THIS IS THE TITLE

by

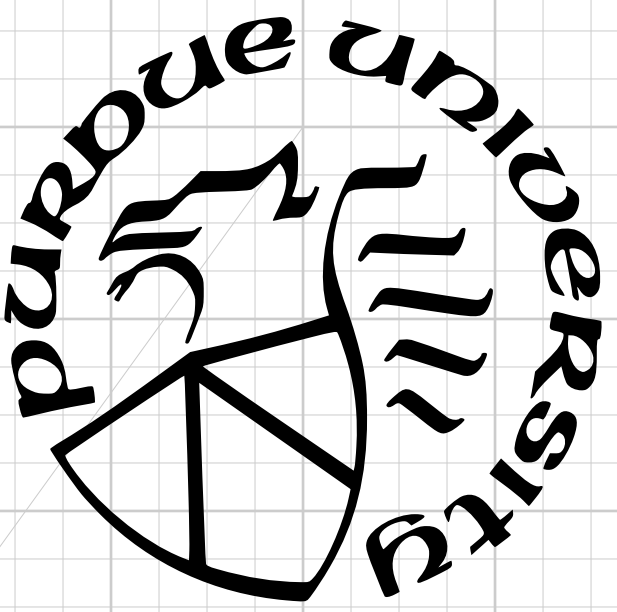
Ima Student

A Dissertation

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Doctor of Philosophy



School of Electrical and Computer Engineering

West Lafayette, Indiana

December 2022

THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. John Doe, Chair

School of Aeronautics and Astronautics

Dr. Jane Doe

School of Aeronautics and Astronautics

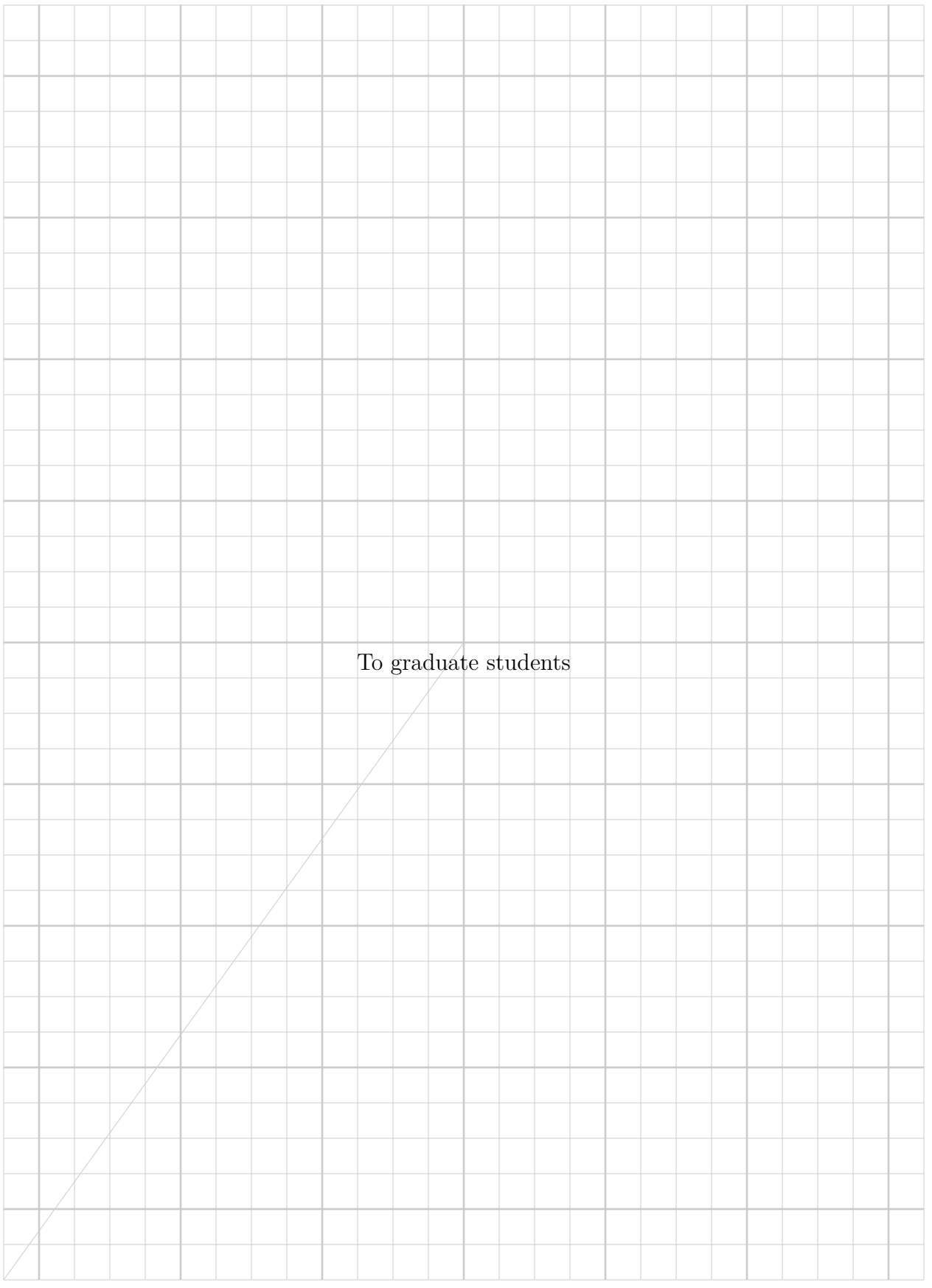
Dr. Jim Doe

School of Aeronautics and Astronautics

Approved by:

Dr. Buck Doe

compiled on 2022-10-13 Thursday 09:40:45



ACKNOWLEDGMENTS

Purdue University's Engineering Computer Network and Graduate School helped fund PurdueThesis development.

PREFACE

This is the preface.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF LISTINGS

LIST OF PROTOCOLS

LIST OF SCHEMES

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, fabulous [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.

test entry

This is a a long test sentence. This is a a long test sentence.

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

TEX is a typesetting system for the creation of beautiful books—and especially for books that contain lots of mathematics [4, page v].

LATEX is a software system for typesetting documents [5, back cover]. It extends TEX with more natural chapter, section, etc. commands that are easier to use. LATEX has document classes for articles, books, reports, etc.

PurdueThesis (*PuTh* for short—rhymes with tooth) is a LATEX document class used for Purdue theses, dissertations, masters bypass reports, and PhD preliminary reports. This template demonstrates how to use PurdueThesis. PurdueThesis is intended to support all Purdue campuses, programs, and graduate degrees.

Figure 1.1 shows the LATEX System Flowchart. Overleaf [6] uses latexmk [7] to run `biblatex` or `bibtex`, `makeindex`, and `lualatex` automatically so the minimum amount of work is done. On Linux, MacOS, and Windows you can run the programs individually or use `latexmk`—I recommend using `latexmk`.

The Thesis and Dissertation Office [8] wrote a formatting manual and Microsoft Word templates for Purdue theses.

1.1 Typographic Conventions

The following typographic conventions are used in this document. These conventions were influenced by [9]–[11]. There are no quotes in the typographic conventions.

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 Element`

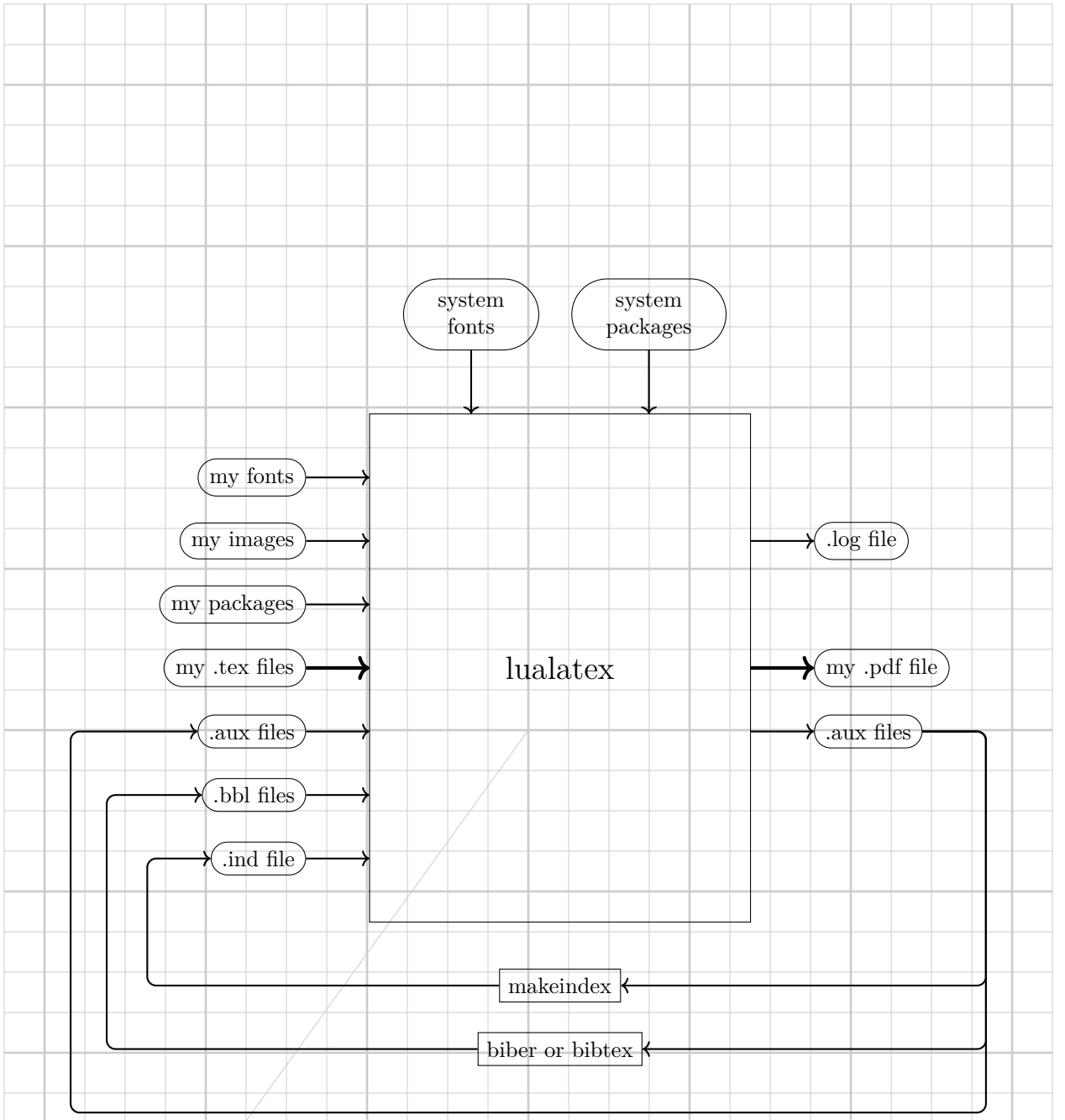


Figure 1.1. LuaLaTeX System Flowchart

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 » Submenu » Item

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

Placeholder

Placeholders need to be replaced with real input.

`shell command`

Command typed on the command line by the user.

1.2 Writing in English Information

1.2.1 Logical punctation

I use logical punctuation [12]:

> 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) ⇒ comma ⇒ 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 LaTeX-related information

1.3.1 Input reading rules

LaTeX 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 LaTeX 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 re
gion is less than or equal to the area of the tiny black-bordered rectan
gle.  More precisely, \[\left|f(x)-\frac{A(x+h)-A(x)}h\right|-\frac{\lef
t|\text{Red Excess}\right|}h\le\frac{h\big(f(x+h_1)-f(x+h_2)\big)}h=f(x+
h_1)-f(x+h_2),\] where \(x+h_1\) and \(x+h_2\) are points where \(f\) re
aches 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,
\[
  \left |
    f(x)
    -
    \frac {A(x+h)-A(x)} {h}
  \right |
  -
  \frac {\left|\text{Red Excess}\right|} {h}
  \le
  \frac {h\big(f(x+h_1)-f(x+h_2)\big)} {h}
  =
```

```
 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 \([x, x + h]\).
```

I've used LaTeX 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 that surrounding characters, looks like camel's hump
kebab-case	letters appear to be slid on shish-kebab skewer, no Shift 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 digits, zero or more `-` characters (but no consecutive `-` characters), and a single period. You won't need to use Shift then.

Do not put spaces in your file names. It makes it easier to run your thesis on other computer operating systems. Linux, MacOS, and Windows are operatings systems.

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.

LaTeX 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

A lowercase letter followed by a period is treated like the end of a sentence with approximately two spaces following the period. To not make it the end of a sentence put \ or ~ after the period. See table below.

. (period) ⇒ spacing!after period

An uppercase letter followed by a period is treated like a person's middle initial with approximately one space following the period. To make it the end of a sentence put \@ before the period. See table below.

. (period) ⇒ spacing!after period

Input	Output	Comment
`Dr. Smith`	Dr. Smith	too much space after `Dr.`
`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 `NASA.`
`at NASA\@. The`	at NASA. The	correct

(I thought the following was too confusing. One or more *lowercase*/*uppercase* letters followed by a period is treated like *the end of a sentence*/*a person's middle initial* with approximately *two*/*one* space(s) following the period.)

maybe move this to writing style appendix?

(I thought some people might think the following is too informal or nonstandard. It is pretty confusing also. One or more uppercase / lowercase letters followed by a period is treated like a middle initial / the end of a sentence with approximately one / two space(s) following the period.)

maybe move this to writing style appendix?

1.7 Five kinds of dashes

There are five kinds of dashes dash

Name	Input	Output	Width in Points (72.27 points/inch)
hyphen	- (one hyphen)	-	3.91667pt
endash	-- (two hyphens)	–	5.87498pt
emdash	--- (three hyphens)	—	11.75pt
figure dash	\FigureDash	‒	5.87498pt
minus sign	\(-\)	−	9.33336pt

hyphen The hyphen is a punctuation mark used to join words and to separate syllables of a single word [13]. 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, LaTeX hyphenates words automatically so you may not ever use this

endash The endash [14] 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 [15] is used for dash ⇒ emdash ⇒ dash!emdash

--- (three hyphens)	—
Input	`the usual suspects---Larry, Moe, and Curly`
Output	the usual suspects—Larry, Moe, and Curly
Comment	— acts like colon
Input	`Larry, Moe, and Curly---the usual suspects`
Output	Larry, Moe, and Curly—the usual suspects
Comment	inverse function of colon
Input	`three people---Larry, Moe, and Curly---%` `are the usual suspects`
Output	three people—Larry, Moe, and Curly—are the usual suspects
Comment	first — acts as `(`, second — acts as `)`
Input	`I believe I shall---no, I'm going to do it.`
Output	I believe I shall—no, I'm going to do it.
Comment	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 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".

dash ⇒ figure dash ⇒ dash!figure dash

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

dash ⇒ minus sign ⇒ dash!minus sign

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

2. DO NOT USE THESE PACKAGES

The `\usepackage{`*packagename*`}` command is used to load a package.

Do not use these packages for the listed purposes. Using them for these purposes is not compatible with PurdueThesis.

Name	For
babel	Translating "Table of Contents", etc. to foreign languages. Reported by Danushka Menikkumbura. Send email to `latex@ecn.purdue.edu` if you need to typset multiple languages in your thesis.
caption	Used to customize captions. Do not load this package, it is not compatible with PurdueThesis.
subfig	For subfigures. This package is deprecated. Do not load this package. See page 72 for how to do subfigures.
subfigure	For subfigures. This package is deprecated. Do not load this package. See page

3. SUMMARY

This is the summary chapter.

3.1 First Section

This is the first section of the summary chapter.

```
\chapter{SUMMARY}

This is the summary chapter.


\section{First Section}

This is the first section of the summary chapter.
```

4. RECOMMENDATIONS

Buy low. Sell high.

5. TEST ENVIRONMENTS AND PER-CHAPTER REFERENCES

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

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

`\cite{thesis2017}` gives "[3]".

`\cite{thesis2020}` gives "[4]".

This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text.

Definition 5.0.1. This is an example definition. This is an example definition. This is an example definition. This is an example definition. This is an example definition. This is an example definition.

This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text.

Observation 5.0.1. This is an example observation. This is an example observation. This is an example observation. This is an example observation. This is an example observation. This is an example observation.

This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text.

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

This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text.

Proposition 5.0.1. This is an example proposition. This is an example proposition. This is an example proposition. This is an example proposition. This is an example proposition.

This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text.

Theorem 5.0.1. This is an example theorem. This is an example theorem. This is an example theorem. This is an example theorem. This is an example theorem.

This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text. This is an example of normal text.

References

[1] D. E. Knuth, *The TEXbook*. Addison-Wesley, ISBN: 978-0-201-13447-6.

[2] L. Lamport, *LATEX: A Document Preparation System*, 2nd ed. Reading Massachusetts: Addison-Wesley, 1994, ISBN: 0-201-52983-1.

[3] Thesis and Dissertation Office, *A manual for the preparation of graduate theses*, The Graduate School, Purdue University, Aug. 30, 2017. [Online]. Available: https://www.purdue.edu/gradschool/documents/thesis/graduate-thesis-manual.pdf, Parts of this are out of date.

[4] Thesis and Dissertation Office, The Graduate School, Purdue University, *Microsoft Word templates*, Feb. 17, 2020. [Online]. Available: https://www.purdue.edu/gradschool/research/thesis/templates.html#accordian.

REFERENCES

[1] Wikipedia contributors, *Gasoline*, version 1024893259, May 24, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Gasoline.

[2] Wikipedia contributors, *Valvoline*, version 1020356743, Apr. 28, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Valvoline.

[3] Oxford English Dictionary. "Supercalifragilisticexpialidocious." (Dec. 2020), [Online]. Available: https://www.oed.com/view/Entry/194228.

[4] D. E. Knuth, *The TEXbook*. Addison-Wesley, ISBN: 978-0-201-13447-6.

[5] L. Lamport, *LATEX: A Document Preparation System*, 2nd ed. Reading Massachusetts: Addison-Wesley, 1994, ISBN: 0-201-52983-1.

[6] Overleaf, *Overleaf*, 2022. [Online]. Available: https://www.overleaf.com.

[7] J. Collins, *Latexmk – generate LATEX document*, version 4.77, Mar. 17, 2022. [Online]. Available: https://mirror.mwt.me/ctan/support/latexmk/latexmk.pdf.

[8] Thesis and Dissertation Office. "Resources." Click on "Menu", then click on "RESOURCES", and then click on "Formatting Guidelines and Deposit Procedures" or "TEMPLATES". (2020), [Online]. Available: https://www.purdue.edu/gradschool/research/thesis/.

[9] R. Sharpe, E. Warnicke, and U. Lamping, *Wireshark users's guide*, version 3.3.0. [Online]. Available: https://www.wireshark.org/docs/wsug_html_chunked/PrefaceTypographicConventions.html.

[10] L. E. van Dijk and C. L. Spiel. "Scilab bag of tricks: The scilab-2.5 iaq (infrequently asked questions)." (Jun. 4, 2000), [Online]. Available: http://kiwi.emse.fr/SCILAB/sci-bot/sci-bot.pdf.

[11] T. Weh. "Menukeys–format menu sequences, paths and keystrokes from lists." version 1.5. (Aug. 8, 2016), [Online]. Available: http://www.ctan.org/pkg/menukeys.

[12] B. Yagoda, "The rise of "logical punctuation"," *Slate*, May 12, 2011. [Online]. Available: https://slate.com/human-interest/2011/05/logical-punctuation-should-we-start-placing-commas-outside-quotation-marks.html.

[13] Wikipedia contributors, *Hyphen*, version 1034109511, Jul. 17, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Hyphen.

[14] Wikipedia contributors, *En dash*, version 1055060523, Nov. 13, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Dash#En_dash.

[15] Wikipedia contributors, *Em dash*, version 1055060523, Nov. 13, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Dash#Em_dash.

[16] The Chicago Manual of Style. "All-numeral dates and other brief forms." Section 9.35. (2017), [Online]. Available: https://www-chicagomanualofstyle-org.ezproxy.lib.purdue.edu/book/ed17/part2/ch09/psec035.html.

[17] The Chicago Manual of Style. "ISO style for dates." Section 9.36. (2017), [Online]. Available: https://www-chicagomanualofstyle-org.ezproxy.lib.purdue.edu/book/ed17/part2/ch09/psec036.html.

[18] M. Goossens, F. Mittelbach, and A. Samarin, *The LaTeX Companion*. Reading Massachusetts: Addison-Wesley, 1994.

[19] H. Kopka and P. W. Daly, *A Guide to LaTeX: Document Preparation for Beginners and Advanced Users*, 3rd ed. Reading Massachusetts: Addison-Wesley, 1999.

[20] H. Kopka and P. W. Daly, *A Guide to LaTeX: Document Preparation for Beginners and Advanced Users*, 2nd ed. Reading Massachusetts: Addison-Wesley, 1995.

[21] A. Anteater, B. Bear, C. Cheetah, D. Deer, and E. Eagle, *An imaginary document not about Mark Senn or NASA*, M. Senn, Ed., version 1.0, Imaginaryville, Indiana, Oct. 27, 2020. DOI: 00.0000/000-0-000-00000-0. [Online]. Available: https://bogus.com/bogus.html.

[22] K. Hambleton, Ed., *Deep Space Gateway to Open Opportunities for Distant Destinations*, NASA, Aug. 24, 2018. [Online]. Available: https://www.nasa.gov/feature/deep-space-gateway-to-open-opportunities-for-distant-destinations.

[23] W. H. Gerstenmaier, *Progress in Defining the Deep Space Gateway and Transport Plan*, https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf, NASA, Mar. 2017.

[24] W. H. Gerstenmaier, *Progress in Defining the Deep Space Gateway and Transport Plan*, NASA, Mar. 28, 2017. [Online]. Available: https://www.nasa.gov/sites/default/files/atoms/files/nss_chart_v23.pdf.

[25] D. K. Farkas, *Managing headings in print and online documents*, 2011. [Online]. Available: https://faculty.washington.edu/farkas/TC510-Fall2011/Farkas-ManagingHeadings.pdf.

[26] MathWorks Help Center. "Text properties." version R2021b. (2022), [Online]. Available: https://www.mathworks.com/help/matlab/ref/matlab.graphics.primitive.text-properties.html#budt_bq-1_sep_shared-Interpreter.

[27] T. G. Kristensen, *Example: Yin and yang*, Feb. 19, 2008. [Online]. Available: https://texample.net/tikz/examples/all/yin-and-yang.

[28] P. O. W. Lab. "Ieee reference list." (), [Online]. Available: https://owl.purdue.edu/owl/research_and_citation/ieee_style/reference_list.html.

[29] IEEEDataPort. "How too cite references: Ieee documentation style." (), [Online]. Available: https://ieee-dataport.org/sites/default/files/analysis/27/IEEE%20Citation%20Guidelines.pdf.

[30] P. Erds, "Diameters of point sets," *Geombinatorics*, vol. 1, no. 4, p. 4, 1992. [Online]. Available: https://www.oakland.edu/Assets/upload/docs/Erdos-Number-Project/erdpubs.2010.pdf.

[31] Wikipedia contributors, *Bushel*, version 1020154300, Apr. 27, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Bushel.

[32] S. Kottwitz, *LaTeX Beginner's Guide*, 2nd ed. Packt Publishing Ltd., Aug. 2021. [Online]. Available: https://learning.oreilly.com/library/view/latex-beginners-guide/9781801078658/cover.xhtml.

[33] IEEE, "IEEE author center," 2021. [Online]. Available: https://journals.ieeeauthorcenter.ieee.org/your-role-in-article-production/ieee-editorial-style-manual/.

[34] IEEE, "IEEE editorial style manual for authors," Aug. 19, 2020. [Online]. Available: http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Editorial-Style-Manual_081920.pdf.

[35] IEEE, "Editing mathematics," Nov. 12, 2018. [Online]. Available: http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/Editing-Mathematics.pdf.

[36] IEEE, "IEEE reference guide," Jan. 29, 2021. [Online]. Available: http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Reference-Guide-Online-v.04-20-2021.pdf.

[37] Stack Exchange contributors, *TEX - LATEX stack exchange*, 2022. [Online]. Available: https://tex.stackexchange.com.

[38] H. Voss, *Typesetting tables with LATEX*. Cambridge, England: UIT Cambridge Ltd., 2011. [Online]. Available: https://www.uit.co.uk/computing/typesetting-mathematics-with-latex.

[39] M. Senn, *This is the t001 title*. Feb. 12, 2019.

[40] M. Senn, *This is the t002 title*. Feb. 12, 2019.

[41] M. Senn, *This is the t003 title*. Feb. 12, 2019.

[42] M. Senn, *This is the t004 title*. Feb. 12, 2019.

[43] M. Senn, *This is the t005 title*. Feb. 12, 2019.

[44] M. Senn, *This is the t006 title*. Feb. 12, 2019.

[45] M. Senn, *This is the t007 title*. Feb. 12, 2019.

[46] M. Senn, *This is the t008 title*. Feb. 12, 2019.

[47] M. Senn, *This is the t009 title*. Feb. 12, 2019.

[48] M. Senn, *This is the t010 title*. Feb. 12, 2019.

[49] M. Senn, *This is the t011 title*. Feb. 12, 2019.

[50] M. Senn, *This is the t012 title*. Feb. 12, 2019.

[51] M. Senn, *This is the t013 title*. Feb. 12, 2019.

[52] M. Senn, *This is the t014 title*. Feb. 12, 2019.

[53] M. Senn, *This is the t015 title*. Feb. 12, 2019.

[54] M. Senn, *This is the t016 title*. Feb. 12, 2019.

[55] M. Senn, *This is the t017 title*. Feb. 12, 2019.

[56] M. Senn, *This is the t018 title*. Feb. 12, 2019.

[57] M. Senn, *This is the t019 title*. Feb. 12, 2019.

[58] M. Senn, *This is the t020 title*. Feb. 12, 2019.

[59] M. Senn, *This is the t021 title*. Feb. 12, 2019.

[60] M. Senn, *This is the t022 title*. Feb. 12, 2019.

[61] M. Senn, *This is the t023 title*. Feb. 12, 2019.

[62] M. Senn, *This is the t024 title*. Feb. 12, 2019.

[63] M. Senn, *This is the t025 title*. Feb. 12, 2019.

[64] M. Senn, *This is the t026 title*. Feb. 12, 2020.

[65] M. Senn, *This is the t027 title*. Feb. 12, 2020.

[66] M. Senn, *This is the t028 title*. Feb. 12, 2020.

[67] M. Senn, *This is the t029 title*. Feb. 12, 2020.

[68] M. Senn, *This is the t030 title*. Feb. 12, 2020.

[69] M. Senn, *This is the t031 title*. Feb. 12, 2020.

[70] M. Senn, *This is the t032 title*. Feb. 12, 2020.

[71] M. Senn, *This is the t033 title*. Feb. 12, 2020.

[72] M. Senn, *This is the t034 title*. Feb. 12, 2020.

[73] M. Senn, *This is the t035 title*. Feb. 12, 2020.

[74] M. Senn, *This is the t036 title*. Feb. 12, 2020.

[75] M. Senn, *This is the t037 title*. Feb. 12, 2020.

[76] M. Senn, *This is the t038 title*. Feb. 12, 2020.

[77] M. Senn, *This is the t039 title*. Feb. 12, 2020.

[78] M. Senn, *This is the t040 title*. Feb. 12, 2020.

[79] M. Senn, *This is the t041 title*. Feb. 12, 2020.

[80] M. Senn, *This is the t042 title*. Feb. 12, 2020.

[81] M. Senn, *This is the t043 title*. Feb. 12, 2020.

[82] M. Senn, *This is the t044 title*. Feb. 12, 2020.

[83] M. Senn, *This is the t045 title*. Feb. 12, 2020.

[84] M. Senn, *This is the t046 title*. Feb. 12, 2020.

[85] M. Senn, *This is the t047 title*. Feb. 12, 2020.

[86] M. Senn, *This is the t048 title*. Feb. 12, 2020.

[87] M. Senn, *This is the t049 title*. Feb. 12, 2020.

[88] M. Senn, *This is the t050 title*. Feb. 12, 2020.

[89] M. Senn, *This is the t051 title*. Feb. 12, 2021.

[90] M. Senn, *This is the t052 title*. Feb. 12, 2021.

[91] M. Senn, *This is the t053 title*. Feb. 12, 2021.

[92] M. Senn, *This is the t054 title*. Feb. 12, 2021.

[93] M. Senn, *This is the t055 title*. Feb. 12, 2021.

[94] M. Senn, *This is the t056 title*. Feb. 12, 2021.

[95] M. Senn, *This is the t057 title*. Feb. 12, 2021.

[96] M. Senn, *This is the t058 title*. Feb. 12, 2021.

[97] M. Senn, *This is the t059 title*. Feb. 12, 2021.

[98] M. Senn, *This is the t060 title*. Feb. 12, 2021.

[99] M. Senn, *This is the t061 title*. Feb. 12, 2021.

[100] M. Senn, *This is the t062 title*. Feb. 12, 2021.

[101] M. Senn, *This is the t063 title*. Feb. 12, 2021.

[102] M. Senn, *This is the t064 title*. Feb. 12, 2021.

[103] M. Senn, *This is the t065 title*. Feb. 12, 2021.

[104] M. Senn, *This is the t066 title*. Feb. 12, 2021.

[105] M. Senn, *This is the t067 title*. Feb. 12, 2021.

[106] M. Senn, *This is the t068 title*. Feb. 12, 2021.

[107] M. Senn, *This is the t069 title*. Feb. 12, 2021.

[108] M. Senn, *This is the t070 title*. Feb. 12, 2021.

[109] M. Senn, *This is the t071 title*. Feb. 12, 2021.

[110] M. Senn, *This is the t072 title*. Feb. 12, 2021.

[111] M. Senn, *This is the t073 title*. Feb. 12, 2021.

[112] M. Senn, *This is the t074 title*. Feb. 12, 2021.

[113] M. Senn, *This is the t075 title*. Feb. 12, 2021.

[114] M. Senn, *This is the t076 title*. Feb. 12, 2022.

[115] M. Senn, *This is the t077 title*. Feb. 12, 2022.

[116] M. Senn, *This is the t078 title*. Feb. 12, 2022.

[117] M. Senn, *This is the t079 title*. Feb. 12, 2022.

[118] M. Senn, *This is the t080 title*. Feb. 12, 2022.

[119] M. Senn, *This is the t081 title*. Feb. 12, 2022.

[120] M. Senn, *This is the t082 title*. Feb. 12, 2022.

[121] M. Senn, *This is the t083 title*. Feb. 12, 2022.

[122] M. Senn, *This is the t084 title*. Feb. 12, 2022.

[123] M. Senn, *This is the t085 title*. Feb. 12, 2022.

[124] M. Senn, *This is the t086 title*. Feb. 12, 2022.

[125] M. Senn, *This is the t087 title*. Feb. 12, 2022.

[126] M. Senn, *This is the t088 title*. Feb. 12, 2022.

[127] M. Senn, *This is the t089 title*. Feb. 12, 2022.

[128] M. Senn, *This is the t090 title*. Feb. 12, 2022.

[129] M. Senn, *This is the t091 title*. Feb. 12, 2022.

[130] M. Senn, *This is the t092 title*. Feb. 12, 2022.

[131] M. Senn, *This is the t093 title*. Feb. 12, 2022.

[132] M. Senn, *This is the t094 title*. Feb. 12, 2022.

[133] M. Senn, *This is the t095 title*. Feb. 12, 2022.

[134] M. Senn, *This is the t096 title*. Feb. 12, 2022.

[135] M. Senn, *This is the t097 title*. Feb. 12, 2022.

[136] M. Senn, *This is the t098 title*. Feb. 12, 2022.

[137] M. Senn, *This is the t099 title*. Feb. 12, 2022.

[138] M. Senn, *This is the t100 title*. Feb. 12, 2022.

[139] M. Senn, *This is a very, very long title*. 2018.

[140] M. FRANZ, *The* `soul` *package*, version v2.19, Nov. 17, 2003. [Online]. Available: https://mirrors.mit.edu/CTAN/macros/generic/soul/soul.pdf.

[141] D. U. Kern, *Extending latexs color facilities: The* **xcolor** *package*, version v2.13, Oct. 31, 2021. [Online]. Available: https://ctan.math.illinois.edu/macros/latex/contrib/xcolor/xcolor.pdf.

[142] Meriam-Webster, *Irregardless*. Merriam-Webster, 2022. [Online]. Available: https:www.merriam-webster.com/dictionary/irregardless.

[143] Meriam-Webster, *out of date / out-of-date*. Merriam-Webster, 2022. [Online]. Available: https://www.merriam-webster.com/dictionary/out-of-date.

[144] TheWriter, *To hyphenate or not to hyphenate?* The Writer. [Online]. Available: http://www.thewriter.com/what-we-think/style-guide/to-hyphenate-or-not-to-hyphenate.

[145] Oxford English Dictionary, *out of date*. Oxford University Press, 2020. [Online]. Available: https://www.oed.com/view/Entry/133785?redirectedFrom=out+of+date.

[146] Meriam-Webster, *Deprecate*. Jan. 18, 2022. [Online]. Available: https:www.merriam-webster.com/dictionary/deprecated.

[147] Wikipedia contributors, *Startup company*, version 1013151991, Jan. 27, 2022. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Startup_company.

[148] W. Rader, Ed., *peace out*. The Online Slang Dictionary, 2020. [Online]. Available: http://onlineslangdictionary.com/search/?q=peace+out&sa=Search.

[149] E. A. Feffin, *The chemplants package*, version 0.9.8, Nov. 19, 2019. [Online]. Available: https://ctan.math.illinois.edu/graphics/pgf/contrib/chemplants/chemplants-doc.pdf.

[150] M. Hensel, *The mhchem bundle*, Jun. 22, 2018. [Online]. Available: https://ctan.org/pkg/mhchem?lang=en.

[151] R. Meerman, *The mathematics of weight loss*, Oct. 10, 2013. [Online]. Available: https://www.youtube.com/watch?v=vuIlsN32WaE.

[152] C. Tellechea, *Chemfig: A TEX package for drawing molecules*, version 1.6a, Feb. 28, 2021. [Online]. Available: https://ctan.org/pkg/chemfig?lang=en.

[153] A. Mittelbach, *Cryptocode - Typesetting Crytography*, version 0.44, Aug. 15, 2021. [Online]. Available: https://ctan.math.washington.edu/tex-archive/macros/latex/contrib/cryptocode/cryptocode.pdf.

[154] R. Jaramillo, *Example: 18W MOSFET amplifier with npn transistor*, May 11, 2014. [Online]. Available: https://texample.net/tikz/examples/mosfet.

[155] M. A. Redaelli, S. Lindner, S. Erhard, and R. Giannetti, *CircuiTikZ - draw electrical networks with TikZ*, version 1.3.7, Jun. 1, 2021. [Online]. Available: https://www.ctan.org/pkg/circuitikz.

[156] B. Lingner, *Kalman filter system model*, Apr. 21, 2010. [Online]. Available: https://texample.net/tikz/examples/kalman-filter/.

[157] Wikipedia contributors, *LaTeX/linguistics*, version 3775673, Nov. 29, 2020. [Online]. Available: https://en.wikibooks.org/w/index.php?title=LaTeX/Linguistics&oldid=3775673.

[158] N. V. Tambe, *Doulossil — a font for typesetting the international phonetic alphabet (ipa)*, version 0.1, Sep. 21, 2020. [Online]. Available: https://www.ctan.org/pkg/doulossil.

[159] M. A. Covington and Jürgen Spitzmüller. "The covington package macros for linguistics." version 2.7, September 1, 2021. (Sep. 1, 2021), [Online]. Available: https://ctan.org/pkg/covington/covington.pdf.

[160] American Mathematical Society, LaTeX3 Project, *User's guide for the AMSmath package*, version 2.1, Oct. 14, 2019. [Online]. Available: http://mirrors.ctan.org/info/amslatex/english/amsldoc.pdf.

[161] G. Grätzer, *More Math Into LaTeX*, 5th ed. Springer International Publishing, Feb. 23, 2016, p. 41, ISBN: 978-3-319-23796-1. DOI: 10.1007/978-3-319-23796-1.

[162] American Mathematical Society, LaTeX3 Project, *User's guide for the AMSmath package*, version 2.1, Oct. 14, 2019. [Online]. Available: https://ctan.org/tex-archive/info/amslatex/english?lang=en.

[163] B. Greene, *For #PiDay, one of the coolest formulae for today's honoree*, Mar. 14, 2021. [Online]. Available: https://twitter.com/bgreene/status/1371234232304082944.

[164] ISO/TC 12 Committee, *ISO 80000-2:2019 Quantities and units — part 2: Mathematics*, Aug. 2019. [Online]. Available: https://www.iso.org/standard/64973.html.

[165] M. Reid. "Jerk, jounce, snap, crackle and pop." (Dec. 11, 2013), [Online]. Available: http://wordpress.mrreid.org/2013/12/11/jerk-jounce-snap-crackle-and-pop/.

[166] Khan Academy, *Quadratic formula proof review*, 2018. [Online]. Available: https://www.khanacademy.org/math/algebra/quadratics/solving-quadratics-using-the-quadratic-formula/a/quadratic-formula-proof-review.

[167] Lumen Learning. "Bayes' theorem." (), [Online]. Available: https://courses.lumenlearning.com/mathforliberalartscorequisite/chapter/bayes-theorem.

[168] Wikipedia contributors, *Squared triangular number*, version 1068580286, Jan. 29, 2022. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Squared_triangular_number&oldid=1068580286.

[169] H. Li, *Latex capabilities: Complicated and important equations*, Feb. 20, 2013. [Online]. Available: https://tex.stackexchange.com/questions/99038/latex-capabilities-complicated-and-important-equations.

[170] B. Greene, *Quantum mechanics in a nutshell*, Apr. 4, 2021. [Online]. Available: https://twitter.com/bgreene/status/1378902329609613312.

[171] yourlazyphysicist, *Question in String Theory / Mass of States / Number Operator*, Nov. 30, 2017. [Online]. Available: https://math.stackexchange.com/questions/2544829/question-in-string-theory-mass-of-states-number-operator.

[172] Wikipedia contributors, *Lilypond*, version 1031722352, Jan. 16, 2022. [Online]. Available: https://en.wikipedia.org/w/index.php?title=LilyPond&oldid=1065994922.

[173] Thesis and Dissertation Office, *Template-One.docx Microsoft Word thesis template*, The Graduate School, Purdue University, 2020. [Online]. Available: https://purdue.edu/gradschool/documents/thesis/Template-One.docx.

[174] Thesis and Dissertation Office, *Template-Two.docx Microsoft Word thesis template*, The Graduate School, Purdue University, 2020. [Online]. Available: https://purdue.edu/gradschool/documents/thesis/Template-Two.docx.

[175] Thesis and Dissertation Office, *Template-Three.docx Microsoft Word thesis template*, The Graduate School, Purdue University, 2020. [Online]. Available: https://purdue.edu/gradschool/documents/thesis/Template-Three.docx.

[176] K. Osworth. “Why you should include a colophon in your book.” (Dec. 29, 2017), [Online]. Available: https://www.diggypod.com/blog/colophon.

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`.

