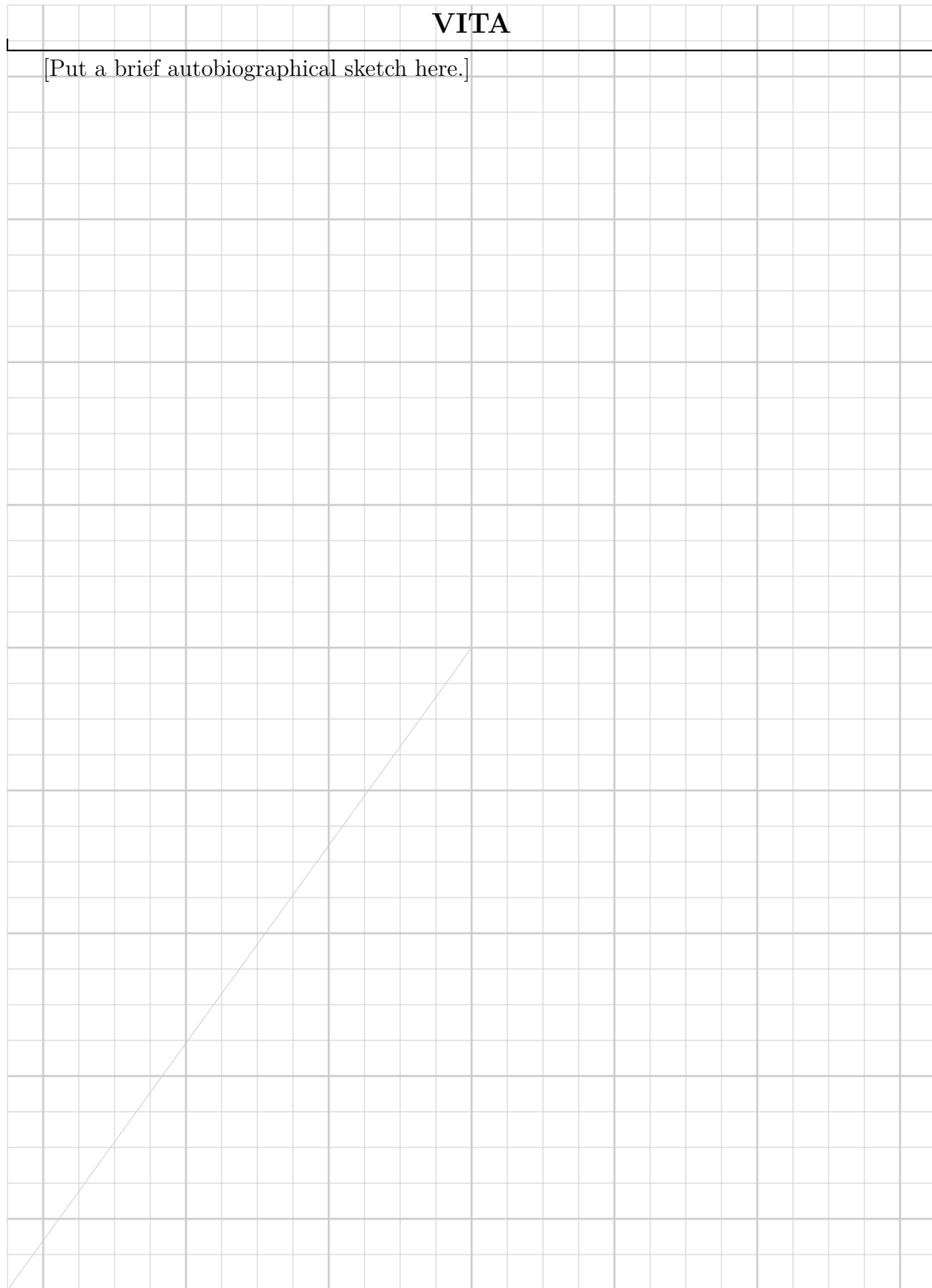
```

```
40     and set {\tt Compiler\} to {\tt LuaLaTeX} to run \LuaLaTeXLogo.)
41     \TeXLiveLogo\ runs on Linux\ix{Linux},
42     MacOS\ix{MacOS},
43     Unix\ix{Unix},
44     and Windows\ix{Windows}.%
45 }
46
47
48 \part{References}
49
50 \qa
51 {URLs are not getting printed. What should I do?}%
52 {Make sure you are processing your docuent with \LuaLaTeXLogo.}
53 }
```

## VITA

vita

[Put a brief autobiographical sketch here.]



**PUBLICATION(S)**

publication,publications

The following is based on information in [170]–[172].

In a publication or publications section you can

- list a single publication
- include a single publication
- list multiple publications
- include multiple publications

Use

```
\begin{publication}...\end{publication}
```

or

```
\begin{publications}...\end{publications}
```

to skip to the next page and put the appropriate heading on the top of the page.

**To List a Single Publication**

```
\begin{publication}
...list a single publication here...
...IMPROVE THIS LATER to show how to do that...
\end{publication}
```

**To Include a Single Publication**

```
\begin{publication}
...put a single publication here...
...IMPROVE THIS LATER to show how to do that...
\end{publication}
```

**To List Multiple Publications**

```
\begin{publications}
...list multiple publications here...
...IMPROVE THIS LATER to show how to do that...
\end{publications}
```

**To Include Multiple Publications**

```
\begin{publications}
...put the multiple publications here...
...IMPROVE THIS LATER to show how to do that...
\end{publications}
```

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# COLOPHON

colophon

This is the colophon.

```
1 \chapter*{COLOPHON}
2 \label{ap:colophon}
3
4 \ix{colophon}
5
6 This is the colophon.
7
```