```
\chapter{ABOUT THE APPENDICES}

% Use single spacing in the appendices from now on to save space.
\ZZbaselinestretch{1}

\textcolor{red}{%
  \textbf{%
     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
\verb+\begin{VerbatimOut}{z.out}+
then has the \LaTeX\ input for the example,
% Don't literally end VerbatimOut on next line.
and ends with {\tt \char'134 end\char'173 VerbatimOut\char'175},
followed by a blank line,
followed by a line that begins with
|\My|.

```

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.

```
\section{Paragraphs}

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

This is the second paragraph.

\section{Section Heading}

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


\subsection{Subsection heading}

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


\subsubsection{Subsubsection heading}

This is a sentence.
This is a sentence.
This is a sentence.
This is a sentence.
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 ~ 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: α, β, and γ. See how the line gets split and the γ is at the beginning of the line?

This text is the correct length to show what happens with and without ties: α, β, and γ. See how the line gets compressed a little bit so the γ is not at the beginning of the line?

```
\section{Text math}

If items in a list are narrow like these Greek characters,\\
    \I2 \verb+$\alpha$, $\beta$, and $\gamma$+\\
I'd input the line like this\\
    \I2 \verb+$\alpha$,~$\beta$, and~$\gamma$+\\
where the \verb+~+ is a tie
that ties together what's before and after it on the same line of the output
\cite[page~92]{knuth2012}.

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?
```

B. BUGS

This appendix lists all bugs/comments/issues/etc. under the generic name 'bug'. Each bug is assigned a number when I learn of it. Bug numbers are 1, 2, ... I started keeping track of bugs in this fashion on February 26, 2022, and some previously known bugs are included in this list. A color indicates a bug's priority:

Priority	Color
high or easy	red
medium	yellow
low	green
waiting on someone else	black
done	black
not assigned yet	gray

See ap-bugs.tex file for the LaTeX input for this appendix.

B.1 These bugs need to be looked at

BUG 1. Table of Contents is double-spaced instead of 1½ spacing. Tighten up section and less significant heading spacing?
Reported by Anita Adams Sale on 2021-03-17 at 11:16.

BUG 2. List of Figures indented ≈¼ inch more than List of Tables.
Reported by Anita Adams Sale on 2021-03-17 at 11:16. Still happening on 2021-11-30. Looked ok on 2022-08-26 but I think this problem is probably intermittent. Keep Ashlee Messersmith, Anita Adams Sale, and Sherrie Tucker informed.

BUG 6. APA reference style indents references too far on left.
Reported by Mark Senn on 2021-04-08 at 21:42.

BUG 8. Use "Last Accessed: yyyy-mm-dd." urldate in bibliography.
Reported by Mark Senn on 2021-04-19 at 17:05.

BUG 9. Check that `@{}` is before the left column and after the right column in all tables.
Reported by Mark Senn on 2021-04-19 at 21:32.

BUG 11. Bibliography change: Change, for example, "Acoustical Science and Technology, vol. 23, no. 1" to "Acoustical Science and Technology **23** (**1**)".
Reported by Daniel Joesph Carr on 2021-06-16 at 09:33.

BUG 12. Bibliography change: Change, for example, `M.~Abramowitz and I.A.~Stegun, Eds.`, to `M.~Abramowitz and I.A.~Stegun, editors,`.
Reported by Daniel Joesph Carr on 2021-06-16 at 09:33.

BUG 13. Headings containing a SmallCaps font do not work.
Reported by Javad (Nima) Darivandpour on 2021-06-29 at 10:25. See R.5.

BUG 14. On Overleaf only, when using `\def\ZZshowtimestamp{true}`, the time and sometimes the date are wrong at the top of the page.
Reported by Mark Senn on 2022-02-25 at 08:36. This might be due to using `\ExplSyntaxOn` ... `\ExplSyntaxOff` and having : and/or other characters having the wrong catcode.

BUG 15. 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.
Reported by Mark Senn on unknown date.

BUG 19. `Bibliography` and `References` missing from navigation panel.
Reported by Mark Senn on 2022-02-28 at 12:11.
REFERENCES was in navigation panel on 2022-08-26.

BUG 20. `Bibliography` and `References` should be in all caps.
Reported by Mark Senn on 2022-02-28 at 12:13.
REFERENCES was in all caps on 2022-08-26.

BUG 21. IE students should be able to specify IEEE or APA bibliography format.
Reported by Patrick Brunese on 2022-03-04.

B.2 These bugs are waiting on a reply from someone other than Mark Senn

BUG 10. Using `linktoc = section` does not work with captions with `\frac`.
Reported by Mark Senn on 2021-05-27 at 13:09. In the short-term, check with Ashlee Messersmith if `linktoc = page` can be used. If that's ok make the change and look into changing captions from my code to LaTeX's code. Waiting on Ashlee Messersmith.

B.3 These bugs have been rejected or fixed

BUG 3. Use "Last Accessed: dd/mm/yy." urldate in bibliography.
Reported by Priyank Kalgaonkar on 2021-04-06 at 15:58.
Answered by Mark Senn on 2022-02-27 at 14:32.
The United States uses mm/dd/yy and other countries use dd/mm/yy [16]. I recommend using what your bibliography style defines or the unambiguous ISO 8601 standard yyyy-mm-dd [17].

BUG 4. Change citation, e.g., `[6], [71]` to `[6,71]`.
Reported by Mark Senn on 2021-04-07. Fixed on 2022-04-14. Tested ok on 2022-04-14.

BUG 5. Change citation, e.g., `[6], [7], [8]` to `[6-8]`.
Reported by Mark Senn on 2021-04-07. Fixed on 2022-04-14. Tested ok on 2022-04-14.

BUG 7. Non-nested description environments have bold items. Nested description environments have non-bold items. How come? Are the indentations correct?
Reported by Mark Senn on 2021-04-09 at 16:49. Tested ok on 2021-05-31.

BUG 16. Add DTECH degree.
Reported by Mark Senn on unknown date.
Program “Technology” and degree “Doctor of Technology” worked ok on 2022-08-26.

BUG 17. Allow , (comma) in `\title`.
Reported by Mark Senn on unknown date. Tested ok on 2021-11-30.

BUG 18. Allow \\ in `\title`.
Reported by Mark Senn on unknown date. Tested ok on 2021-11-30.

C. CHECK MARGINS

```
\chapter{CHECK MARGINS}
```

This is a sentence. This

is a sentence. This is a sentence.

```
\MyRepeat{This is a sentence. }{300}
```

D. CHAPTER APPENDICES

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

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

I suggest only using `\chapterappendix` or `\chapterappendices` in chapters—using them in appendices is too confusing.

```
\chapter{CHAPTER APPENDICES}

Using |\chapterappendix|
or |\chapterappendices|
in a chapter will number sections,
for example,
1.1,
1.2,
\ldots,
1.A,
1.B,
\ldots\,.

Using |\chapterappendix|
or |\chapterappendices|
in an appendix will number sections,
for example,
A.1,
A.2,
\ldots,
A.A,
A.B,
\ldots\,.

I suggest only using |\chapterappendix|
or |\chapterappendices| in chapters---%
using them in appendices is too confusing.
```

D.1 This is a section heading

This is a paragraph.

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

D.A This is a chapter appendix

This is a paragraph.

```
\newpage


\section{This is a section heading}

This is a paragraph.

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


\chapterappendix


\section{This is a chapter appendix}

This is a paragraph.
```

E. CITATIONS AND REFERENCES

```
\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.

```

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.
```

E.1 Citations

```


\section{Citations}
```

For LaTeX answers I refer to [5] and then to [18] or [19]. [19] is an update to [20].

```
For \LaTeX\ answers I refer to
\cite{lamport1994}
and then to
\cite{goossens1994}
or
\cite{kopka1999}.
\cite{kopka1999}
is an update to
\cite{kopka1995}.
```

Here is an example .bib file entry:

```
@misc{example2020,
  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\FigureDash 0\FigureDash 000\FigureDash 00000\FigureDash 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},
}
```

```

Here is an example .bib file entry:

{\footnotesize
\begin{verbatim}
@misc{example2020,
```

```
  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\FigureDash 0\FigureDash 000\FigureDash 00000\FigureDash 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},
}
\end{verbatim}
}
```

PurdueThesis only uses BibLaTeX. Here are some example BibLaTeX citations for your document.

Input	Output
\cite{example2020}	[21]
\cite*{example2020}	[21]
\citeauthor{example2020}	Anteater, Bear, Cheetah, *et al.*
\citeauthor*{example2020}	Anteater *et al.*
\citedate{example2020}	Oct. 27, 2020
\citetitle{example2020}	*An Imaginary Document Not About Mark Senn or NASA*
\citetitle*{example2020}	*An Imaginary Document Not About Mark Senn or NASA*
\citeurl{example2020}	https://bogus.com/bogus.html
\citeyear{example2020}	2020
\parencite{example2020}	[21]
\textcite{example2020}	Anteater, Bear, Cheetah, *et al.* [21]

```
\PurdueThesisLogo\ only uses \BibLaTeXLogo.
Here are some example \BibLaTeXLogo\ citations for your document.

\begin{tabular}{@{}ll@{}}
  \bf Input&                          \bf Output\\
  \verb+\cite{example2020}+&          \cite{example2020}\\
  \verb+\cite*{example2020}+&         \cite*{example2020}\\
  \verb+\citeauthor{example2020}+&    \citeauthor{example2020}\\
  \verb+\citeauthor*{example2020}+&   \citeauthor*{example2020}\\
  \verb+\citedate{example2020}+&      \citedate{example2020}\\
  \verb+\citetitle{example2020}+&     \citetitle{example2020}\\
  \verb+\citetitle*{example2020}+&    \citetitle*{example2020}\\
  \verb+\citeurl{example2020}+&       \citeurl{example2020}\\
  \verb+\citeyear{example2020}+&      \citeyear{example2020}\\
  \verb+\parencite{example2020}+&     \parencite{example2020}\\
  \verb+\textcite{example2020}+&      \textcite{example2020}\\
\end{tabular}
```

E.2 References

```


\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 [22], [23], and [24] 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
2  Emily Spreen wrote that the following URLs are invisible in the PDF file.
3  They worked fine for me on 2021-04-08.
4  See \cite{hambleton}, \cite{gerstenmaier}, and \cite{gerstenmaier2} in the REFERENCES.
5
6  {\footnotesize
7  \begin{verbatim}
8  @misc{hambleton,
9    key = {Deep Space Gateway},
10   title = {{Deep Space Gateway to Open Opportunities for Distant Destinations}},
11   note = {Editor: Kathryn Hambleton},
12   year = {2018},
13   month = {August 24,},
14   howpublished = {\url{https://www.nasa.gov/feature/deep-space-gateway-to-open-...}},
15   organization = {NASA},
16 }
17 \end{verbatim}
18 }
19
20 {\footnotesize
21 \begin{verbatim}
22 @misc{gerstenmaier,
23   author = {William H. Gerstenmaier},
24   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},
}
\end{verbatim}
}

I suggest using the following
(added a '2' to the key so they'd have separate entries in the references.).
{\footnotesize
\begin{verbatim}
@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},
}
\end{verbatim}
}
```

F. COMMON MISTAKES

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

F.1 Headings

Farkas [25, 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.

```
\chapter{COMMON MISTAKES}

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


\section{Headings}

\textcite[page~289]{farkas2011}
wrote

\begin{quotation}
  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.
  \begin{quotation}
    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.
  \end{quotation}
\end{quotation}
```

F.2 Mathematics

F.2.1 Put a little extra horizontal space before dx

```

```

```
\section{Mathematics}

\subsection{Put a little extra horizontal space before dx}
```

F.3 Text

```


\section{Text}
```

F.3.1 e.g.,

e.g.

"e.g." should always be followed by a comma.

```

\subsection{e.g.,}
\ix{e.g.}

``e.g.'' should always be followed by a comma.
```

F.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—LaTeX 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

```

\subsection{``et al.'' is an abbreviation}
\ix{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:\\[6pt]
\indent\indent
\begin{tabular}{@{}ll@{}}
  input&   \verb+Thun et al.~used data from Santa Claus.+\\
  output&  Thun et al.~used data from Santa Claus.\\
```

```
    comment& my recommendation\\[6pt]
    input&   \verb+Thun et al. used data from Santa Claus.+\\
    output&  Thun et al. used data from Santa Claus.\\
    comment& too much space after period---\LaTeX\ thinks period is end of sentence\\[6pt]
    input&   \verb+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\\
  \end{tabular}
```

F.3.3 i.e.,

i.e.

"i.e." should always be followed by a comma.

```

  \subsection{i.e.,}
  \ix{i.e.}

  ``i.e.'' should always be followed by a comma.
```

G. 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.

```
\chapter{DEFINING COMMANDS}

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

\renewcommand{\t}[2]
{% The "{%" hides the space caused by the newline.  LaTeX ignores leading spaces on a line.
  Editors recommend that a #1 should never be
  followed by a #2 without some intervening text.
}

\t{chapter title}{section heading}
I suggest writing for readers.
Break the rules if necessary.
```

H. FIGURES

```
\chapter{FIGURES}
```

The `h` specifier used in all the examples below tells 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!]`".

```

The
\verb+h+
specifier used in all the examples below
tells \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,
``\verb+\begin{figure}[htbp!]+''.
```

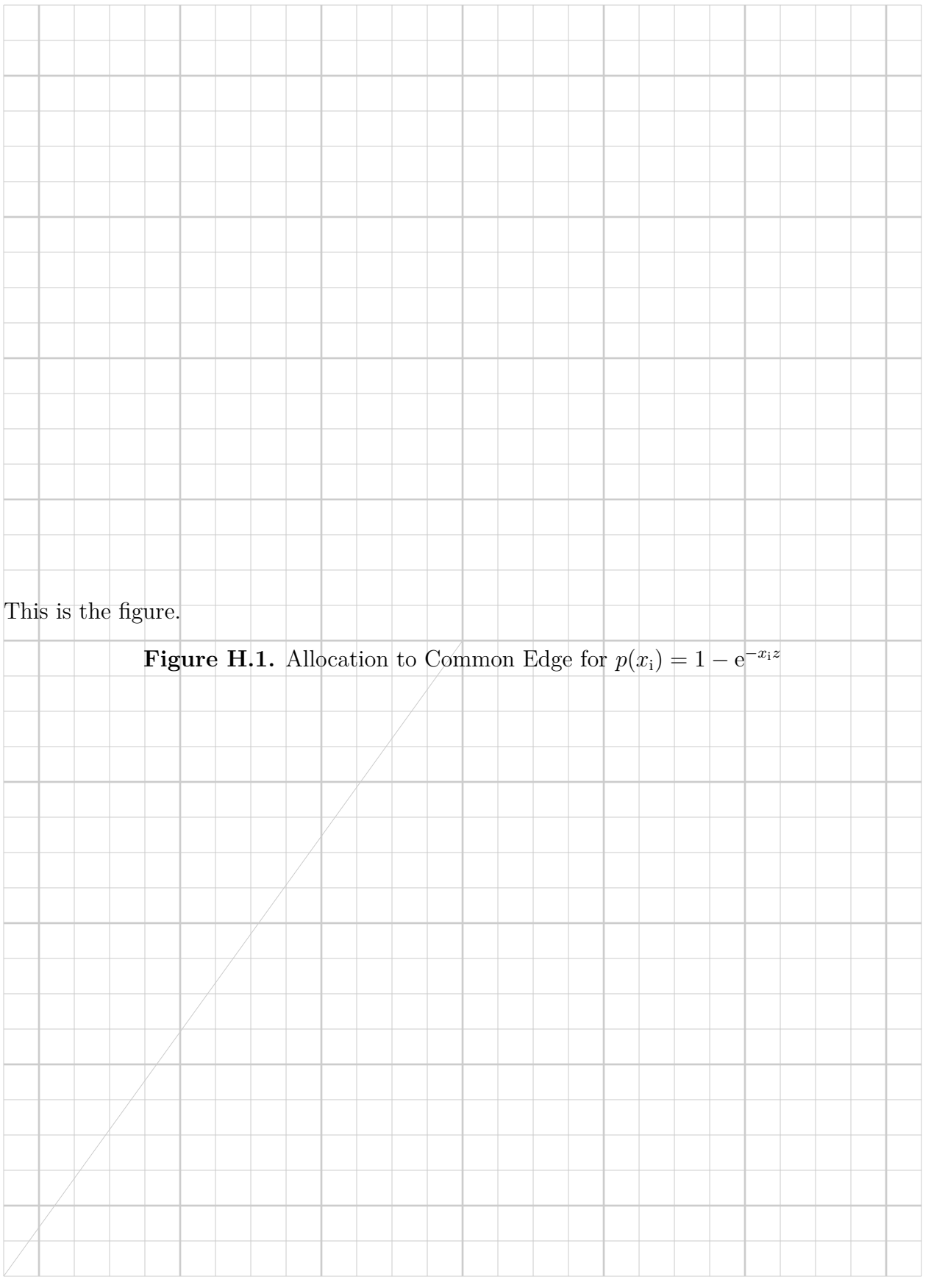
The complete list of figure placement specifiers:

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

```

The complete list of figure placement specifiers:
\vspace*{6pt}
\begin{center}
  \begin{tabular}{@{}ll@{}}
    \toprule
    \bf Specifier& \bf Description\\
    \midrule
    \noalign{\vspace*{2pt}}
    \tt b& bottom of page\\
    \tt h& here on page\\
    \tt p& on separate page of figures\\
    \tt t& top of page\\
    \tt !& try hard to put figure as early as possible\\
    \bottomrule
  \end{tabular}
\end{center}
\index{figure!placement specifiers (\verb+b+, \verb+h+, \verb+p+, \verb+t+, {\tt \char'041})}
\index{\verb+\begin{tabular}+}
```

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. This is the first paragraph.

```

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



This is the figure.

Figure H.1. Allocation to Common Edge for $p(x_{\mathrm{i}}) = 1 - \mathrm{e}^{-x_{\mathrm{i}} z}$

```
\begin{figure}
  This is the figure.
  \caption{%
    Allocation to Common Edge for
    \(p(x_i) = 1-e^{-x_iz}\)% \frac{-x_i}z}\)%
  }
\end{figure}
```

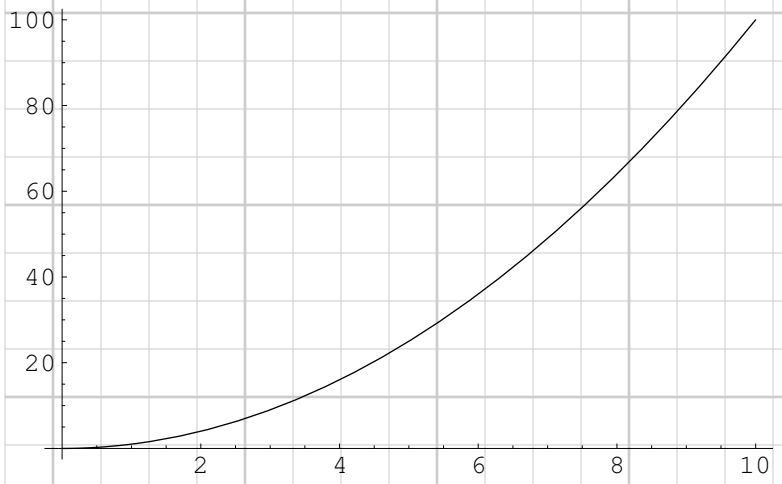


Figure H.2. By default figures are not centered. This is a long caption to demonstrate that captions are single spaced. This is a long caption to demonstrate that captions are single spaced.

```
\begin{figure}[ht]
  \includegraphics{gr-plot.pdf}
  \caption
  {%
    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.%
  }
  \label{fi:not-centered}
\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.

```
\MyRepeat{This is the second paragraph.  }{10}
```

```
\begin{figure}[ht]
  \centering
  \includegraphics{gr-plot.pdf}
  \caption{Use {\tt \char'134centering\/} to center figures.}
  \label{fi:centered}
\end{figure}
```

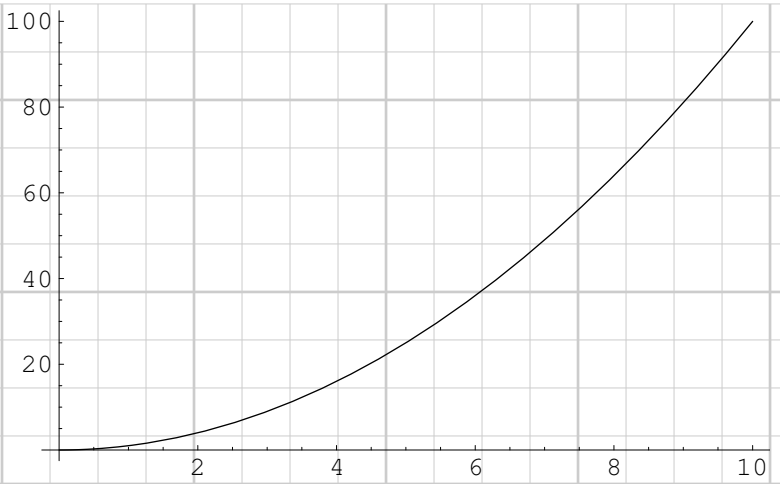


Figure H.3. Use `\centering` to center figures.

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.

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

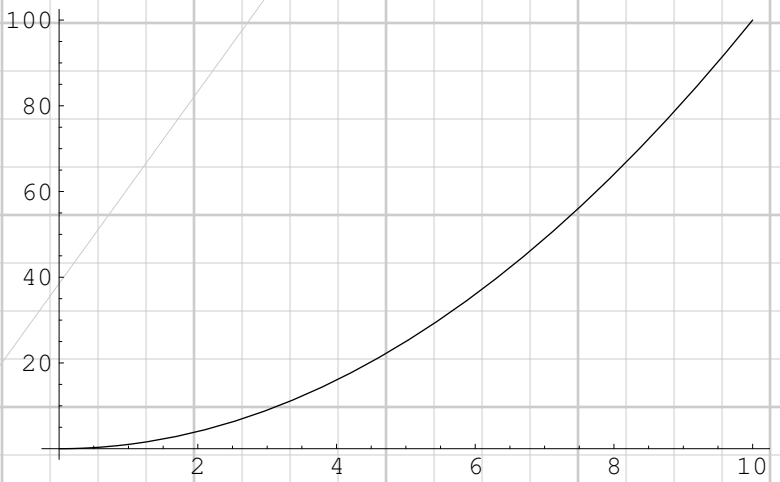


Figure H.4. This is another figuure.

```
1
2  \begin{figure}[ht]
```

```
    \centering
    \includegraphics{gr-plot.pdf}
    \caption{This is another figuure.}
    \label{fi:another}
  \end{figure}
```

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.

```

  \MyRepeat{This is the fourth paragraph.  }{10}
```

First subfigure. (a) First subcaption.

Second subfigure. (b) Second subcaption.

Figure H.5. This figure has two subfigures arranged horizontally.

figure!subfigures!1 row × 2 columns

```

  % See pages 4--5 of
  %   http://mirrors.ibiblio.org/CTAN/macros/latex/contrib/caption/subcaption.pdf
  % for how to use \subcaptionbox.
  \begin{figure}[ht]
    % Center the entire figure (containing the two subfigures).
    \centering
      % The \subcaptionbox for the first subfigure.
      \subcaptionbox
        % The first subcaption with a \label.
        % Use \ref{sf:two-parts-a} to print the subcaption number.
        {First subcaption.\label{sf:two-parts-a}}%
        % The first subfigure is this wide.
        [2in]%
        % This is the first subfigure.
        % You'll usually use an \includegraphics{filename}
        % inside the braces on the next line.
        {\bfseries First subfigure.}%
      % Put 0.5 inches of blank space between the subfigures.
      \hskip 0.5truein
      \subcaptionbox
        {Second subcaption.\label{sf:two-parts-b}}%
        [2in]%
        {\bfseries Second subfigure.}%
      % The caption for the entire figure (containing two subfigures).
      \caption{This figure has two subfigures arranged horizontally.}
      % The label for the entire figure.
      \label{fi:two-horizontal-parts}
  \end{figure}
  \ix{figure!subfigures!\(\text{1 row} \times \text{2 columns}\)}
```

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.

First subfigure.

(a) First subcaption.

Second subfigure.

(b) Second subcaption.

Figure H.6. This figure has two subfigures arranged vertically.

```

\MyRepeat{This is the fifth paragraph.  }{10}
```

figure!subfigures!2 rows × 1 column

```
% See pages 4--5 of
%   http://mirrors.ibiblio.org/CTAN/macros/latex/contrib/caption/subcaption.pdf
% for how to use \subcaptionbox.
\begin{figure}[ht]
  % Center the entire figure (containing the two subfigures).
  \centering
    % The \subcaptionbox for the first subfigure.
    \vbox{\subcaptionbox  % use \vbox to stack subcaption boxes vertically
      % The first subcaption with a \label.
      % Use \ref{sf:two-vertical-parts-a} to print the subcaption number.
      {First subcaption.\label{sf:two-vertical-parts-a}}
      [2in]%
      {\bfseries First subfigure.}}%
    % Put \baselineskip blank space between the subfigures.
    \vspace*{\baselineskip}
    % The \subcaptionbox for the second subfigure.
    \vbox{\subcaptionbox  % use \vbox to stack subcaption boxes vertically
      {Second subcaption.\label{sf:two-vertical-parts-b}}
      [2in]%
      {\bfseries Second subfigure.}}%
  \caption{This figure has two subfigures arranged vertically.}
  \label{fi:two-vertical-parts}
\end{figure}
\ix{figure!subfigures!\(\text{2 rows} \times \text{1 column}\)}
```

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.

```

\MyRepeat{This is the sixth paragraph.  }{10}
```

figure!subfigures!2 rows × 2 columns

```
% See pages 4--5 of
%   http://mirrors.ibiblio.org/CTAN/macros/latex/contrib/caption/subcaption.pdf
% for how to use \subcaptionbox.
\begin{figure}[ht]
  \centering
    \subcaptionbox
```

First subfigure.
(a) First subcaption.

Second subfigure.
(b) Second subcaption.

Third subfigure.
(c) Third subcaption.

Fourth subfigure.
(d) Fourth subcaption.

Figure H.7. This figure has four parts.

```
    {First subcaption.\label{sf:four-parts-a}}
    [2in]%
    {\bfseries First subfigure.}%
  \hskip 0.5truein
  \subcaptionbox
    {Second subcaption.\label{sf:four-parts-b}}
    [2in]%
    {\bfseries Second subfigure.}%
  \vspace*{\baselineskip}
  \subcaptionbox
    {Third subcaption.\label{sf:four-parts-c}}
    [2in]%
    {\bfseries Third subfigure.}%
  \hskip 0.5truein
  \subcaptionbox
    {Fourth subcaption.\label{sf:four-parts-d}}
    [2in]%
      {\bfseries Fourth subfigure.}%
  \caption{This figure has four parts.}
  \label{fi:four-parts}
\end{figure}
\ix{figure!subfigures!\(\text{2 rows} \times \text{2 columns}\)}
```

This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph. This is the seventh paragraph.

```

\MyRepeat{This is the seventh paragraph.  }{10}
```

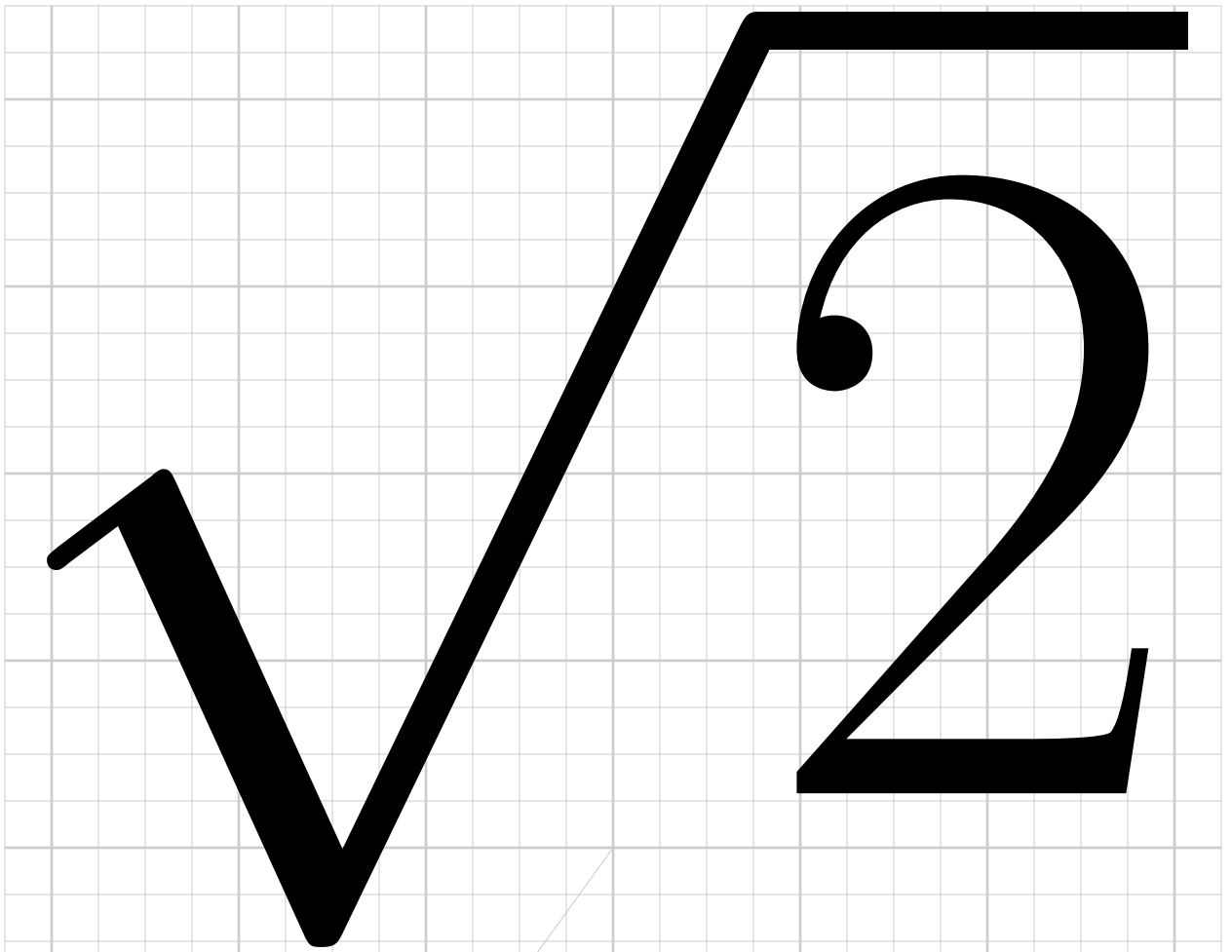
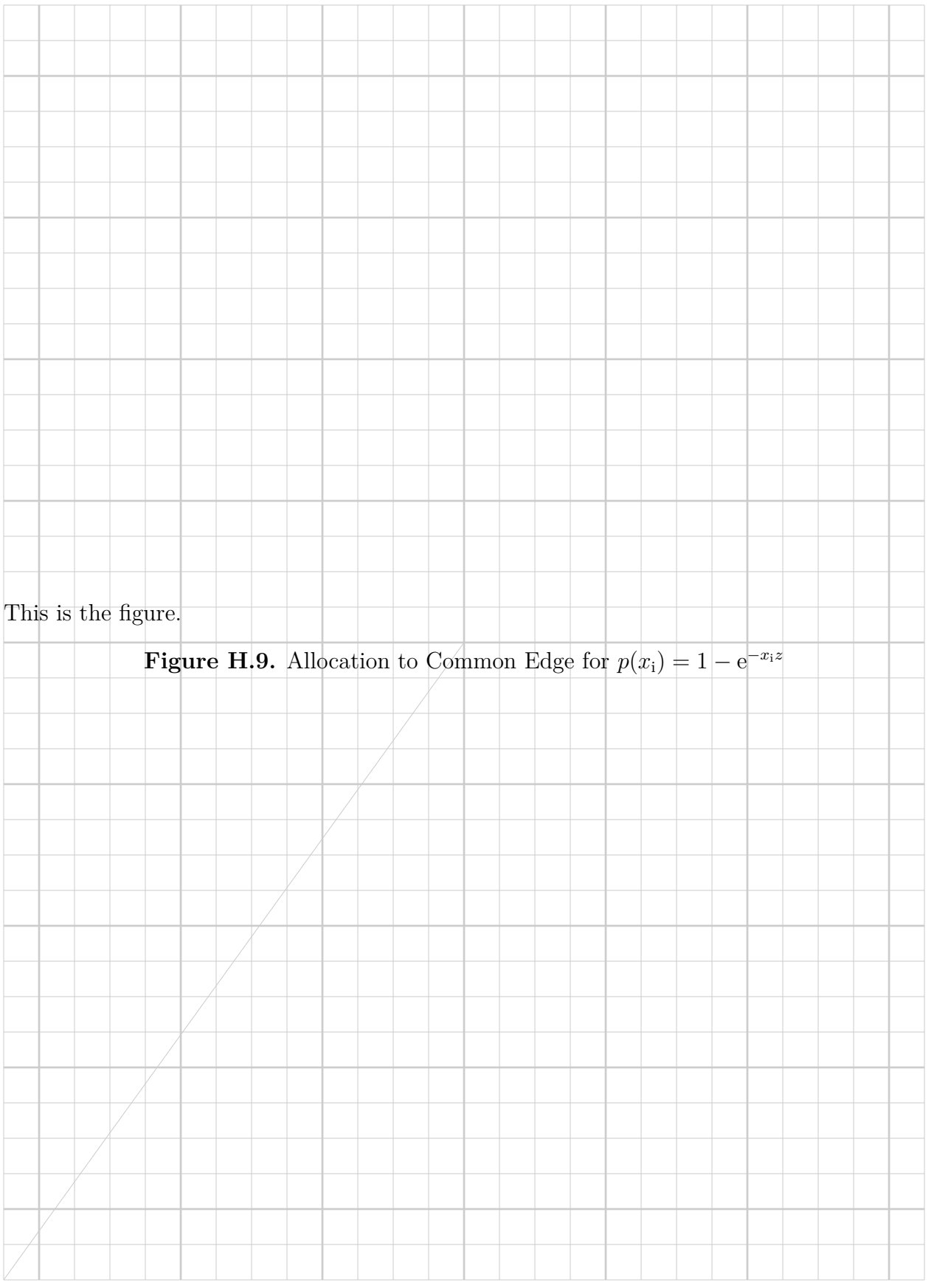


Figure H.8. A big "$\sqrt{2}$". LaTeX can make output big enough for T-shirts or posters. Square roots are printed with space before them, I put some negative horizontal space before this one to center it.

figure!$\sqrt{2}$

```
\newpage

\begin{figure}[ht]
  \centering
    % Use a 5" font.
    {\fontsize{5in}{5in}\selectfont\(\hspace*{-0.07em}\sqrt 2\)}
    \caption{%
      A big ``\(\sqrt 2\)''.
      \LaTeX\ 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.%
    }
\end{figure}
\ix{figure!\(\sqrt 2\)}
```

subfigure|seefigure, subfigures



This is the figure.

Figure H.9. Allocation to Common Edge for $p(x_\mathrm{i}) = 1 - \mathrm{e}^{-x_\mathrm{i} z}$

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

Figure H.10. Test figure 1 of 20.

Figure H.11. Test figure 2 of 20.

Figure H.12. Test figure 3 of 20.

Figure H.13. Test figure 4 of 20.

Figure H.14. Test figure 5 of 20.

Figure H.15. Test figure 6 of 20.

```
\newpage

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

\begin{figure}[ht]
  \centering
  \includegraphics[scale=0.5]{gr-metapost-tally-01.pdf}
  \caption{Test figure 1 of 20.}
  \label{fi:1of20}
\end{figure}

\begin{figure}[ht]
  \centering
```

Figure H.16. Test figure 7 of 20.

Figure H.17. Test figure 8 of 20.

Figure H.18. Test figure 9 of 20.

Figure H.19. Test figure 10 of 20.

Figure H.20. Test figure 11 of 20.

Figure H.21. Test figure 12 of 20.

Figure H.22. Test figure 13 of 20.

```
    \includegraphics[scale=0.5]{gr-metapost-tally-02.pdf}
    \caption{Test figure 2 of 20.}
    \label{fi:2of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-03.pdf}
    \caption{Test figure 3 of 20.}
    \label{fi:3of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-04.pdf}
    \caption{Test figure 4 of 20.}
    \label{fi:4of20}
  \end{figure}
```

Figure H.23. Test figure 14 of 20.

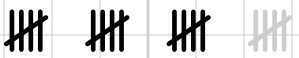


Figure H.24. Test figure 15 of 20.

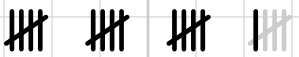


Figure H.25. Test figure 16 of 20.

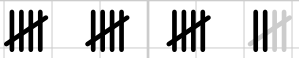


Figure H.26. Test figure 17 of 20.

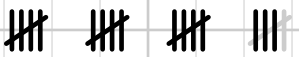


Figure H.27. Test figure 18 of 20.

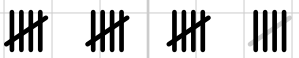


Figure H.28. Test figure 19 of 20.

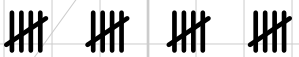


Figure H.29. Test figure 20 of 20.

```
34
35  \begin{figure}[ht]
36    \centering
37    \includegraphics[scale=0.5]{gr-metapost-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-metapost-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-metapost-tally-07.pdf}
```

```
    \caption{Test figure 7 of 20.}
    \label{fi:7of20centered7}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-08.pdf}
    \caption{Test figure 8 of 20.}
    \label{fi:8of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-09.pdf}
    \caption{Test figure 9 of 20.}
    \label{fi:9of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-10.pdf}
    \caption{Test figure 10 of 20.}
    \label{fi:10of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-11.pdf}
    \caption{Test figure 11 of 20.}
    \label{fi:11of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-12.pdf}
    \caption{Test figure 12 of 20.}
    \label{fi:12of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-13.pdf}
    \caption{Test figure 13 of 20.}
    \label{fi:13of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-14.pdf}
    \caption{Test figure 14 of 20.}
    \label{fi:14of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-15.pdf}
    \caption{Test figure 15 of 20.}
    \label{fi:15of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-16.pdf}
    \caption{Test figure 16 of 20.}
```

```
    \label{fi:16of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-17.pdf}
    \caption{Test figure 17 of 20.}
    \label{fi:17of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-18.pdf}
    \caption{Test figure 18 of 20.}
    \label{fi:18of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-19.pdf}
    \caption{Test figure 19 of 20.}
    \label{fi:19of20}
  \end{figure}

  \begin{figure}[ht]
    \centering
    \includegraphics[scale=0.5]{gr-metapost-tally-20.pdf}
    \caption{Test figure 20 of 20.}
    \label{fi:20of20}
  \end{figure}
```

I. FREQUENTLY ASKED QUESTIONS

This appendix lists all frequently asked questions. Each frequently asked question is assigned a number when I learn of it. Numbers are 1, 2, ... I started keeping track of frequently asked questions in this fashion on March 1, 2022.

Priority	Color
high or easy	red
medium	yellow
low	green
waiting on someone else	black
done	black
not assigned yet	gray

See the `ap-frequently-asked-questions.tex` file for the LaTeX input for this appendix.

I.1 These questions need to be answered

I.2 These questions are waiting on a reply from someone other than Mark Senn

I.3 These questions have been answered

The subsection headings below are what part of the document the question is about.

Everywhere

FAQ 1. The LaTeX input
(Mark Senn recommends using `\(a | b\)` instead)
gives

```
! LaTeX Error: Command \ttfamily invalid in math mode.
```

Reported by Negin Karisani.
A: In thesis.tex, change

```
\DefineShortVerb{\|} % so "|verbatim|" will be verbatim
```

to

```
% \DefineShortVerb{\|} % so "|verbatim|" will be verbatim
```

Table of Contents

FAQ 2. I want text instead of page number to be the link in the table of contents. Asked by Danushka Menikkumbura on 2022-03-11.
A: In PurdueThesis.cls change `linktoc = page` to `linktoc = section`. I do not recommend doing this because

- you'll need to put this change in new PurdueThesis.cls files in the future

- people are used to using page numbers instead of chapter/section/etc. titles for where they start

J. GRAPHICS

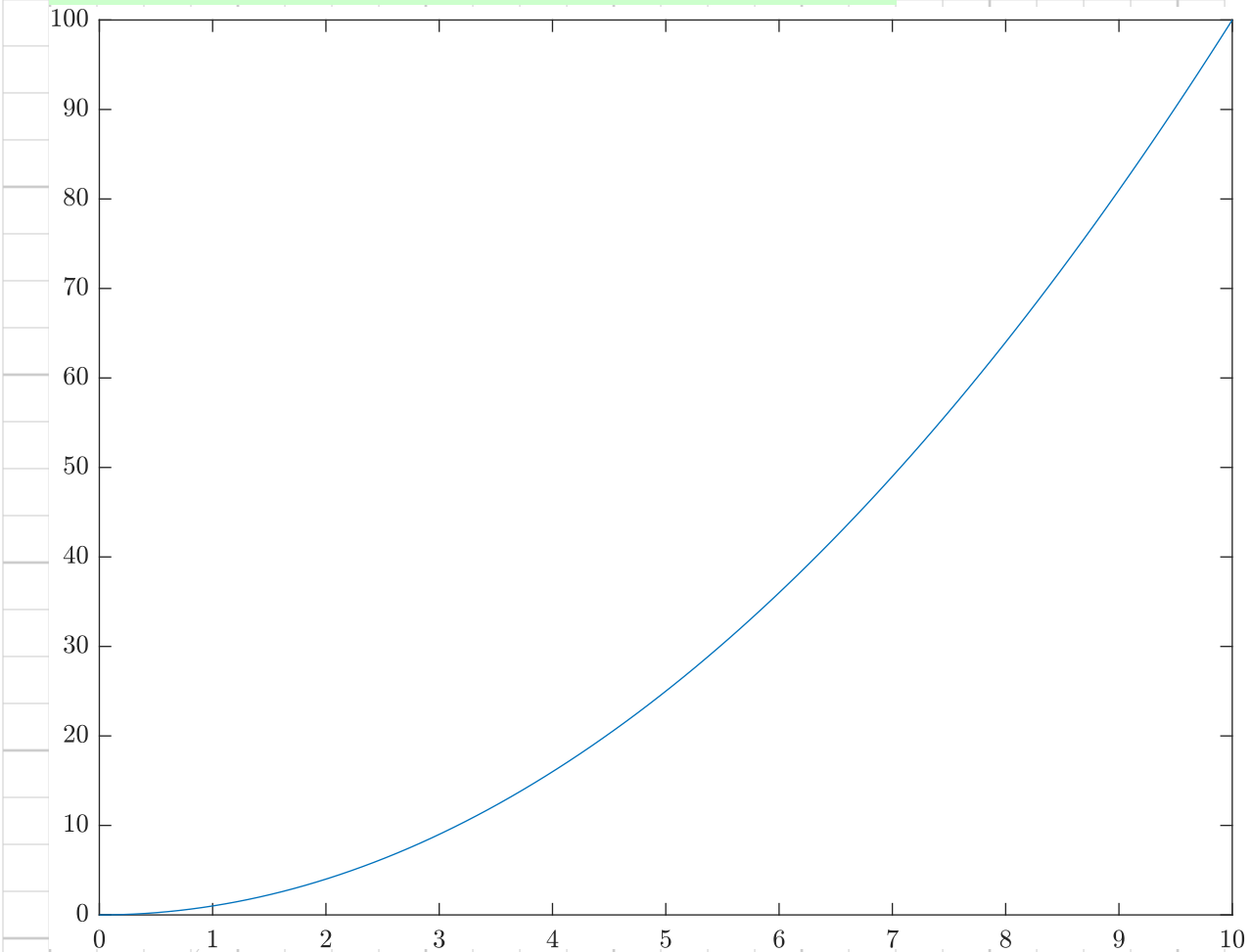
There are many ways to make graphics for LaTeX. I like to use a system that uses LaTeX fonts so the appearance of the output is professional.

```
\chapter{GRAPHICS}

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

J.1 MATLAB programming language

MATLAB programming language

By default, MATLAB supports a subset of TeX markup [26].



This is the `misc/gr_matlab.m` input file:

```
%  gr_matlab.m    2021-11-11    Mark Senn <mark@purdue.edu>

% On Linux, I typed
%     lm matlab
%     matlab -nodesktop -nosplash -r gr_matlab
% to run this program.

% See
```

```
%    https://www.mathworks.com/matlabcentral/answers/346436-how-to-use-latex-interpreter-for-xticklabels
% Do axis labels using LaTeX.
set(groot, 'defaultAxesTickLabelInterpreter', 'latex');
% Do legends using LaTeX.
set(groot, 'defaultLegendInterpreter', 'latex');
% Do text using LaTeX.
set(groot, 'defaulttextinterpreter', 'latex');

x = linspace(0,10,100);
y = x .^ 2;
plot(x, y);
saveas(gcf, '../graphics/gr-matlab.pdf');

% The following line worked for me on Linux.
!pdfcrop ../graphics/gr-matlab.pdf ../graphics/gr-matlab.pdf;

exit;
```

I typed, on Linux, **matlab -nodisplay -nodesktop -nosplash -r gr_matlab** in the `misc` subdirectory to make the `graphics/gr-matlab.pdf` output file.

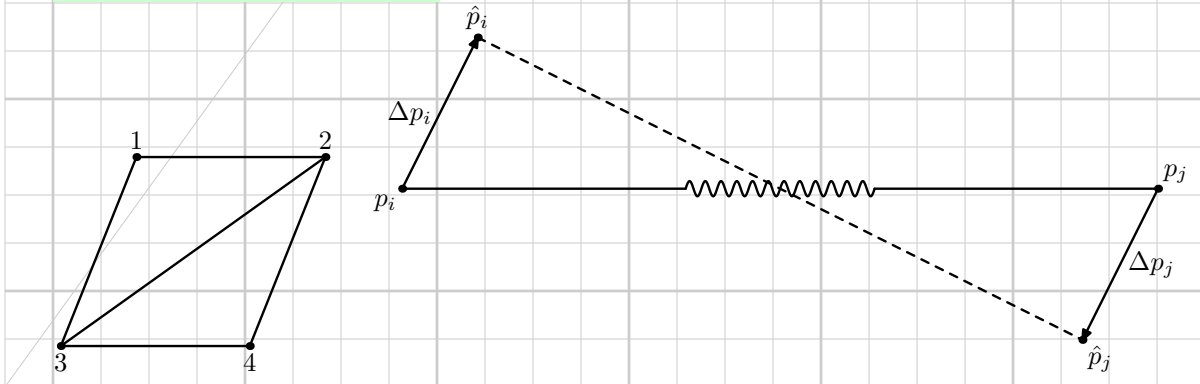
```

\section{MATLAB programming language}
\ix{MATLAB programming language}

\def\gray#1{\colorbox{gray!15}{#1}}
\def\lightred#1{\colorbox{red!15}{#1}}
\def\lightgreen#1{\colorbox{green!20}{#1}}
\lightgreen{%
  By default,
  MATLAB supports a subset of TeX markup
  \cite{mathworks-help-center-text-properties}.
}

\includegraphics{gr-matlab.pdf}

This is the |misc/gr_matlab.m| input file:
\MyI{misc/gr_matlab.m}

I typed, on Linux,
\Shell{matlab -nodisplay -nodesktop -nosplash -r gr\_matlab}
in the |misc| subdirectory
to make the |graphics/gr-matlab.pdf| output file.
```

J.2 METAPOST programming language

METAPOST

MetaPost

MetaPost uses LaTeX fonts.



This is the misc/gr-metapost-kim.mp input file:

```
%  gr-metapost.mp  2021-11-16  Mark Senn  https://bit.ly/marksenn
%
%  Thanks to Yanghyun Kim for asking how to do this figure.
%

prologues := 3;  % make .eps files with embedded fonts

outputtemplate := "%j-%c.mps"; % make output files gr-metapost-1.mps and gr-metapost-2.mps

beginfig(1);
    pickup pencircle scaled 1pt;  % line width

    u := 0.5cm;  % unit size

    deltax := 5u;
    deltay := 5u;
    xoff   := 2u;

    pair ll, lr, ul, ur;
    ll := (0, 0);                % lower left point
    lr := ll + (deltax, 0);      % lower right point
    ul := ll + (xoff,   deltay); % upper left point
    ur := ul + (deltax, 0);      % upper right point

    draw ll--lr--ur--ul--ll;
    draw ll--ur;

    dotlabel.top(btex 1 etex, ul);  % top label
    dotlabel.top(btex 2 etex, ur);  % top label
    dotlabel.bot(btex 3 etex, ll);  % bottom label
    dotlabel.bot(btex 4 etex, lr);  % bottom label
endfig;

beginfig(2);
    pickup pencircle scaled 1pt;  % line width

    u := 2cm;  % unit size

    deltax := 5u;
    deltay := 1u;
    xoff   := 0.5u;

    pair ll, lr, ul, ur;
    ll := (0, 0);                % lower left point
    ur := ll + (deltax, 0);      % upper right point
    ul := ll + (xoff,   deltay); % upper left point
    lr := ur + (-xoff,  -deltay); % lower right point

    dotlabel.llft(btex $p_i$ etex,       ll);         % lower left label
    label.lft(    btex $\Delta p_i$ etex, 1/2[ll,ul]); % left label
    dotlabel.top( btex ${\hat p}_i$ etex, ul);         % upper left label

    dotlabel.lrt(btex ${\hat p}_j$ etex, lr);          % lower rigt label
    label.rt(    btex $\Delta p_j$ etex, 1/2[lr,ur]);  % right label
    dotlabel.urt(btex $p_j$ etex,        ur);          % upper right label

    drawarrow ll--ul;
    drawarrow ur--lr;
    draw ul--lr dashed evenly;
    draw ll--3/8[ll,ur];
    draw 3/8[ll,ur]{up}
        for  i = 0 upto 360:
```

```
            ..3/8[ll,ur] + ((i/360)*(deltax/4), (u/20)*sind(12i))
        endfor;
    draw 5/8[ll,ur]--ur;
endfig;

end.
```

I typed, on Linux,

```
mpost gr-metapost-kim
epstopdf gr-metapost-kim-1.mps; epstopdf gr-metapost-kim-2.mps
mv -i gr-metapost-kim-1.pdf gr-metapost-kim-2.pdf ../graphics
```

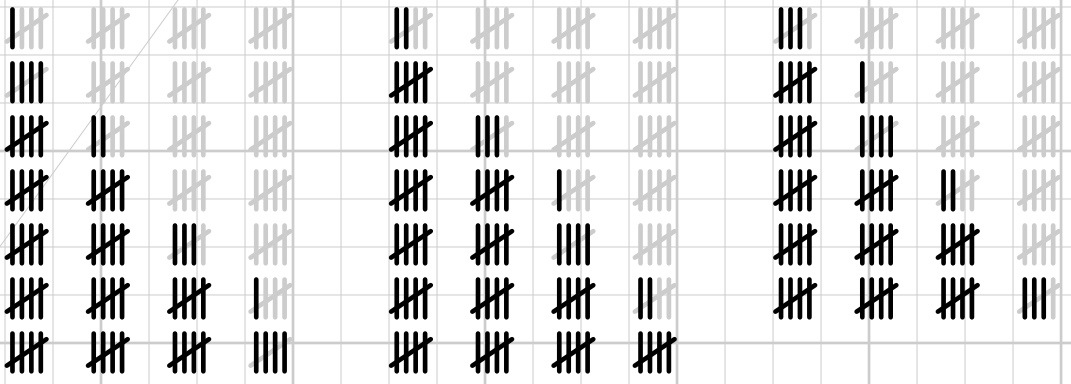
to run MetaPost and make two PDF files, `gr-metapost-kim-1.pdf` and `gr-metapost-kim-2.pdf`, and move them to the graphics subfolder.

```

\section{\protect\METAPOSTLogo\ programming language}
\index{METAPOST@\METAPOSTLogo}
\todoindex{\METAPOSTLogo}

\lightgreen{\MetaPostLogo\ uses \LaTeX\ fonts.}
\todoindex{\MetaPostLogo}

\includegraphics{gr-metapost-kim-1.pdf}
\hspace*{0.1truein}
\includegraphics{gr-metapost-kim-2.pdf}

This is the |misc/gr-metapost-kim.mp| input file:
\MyI{misc/gr-metapost-kim.mp}

I typed, on Linux,\\
\hspace*{3\parindent}\Shell{mpost gr-metapost-kim}\\
\hspace*{3\parindent}\Shell{epstopdf gr-metapost-kim-1.mps;  epstopdf gr-metapost-kim-2.mps}\\
\hspace*{3\parindent}\Shell{mv -i gr-metapost-kim-1.pdf gr-metapost-kim-2.pdf ../graphics}\\
to run MetaPost and make two PDF files, |gr-metapost-kim-1.pdf| and |gr-metapost-kim-2.pdf|,
and move them to the graphics subfolder.
```

J.2.1 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-metapost-tally-01.pdf` through `gr-metapost-tally-20.pdf`)



were produced by

```
%
%  gr-metapost-tally.mp    2022-01-14    Mark Senn    https://bit.ly/marksenn
%
%  Make 20 .pdf files for the tally mark representations for 1 to 20.
%
%  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.
%
%  Do these commands:
%      mpost gr-metapost-tally
%      epspdf gr-metapost-tally-1.mps;   mv gr-metapost-tally-1.pdf  gr-metapost-tally-01.pdf
%      epspdf gr-metapost-tally-2.mps;   mv gr-metapost-tally-2.pdf  gr-metapost-tally-02.pdf
%      ...
%      epspdf gr-metapost-tally-9.mps;   mv gr-metapost-tally-9.pdf  gr-metapost-tally-09.pdf
%      epspdf gr-metapost-tally-20.mps;  mv gr-metapost-tally-20.pdf gr-metapost-tally-20.pdf
%
%  If you use bash you can do
%      for i in $(seq 1 20); \
%          do epspdf gr-tally-$i.mps ; printf -v var "%02d" "$i"; mv gr-tally-$i.pdf gr-tally-$var.pdf; \
%      done
%  to do all the lines that start with epspdf.
%

prologues      := 3;
outputtemplate := "gr-%j-%c.mps";
outputformat   := "eps";

% Define dimensions.
adjust = 0.15cm;  % x and y adjustment
dx     = 0.25cm;  % delta x
h      = 1cm;     % tally height
s      = 1cm;     % spacing between groups of tally marks

% Define number of tally marks.
n = 20;  % number of marks

% Compute the tally mark paths.
path p[];
x := 0;  xstart := x;
for i = 1 upto n:
    if (i mod 5 = 1):
        p[i] = ((x,0)--(x,h));  x := x + dx;
    fi;
    if (i mod 5 = 2):
        p[i] = ((x,0)--(x,h));  x := x + dx;
    fi;
    if (i mod 5 = 3):
        p[i] = ((x,0)--(x,h));  x := x + dx;
    fi;
    if (i mod 5 = 4):
        p[i] = ((x,0)--(x,h));
    fi;
    if (i mod 5 = 0):
        p[i] = ((xstart-adjust,adjust)--(x+adjust,h-adjust));
        x := x + dx + adjust + s;  xstart := x;
    fi;
endfor;
show p[1];

%
%  Write the tally-*.mps files
%

for i = 1 upto n:
```

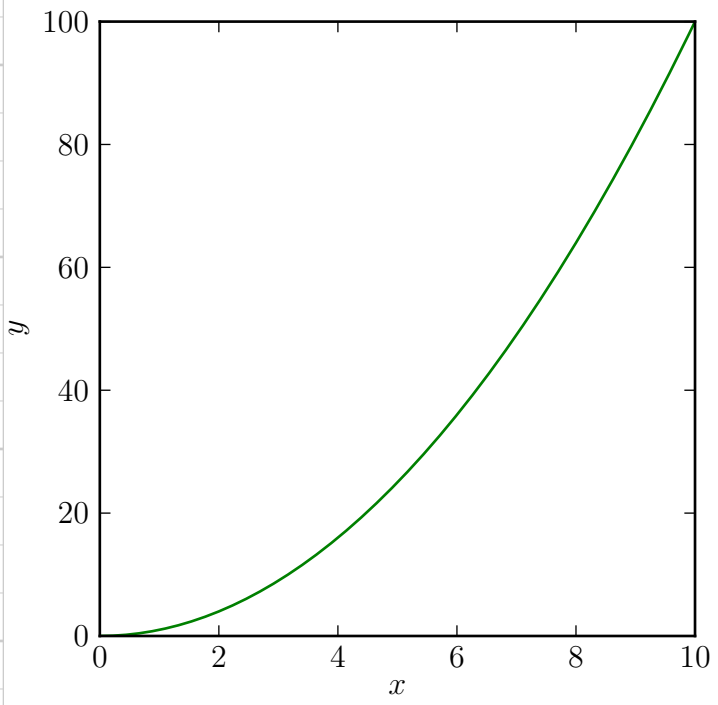
```
65
66      beginfig(i);
67
68          % Define pen---this must go between beginfig and endfig.
69          pen mypen;
70          mypen = pencircle scaled 3.5;
71          pickup mypen;
72
73          % Draw gray tally marks.
74          for j = i+1 upto n:
75              draw p[j] withcolor 0.8white;
76          endfor;
77
78          % Draw black tally marks.
79          % Do this last so the dark tally marks
80          % will be on top of the light tally marks.
81          for j = 1 upto i:
82              draw p[j] withcolor black;
83          endfor;
84
85      endfig;
86
87  endfor;
88
89  end.
```

```
1
2   \subsection{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-metapost-tally-01.pdf| through |gr-metapost-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-metapost-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/gr-metapost-tally.mp}
44
```

J.3 Python programming language

Python can be set up to use LaTeX fonts.



This is the `misc/gr-python2.py` input file:

```
1   #!/bin/python2
2
3   #  gr-python2.py    2022-02-11    Mark Senn <mark@purdue.edu>
4
5   # On Linux, I typed
6   #     ./gr-python2.py
7   # to run this program.
8
9   import matplotlib as mpl
10
11  # From https://matplotlib.org/stable/gallery/text_labels_and_annotations/tex_demo.html
12  #     You can use TeX to render all of your Matplotlib text by setting
13  #     rcParams["text.usetex"] (default: False) to True. This requires
14  #     that you have TeX and the other dependencies described in the
15  #     Text rendering With LaTeX tutorial properly installed on your
16  #     system. Matplotlib caches processed TeX expressions, so that
17  #     only the first occurrence of an expression triggers a TeX
18  #     compilation. Later occurrences reuse the rendered image from the
19  #     cache and are thus faster.
20  mpl.rcParams['text.usetex'] = True
```

```
# From https://stackoverflow.com/questions/2801882/generating-a-png-with-matplotlib-when-display-is-undefined
#     # Force matplotlib to not use any Xwindows backend.
#     matplotlib.use('Agg')
mpl.use('Agg')

import matplotlib.pyplot as plt

plt.figure(figsize=(4,4))

import numpy as np

x = [ ]
y = [ ]
for i in range(0,1001):
    x.append(i / 100.0)
    y.append((i/100.0) ** 2)

# Normally, there is extra space to the left, right, top, and bottom
# of plotted data in a graph.  This gets rid of that space.
plt.autoscale(enable=None, tight=True)

plt.plot(x, y, 'g')

plt.xlabel('$x$')
plt.ylabel('$y$')

plt.savefig('../graphics/gr-python2.pdf')
```

I typed, on Linux, **./gr-python2.py** in the misc subdirectory to make the graphics/gr-python2.pdf output file.

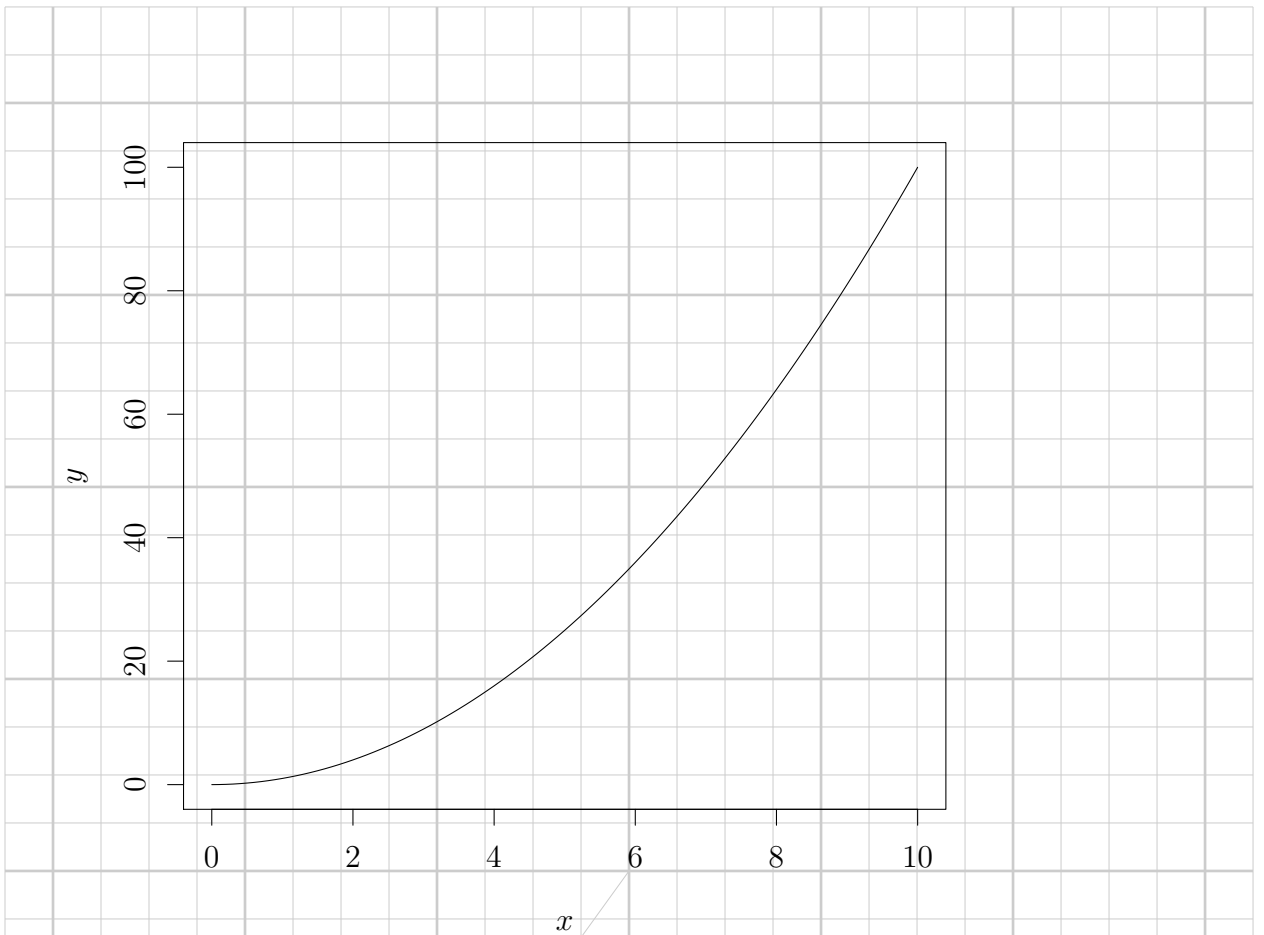
```
\section{Python programming language}
\ix{Python programming language}

\lightgreen{Python can be set up to use \LaTeX\ fonts.}

\includegraphics{gr-python2.pdf}

This is the |misc/gr-python2.py| input file:
\MyI{misc/gr-python2.py}

I typed, on Linux,
\Shell{./gr-python2.py}
in the |misc| subdirectory
to make the |graphics/gr-py|\\
|thon2.pdf| output file.
```

J.4 R programming language

R programming language

R can be set up to use LaTeX fonts.

compiled on 2022-10-13 Thursday 09:40:45



This is the `misc/gr-r.R` input file:

```
#  gr-r.R    2021-11-24    Mark Senn    https://bit.ly/marksenn

# See
#     https://texample.net/tikz/examples/tikzdevice-demo/
# for information on tikzDevice.

# Load the tikzDevice package.
# If you don't have it, install with
#     install.packages("tikzDevice", repos="http://R-Forge.R-project.org")
require(tikzDevice)

tikz(file = '../gr-r.tex', height=5, width=5)

curve(x^2, from=0, to=10, xlab="$x$", xlim=c(0,10), ylab="$y$", ylim=c(0,100))

dev.off()
```

I typed, on Linux, **`R CMD BATCH gr-r`** in the `misc` subdirectory to make the `gr-r.tex` outfile file.

```

\section{R programming language}
\ix{R programming language}

\lightgreen{R can be set up to use \LaTeX\ fonts.}
```

```

\input{gr-r.tex}

This is the |misc/gr-r.R| input file:
\MyI{misc/gr-r.R}

I typed, on Linux,
\Shell{R CMD BATCH gr-r}
in the |misc| subdirectory to make the |gr-r.tex| outfile file.
```

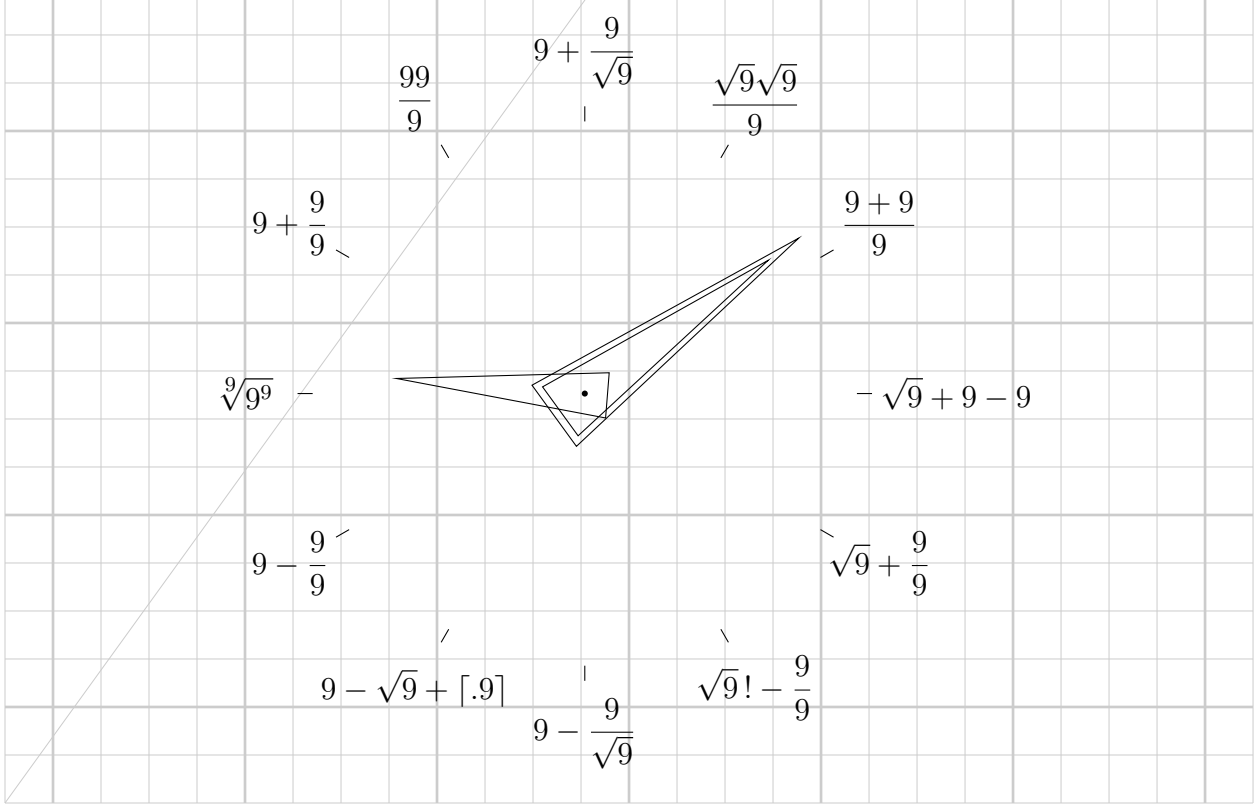
J.5 Ti*k*Z LaTeX package

TikZ uses LaTeX fonts.

```

\section{\TikZLogo\ \LaTeX\ package}
\index{TikZ@\TikZLogo\ \LaTeX\ package}
\todoindex{\TikZLogo\ \LaTeX\ package}

\lightgreen{\TikZLogo\ uses \LaTeX\ fonts.}
```

J.5.1 Clock example

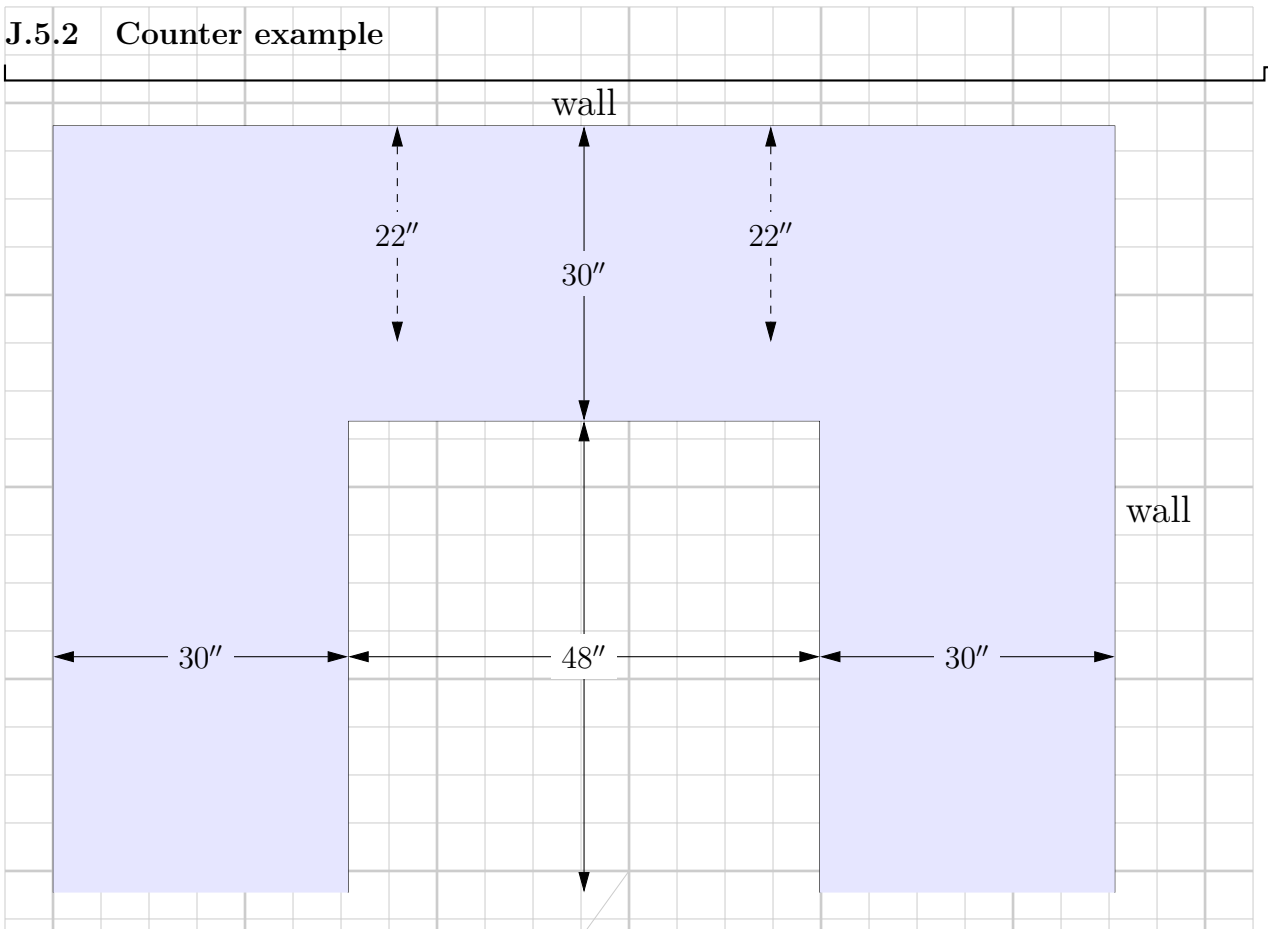

```

\subsection{Clock example}
\index{clock \TikZLogo\ example}
\todoindex{clock \TikZLogo\ example}
```



```
\index{TikZ@\TikZLogo}

\hbox to\textwidth{%
  \hfil
  % The idea for this clock was originally from a Google+ posting by Afamefuna ‘‘Ferdy’’ Ibeabuchia.
  \begin{tikzpicture}
    \def\CenterRadius{0.04cm}
    \def\InnerTickRadius{3.6cm}
    \def\OuterTickRadius{3.8cm}
    % Make \LR be an abbreviation for \LabelRadius so the
    % lines below will fit within the width of the page.
    \def\LabelRadius{4.5cm}      \let\LR=\LabelRadius
    \def\HourHandRadius{2.5cm}   \def\HourHandBase{0.3cm}
    \def\MinuteHandRadius{3cm}   \def\MinuteHandBase{0.4cm}
    \def\SecondHandRadius{3.5cm} \def\SecondHandBase{0.5cm}
    \def\DS{\displaystyle}
    \fill (0,0) circle (\CenterRadius);
    \foreach \i in {0,30,...,330}
    \draw (\i:\InnerTickRadius)--(\i:\OuterTickRadius);
    \node at (  0:\LR) {$\DS \qquad \sqrt9 + 9 - 9$};        %  3
    \node at ( 30:\LR) {$\DS \frac{9+9}9$};                  %  2
    \node at ( 60:\LR) {$\DS \frac{\sqrt9\sqrt9}9$};         %  1
    \node at ( 90:\LR) {$\DS 9 + \frac9{\sqrt9}$};           % 12
    \node at (120:\LR) {$\DS \frac{99}9$};                   % 11
    \node at (150:\LR) {$\DS 9 + \frac99$};                  % 10
    \node at (180:\LR) {$\DS \sqrt[\scriptstyle 9]{9^9}$};   %  9
    \node at (210:\LR) {$\DS 9 - \frac99$};                  %  8
    \node at (240:\LR) {$\DS 9 - \sqrt9 + \lceil.9\rceil$};  %  7
    \node at (270:\LR) {$\DS 9 - \frac9{\sqrt9}$};           %  6
    \node at (300:\LR) {$\DS \sqrt9\,! - \frac99$};          %  5
    \node at (330:\LR) {$\DS \sqrt9 + \frac99$};             %  4
    % In the following
    %   ABBREVIATION    DESCRIPTION
    %   deg             degrees
    %   min             minutes
    %   sec             seconds
    % for second hand:
    %   (9 sec/60 sec) * 360 deg = 54 deg;
    %   90 deg - 54 deg = 36 deg
    \draw[rotate around={36:(0,0)}]
      (-\SecondHandBase,\SecondHandBase) -- (\SecondHandRadius,0)
        -- (-\SecondHandBase,-\SecondHandBase) -- cycle;
    % for minute hand:
    %   (9 min/60 min) * 360 deg = 54 deg;
    %   90 deg - 54 deg = 36 deg
    \draw[rotate around={36:(0,0)}]
      (-\MinuteHandBase,\MinuteHandBase) -- (\MinuteHandRadius,0)
        -- (-\MinuteHandBase,-\MinuteHandBase) -- cycle;
    % for hour hand:
    %   (9 min * (60 sec/1 min)) + 9 sec) / 3600 sec
    %     = 549 sec / 3600 sec = 0.1525
    %   The hour hand is 0.1525 of the way from 9:00 to 10:00.
    %   Each hour is 30 degrees on the clock, so the hour hand
    %   position is
    %     30 deg * 0.1525 = 4.575 deg past 9:00
    %   180 deg - 4.575 deg = 175.425 deg
    \draw[rotate around={175.425:(0,0)}]
      (-\HourHandBase,\HourHandBase) -- (\HourHandRadius,0)
      -- (-\HourHandBase,-\HourHandBase) -- cycle;
  \end{tikzpicture}
  \hfil
}
```

J.5.2 Counter example

Counter Ti*k*Z example




```
1
2  \newpage
3
4  \subsection{Counter example}
5  \index{Counter \TikZLogo\ example}
6  \todoindex{Counter \TikZLogo\ example}
7
8  \begin{tikzpicture}[scale=0.13]
9    % Define points.
10   \coordinate   (p11) at (  0, 78);
11     \coordinate (p14) at ( 35, 78);
12     \coordinate (p15) at ( 54, 78);
13     \coordinate (p16) at ( 73, 78);
14     \coordinate (p19) at (108, 78);
15   \coordinate   (p24) at ( 35, 67);
16     \coordinate (p26) at ( 73, 67);
17   \coordinate   (p35) at ( 54, 63);
18   \coordinate   (p44) at ( 35, 56);
19     \coordinate (p46) at ( 73, 56);
20   \coordinate   (p53) at ( 30, 48);
21     \coordinate (p55) at ( 54, 48);
22     \coordinate (p57) at ( 78, 48);
23   \coordinate   (p69) at (108, 39);
24   \coordinate   (p71) at (  0, 24);
25     \coordinate (p72) at ( 15, 24);
26     \coordinate (p73) at ( 30, 24);
27     \coordinate (p75) at ( 54, 24);
28     \coordinate (p77) at ( 78, 24);
29     \coordinate (p78) at ( 93, 24);
30     \coordinate (p79) at (108, 24);
```

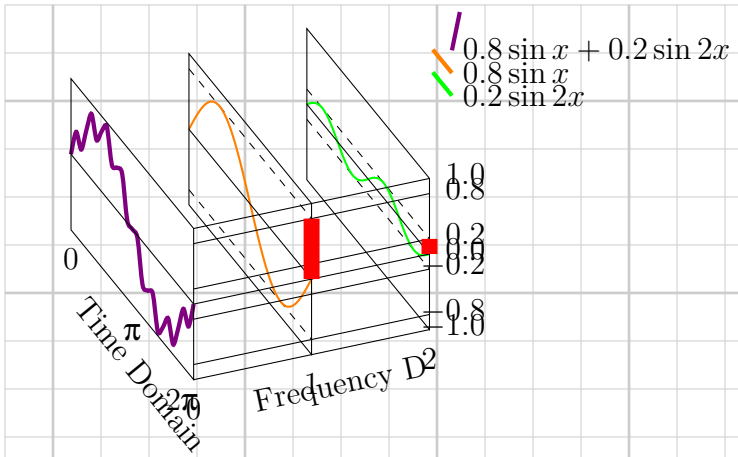
```
    \coordinate   (p81) at (  0,  0);
      \coordinate (p83) at ( 30,  0);
      \coordinate (p85) at ( 54,  0);
      \coordinate (p87) at ( 78,  0);
      \coordinate (p89) at (108,  0);
    % Put "wall" above drawing.
    \draw (p15) node[above] {\large wall};
    % Plot outer edge.
    \draw (p81) -- (p11) -- (p19) -- (p89);
    % Plot inner edge.
    \draw (p83) -- (p53) -- (p57) -- (p87);
    % Color the counter.
    \fill[blue!10] (p81) -- (p11) -- (p19) -- (p89) -- (p87) -- (p57) -- (p53) -- (p83) -- cycle;
    % Vertical measurement lines.
    \draw[dashed, arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}]
      (p14) -- (p44);
    \draw (p24) node[fill=blue!10] {$22''$};
    \draw[arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}] (p15) -- (p55);
    \draw (p35) node[fill=blue!10] {$30''$};
    \draw[dashed, arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}]
      (p16) -- (p46);
    \draw (p26) node[fill=blue!10] {$22''$};
    \draw[arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}] (p55) -- (p85);
    % Horizontal measurement lines.
    \draw[arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}] (p71) -- (p73);
    \draw (p72) node[fill=blue!10] {$30''$};
    \draw[arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}] (p73) -- (p77);
    \draw (p75) node[fill=white] {$48''$};
    \draw[arrows = {Stealth[inset=0pt, angle=30:8pt]-Stealth[inset=0pt, angle=30:8pt]}] (p77) -- (p79);
    \draw (p78) node[fill=blue!10] {$30''$};
    % Put "wall" to the right of drawing.
    \draw (p69) node[right] {\large wall};
\end{tikzpicture}
```

J.5.3 Fourier transform example

Fourier transform Ti*k*Z example

The Fourier transform decomposes a function into the frequencies that make it up. The inverse Fourier transformation combines the contributions of all the different frequencies to recover the original function.

(Mark Senn <mark@purdue.edu> wrote sales@aavos.be on 2021-09-03 to ask permission to use Fourier transform as the starting point for an example Ti*k*Z figure. Dominique Demurie <sales@aavos.be> replied on 2021-09-06 with "I think it is not an original drawing from us either. We had it for years on our website, but I cannot remember where we got it from. We don't mind you using it for a thesis.")




```
\subsection{Fourier transform example}
\index{Fourier transform \TikZLogo\ example}
\todoindex{Fourier transform \TikZLogo\ example}

The Fourier transform decomposes a function
into the frequencies that make it up.
The inverse Fourier transformation combines the contributions
of all the different frequencies to recover the original function.

(Mark Senn {\tt\char'074}mark@purdue.edu{\tt\char'076} wrote sales@aavos.be on 2021-09-03
to ask permission
to use
\href{https://aavos.eu/glossary/fourier-transform/}{Fourier transform}
as the starting point
for an example \TikZLogo\ figure.
Dominique Demurie {\tt\char'074}sales@aavos.be{\tt\char'076} replied
on 2021-09-06 with
``I think it is not an original drawing from us either.
We had it for years on our website,
but I cannot remember where we got it from.
We don't mind you using it for a thesis.'')

% Run this with
%     pdflatex --shell-escape t
% That makes the t.table.* files.
%
% See
%     https://ctan.math.washington.edu/tex-archive/graphics/pgf/base/doc/pgfmanual.pdf
%     PAGE    TOPIC
%      655    decorations.text library to draw text
%     1221    animations
%
% for text decorations, which includes text along a path information.
% Also see
%     https://tex.stackexchange.com/questions/427454/tikz-3dplot-and-rotation-of-coordinates
%     https://tex.stackexchange.com/questions/67573/tikz-shift-and-rotate-in-3d
%     http://tug.ctan.org/graphics/pgf/contrib/tikz-3dplot/tikz-3dplot_documentation.pdf
%     https://tex.stackexchange.com/questions/45848/rotate-node-text-and-use-relative-positioning-in-tikz

% was scale = 2
\begin{tikzpicture}[domain=0:6.283185, rotate around y=-55, scale=1]

  % total plot
  \begin{scope}[canvas is xy plane at z=0]
    \node[below=3pt] at (0,       -1) {0};
```

```
    \node[below=3pt] at (3.141593, -1) {$\pi$};
    \node[below=5pt] at (5.683185, -1) {$2\pi$};
    \draw[ultra thick,color=violet] plot[id=total,smooth] function{0.8*sin(x)+0.2*sin(8*x)};
    \draw[thin,color=black] (0,-1) -- (0,1) -- (6.283185,1) -- (6.283185,-1) -- cycle;
    \draw[thin,color=black] (0,0) -- (6.283185,0);
    \path[decorate,decoration={text along path,
% |\LARGE|
      text={Time Domain}}] (0.1,-2) -- (6.283185,-2);
    % $s(t)$
  \end{scope}

  % tall plot
  \begin{scope}[canvas is xy plane at z=-1.5]
    \draw[dashed] (0,0.8) -- (6.283185,0.8);
    \draw[dashed] (0,-0.8) -- (6.283185,-0.8);
    \draw[thick,color=orange] plot[id=tall,smooth] function{0.8*sin(x)};
    \draw[thin,color=black] (0,-1) -- (0,1) -- (6.283185,1) -- (6.283185,-1) -- cycle;
    \draw[thin,color=black] (0,0) -- (6.283185,0);
  \end{scope}

  % short plot
  \begin{scope}[canvas is xy plane at z=-3.0]
    \draw[dashed] (0, 0.2) -- (6.283185,  0.2);
    \draw[dashed] (0,-0.2) -- (6.283185, -0.2);
    \draw[thick,color=green] plot[id=short,smooth] function{0.2*sin(2*x)};
    \draw[thin,color=black] (0,-1) -- (0,1) -- (6.283185,1) -- (6.283185,-1) -- cycle;
    \draw[thin,color=black] (0,0) -- (6.283185,0);
  \end{scope}

  % frequency plot
  \begin{scope}[canvas is zy plane at x=6.283185]
    \node[below=3pt] at ( 0.0,-1) {0};
    \node[below=3pt] at (-1.5,-1) {1};
    \node[below=3pt] at (-3.0,-1) {2};
    \draw[thin,color=black] (0,-1.0) -- (-3.0,-1.0);  \node[above=-9pt] at (-3.3,-1.0) {$-1.0$};
    \draw[thin,color=black] (0,-0.8) -- (-3.0,-0.8);  \node[above=-9pt] at (-3.3,-0.8) {$-0.8$};
    \draw[thin,color=black] (0,-0.2) -- (-3.0,-0.2);  \node[above=-9pt] at (-3.3,-0.2) {$-0.2$};
    \draw[thin,color=black] (0, 0.0) -- (-3.0, 0.0);  \node[above=-9pt] at (-3.3, 0.0) {$\phantom{-}0.0$};
    \draw[thin,color=black] (0, 0.2) -- (-3.0, 0.2);  \node[above=-9pt] at (-3.3, 0.2) {$\phantom{-}0.2$};
    \draw[thin,color=black] (0, 0.8) -- (-3.0, 0.8);  \node[above=-9pt] at (-3.3, 0.8) {$\phantom{-}0.8$};
    \draw[thin,color=black] (0, 1.0) -- (-3.0, 1.0);  \node[above=-9pt] at (-3.3, 1.0) {$\phantom{-}1.0$};
    \draw[line width=6pt,color=red] (-1.5,0) -- (-1.5,0.8);
    \draw[line width=6pt,color=red] (-3.0,0) -- (-3.0,0.2);
    \path[decorate,decoration={text along path,
% |\LARGE|
      text={Frequency Domain}}] (-0.8,-1.6) -- (-3.0,-1.6);
    % $S(\omega)$
  \end{scope}

  %% legend
  %% Wolfram Language code:
  %%     In[1]:= ry[theta_] :=
  %%     {
  %%         {Cos[theta Degree],  0, Sin[theta Degree]},
  %%         {0,                  1, 0},
  %%         {-Sin[theta Degree], 0, Cos[theta Degree]}
  %%     }
  %%
  %%     ry[55] . {Pi, 0.7, -3.5}
  %%     # Out[] = {-1.06509, 0.7, -4.58096}
  %%     ry[55] . {(3/4)Pi, 0.7, -3.5}
  %%     # Out[] = {-1.51557, 0.7, -3.9376}

  \draw[ultra thick,color=violet] (2.45782, 1.7, -4.33538) -- (1.06509, 0.7, -4.58096);
```

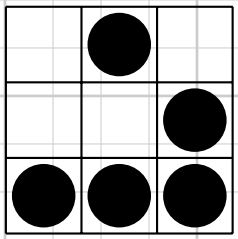
```
    \node[right] at                                    (1.06509, 0.7, -4.58096) {$0.8\sin x + 0.2\sin 2x$};
  \draw[ultra thick,color=orange] ( 0.08509, 0.4, -4.58096) -- (1.06509, 0.4, -4.58096);
    \node[right] at                                    (1.06509, 0.4, -4.58096) {$0.8\sin x$};
  \draw[ultra thick,color=green]  ( 0.08509, 0.1, -4.58096) -- (1.06509, 0.1, -4.58096);
    \node[right] at                                    (1.06509, 0.1, -4.58096) {$0.2\sin 2x$};
\end{tikzpicture}
```

J.5.4 Glider example

Hirzel, Alex

glider Ti*k*Z example

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

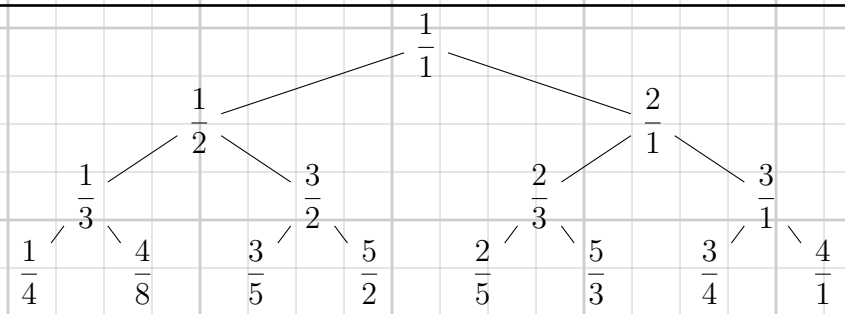


```

\subsection{Glider example}
\ix{Hirzel, Alex}
\index{glider \TikZLogo\ example}
\todoindex{glider \TikZLogo\ example}

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

\begin{tikzpicture}[thick]
  \draw (0,0) grid (3,3);
  \foreach \c in {(0,0), (1,0), (2,0), (2,1), (1,2)}
    \fill \c + (0.5,0.5) circle (0.42);
\end{tikzpicture}
```

J.5.5 Tree example

???, ???

tree Ti*k*Z example



The node with value $\frac{n}{d}$

with additional conditions	has	with value
(none)	left child	$\frac{n}{n+d}$
(none)	right child	$\frac{n+d}{d}$
$n < d$	parent	$\frac{n}{d-n}$
$n = d$	no parent	(not applicable)
$n > d$	parent	$\frac{n-d}{d}$

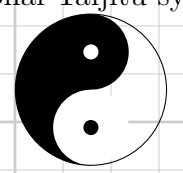
```
\newpage

\subsection{Tree example}
\ix{???, ???}
\index{tree \TikZLogo\ example}
\todoindex{tree \TikZLogo\ example}

{
  \def\f#1#2{$\displaystyle\frac #1#2$}
  \begin{tikzpicture}%
  [%
    level 1/.style={sibling distance=60mm},
    level 2/.style={sibling distance=30mm},
    level 3/.style={sibling distance=15mm}
  ]
    \node {\f 11}
      child {node {$\displaystyle\frac 12$}
        child {node {\f 13}
          child {node {\f 14}}
          child {node {\f 48}}
        }
        child {node {\f 32}
          child {node {\f 35}}
          child {node {\f 52}}
        }
      }
      child {node {\f 21}
        child {node {\f 23}
```

```
          child {node {\f 25}}
          child {node {\f 53}}
        }
        child {node {\f 31}
          child {node {\f 34}}
          child {node {\f 41}}
        }
      };
  \end{tikzpicture}

\vspace*{4pt}
The node with value \f nd\\[2pt]
\indent\hspace*{4\parindent}
\begin{tabular}{@{}llll@{}}
  \bfseries with additional conditions& \bfseries has& \bfseries with value\\
  \noalign{\vspace{2pt}}
  (none)&                    left child&     \f n{{n+d}}\\
  \noalign{\vspace{12pt}}
  (none)&                    right child&    \f {{n+d}}d\\
  \noalign{\vspace{12pt}}
  $n<d$&                     parent&         \f n{{d-n}}\\
  \noalign{\vspace{12pt}}
  $n=d$&                     no parent&      (not applicable)\\
  \noalign{\vspace{12pt}}
  $n>d$&                     parent&         \f {{n-d}}d\\
\end{tabular}
}
```

J.5.6 Yin and yang example

This Yin and yang example was done by Thomas G. Kristensen [27]. This is the "traditional Taijitu symbol from Chinese philosophy".

Kristensen, Thomas G. ⇒ Taijitu symbol ⇒ Yin and yang symbol



```


\subsection{Yin and yang example}

This Yin and yang example was done by Thomas G. Kristensen \cite{kristensen}.
This is the ``traditional Taijitu symbol from Chinese philosophy''.
\ix{Kristensen, Thomas G.//Taijitu symbol//Yin and yang symbol}

\index{TikZ@\TikZLogo}
\begin{tikzpicture}
  % Yin and yang
  % Author: Thomas G. Kristensen

  % color one half of a unit circle
  \begin{scope}
    \clip (0,0) circle (1cm);
    \fill[black] (0cm,1cm) rectangle (-1cm, -1cm);
  \end{scope}

  % fill heads
  \fill[black] (0,0.5) circle (0.5cm);
  \fill[white] (0,-0.5) circle (0.5cm);
```

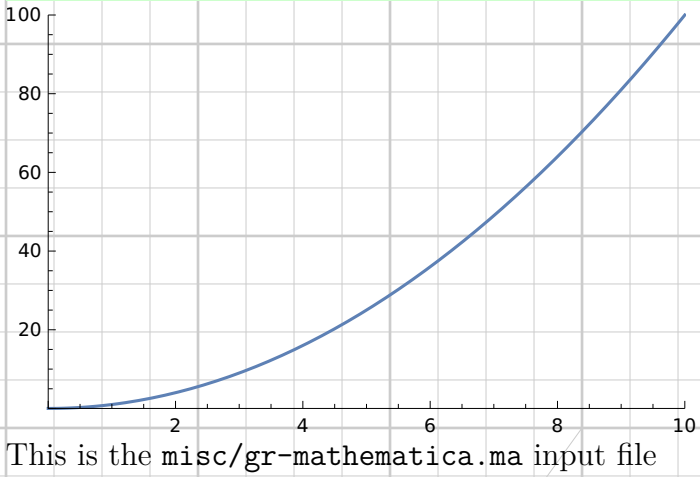
```
23
24    % fill eyes
25    \fill[white] (0,0.5) circle (0.1cm);
26    \fill[black] (0,-0.5) circle (0.1cm);
27
28    % outer line
29    \draw (0,0) circle (1cm);
30
31  \end{tikzpicture}
```

J.6 Wolfram Language (Mathematica uses this)

Mathematica

Wolfram Language

Wolfram Language can be set up to use LaTeX fonts.



This is the `misc/gr-mathematica.ma` input file

```
(*
    MaTeX is a Wolfram Language package to use LaTeX fonts in
    Wolfram Language graphics.  See
        http://szhorvat.net/pelican/latex-typesetting-in-mathematica.html
    for instructions on how to use MaTeX.
*)

(* Install MaTeX. *)
ResourceFunction["MaTeXInstall"][];

(* Load MaTeX. *)
<<MaTeX`;

latexStyle = {FontFamily->"Latin Modern Roman", FontSize->10};

g = Graphics[
  Plot[x^2,
    {x,0,10},
    BaseStyle->latexStyle,
    PlotRange->{{0,10},{0,100}}
  ]
];
I
Export["../graphics/gr-mathematica.pdf", g];
```

I typed, on Linux, **`math < gr-mathematica.ma`** in the `misc` subdirectory to make the `graphics/gr-mathematica.pdf` output file.

```

\section{Wolfram Language (Mathematica uses this)}
```

```
\ix{Mathematica}
\ix{Wolfram Language}

\lightgreen{Wolfram Language can be set up to use \LaTeX\ fonts.}

\includegraphics{gr-mathematica.pdf}

This is the |misc/gr-mathematica.ma| input file
\MyI{misc/gr-mathematica.ma}

I typed, on Linux,
\Shell{math < gr-mathematica.ma}
in the |misc| subdirectory
to make the |graphics/gr-mathematica.pdf| output file.
```

K. IGNORE THESE REFERENCES—THEY ARE WRONG

```
\chapter{IGNORE THESE REFERENCES---THEY ARE WRONG}
```

You may have seen these references on the web. Ignore them—they're wrong.

Purdue Online Writing Lab, IEEE Reference List [28]

The IEEE (The world's largest technical professional organization for the advancement of technology) has changed their references format from, for example,

[1] W. K. Chen, Linear Networks and Systems. Belmont, CA: Wadsworth Press, 2003.

to

[1] W. K. Chen, Linear Networks and Systems. Belmont, CA: Wadsworth Press, 2003.

See [29, page 2].

```

You may have seen these references on the web.
Ignore them---they're wrong.

\noindent
\textbf{Purdue Online Writing Lab, IEEE Reference List}
\cite{owl}

The IEEE
(The world's largest technical professional organization
for the advancement
of technology)
has changed their references format from,
for example,

\noindent
\begin{tabular}{@{}ll@{}}
\noalign{\vspace*{6pt}}
  [1]& W. K. Chen, Linear Networks and Systems. Belmont, CA: Wadsworth Press,\\
  \multispan{2}{2003.\hfil}\\
\noalign{\vspace*{6pt}}
\noalign{\noindent to}
\noalign{\vspace*{6pt}}
  [1]& W. K. Chen, Linear Networks and Systems. Belmont, CA: Wadsworth Press,\\
  & 2003.\hfil\\
\noalign{\vspace*{6pt}}
\end{tabular}
See
\cite[page~2]{ieeedataport}.
```

L. LOGOS

These logos are defined in `pa-logos.sty`:

Input	Output
`\AMSmathLogo`	AMSmath
`\BibLaTeXLogo`	BibLaTeX
`\BiberLogo`	Biber
`\CalligraphicAMSLaTeXLogo`	$\mathcal{AMS}$-LaTeX
`\CircuiTikZLogo`	CircuiTi*k*Z
`\CTANLogo{\texttt{CTAN}\xspace}`	CTAN
`\LaTeXLogo`	LaTeX
`\LuaLaTeXLogo`	LuaLaTeX
`\METAFONTLogo`	METAFONT
`\METAPOSTLogo`	METAPOST
`\MetaPostLogo`	MetaPost
`\NonCalligraphicAMSLaTeXLogo`	AMS-LaTeX
`\PurdueThesisLogo`	PurdueThesis
`\PuThLogo`	PuTh
`\TeXLogo`	TeX
`\TeXLiveLogo`	TeX Live
`\TikZLogo`	Ti*k*Z
`\TEXUsersGroupLogo`	TeX Users Group
`\TUGboatLogo`	*TUGboat*

```
1  \chapter{LOGOS}
2
3  These logos are defined in |pa-logos.sty|:
4
5  \begin{tabular}{@{}ll@{}}
6    \toprule
7    \bfseries Input& \bfseries Output\\
8    \midrule
9    % From thesis.tex
10   %     \newcommand{\tabularspace}{\noalign{\vspace*{2pt}}}
11   % \tabularspace
12   \verb+\AMSmathLogo+& \AMSmathLogo\\[2pt]
13   \verb+\BibLaTeXLogo+& \BibLaTeXLogo\\[2pt]
14   \verb+\BiberLogo+& \BiberLogo\\[2pt]
15   \verb+\CalligraphicAMSLaTeXLogo+& \CalligraphicAMSLaTeXLogo\\[2pt]
16   \verb+\CircuiTikZLogo+& \CircuiTikZLogo\\[2pt]
17   \verb+\CTANLogo{\texttt{CTAN}\xspace}+& \CTANLogo\\[2pt]
18   \verb+\LaTeXLogo+& \LaTeXLogo\\[2pt]
19   \verb+\LuaLaTeXLogo+& \LuaLaTeXLogo\\[2pt]
20   \verb+\METAFONTLogo+& \METAFONTLogo\\[2pt]
21   \verb+\METAPOSTLogo+& \METAPOSTLogo\\[2pt]
22   \verb+\MetaPostLogo+& \MetaPostLogo\\[2pt]
23   \verb+\NonCalligraphicAMSLaTeXLogo+& \NonCalligraphicAMSLaTeXLogo\\[2pt]
24   \verb+\PurdueThesisLogo+& \PurdueThesisLogo\\[2pt]
25   \verb+\PuThLogo+& \PuThLogo\\[2pt]
```

```
    \verb+\TeXLogo+& \TeXLogo\\[2pt]
    \verb+\TeXLiveLogo+& \TeXLiveLogo\\[2pt]
    \verb+\TikZLogo+& \TikZLogo\\[2pt]
    \verb+\TEXUsersGroupLogo+& \TeXUsersGroupLogo\\[2pt]
    \verb+\TUGboatLogo+& \TUGboatLogo\\[2pt]
    \bottomrule
  \end{tabular}
```

M. MISCELLANEOUS

miscellaneous ⇒ Miscellaneous appendix

```
\chapter{MISCELLANEOUS}
\ix{miscellaneous//Miscellaneous appendix}
```

Demonstrate using a long Hungarian umlaut (double acute) (ő) in text and bibligraphy [30].

```
Demonstrate using a long Hungarian umlaut
(double acute)
(\H{o})
in text and bibligraphy
\cite{erdos1992}.
```

N. NUMBERS AND UNITS

```
\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.

```

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.
```

N.1 Number Examples

```

\section{Number Examples}
```

Input	Output	Comment
`\num{-0.12345}`	$-0.123\,45$	note the small space after the “3”
`\num{-0.1234}`	-0.1234	note no space between the “3” and “4”
`\num{-.123}`	-0.123	the “0.” is inserted automatically
`\num{123}`	123	
`\num{1234}`	1234	
`\num{12345}`	$12\,345$	note the small space after the “2”
`\num{2e4}`	2×10^{4}	
`\num{e5}`	1×10^{5}	
`\num{2.34567e6}`	$2.345\,67 \times 10^{6}$	note the small space after the “5”

```
\noindent\begin{tabular}{@{}lll@{}}
  \bfseries Input& \bfseries Output& \bfseries Comment\\
  \tabularspace
  \verb+\num{-0.12345}+& \num{-0.12345}& note the small space after the ``3''\\
  \verb+\num{-0.1234}+&
    \num{-0.1234}&
    note no space between the ``3'' and ``4''\\
  \verb+\num{-.123}+& \num{-.123}& the ``0.'' is inserted automatically\\
  \verb+\num{123}+& \num{123}\\
  \verb+\num{1234}+& \num{1234}\\
  \verb+\num{12345}+& \num{12345}& note the small space after the ``2''\\
  \verb+\num{2e4}+& \num{2e4}\\
  \verb+\num{e5}+& \num{e5}\\
  \verb+\num{2.34567e6}+&
    \num{2.34567e6}&
    note the small space after the ``5''\\
\end{tabular}
```

N.2 Unit Examples

```

\section{Unit Examples}
```

See page 113 for the complete list of units defined by PurdueThesis.

Input	Output	Comment
\si{\kg}	kg	kilogram
\si{\m}	m	meter
\si{\kg\per\m\squared}	$\mathrm{kg\,m^{-2}}$	$= \mathrm{kg/m^2}$

```
See page~\pageref{se:Complete-List-of-Units}
for the complete list
of units defined by \PurdueThesisLogo.

\noindent\begin{tabular}{@{}lll@{}}
  \bfseries Input& \bfseries Output& \bfseries Comment\\
  \tabularspace
  \verb+\si{\kg}+& \si{\kg}& kilogram\\
  \verb+\si{\m}+& \si{\m}& meter\\
  \verb+\si{\kg\per\m\squared}+&
    \si{\kg\per\m\squared}&
    \(= \si{\kg}/\si{\m\squared}\)\\
\end{tabular}
```

N.3 Combined Number and Unit Examples

```
\section{Combined Number and Unit Examples}
```

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

```
\begin{tabular}{@{}lll@{}}
  \bfseries Input& \bfseries Output& \bfseries Comment\\
  \tabularspace
  \verb+\SI{12}{\kg}+& \SI{12}{\kg}& 12 kilograms\\
  \verb+\SI{34}{\m}+&  \SI{34}{\m}& 34 meters\\
  % The next input line is too wide for the margins
  % so I'm splitting it into pieces.
  \verb+\SI{4.5e3}{\kg\per\m\squared}+&
    \SI{4.5e3}{\kg\per\m\squared}&
    \(= \num{4.5e3}\,\si{\kg}/\si{\m\squared}\)\\
\end{tabular}
```

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

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

```

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

N.4 Binary Prefixes

```

\section{Binary Prefixes}
```

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

```

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

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

```

\newcolumntype{m}{>{$}r<{$}}  % math mode version of "r" column type
\renewcommand{\t}[4]{\(2^{#1}\) bytes is a #2, \(10^{#3}\) bytes is a #4}
\begin{tabular}{@{}mllll@{}}
  \multicolumn{1}{l}{\bfseries Power}&
    \bfseries Prefix&
    \bfseries Symbol&
```

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

N.5 Decimal Prefixes

```

\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	ţ	`\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}`	

```

\newcolumntype{m}{>{$}r<{$}}  % math mode version of "r" column type
\begin{tabular}{@{}mllll@{}}
  \multicolumn{1}{l}{\bfseries Power}&
    \bfseries Prefix&
    \bfseries Symbol&
    \bfseries Command&
    \bfseries Comment\\
  \tabularspace
  -24& yocto& \unit{\yocto\nounit}& \verb+\si{\yocto}+\\
  -21& zepto& \unit{\zepto\nounit}& \verb+\si{\zepto}+\\
```

```
   -18& atto&  \unit{\atto\nounit}&  \verb+\si{\atto}+\\
   -15& femto& \unit{\femto\nounit}& \verb+\si{\femto}+\\
   -12& pico&  \unit{\pico\nounit}&  \verb+\si{\pico}+\\
    -9& nano&  \unit{\nano\nounit}&  \verb+\si{\nano}+\\
    -6& micro& \unit{\micro\nounit}& \verb+\si{\micro}+\\
    -3& milli& \unit{\milli\nounit}& \verb+\si{\milla}+\\
    -2& centi& \unit{\centi\nounit}& \verb+\si{\centi}+\\
    -1& deci&  \unit{\deci\nounit}&  \verb+\si{\deci}+\\
     1& deca&  \unit{\deca\nounit}&  \verb+\si{\deca}+\\
     1& deka&  \unit{\deka\nounit}&  \verb+\si{\deka}+& same as \verb+\si{\deca}+\\
     2& hecto& \unit{\hecto\nounit}& \verb+\si{\hecto}+\\
     3& kilo&  \unit{\kilo\nounit}&  \verb+\si{\kilo}+\\
     6& mega&  \unit{\mega\nounit}&  \verb+\si{\mega}+\\
     9& giga&  \unit{\giga\nounit}&  \verb+\si{\giga}+\\
    12& tera&  \unit{\tera\nounit}&  \verb+\si{\tera}+\\
    15& peta&  \unit{\peta\nounit}&  \verb+\si{\peta}+\\
    18& exa&   \unit{\exa\nounit}&   \verb+\si{\exa}+\\
    21& zetta& \unit{\zetta\nounit}& \verb+\si{\zetta}+\\
    24& yotta& \unit{\yotta\nounit}& \verb+\si{\yotta}+\\
\end{tabular}
```

N.6 SI Units

```

\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

```

The International System of Units
(SI)
% !!! Doing
% !!!     \include{tipa}
% !!! in thesis.tex so \textprimstress works
% !!! apparently causes problems with math commands.
% !!! Figure out why the following doesn't work later.
% (%
%   SI,
%   abbreviated from the French Syst\'eme International
%   (d\textprimstress unit\'es)%
% )
is the modern form of the metric system.
There are seven SI base units:

\hspace{40pt}
\begin{tabular}{@{}lll@{}}
  \tabularspace
  \bfseries Name& \bfseries Unit Of&         \bfseries Symbol\\
```

```
    \tabularspace
    ampere&          electrical current&        \si{\ampere}\\
    candela&         luminous intensity&        \si{\candela}\\
    kelvin&          thermodynamic temperature& \si{\kelvin}\\
    kg&              mass&                      \si{\kilogram}\\
    meter&           length&                    \si{\meter}\\
    mole&            amount of substance&       \si{\mole}\\
    second&          time&                      \si{\second}\\
  \end{tabular}
```

N.7 Complete List of Units

```

\section{Complete List of Units}
\label{se:Complete-List-of-Units}
```

Table N.1. Units and Corresponding Symbols

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

continued on next page

Table N.1. *continued*

Name	Unit Of	Symbol	Command	Is equal to
decibel	″	dB	`\si{\dB}`	1×10^{-1} B
bohr	length	a_0	`\si{\bohr}`	distance between nucleus and electron in hydrogen atom
bushel	quantity	bu	`\si{\bu}`	see [31]
candela	luminous intensity	cd	`\si{\cd}`	(SI base unit)
coulomb	electrical charge	C	`\si{\C}`	$\mathrm{A\,s^{-1}}$
dalton	mass	Da	`\si{\Da}`	another name for atomic mass unit
day	time	d	`\si{\d}`	86 400 s
degree	plane angle	ř	`\si{\degree}`	1/360 of a cicle
degree Celsius	temperature	řC	`\si{\celsius}`	xxx
electron mass	mass	m_e	`\si{\em}`	xxx
electronvolt	energy	eV	`\si{\eV}`	xxx
millielectronvolt	″	meV	`\si{meV}`	1×10^{-3} eV
kiloelectronvolt	″	keV	`\si{keV}`	1×10^{3} eV
megaelectronvolt	″	MeV	`\si{MeV}`	1×10^{6} eV
gigaelectronvolt	″	GeV	`\si{\GeV}`	1×10^{9} eV
teraelectronvolt	″	TeV	`\si{\TeV}`	1×10^{12} eV
elementary charge	electrical charge	e	`\si{\ec}`	$\approx 1.6 \times 10^{19}$ C
farad	electrical capacitance	F	`\si{\F}`	$\mathrm{s^4\,A^2\,m^{-2}\,kg^{-1}}$
femtofarad	″	fF	`\si{\fF}`	1×10^{-15} F

continued on next page

Table N.1. *continued*

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

continued on next page

Table N.1. *continued*

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

continued on next page

Table N.1. *continued*

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

continued on next page

Table N.1. *continued*

Name	Unit Of	Symbol	Command	Is equal to
millisecond	″	ms	`\si{\ms}`	$1 \times 10^{-3}\,\mathrm{s}$
siemens	conductance	S	`\si{\S}`	$\mathrm{kg}^{-1}\,\mathrm{m}^{-2}\,\mathrm{s}^{3}\,\mathrm{A}^{2}$
sievert	dosage of ionizing radiation	Sv	`\si{\Sv}`	$\mathrm{m}^{2}\,\mathrm{s}^{-2}$
speed of light	speed	c_0	`\si{\clight}`	$299\,792\,458\,\mathrm{m\,s^{-1}}$
standard deviation	amount of variation	SD	`\si{\SD}`	$\sqrt{\frac{1}{N-1}\sum_{\mathrm{i}=1}^{N}(x_\mathrm{i}-\bar{x})^2}$
steradian	measure of solid angles	sr	`\si{\sr}`	$1\,\mathrm{m}^{2}\,\mathrm{m}^{-2}$
tesla	magnetic flux density	T	`\si{\T}`	$\mathrm{kg\,s^{-2}\,A^{-1}}$
metric ton	mass	t	`\si{\t}`	$1 \times 10^{3}\,\mathrm{kg}$
volt	electrical potential difference	V	`\si{\V}`	$\mathrm{kg\,m^{2}\,s^{-3}\,A^{-1}}$
picovolt	″	pV	`\si{\pV}`	$1 \times 10^{-12}\,\mathrm{V}$
nanovolt	″	nV	`\si{\nV}`	$1 \times 10^{-9}\,\mathrm{V}$
microvolt	″	ţV	`\si{\uV}`	$1 \times 10^{-6}\,\mathrm{V}$
millivolt	″	mV	`\si{\mV}`	$1 \times 10^{-3}\,\mathrm{V}$
kilovolt	″	kV	`\si{\kV}`	$1 \times 10^{3}\,\mathrm{V}$
watt	power	W	`\si{\W}`	$\mathrm{kg\,m^{2}\,s^{-3}}$
microwatt	″	ţW	`\si{\uW}`	$1 \times 10^{-6}\,\mathrm{W}$
milliwatt	″	mW	`\si{\mW}`	$1 \times 10^{-3}\,\mathrm{W}$
kilowatt	″	kW	`\si{\kW}`	$1 \times 10^{3}\,\mathrm{W}$
megawatt	″	MW	`\si{\MW}`	$1 \times 10^{6}\,\mathrm{W}$
gigawatt	″	GW	`\si{\GW}`	$1 \times 10^{9}\,\mathrm{W}$
weber	magnetic flux	Wb	`\si{\Wb}`	$\mathrm{kg\,m^{2}\,s^{-2}\,A^{-1}}$
yard	length	yd	`\si{\yd}`	$0.9144\,\mathrm{m}$
year	time	y	`\si{\y}`	$\approx 365.25\,\mathrm{d}$

```
1
2  {%
3    \ZZbaselinestretch{1}
4    \newcommand\vsp{\noalign{\vspace*{6pt}}}
5    % From
6    % https://tex.stackexchange.com/questions/31508/flushleft-with-p-option-in-tabular
7    %     It's necessary to use the \arraybackslash in the last column,
```

```
  %     otherwise \\ would not end the table row.  You can use \newline
  %     to end lines in the last column cells (and the regular \\ in
  %     the other column cells).
  %     ...
  %     If you need it often, consider defining a new column type using
  %     array features, as I did here:
  %         \newcolumntype{P}[1]{>{\raggedright\arraybackslash}p{#1}}
  \newcolumntype{P}[1]{>{\raggedright\arraybackslash}p{#1}}%
% \begin{longtable}{@{}P{1.4in}P{1in}llP{1.8in}@{}}
% \begin{longtable}{@{}P{1in}P{1in}llP{1.8in}@{}}
% \begin{longtable}{@{}P{1.2in}P{1in}llP{1.8in}@{}}
% \begin{longtable}{@{}P{90.72pt}P{1in}llP{1.8in}@{}}  % 1.2in (86.72pt) + 4pt = 90.72pt
  \begin{longtable}{@{}P{1.4in}P{1in}llP{1.8in}@{}}% 1.2in (86.72pt) + 4pt = 90.72pt
      \caption{Units and Corresponding Symbols}\\
      \bfseries Name&
        \bfseries Unit Of&
        \bfseries Symbol&
        \bfseries Command&
        \bfseries Is equal to\\
      \vsp
    \endfirsthead
      \caption[]{~\emph{continued}}\\
      \bfseries Name&
        \bfseries Unit Of&
        \bfseries Symbol&
        \bfseries Command&
        \bfseries Is equal to\\
      \vsp
    \endhead
      \vsp
      % I don't know why the \hspace*{-7.5mm} was
      % needed to center this horizontally.
      \multicolumn{5}{@{}c@{}}{\hspace*{-7.5mm}\emph{continued on next page}}%
    \endfoot
    \endlastfoot
    ampere&
      electrical current&
      \si{\A}&
      \verb+\si{\A}+&
      (SI base unit)\\
    \quad picoampere&
      \ditto&
      \si{\pA}&
      \verb+\si{\pA}+&
      \SI{e-12}{\A}\\
    \quad nanoampere&
      \ditto&
      \si{\nA}&
      \verb+\si{\nA}+&
      \SI{e-9}{\A}\\
    \quad microampere&
      \ditto&
      \si{\uA}&
      \verb+\si{\uA}+&
      \SI{e-6}{\A}\\
    \quad milliampere&
      \ditto&
      \si{\mA}&
      \verb+\si{\mA}+&
      \SI{e-3}{\A}\\
    \quad kiloampere&
      \ditto&
      \si{\kA}&
      \verb+\si{\kA}+&
```

```
      \SI{e3}{\A}\\
    \vsp
    % \aa ngstr\"om&
    %   length&
    %   \si{\AA}&
    %   \verb+\si{\AA}+&
    %   \SI{e-10}{\m}\\
    \vsp
    arcminute&
      plane angle&
      \si{\arcmin}&
      \verb+\si{\arcmin}+&
      % Changed
      %     \SI{1/60}{\degree}\\
      % to
      1/60\unit{\degree\nounit}\\
    arcsecond&
      plane angle&
      \si{\arcsec}&
      \verb+\si{\arcsec}+&
      % Changed
      %     \SI{1/60}{\arcmin}\\
      % to
      1/60\unit{\arcmin\nounit}\\
    \vsp
    astronomical unit&
      length&
      \si{\au}&
      \verb+\si{\au}+&
      mean earth to\newline sun distance\\
    \vsp
    % From
    %     siunitx - A comprehensive (SI) units package
    %     Joseph Wright
    %     Released 2021-08-04
    %     (this describes v3.0.24, last revised 2021-08-04)
    %     https://mirror.las.iastate.edu/tex-archive/macros/latex/contrib/siunitx/siunitx.pdf
    % page 51:
    %     ...the unit \atomicmassunit has similar deprecated status:
    %     this was listed as with experimentally-determined units
    %     in the 8th Edition of the si Brochure but is equivalent
    %     to the dalton, a unit which remains accepted.
    % atomic mass unit&
    %   mass&
    %   \si{\amu}&
    %   \verb+\si{\amu}+&
    %   \(1/12\) mass of\newline carbon-12 atom\\
    % \vsp
    bar&
      pressure&
      \si{\bar}&
      \verb+\si{\bar}+&
      \SI{e-5}{\Pa}\\
    \quad millibar&
      \ditto&
      \si{\mbar}&
      \verb+\si{\mbar}+&
      \SI{e-3}{\bar}\\
    \vsp
    barn&
      area&
      \si{\b}&
      \verb+\si{\b}+&
      \SI{e-28}{\m\squared}\\
```

```
    \vsp
    becquerel&
      radioactivity&
      \si{\Bq}&
      \verb+\si{\Bq}+&
      one radioactive\newline decay per second\\
    \vsp
    bel&
      sound intensity&
      \si{\B}&
      \verb+\si{\B}+&
      10 decibels\\
    \quad decibel&
      \ditto&
      \si{\dB}&
      \verb+\si{\dB}+&
      \SI{e-1}{\B}\\
    \vsp
    bohr&
      length&
      \si{\bohr}&
      \verb+\si{\bohr}+&
      distance between\newline nucleus and electron\newline in hydrogen atom\\
    \vsp
    bushel&
      quantity&
      \si{\bu}&
      \verb+\si{\bu}+&
      see \cite{wikipedia-bushel}\\
    \vsp
    candela&
      luminous intensity&
      \si{\cd}&
      \verb+\si{\cd}+&
      (SI base unit)\\
    \vsp
    coulomb&
      electrical charge&
      \si{\C}&
      \verb+\si{\C}+&
      \si{\A\per\s}\\
    \vsp
    dalton&
      mass&
      \si{\Da}&
      \verb+\si{\Da}+&
      another name for\newline atomic mass unit\\
    \vsp
    day&
      time&
      \si{\d}&
      \verb+\si{\d}+&
      \SI{86400}{\s}\\
    \vsp
    degree&
      plane angle&
      \si{\degree}&
      \verb+\si{\degree}+&
      1/360 of a cicle\\
    \vsp
    degree Celsius&
      temperature&
      \si{\celsius}&
      \verb+\si{\celsius}+&
```

```
      xxx\\
    \vsp
    electron mass&
      mass&
      \si{\em}&
      \verb+\si{\em}+&
      xxx\\
    \vsp
    electronvolt&
      energy&
      \si{\eV}&
      \verb+\si{\eV}+&
      xxx\\
    \quad millielectronvolt&
      \ditto&
      \si{\meV}&
      \verb+\si{meV}+&
      \SI{e-3}{\eV}\\
    \quad kiloelectronvolt&
      \ditto&
      \si{\keV}&
      \verb+\si{keV}+&
      \SI{e3}{\eV}\\
    \quad megaelectronvolt&
      \ditto&
      \si{\MeV}&
      \verb+\si{MeV}+&
      \SI{e6}{\eV}\\
    \quad gigaelectronvolt&
      \ditto&
      \si{\GeV}&
      \verb+\si{\GeV}+&
      \SI{e9}{\eV}\\
    \quad teraelectronvolt&
      \ditto&
      \si{\TeV}&
      \verb+\si{\TeV}+&
      \SI{e12}{\eV}\\
    \vsp
    elementary charge&
      electrical charge&
      \si{\ec}&
      \verb+\si{\ec}+&
      \href{https://en.wikipedia.org/wiki/Elementary_charge}{\SI{\approx 1.6e19}{\C}}\\
    \vsp
    farad&
      electrical capacitance&
      \si{\F}&
      \verb+\si{\F}+&
      \si{\s\tothe{4}\A\squared\per\m\squared\per\kg}\\
    \quad femtofarad&
      \ditto&
      \si{\fF}&
      \verb+\si{\fF}+&
      \SI{e-15}{\F}\\
    \quad picofarad&
      \ditto&
      \si{\pF}&
      \verb+\si{\pF}+&
      \SI{e-12}{\F}\\
    \vsp
    foot&
      length&
      \si{\ft}&
```

```
      \verb+\si{\ft}+&
      \SI{0.3048}{\m}\\  % not an SI unit
    \vsp
    % gauss: The gauss, symbol G, sometimes Gs, is the cgs unit of measurement of magnetic flux.
    gray&
      absorbed dose of ionizing radiation&
      \si{\Gy}&
      \verb+\si{\Gy}+&
      \si{\J\per\kg}\\
    \vsp
    hartree&
      energy used in molecular orbital calculations&
      \si{\hartree}&
      \verb+\si{\hartree}+&
      xxx\\
    \vsp
    hectare&
      area&
      \si{\ha}&
      \verb+\si{\ha}+&
      \SI{e4}{\m\squared}\\
    \vsp
    henry&
      electrical inductance&
      \si{\H}&
      \verb+\si{\H}+&
      \si{\kg\m\squared\per\s\squared\per\A\squared}\\
    \vsp
    hertz&
      frequency&
      \si{\Hz}&
      \verb+\si{\Hz}+&
      \si{\per\s}\\
    \quad millihertz&
      \ditto&
      \si{\mHz}&
      \verb+\si{\mHz}+&
      \SI{e-3}{\Hz}\\
    \quad kilohertz&
      \ditto&
      \si{\kHz}&
      \verb+\si{\kHz}+&
      \SI{e3}{\Hz}\\
    \quad megahertz&
      \ditto&
      \si{\MHz}&
      \verb+\si{\MHz}+&
      \SI{e6}{\Hz}\\
    \quad gigahertz&
      \ditto&
      \si{\GHz}&
      \verb+\si{\GHz}+&
      \SI{e9}{\Hz}\\
    \quad terahertz&
      \ditto&
      \si{\THz}&
      \verb+\si{\THz}+&
      \SI{e12}{\Hz}\\
    \vsp
    horsepower&
      power&
      \si{\hp}&
      \verb+\si{\hp}+&
      \SI{\approx 745.7}{\W}, {\bfseries IMPORTANT:\newline
```

```
        see \href{https://en.wikipedia.org/wiki/Horsepower#Mechanical_horsepower}{Horsepower}}\\
        % not an SI unit
    \vsp
    hour&
      time&
      \si{\h}&
      \verb+\si{\h}+&
      \SI{3600}{\s}\\
    \vsp
    inch&
      length&
      \si{\in}&
      \verb+\si{\in}+&
      \SI{25.4}{\mm}\\  % not an SI unit
    \vsp
    joule&
      work or energy&
      \si{\J}&
      \verb+\si{\J}+&
      \si{\kg\m\squared\per\s\squared}\\
    \quad microjoule&
      \ditto&
      \si{\uJ}&
      \verb+\si{\uJ}+&
      \SI{e-6}{\J}\\
    \quad millijoule&
      \ditto&
      \si{\mJ}&
      \verb+\si{\mJ}+&
      \SI{e-3}{\J}\\
    \quad kilojoule&
      \ditto&
      \si{\kJ}&
      \verb+\si{\kJ}+&
      \SI{e3}{\J}\\
    \quad megajoule&
      \ditto&
      \si{\MJ}&
      \verb+\si{\MJ}+&
      \SI{e6}{\J}\\
    \vsp
    katal&
      catalytic activity&
      \si{\kat}&
      \verb+\si{\kat}+&
      \si{\mol\per\s}\\
    \vsp
    kelvin&
      thermodynamic temperature&
      \si{\K}&
      \verb+\si{\K}+&
      (SI base unit)\\
    \vsp
    kilogram&
      mass&
      \si{\kg}&
      \verb+\si{\kg}+&
      (SI base unit)\\
    \quad femtogram&
      \ditto&
      \si{\fg}&
      \verb+\si{\fg}+&
      \SI{e-15}{\g}\\
    \quad picogram&
```

```
    \ditto&
    \si{\pg}&
    \verb+\si{\pg}+&
    \SI{e-12}{\g}\\
  \quad nanogram&
    \ditto&
    \si{\ng}&
    \verb+\si{\ng}+&
    \SI{e-9}{\g}\\
  \quad microgram&
    \ditto&
    \si{\ug}&
    \verb+\si{\ug}+&
    \SI{e-6}{\g}\\
  \quad milligram&
    \ditto&
    \si{\mg}&
    \verb+\si{\mg}+&
    \SI{e-3}{\g}\\
  \quad gram&
    \ditto&
    \si{\g}&
    \verb+\si{\g}+&
    \SI{e-3}{\kg}\\
  \vsp
  kilowatt hour&
    electrical energy&
    \si{\kWh}&
    \verb+\si{\kWh}+&
    \si{\kW\h}\\
  \vsp
  knot&
    speed&
    \si{\kn}&
    \verb+\si{\kn}+&
    \si{\M\per\h}\\
  \vsp
  liter&
    volume&
    \si{\L}&
    \verb+\si{\L}+&
    \SI{e-3}{m\cubed}\\
  \quad microliter&
    \ditto&
    \si{\uL}&
    \verb+\si{\uL}+&
    \SI{e-6}{\L}\\
  \quad milliliter&
    \ditto&
    \si{\mL}&
    \verb+\si{\mL}+&
    \SI{e-3}{\L}\\
  \quad hectoliter&
    \ditto&
    \si{\hL}&
    \verb+\si{\hL}+&
    \SI{e2}{\L}\\
  \vsp
  lumen&
    luminous flux&
    \si{\lm}&
    \verb+\si{\lm}+&
    \si{\cd\sr}\\
  \vsp
```

```
    lux&
      illumination&
      \si{\lx}&
      \verb+\si{\lx}+&
      \si{\lm\per\m\squared}\\
    \vsp
    meter&
      length&
      \si{\m}&
      \verb+\si{\m}+&
      (SI base unit)\\
    \quad picometer&
      \ditto&
      \si{\pm}&
      \verb+\si{\pm}+&
      \SI{e-12}{\m}\\
    \quad nanometer&
      \ditto&
      \si{\nm}&
      \verb+\si{\nm}+&
      \SI{e-9}{\m}\\
    \quad micrometer&
      \ditto&
      \si{\um}&
      \verb+\si{\um}+&
      \SI{e-6}{\m}\\
    \quad millimeter&
      \ditto&
      \si{\mm}&
      \verb+\si{\mm}+&
      \SI{e-3}{\m}\\
    \quad centimeter&
      \ditto&
      \si{\cm}&
      \verb+\si{\cm}+&
      \SI{e-2}{\m}\\
    \quad decimeter&
      \ditto&
      \si{\dm}&
      \verb+\si{\dm}+&
      \SI{e-1}{\m}\\
    \quad kilometer&
      \ditto&
      \si{\km}&
      \verb+\si{\km}+&
      \SI{e3}{\m}\\
    \vsp
    % mile: not an SI unit
    millimeter of mercury&
      pressure&
      \si{\mmHg}&
      \verb+\si{\mmHg}+&
      \href{https://en.wikipedia.org/wiki/Millimetre_of_mercury}{\SI{\approx 133}{\Pa}}\\
    \vsp
    minute&
      time&
      \si{\min}&
      \verb+\si{\min}+&
      \SI{60}{\s}\\
    \vsp
    mole&
      amount of substance&
      \si{\mol}&
      \verb+\si{\mol}+&
```

```
      (SI base unit)\\
    \quad femtomole&
      \ditto&
      \si{\fmol}&
      \verb+\si{\fmol}+&
      \SI{e-15}{\mol}\\
    \quad picomole&
      \ditto&
      \si{\pmol}&
      \verb+\si{\pmol}+&
      \SI{e-12}{\mol}\\
    \quad nanomole&
      \ditto&
      \si{\nmol}&
      \verb+\si{\nmol}+&
      \SI{e-9}{\mol}\\
    \quad micromole&
      \ditto&
      \si{\umol}&
      \verb+\si{\umol}+&
      \SI{e-6}{\mol}\\
    \quad millimole&
      \ditto&
      \si{\mmol}&
      \verb+\si{\mmol}+&
      \SI{e-3}{\mol}\\
    \quad kilomole&
      \ditto&
      \si{\kmol}&
      \verb+\si{\kmol}+&
      \SI{e3}{\mol}\\
    \vsp
    nautical mile&
      distance&
      \si{\M}&
      \verb+\si{\M}+&
      \SI{1852}{\m}\\
    \vsp
    neper&
      gain, loss, and relative values&
      \si{\Np}&
      \verb+\si{\Np}+&
      1\\
    \vsp
    newton&
      force&
      \si{\N}&
      \verb+\si{\N}+&
      \si{\kg\m\per\s\squared}\\
    \quad millinewton&
      \ditto&
      \si{\mN}&
      \verb+\si{\mN}+&
      \SI{e-3}{\N}\\
    \quad kilonewton&
      \ditto&
      \si{\kN}&
      \verb+\si{\kN}+&
      \SI{e3}{\N}\\
    \quad meganewton&
      \ditto&
      \si{\MN}&
      \verb+\si{\MN}+&
      \SI{e6}{\N}\\
```

```
      \vsp
      ohm&
        electrical resistance&
        \si{\ohm}&
        \verb+\si{\ohm}+&
        \si{\kg\m\squared\per\s\cubed\per\A\squared}\\
      \quad milliohm&
        \ditto&
        \si{\mohm}&
        \verb+\si{\mohm}+&
        \SI{e-3}{ohm}\\
      \quad kiloohm&
        \ditto&
        \si{\kohm}&
        \verb+\si{\kohm}+&
        \SI{e3}{ohm}\\
      \quad megaohm&
        \ditto&
        \si{\Mohm}&
        \verb+\si{\Mohm}+&
        \SI{e6}{ohm}\\
      \vsp
      pascal&
        pressure&
        \si{\Pa}&
        \verb+\si{\Pa}+&
        \si{\kg\per\m\per\s\squared}\\
      \qquad kilopascal&
        \ditto&
        \si{\kPa}&
        \verb+\si{\kPa}+&
        \SI{e3}{\Pa}\\
      \qquad megapascal&
        \ditto&
        \si{\MPa}&
        \verb+\si{\MPa}+&
        \SI{e6}{\Pa}\\
      \qquad gigapascal&
        \ditto&
        \si{\GPa}&
        \verb+\si{\GPa}+&
        \SI{e9}{\Pa}\\
      \vsp
      percent&
        hundredths&
        \si{\percent}&
        \verb+\si{\percent}+&
        \SI{e-2}{}\\
      \vsp
      pound&
        weight&
        \si{\lb}&
        \verb+\si{\lb}+&
        \SI{.45359237}{\kg}\\  % not an SI unit
      \vsp
      radian&
        plane angular measurement&
        \si{\rad}&
        \verb+\si{\rad}+&
        \(180/\pi\) \unit{\degree\nounit}\\
      \vsp
      reduced Planck constant&
        angular momentum&
        \si{\planckbar}&
```

```
      \verb+\si{\planckbar}+&
      \(\approx \SI{1.05e-34}{\J\s}\)\\
    \vsp
    second&
      time&
      \si{\s}&
      \verb+\si{\s}+&
      (SI base unit)\\
    \quad attosecond&
      \ditto&
      \si{\as}&
      \verb+\si{\as}+&
      \SI{e-18}{\s}\\
    \quad femtosecond&
      \ditto&
      \si{\fs}&
      \verb+\si{\fs}+&
      \SI{e-15}{\s}\\
    \quad picosecond&
      \ditto&
      \si{\ps}&
      \verb+\si{\ps}+&
      \SI{e-12}{\s}\\
    \quad nanosecond&
      \ditto&
      \si{\ns}&
      \verb+\si{\ns}+&
      \SI{e-9}{\s}\\
    \quad microsecond&
      \ditto&
      \si{\us}&
      \verb+\si{\us}+&
      \SI{e-6}{\s}\\
    \quad millisecond&
      \ditto&
      \si{\ms}&
      \verb+\si{\ms}+&
      \SI{e-3}{\s}\\
    \vsp
    siemens&
      conductance&
      \si{\S}&
      \verb+\si{\S}+&
      \si{\per\kg\per\m\squared\s\cubed\A\squared}\\
    \vsp
    sievert&
      dosage of ionizing radiation&
      \si{\Sv}&
      \verb+\si{\Sv}+&
      \si{\m\squared\per\s\squared}\\
    \vsp
    speed of light&
      speed&
      \si{\clight}&
      \verb+\si{\clight}+&
      \SI{299792458}{\m\per\s}\\
    \vsp
    standard deviation&
      amount of variation&
      \si{\SD}&
      \verb+\si{\SD}+&
      $\displaystyle \sqrt{\frac 1{N-1} \sum_{i=1}^N(x_i-\bar x)^2}$\\
    \vsp
    steradian&
```

```
      measure of solid angles&
      \si{\sr}&
      \verb+\si{\sr}+&
      \SI{1}{\m\squared\per\m\squared}\\
    \vsp
    tesla&
      magnetic flux density&
      \si{\T}&
      \verb+\si{\T}+&
      \si{\kg\per\s\squared\per\A}\\
    \vsp
    metric ton&
      mass&
      \si{\t}&
      \verb+\si{\t}+&
      \SI{e3}{\kg}\\
    \vsp
    volt&
      electrical potential difference&
      \si{\V}&
      \verb+\si{\V}+&
      \si{\kg\m\squared\per\s\cubed\per\A}\\
    \quad picovolt&
      \ditto&
      \si{\pV}&
      \verb+\si{\pV}+&
      \SI{e-12}{\V}\\
    \quad nanovolt&
      \ditto&
      \si{\nV}&
      \verb+\si{\nV}+&
      \SI{e-9}{\V}\\
    \quad microvolt&
      \ditto&
      \si{\uV}&
      \verb+\si{\uV}+&
      \SI{e-6}{\V}\\
    \quad millivolt&
      \ditto&
      \si{\mV}&
      \verb+\si{\mV}+&
      \SI{e-3}{\V}\\
    \quad kilovolt&
      \ditto&
      \si{\kV}&
      \verb+\si{\kV}+&
      \SI{e3}{\V}\\
    \vsp
    watt&
      power&
      \si{\W}&
      \verb+\si{\W}+&
      \si{\kg\m\squared\per\s\cubed}\\
    \quad microwatt&
      \ditto&
      \si{\uW}&
      \verb+\si{\uW}+&
      \SI{e-6}{\W}\\
    \quad milliwatt&
      \ditto&
      \si{\mW}&
      \verb+\si{\mW}+&
      \SI{e-3}{\W}\\
    \quad kilowatt&
```

```
      \ditto&
      \si{\kW}&
      \verb+\si{\kW}+&
      \SI{e3}{\W}\\
    \quad megawatt&
      \ditto&
      \si{\MW}&
      \verb+\si{\MW}+&
      \SI{e6}{\W}\\
    \quad gigawatt&
      \ditto&
      \si{\GW}&
      \verb+\si{\GW}+&
      \SI{e9}{\W}\\
    \vsp
    weber&
      magnetic flux&
      \si{\Wb}&
      \verb+\si{\Wb}+&
      \si{\kg\m\squared\per\s\squared\per\A}\\
    \vsp
    yard&
      length&
      \si{\yd}&
      \verb+\si{\yd}+&
      \SI{.9144}{\m}\\  % not an SI unit
    \vsp
    year&
      time&
      \si{\y}&
      \verb+\si{\y}+&
      \SI{\approx 365.25}{\d}\\  % not an SI unit
    \end{longtable}
  }
```

O. RESOURCES

Books:

- *LaTeX Beginner's Guide*, second edition, [32].

From the IEEE Author Center [33]

- The IEEE Editorial Style Manual for Authors [34] contains a formal set of editorial guidelines.
- Editing Mathematics [35] illustrates how to do mathematics.
- The IEEE Reference Guide [36] outlines how to cite references.

Question and Answer site:

- TeX – LaTeX Stack Exchange is a question and answer site for users of TeX, LaTeX, and related typesetting systems [37].

```
\chapter{RESOURCES}

Books:
\begin{itemize}
  \item
  \citetitle{kottwitz2021}, second edition, \cite{kottwitz2021}.
\end{itemize}

\noindent
From the
IEEE Author Center
\cite{ieee-author-center}
\begin{itemize}
  \item
    The
    IEEE Editorial Style Manual for Authors
    \cite{ieee-editorial-style-manual-for-authors}
    contains a formal set of editorial guidelines.
  \item
    Editing Mathematics
    \cite{editing-mathematics}
    illustrates how to do mathematics.
  \item
    The
    IEEE Reference Guide
    \cite{ieee-reference-guide}
    outlines how to cite references.
\end{itemize}

\noindent
Question and Answer site:
\begin{itemize}
  \item
    \TeX\ -- \LaTeX\ Stack Exchange
    is a question and answer site
    for users of
    \TeX,
    \LaTeX,
    and related typesetting systems
    \cite{tex-stackexchange}.
\end{itemize}
```

P. TABLES

table

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

```

Here is a really simple table. I was greatly influenced by Herbert Voss' following ideas on typsetting tables [38]: Use `\toprule`, `\midrule`, and `\bottomrule`. Don't have blank horizontal space to the left or right of body of table.

Voss, Herbert

Table P.1. The first three American Presidents.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

table

```

Here is a really simple table.
I was greatly influenced
by Herbert Voss' following ideas
on typsetting tables
\cite{voss2011}:
Use |\toprule|, |\midrule|, and |\bottomrule|.
\index{\verb+\toprule+}
\index{\verb+\midrule+}
\index{\verb+\bottomrule+}
Don't have blank horizontal space to the left
or right of body of table.
\ix{Voss, Herbert}

% "h" means put table "here"---don't let it float to top or bottom of page
\begin{table}[ht]
  \caption{The first three American Presidents.}
  \vspace*{6pt}
  \centering
    % Table format:
    %     WHAT    DESCRIPTION
    %     @{}     don't put extra space before first column
    %     r       right justify first column
    %     l       left justify second column
    %     @{}     don't put extra space after second column
    \begin{tabular}{@{}rl@{}}
      \toprule
      \bf Number& \bf Name\\
      \midrule
      1& George Washington\\
      2& John Adams\\
      3& Thomas Jefferson\\
      \bottomrule
    \end{tabular}
  \label{ta:first-three-american-presidents}
\end{table}
\ix{table}
\index{\verb+\begin{table}+}
```

Here is the same table with a longer caption.

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

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

```
\newpage

Here is the same table with a longer caption.

% "h" means put table "here"---don't let it float to top or bottom of page
\begin{table}[ht]
  \caption{%
    The first three American Presidents.
    This caption is
    much, much, much, much, much, much,
    much, much, much, much, much, much
    longer.%
  }
  \vspace*{6pt}
  \centering
    % Table format:
    %     WHAT    DESCRIPTION
    %     @{}     don't put extra space before first column
    %     r       right justify first column
    %     l       left justify second column
    %     @{}     don't put extra space after second column
    \begin{tabular}{@{}rl@{}}
      \toprule
      \bf Number& \bf Name\\
      \midrule
      1& George Washington\\
      2& John Adams\\
      3& Thomas Jefferson\\
      \bottomrule
    \end{tabular}
  \label{ta:first-three-american-presidents-longer-caption}
\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 P.3. The first three American Presidents with horizontal and vertical lines

#	**Name**
1	George Washington
2	John Adams
3	Thomas Jefferson

```
\newpage

\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.
\begin{table}[ht]
  \caption{The first three American Presidents with horizontal and vertical lines}
  \vspace*{6pt}
  \centering
    % Table format:
    %     WHAT    DESCRIPTION
    %     @{}     don't put any space left of first column
    %     |       print a vertical rule
    %     c       center column
    %     |       print a vertical rule
    %     l       left justify column
    %     |       print a vertical rule
    %     @{}     don't put any space right of last column
    \begin{tabular}{@{}|c|l|@{}}
      % "\hline" prints a horizontal rule
      \hline
      \bf \#& \bf Name\\
      \hline
      1& George Washington\\
      \hline
      2& John Adams\\
      \hline
      3& Thomas Jefferson\\
      \hline
    \end{tabular}
  \label{ta:American-Presidents-with-horizontal}
\end{table}
```

Here is a more complicated table.

Table P.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

```

\newpage

Here is a more complicated table.

{
  \UndefineShortVerb{\|}
\begin{table}[ht]
  \caption{C Bitwise Operators}
  \vspace*{6pt}
  \centering
    % Table format:
    %     WHAT    DESCRIPTION
    %     @{}     don't put extra space before first column
    %     c       first column is centered
    %     c       second column is centered
    %     c       third column is centered
    %     c       fourth column is centered
    %     @{}     don't put extra space after fourth column
    \begin{tabular}{@{}cccc@{}}
      \toprule
      \bf A& \bf B& \bf A\(|\)B& \bf A\&B\\[2pt]
      \midrule
      0& 0& 0& 0\\
      0& 1& 1& 0\\
      1& 0& 1& 0\\
      1& 1& 1& 1\\
      \bottomrule
    \end{tabular}
  \label{ta:C-Bitwise}
\end{table}
}



\begin{table}[ht]
  \caption{Participant descriptors for twelve practitioners engaged in co-creation activities}
  \label{tab:22participants}
  \center
  \begin{tabular}{@{}cllS@{}}
    \toprule
    \multicolumn{1}{@{}l}{\textbf{Pseudonym}}&
      \textbf{Disciplinary Role}&
      \textbf{Company Type}&
      \multicolumn{1}{l@{}}{\textbf{\# Years of Experience}}\\
    \midrule
    \multicolumn{4}{@{}l@{}}%
```

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

Pseudonym	Disciplinary Role	Company Type	# Years of Experience
Sequence 1: 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
Sequence 2: 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

```
    {%
      \textbf{Sequence 1:} $\text{A1.1}\to\text{B2.1}$:
      Overlapping dilemma cards to strengthen and represent%
    }\\
    \multicolumn{4}{@{}l}{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\\
    \noalign{\vspace{8pt}}
    \multicolumn{4}{@{}l@{}}%
    {%
      \textbf{Sequence 2:} $\text{B2.1}\to\text{A1.1}$:
      Building and tracing complexity based on Dilemmas Cards%
    }\\
    \multicolumn{4}{@{}l}{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\\
    \bottomrule
  \end{tabular}
\end{table}
```

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

Table P.6. State Abbreviations

State	Abbreviation
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

Table P.6. *continued*

State	Abbreviation
New York	NY
North Carolina	NC
North Dakota	ND
Northern Mariana Islands	MP
Ohio	OH
Oklahoma	OK
Oregon	OR
Pennsylvania	PA
Puerto Rico	PR
Rhode Island	RI
South Carolina	SC
South Dakota	SD
Tennessee	TN
Texas	TX
Utah	UT
Vermont	VT
Virgin Islands	VI
Virginia	VA
Washington	WA
West Virginia	WV
Wisconsin	WI
Wyoming	WY
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	

continued on next page

Table P.6. *continued*

State	Abbreviation
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	
make this three pages long	

```
\newpage

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

% This is very loosely based on page 106 of _A Guide to LaTeX_, third edition,
% by Helmut Kopka and Patrick W. Daly.
\begin{longtable}{@{}ll@{}}
    \caption{State Abbreviations}\\
    \toprule
    \bf State& \bf Abbreviation\\
    \hline
  \endfirsthead
    \caption[]{\emph{continued}}\\
    \midrule
    \bf State& \bf Abbreviation\\
    \midrule
  \endhead
    \hline
    \multicolumn{2}{r}{\emph{continued on next page}}
  \endfoot
    \bottomrule
  \endlastfoot
  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\\
   New York& NY\\
   North Carolina& NC\\
   North Dakota& ND\\
   Northern Mariana Islands& MP\\
   Ohio& OH\\
   Oklahoma& OK\\
   Oregon& OR\\
   Pennsylvania& PA\\
   Puerto Rico& PR\\
   Rhode Island& RI\\
   South Carolina& SC\\
   South Dakota& SD\\
   Tennessee& TN\\
   Texas& TX\\
   Utah& UT\\
   Vermont& VT\\
   Virgin Islands& VI\\
   Virginia& VA\\
   Washington& WA\\
   West Virginia& WV\\
   Wisconsin& WI\\
   Wyoming& WY\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \multicolumn{2}{c}{make this three pages long}\\
   \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}
```

```
% The table is on the next page.

\newpage

% Set \LTcapwidth (the longtable caption width)
% to \textwidth minus 4 paragraph indent widths.
\setlength{\LTcapwidth}{\textwidth}
\addtolength{\LTcapwidth}{-4\parindent}

\newlength{\twidth}
\newlength{\theight}

\setlength{\twidth}{\textwidth}
\setlength{\theight}{\textheight}

\begin{sidewaystable}
  % The following two lines compensate for what I think is a bug.
  \setlength{\textwidth}{\theight}
  \setlength{\textheight}{\twidth}
  \caption{Sidewaystable of the first three American Presidents.}
  \vspace*{6pt}
  \centering
    \begin{tabular}{@{}rl@{}}
      \toprule
      \bf Number& \bf Name\\
      \midrule
      1& George Washington\\
      2& John Adams\\
      3& Thomas Jefferson\\
      \bottomrule
    \end{tabular}
\end{sidewaystable}
```

Table P.7. Sidewaystable of the first three American Presidents.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

```
\begin{sidewaystable}
  % The following two lines compensate for what I think is a bug.
  \setlength{\textwidth}{\theight}
  \setlength{\textheight}{\twidth}
  \caption{Two tables can be placed vertically in a sidewaystable environment.}
  \vspace*{6pt}
  \centering
    \begin{tabular}{@{}rl@{}}
      \toprule
      \bf Number& \bf Name\\
      \midrule
      1& George Washington\\
      2& John Adams\\
      3& Thomas Jefferson\\
      \bottomrule
    \end{tabular}
  \vspace*{2\baselineskip}
  \caption{This is the second table in the sideways environment.}
  \vspace*{6pt}
    \begin{tabular}{@{}rl@{}}
      \toprule
      \bf Number& \bf Name\\
      \midrule
      1& George Washington\\
      2& John Adams\\
      3& Thomas Jefferson\\
      \bottomrule
    \end{tabular}
\end{sidewaystable}
```

Table P.8. Two tables can be placed vertically in a sidewaystable environment.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

Table P.9. This is the second table in the sideways environment.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

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

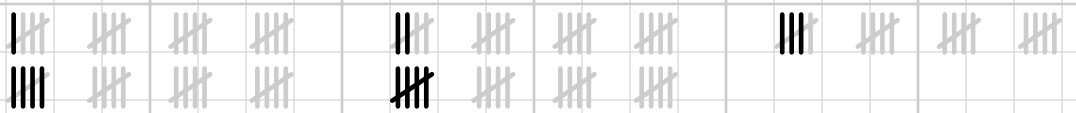
Table P.10. Live Guitar Open String Testing Data - Pitch (f_0)

Note Name	Computed f_0 (Hz)	Live Guitar Test 1 Measured f_0 (Hz)	% Error	Accuracy Range (¢)	Live Guitar Test 2 Measured f_0 (Hz)	% Error	Accuracy Range (¢)	Live Guitar Test 3 Measured f_0 (Hz)	% Error	Accuracy Range (¢)
E_2	82.407	82.333	0.0897	+2	82.616	0.2538	+6	82.474	0.0814	+2
A_2	110.000	110.092	0.0836	+2	110.092	0.0836	+2	110.092	0.0836	+2
D_3	146.832	146.789	0.0295	−2	146.789	0.0295	−2	147.239	0.2769	+6
G_3	195.998	196.721	0.3690	+8	195.918	0.0407	+2	196.721	0.3690	+8
B_3	246.942	247.423	0.1949	+4	246.517	0.1720	−4	247.423	0.1949	+4
E_4	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.

```
% Define a control sequence to save typing.
% Let * represent zero or more spaces!
% Method 1: \def\g#1{ requires using \g*{10} for 10.
%           Two shifted characters, { and } are needed.
% Method 2: \def\g#1/{ requires using \g*10/ for 10.
%           One unshifted character, / is needed.
% Method 2 requires less work than Method 1.
\def\g#1/{\includegraphics[scale=0.5]{gr-metapost-tally-#1.pdf}}%

% Define a length for use later.
\newlength{\tlen}
\setlength{\tlen}{2\parindent}
```

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



```
\begin{table}[h]%
  \label{ta:first-tally-table}
  \caption
  [%
    First tally table.  Use this method.%
  ]%
  {%
    First tally table.  Use this method.  I think it is the simplest.
  }
  \vspace*{6pt}
  %   Note that tabular* instead of tabular is used below.
  %   The {\textwidth} makes the total width of the table the width
  % of the printed area of the page.
  %   The @{\kern\tlen} puts blank space the width of two paragraph indents
  % before the first column.
  %   The @{extracolsep{\fill}} adds \fill space between all subsequent
  % columns.
  %   The lll left justifies the next three columns.
  % after the column.
  %   The @{\kern\tlen} puts blank space the width of two
  % paragraph indents before the first column.
  \begin{tabular*}{\textwidth}{@{\kern\tlen}@{\extracolsep{\fill}}lll@{\kern\tlen}}%
    \g 01/& \g 02/& \g 03/\\
    \g 04/& \g 05/\\
  \end{tabular*}%
\end{table}
```

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

```
\begin{table}[h]
  \caption{%
    Second tally table.
    Don't use this method.
    The method used in the first tally table
    is easier to understand.%
  }%
  \vspace*{6pt}
  %   Note that tabularx instead of tabular is used below.
  %   The {\textwidth} makes the total width of the table the width
  % of the printed area on the page.
  %   The @{\kern\tlen} puts blank space the width of two paragraph indents
  % before the first column.
  %   The XX makes the first two columns the same width including the space
  % after the column.
  %   The l left justifies the last column.
  %   The @{\kern\tlen} puts blank space the width of two paragraph indents
  % after the last column.
  \begin{tabularx}{\textwidth}{@{\kern\tlen}XXl@{\kern\tlen}}%
    \g 01/& \g 02/& \g 03/\\
    \g 04/& \g 05/\\
  \end{tabularx}%
\end{table}
```

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

```
\begin{table}[h!]
  \caption{
    Third tally table.
    Don't use this method.
    The method used in the first tally table
    is easier to understand.%
  }%
  \vspace*{6pt}
  \def\t #1/#2/#3/%
  {%
    \hbox to\textwidth{%
      \kern\tlen \g #1/\hfil \g #2/\hfil \g #3/\kern\tlen
    }%
  }%
  \vbox{
    \t 01/02/03/
    \hbox to\textwidth{%
      \kern\tlen \g 04/\hfil \g 05/\hfil \phantom{\g 05/}\kern\tlen
    }%
    }
  \end{table}


% Process all unprocessed floats.
% None of the current floats will be after the \FloatBarrier.
\FloatBarrier
```

Q. SPECIAL CHARACTERS

special characters⇒Special Characters appendix

```
\chapter{SPECIAL CHARACTERS}
\ix{special characters//Special Characters appendix}
```

Symbol	LaTeX Input	Comment
¡	\textexclamdown	inverted exclamation mark !‘ also works in PurdueThesis
¿	\textquestiondown	inverted question mark ?‘ also works in PurdueThesis
ő	\H{o}	Hungarian o with double acute

```
% The following two lines compensate for what I think is a bug.
\begin{tabular}{@{}lll@{}}
  \toprule
  \textbf{Symbol}  & \textbf{\LaTeX\ Input}& \textbf{Comment}\\
  \midrule
  \textexclamdown  & |\textexclamdown|     & inverted exclamation mark\\
                   &                       & |!‘| also works in PurdueThesis\\
  \textquestiondown& |\textquestiondown|   & inverted question mark\\
                   &                       & |?‘| also works in PurdueThesis\\
  \H{o}            & |\H{o}|               & Hungarian o with double acute\\
  \bottomrule
\end{tabular}
\index{special characters}
\index{\verb+\begin{tabular}+}
```

R. TESTING (THIS APPENDIX IS USED FOR TESTING, DOES THIS VERY, VERY, 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

R.1 Figure Captions

This is a paragraph.

```
1
2  \paragraph{This is a paragraph.}
```

This is the figure.

Figure R.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}
```

R.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}
```

```

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

Test apostrophes in math mode: \(f',\ f'',\text{ and }f'''\).
```

R.3 Citations

Do a bunch of citations:
[39]–[48]
[49]–[58]
[59]–[68]
[69]–[78]
[79]–[88]
[89]–[98]
[99]–[108]
[109]–[118]
[119]–[128]
[129]–[138].

If numeric citations are used, these numeric citations get "compressed":
[39]–[41], [43], [45], [46], [136]–[138].

```

\section{Citations}

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

If numeric citations are used,
these numeric citations get ``compressed'':\\
\cite{t100,t099,t001,t002,t003,t005,,t007,t008,t098}.\\
```

R.4 Footnote

This is a footnote[1]

footnote

```


\section{Footnote}

```

[1] This is a footnote.

```
This is a footnote\footnote{This is a footnote.}%
\index{\verb+\footnote+}%
\ix{footnote}
```

R.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}
```

use

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

instead.

R.6 To-do notes

Make a todo comment.

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

The Purdue football game is at noon tomorrow.

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

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

$n - 1$ should be n.

```


\section{To-do notes}

Make a todo comment.%
\todocomment{Some people use ``to-do'',
  but I want to be consistent with command names.}

The Purdue football game is at noon tomorrow.%
\todowarn{Leave at 10:00---the traffic will be terrible.}

\[
  \sum_1^n = 1, 2, \ldots, n - 1
\]%
\todoerror{\(n-1\) should be \(n\).}
```

Cite a reference with a very, very, very, ... long title [139].

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

@mischambleton, 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 [23] and [24] 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.
```

S. TEXT

Text

```
\chapter{TEXT}

\ix{Text}
```

S.1 Color

The soul package [140] package is loaded by `thesis.tex`. The package defines the following commands: this text is highlighted in yellow and is so long it is absolutely guaranteed to go to the next line for testing. See the citation for much more information.

The xcolor package [141] package is loaded by PurdueThesis. The package defines the following commands: ~~this text is printed in red and is so long it is absolutely guaranteed to go to the next line~~ for testing. See the citation for much more information.

```


\section{Color}

The soul package \cite{franz2003} package is loaded by |thesis.tex|.
The package defines the following commands:
\hl{%
  this text is highlighted in yellow
  and is so long it is absolutely guaranteed
  to go to the next line%
} for testing.
See the citation for much more information.

The xcolor package \cite{kern2021} package is loaded by \PurdueThesisLogo.
The package defines the following commands:
\textcolor{red}{%
  this text is printed in red
  and is so long it is absolutely guaranteed
  to go to the next line%
} for testing.
See the citation for much more information.
```

S.2 Description, enumerate, and itemize environments

description environment ⇒ enumerate environment ⇒ itemize environment

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.

```
% The \sentence command is also defined in the convington package
% so I'll comment this one out.  I don't think this sentence
% command is used.
% \newcommand\sentence[1]{\MyRepeat{This is a sentence.  }{#1}}

\section{Description, enumerate, and itemize environments}
\ix{description environment//enumerate environment//itemize environment}
\index{\verb+\begin{description}+}
\index{\verb+\begin{enumerate}+}
\index{\verb+\begin{itemize}+}

The first example:

\begin{description}
  \item[elephant]
    \MyRepeat{This is the elephant item of a description environment. }{3}
  \item[frog]
    \MyRepeat{This is the frog item of a description environment. }{3}
\end{description}

\begin{enumerate}
  \item
    \MyRepeat{This is the first item of an enumerate environment. }{3}
  \item
    \MyRepeat{This is the second item of an enumerate environment. }{3}
\end{enumerate}

\begin{itemize}
  \item
    \MyRepeat{This is the first item of an itemize environment. }{3}
  \item
    \MyRepeat{This is the second item of an itemize environment. }{3}
\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 iitem of a level one enumerate environment. This is the second iitem 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.

```
The second example:

\begin{description}
  \item[elephant]
    \MyRepeat{This is the elephant item of a level zero description environment. }{2}
    \begin{enumerate}
      \item
        \MyRepeat{This is the first item of a level one enumerate environment. }{2}
      \begin{itemize}
        \item
          \MyRepeat{This is the first item of a level two itemize environment. }{2}
        \item
          \MyRepeat{This is the first item of a level two itemize environment. }{2}
      \end{itemize}
      \item
        \MyRepeat{This is the second iitem of a level one enumerate environment. }{2}
    \end{enumerate}
  \item[frog]
    \MyRepeat{This is the frog item of a level zero description environment. }{2}
\end{description}
```

S.3 Computer program listings

```

\section{Computer program listings}

\lstset{language=Pascal}

\begin{ZZlisting}
  \caption{This is the caption.}
  \begin{CenteredBox}
     This is the listing.
  \end{CenteredBox}
\end{ZZlisting}
```

Listing S.1. This is the caption.
This is the listing.

Listing S.2. A Pascal Program

```
for i:=maxint to 0 do
begin
    { do nothing }
end;
Write('Case insensitive.');
WritE('Pascal keywords.');
```

```
\begin{ZZlisting}
  \caption{A Pascal Program}
  \begin{CenteredBox}
    \begin{lstlisting}
for i:=maxint to 0 do
begin
    { do nothing }
end;
Write('Case insensitive.');
WritE('Pascal keywords.');
    \end{lstlisting}
  \end{CenteredBox}
\end{ZZlisting}
```

S.4 Frenchspacing

frenchspacing ⇒ nonfrenchspacing

The \frenchspacing \nonfrenchspacing command puts approximately one two spaces after sentences. The default is \nonfrenchspacing.

Lorem ipsum dolor sit amet, consectetuer 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, consectetuer 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.

```


\section{Frenchspacing}%
\ix{frenchspacing//nonfrenchspacing}
\index{\verb+\frenchspacing+}
\index{\verb+\nonfrenchspacing+}

The
\def\t{{\tt\char'134 frenchspacing}}
\def\u{{\tt\char'134 nonfrenchspacing}}
\raise6pt\hbox{\rlap{\t}}%
\lower6pt\hbox{\u}
command puts approximately
\raise6pt\hbox{\rlap{one}}%
\lower6pt\hbox{two}
spaces after sentences.
The\\[3pt]
```

```
default is |\nonfrenchspacing|.

{\frenchspacing
Lorem ipsum dolor sit amet, consectetuer 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.\endgraf
}

Lorem ipsum dolor sit amet, consectetuer 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.
```

S.5 Multiple Columns

Depending on what version of LaTeX 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 two columns. This is two columns.

This is three columns. This is three columns. This is three columns. This is three columns. This is three columns. This is three columns. This is three columns. This is three columns. This is three 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. This is four columns. This is four columns. This is four columns. This is four columns.

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

```
\section{Multiple Columns}

Depending on what version of \LaTeX\ you're running
the \verb+multicols+ package may or may not do what
you want.

% The multicols package must be loaded for this to work.
% To load the multicols package put
%     \usepackage{multicols}
% between the "\documentclass" and "\begin{document}" commands.

% Put this amount of space between the columns.
% Let's use the default column separation to see what happens.
% \setlength{\columnsep}{0.5truein}

% Separate the columns with a vertical rule this wide.
% Make the column three times the default width.
\setlength{\columnseprule}{1.2pt}

This is one column\MyRepeat{This is one column.  }{10}

\begin{multicols}{2}
  \MyRepeat{This is two columns.  }{12}
\end{multicols}

\begin{multicols}{3}
  \MyRepeat{This is three columns.  }{9}
\end{multicols}

\begin{multicols}{4}
  \MyRepeat{This is four columns.  }{10}
\end{multicols}

\begin{multicols}{5}
  \MyRepeat{This is five columns.  }{10}
\end{multicols}
```

S.6 Words

irregardless is a nonstandard word that means regardless. Use *regardless* instead [142].

out of date / out-of-date means "outmoded, obsolete". [143].

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 [144]. Also see [145].

In the context of writing about out-of-date software you may want to use "deprecated" [146] instead.

start-up / start-up company means a fledgling business enterprise [147]. I would use the more modern *startup* and only use *company* if not clear from the context.

peace out means "goodbye" [148]

```
\section{Words}

\newenvironment{entry}
{%
  \bigskip
  % Start a \vbox here.
  % Everything in a \vbox is guaranteed to be on the same page.
  \vbox\bgroup
    \noindent
}
{%
  % End the \vbox here.
  \egroup
}

\begin{entry}
  {\bfseries irregardless}\qquad
  is a nonstandard word that means regardless.
  Use \emph{regardless} instead
  \cite{merriam-webster-irregardless}.
\end{entry}

\begin{entry}
  {\bfseries out of date / out-of-date}\qquad
  means ``outmoded, obsolete''.
  \cite{merriam-webster-out-of-date}.

  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
  \cite{thewriter-to-hyphenate-or-not-to-hyphenate}.
  Also see
  \cite{oed-out-of-date}.

  In the context of writing about out-of-date software you may want to
  use ``deprecated'' \cite{merriam-webster-deprecated} instead.
\end{entry}

\begin{entry}
  {\bfseries start-up / start-up company}\qquad
  means a fledgling business enterprise
  \cite{wikipedia-startup-company}.
  I would use the more modern \emph{startup}
  and only use \emph{company} if not clear from the context.
\end{entry}

\begin{entry}
  {\bfseries peace out}\qquad
  means
  ``goodbye''
  \cite{online-slang-dictionary-peace-out}
\end{entry}
```

T. ASTRONOMY

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

astronomy ⇒ Astronomy appendix

astronomy

U. BIOLOGY

Biology appendix

```
\chapter{BIOLOGY}

\ix{Biology appendix}
```

V. CHEMISTRY

chemistry

Chemistry appendix

```
\chapter{CHEMISTRY}
\label{ch:chemistry}

\ix{chemistry}
\ix{Chemistry appendix}

```

V.1 Chemical Diagrams

The chemplants package [149] extends the TikZ package to draw chemical process units.

```


\section{Chemical Diagrams}

The chemplants package
\cite{feffin2019}
extends the
\href{http://ctan.math.washington.edu/tex-archive/graphics/pgf/base/doc/pgfmanual.pdf}{\TikZLogo}
package
to draw chemical process units.

```

V.2 Chemical Equations

The mhchem Bundle [150] contains mhchem v4.08 (chemical equations), hpstatement v1.02 (official hazard and precautionary statements), and rsphrase v3.11 (official rist and safety phrases).

```


\section{Chemical Equations}

The mhchem Bundle
\cite{hensel2018}
contains mhchem v4.08 (chemical equations),
hpstatement v1.02 (official hazard and precautionary statements),
and rsphrase v3.11 (official rist and safety phrases).
```

Defined in thesis.tex: NO_3-.

```

Defined in thesis.tex: \nitrate.
```

$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O$

```

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

$2\,H_2(g) + O_2(g) \longrightarrow 2\,H_2O\,(l)$

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

$\mathrm{Ag^+(aq) + NO_3{}^-(aq) + Na^+(aq) + Cl^-(aq) \longrightarrow AgCl(s) + Na^+(aq) + NO_3{}^-(aq)}$ is an ionic equation of the chemical reaction: $\mathrm{AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)}$

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

$\mathrm{Fe_2O_3 + C \longrightarrow Fe + CO_2}$

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

For example, in the reaction between sodium chloride (NaCl) and silver nitrate ($\mathrm{AgNO_3}$), the molecular reaction is:
$\mathrm{NaCl(aq) + AgNO_3 \longrightarrow NaNO_3(aq) + AgCl(s)}$

```
% From page 1 of
%     https://www.thoughtco.com/definition-of-molecular-equation-605366
For example, in the reaction between sodium chloride
(\ce{NaCl})
and silver nitrate
(\ce{AgNO3}),
the molecular reaction is:

\ce{NaCl(aq) + AgNO3 -> NaNO3(aq) + AgCl(s)}
```

The complete ionic equation is:
$\mathrm{Na^+(aq) + Cl^-(aq) + Ag^+(aq) + NO_3{}^-(aq) \longrightarrow AgCl(s) + Na^+(aq) + NO_3{}^-(aq)}$

```
The complete ionic equation is:

\ce{Na+(aq) + Cl-(aq) + Ag+(aq) + NO3-(aq) -> AgCl(s) + Na+(aq) + NO3-(aq)}
```

Ruben [151, starting at 5:25] claims this equation

$$\mathrm{C_{55}H_{104}O_6 + 78\,O_2 \longrightarrow 55\,CO_2 + 52\,H_2O} + \text{energy}$$

describes weight loss.

```
Ruben
\cite[starting at 5:25]{meerman2013}
claims this equation
\begin{center}
  \ce{C55H104O6 + 78O2 -> 55CO2 + 52H2O + energy}\endgraf
\end{center}
describes weight loss.
```

And with better annotation:

$$\underset{\text{human fat}}{C_{55}H_{104}O_6} + \underset{\text{oxygen}}{78\,O_2} \longrightarrow \underset{\text{carbon dioxide}}{55\,CO_2} + \underset{\text{water}}{52\,H_2O} + \underset{\text{body heat, moving, thinking, growing}}{\text{energy}}$$

```
And with better annotation:

\begin{center}
  \newcommand{\vph}{{\vphantom{\large Ag}}}
  \ce{
    $\underset{\text{\vph \footnotesize human fat}}{\ce{C55H104O6}}$
    +
    $\underset{\text{\vph \footnotesize oxygen}}{\ce{78O2}}$
    ->
    $\underset{\text{\vph \footnotesize carbon dioxide}}{\ce{55CO2}}$
    +
    $\underset{\text{\vph \footnotesize water}}{\ce{52H2O}}$
    +
    $\underset{\text{\vph \footnotesize body heat, moving, thinking, growing}}{\text{energy}}$
  }
\end{center}
```

And with still better annotation:

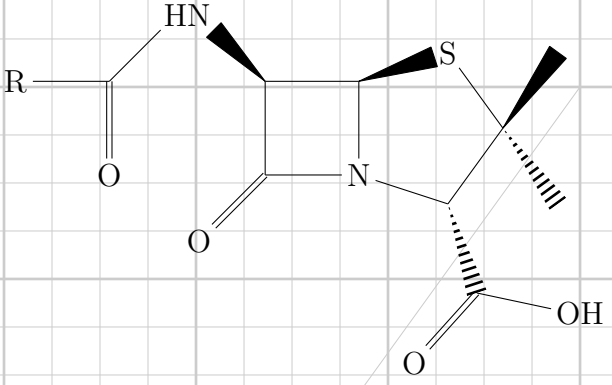
								calories
kg		kg		kg		kg		kJ
$C_{55}H_{104}O_6$	$+$	$78\,O_2$	$\longrightarrow$	$55\,CO_2$	$+$	$52\,H_2O$	$+$	energy
human fat		oxygen		carbon dioxide		water		body heat, moving, thinking, growing

```
And with still better annotation:

\begin{center}
  \newcommand{\Fs}{\scriptsize}
  \begin{tabular}{@{}c@{}c@{}c@{}c@{}c@{}c@{}c@{}c@{}c@{}}
    &                                                  %  1. C55H104O6
      &                                                %  2. +
      &                                                %  3. 78O2
      &                                                %  4. ->
      &                                                %  5. 55CO2
      &                                                %  6. +
      &                                                %  7. 52H2O
      &                                                %  8. +
      \Fs calories\\                                   %  9. energy
    %
    \Fs kg&                                            %  1.
      &                                                %  2.
      \Fs kg&                                          %  3.
      &                                                %  4.
      \Fs kg&                                          %  5.
      &                                                %  6.
      \Fs kg&                                          %  7.
      &                                                %  8.
      \Fs kJ\\                                         %  9.
    %
    \noalign{\vspace{3pt}}
    %
    \ce{C55H104O6}                                     %  1.
      & \ce{+}                                         %  2.
```

```
      & \ce{78O2}                                                  %  3.
      & \ce{->}                                                    %  4.
      & \ce{55CO2}                                                 %  5.
      & \ce{+}                                                     %  6.
      & \ce{52H2O}                                                 %  7.
      & \ce{+}                                                     %  8.
      & energy\\                                                   %  9.
    %
    \Fs human fat&                                                 %  1.
      &                                                            %  2.
      \Fs oxygen&                                                  %  3.
      &                                                            %  4.
      \Fs carbon dioxide&                                          %  5.
      &                                                            %  6.
      \Fs water&                                                   %  7.
      &                                                            %  8.
      \Fs body heat, moving, thinking, growing\\                   %  9.
  \end{tabular}
\end{center}
```

V.3 Chemical Figures

Below is an example of how to use the chemfig package [152].
Here is the chemical figure for Penicillin [152, pages 72–73]




```


\section{Chemical Figures}

Below is an example of how to use the chemfig package
\cite{tellechea2021}.

% Chicago Manual of Style Online, 17 edition, section 9.61 states
% that 72--73, not 72--3, should be used.
Here is the chemical figure
for Penicillin
\cite[pages~72--73]{tellechea2021}\\

\chemfig{
  [:-90]HN(-[::-45](-[::-45]R)=[::+45]O)>[::+45]*4(-(=O)-N*5(-(<:(=[::-60]O)
  -[::+60]OH)-(<[::+0])(<:[::-108])-S>)--)
}
```

V.4 Chemical Schemes

Below are some examples of how to do schemes.

Scheme V.1. This is the first scheme caption.

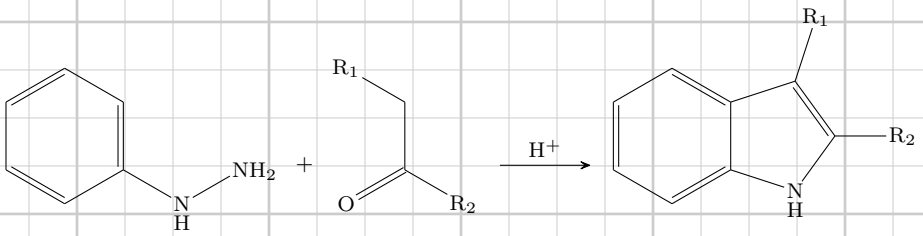
This is the first scheme.

```
\newpage
\section{Chemical Schemes}

Below are some examples of how to do schemes.

\begin{scheme}[ht]
  \caption{This is the first scheme caption.}
  \vspace*{6pt}
  \begin{center}
    This is the first scheme.
  \end{center}
\end{scheme}
```

Scheme V.2. This is the second scheme caption.

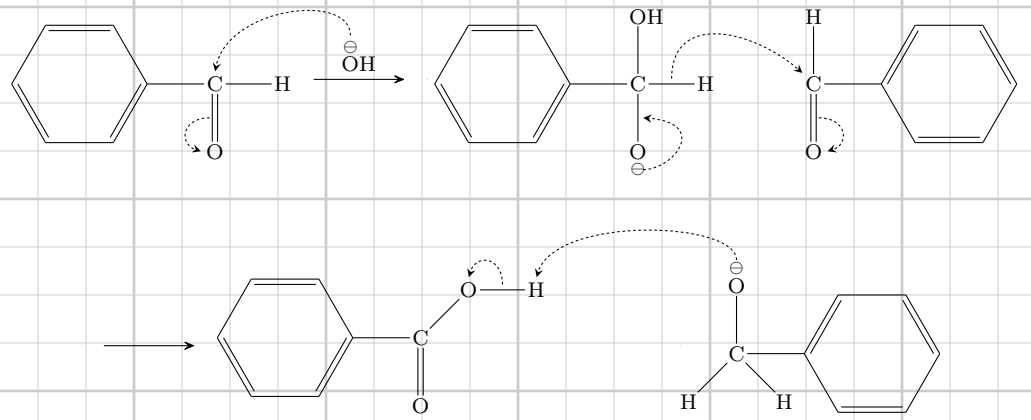

```
\begin{scheme}[ht]
  \caption{This is the second scheme caption.}
  \vspace*{6pt}
  \begin{center}
    % Next line was added to make scheme a little smaller.
    \scriptsize\setchemfig{bond offset=1pt,atom sep=3em,compound sep=6em}
    \schemestart
      \chemfig{-[:30](-[2])-[:-30]OH}
      \arrow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

Scheme V.3. The Fischer indole synthesis [152, pages 74–75].




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

Scheme V.4. The Cannizzaro reaction [152, pages 77–78].




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

W. COMPUTER SCIENCE

computer science ⇒ Computer Science appendix

The cryptocode package [153] is used to typeset pseudocode, algorithms, and protocols.

cryptocode ⇒ pseudocode ⇒ algorithm ⇒ protocol

```
\chapter{COMPUTER SCIENCE}
\ix{computer science//Computer Science appendix}

The cryptocode package
\cite{mittelbach2020}
\ix{cryptocode//pseudocode//algorithm//protocol}%
is used to typeset pseudocode,
algorithms,
and protocols.
```

W.1 Protocol examples

Protocol W.1. This is the first protocol caption.

This is the first protocol.

Protocol W.2. This is the second protocol caption.

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

```


\section{Protocol examples}

\begin{protocol}[ht]
  \caption{This is the first protocol caption.}
  This is the first protocol.
\end{protocol}

\begin{protocol}[ht]
  \caption{This is the second protocol caption.}
  \pseudocodeblock
  {
    \textbf{Alice} \> \> \textbf{Bob}\\
    b \sample \bin \> \>\\
    \> \xrightarrow{\text{send over } b} \> \\
    \> \> \text{do something}
  }
\end{protocol}
```

X. ELECTRICAL ENGINEERING

electrical engineering ⇒ Electrical Engineering appendix

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

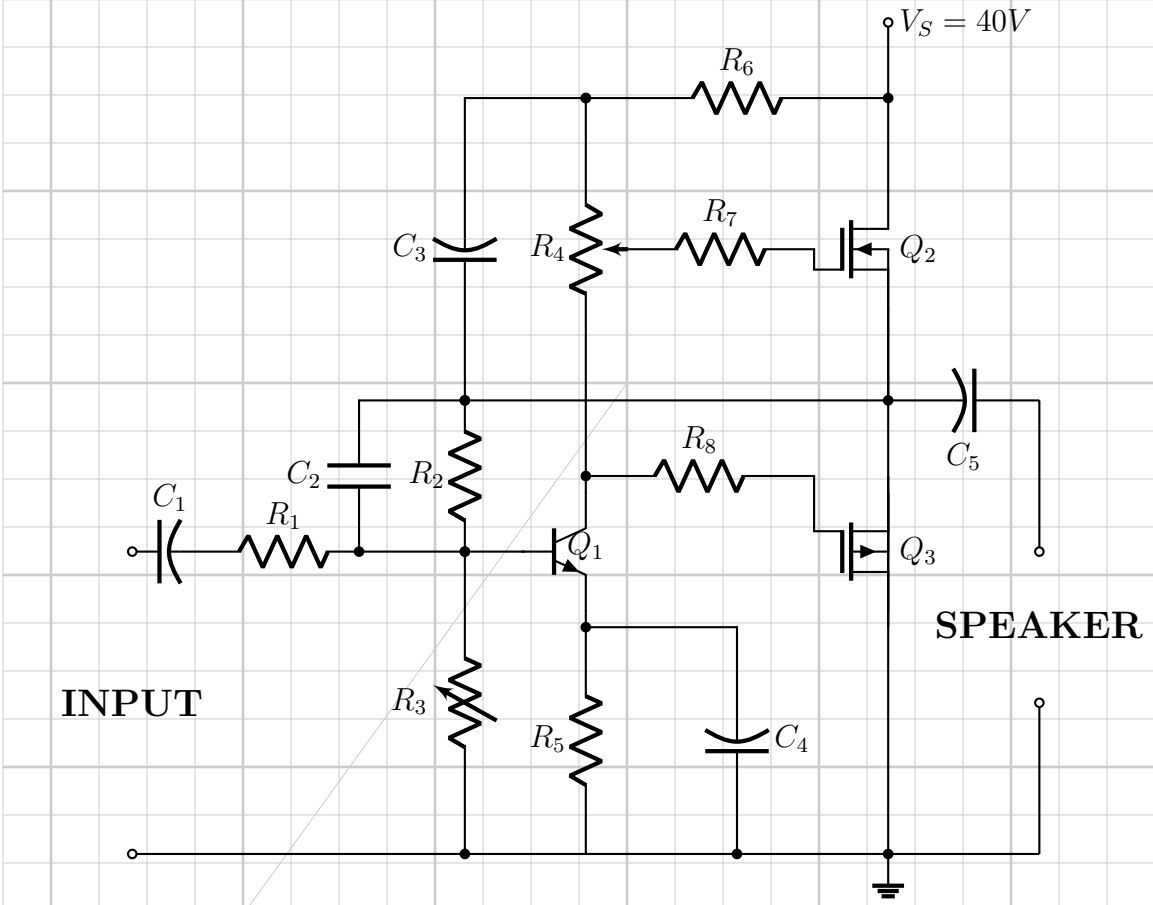
X.1 Amplifiers

```


\section{Amplifiers}
```

This 18 W MOSFET amplifier with npn transistor was done by Ramón Jaramillo [154]. This example make uses the CircuiTi*k*Z [155] and siunitx packages.

Jaramillo, Ramón

Redaelli, Massimo A.




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

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

```
    (0,0) to [short,o-] (6,0){} % Baseline for connection to ground
    % Input and ground
    (0,1) node[]{\large{\textbf{INPUT}}}
    % Connection of passive components
    (5,0) node[ground]{} node[circ](4.5,0){}
    (0,2) to [cC, l=$C_1$, o-] (0.5,2)
    to [R,l=$R_1$,](1.5,2)
    to node[short]{}(2.6,2)
    (1.5,2) to [C, l=$C_2$, *-] (1.5,3) -| (5,3)
    (2.2,2) to [R, l=$R_2$, *-*] (2.2,3)
    (2.2,3) to [cC, l=$C_3$, *-] (2.2,5) -| (3,5)
    % Transistor Bipolar Q1
    (3,0) to [R,l=$R_5$,-*] (3,1.5)
    to [Tnpn,n=npn1] (3,2.5)
    (npn1.E) node[right=3mm, above=5mm]{$Q_1$} % Labelling the NPN transistor
    (4,0) to [cC, l_=$C_4$, *-] (4, 1.5)--(3,1.5)
    (2.2,0) to [vR, l=$R_3$, *-*] (2.2,2)
    (3,2.5) to node[short]{}(3,3)
    (3,5) to [pR, n=pot1, l_=$R_4$, *-] (3,3)
    (3,5) to [R, l=$R_6$, *-] (5,5)
    to [short,*-o](5,5.5) node[right]{$V_S=40 V$}
    % Mosfet Transistors
    (5,3) to [Tnigfetd,n=mos1] (5,5)
    (mos1.B) node[anchor=west]{$Q_2$} % Labelling MOSFET Q2 Transistor
    (pot1.wiper) to [R, l=$R_7$] (4.5,4) -| (mos1.G)
    (5,1.5) to [Tpigfetd,n=mos2] (5,2.5)
    (5,0) to (mos2.S)
    (3,2.5) to [R, l=$R_8$, *-] (4.5,2.5)
    -| (mos2.G)
    (mos2.B) node[anchor=west]{$Q_3$} % Labelling MOSFET Q3 Transistor
    % Output
    (6,3) to [cC, l=$C_5$,-*](5,3)
    (6,3) to [short,-o] (6,2){}
    (mos1.S)--(mos2.D)
    (6,0) to [short,-o] (6,1){} node[above=7mm]{\large{\textbf{SPEAKER}}}
    ;
\end{tikzpicture}
```

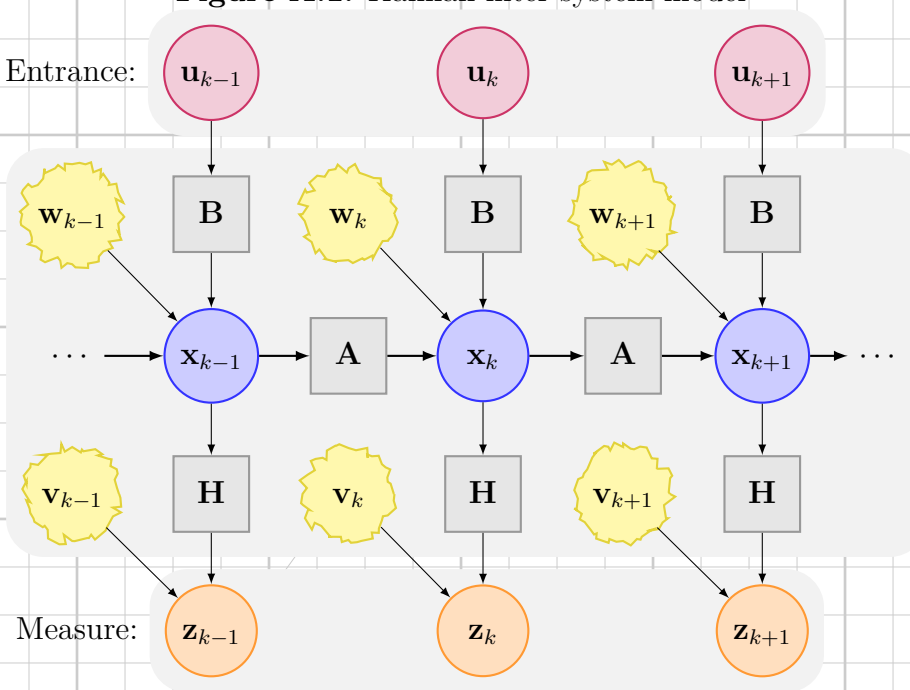
X.2 Kalman Filter System Model

This Kalman filter system model was done by Burkart Lingner [156].

Lingner, Burkart

```

\section{Kalman Filter System Model}

This Kalman filter system model was done by Burkart Lingner
\cite{lingner2010}.
\ix{Lingner, Burkart}

% An example using TikZ/PGF 2.00
%
% Features: Decorations, Fit, Layers, Matrices, Styles
% Tags: Block diagrams, Diagrams
% Technical area: Electrical engineering

%%%% \documentclass[a4paper,10pt]{article}
%%%%
%%%% \usepackage[english]{babel}
%%%% \usepackage[T1]{fontenc}
%%%% \usepackage[ansinew]{inputenc}
```

Figure X.1. Kalman filter system model



```
%%%%
%%%% \usepackage{lmodern}        % font definition
%%%% \usepackage{amsmath}        % math fonts
%%%% \usepackage{amsthm}
%%%% \usepackage{amsfonts}
%%%%
%%%% \usepackage{tikz}
%%%%
%%%% %%%<
%%%% \usepackage{verbatim}
%%%% \usepackage[active,tightpage]{preview}
%%%% \PreviewEnvironment{tikzpicture}
%%%% \setlength\PreviewBorder{5pt}%
%%%% %%%>
%%%%
%%%% \begin{comment}
%%%% :Title: Kalman Filter System Model
%%%% :Slug: kalman-filter
%%%% :Author: Burkart Lingner
%%%%
%%%% This is the system model of the (linear) Kalman filter.
%%%%
%%%% \end{comment}
%%%%
%%%%

\begin{figure}[htbp]
\caption{Kalman filter system model}
\centering
% The state vector is represented by a blue circle.
% "minimum size" makes sure all circles have the same size
% independently of their contents.
\tikzstyle{state}=[circle,
                                  thick,
                                  minimum size=1.2cm,
                                  draw=blue!80,
                                  fill=blue!20]

% The measurement vector is represented by an orange circle.
\tikzstyle{measurement}=[circle,
                                              thick,
                                              minimum size=1.2cm,
                                              draw=orange!80,
                                              fill=orange!25]

% The control input vector is represented by a purple circle.
\tikzstyle{input}=[circle,
                                  thick,
                                  minimum size=1.2cm,
                                  draw=purple!80,
                                  fill=purple!20]

% The input, state transition, and measurement matrices
% are represented by gray squares.
% They have a smaller minimal size for aesthetic reasons.
\tikzstyle{matrx}=[rectangle,
                                  thick,
                                  minimum size=1cm,
                                  draw=gray!80,
                                  fill=gray!20]

% The system and measurement noise are represented by yellow
% circles with a "noisy" uneven circumference.
% This requires the TikZ library "decorations.pathmorphing".
```

```
\tikzstyle{noise}=[circle,
                                thick,
                                minimum size=1.2cm,
                                draw=yellow!85!black,
                                fill=yellow!40,
                                decorate,
                                decoration={random steps,
                                                    segment length=2pt,
                                                    amplitude=2pt}]

% Everything is drawn on underlying gray rectangles with
% rounded corners.
\tikzstyle{background}=[rectangle,
                                            fill=gray!10,
                                            inner sep=0.2cm,
                                            rounded corners=5mm]

\begin{tikzpicture}[>=latex,text height=1.5ex,text depth=0.25ex]
    % "text height" and "text depth" are required to vertically
    % align the labels with and without indices.

  % The various elements are conveniently placed using a matrix:
  \matrix[row sep=0.5cm,column sep=0.5cm] {
    % First line: Control input
    &
        \node (u_k-1) [input]{$\mathbf{u}_{k-1}$}; &
        &
        \node (u_k)   [input]{$\mathbf{u}_k$};     &
        &
        \node (u_k+1) [input]{$\mathbf{u}_{k+1}$}; &
        \\
        % Second line: System noise & input matrix
        \node (w_k-1) [noise] {$\mathbf{w}_{k-1}$}; &
        \node (B_k-1) [matrx] {$\mathbf{B}$};       &
        \node (w_k)   [noise] {$\mathbf{w}_k$};     &
        \node (B_k)   [matrx] {$\mathbf{B}$};       &
        \node (w_k+1) [noise] {$\mathbf{w}_{k+1}$}; &
        \node (B_k+1) [matrx] {$\mathbf{B}$};       &
        \\
        % Third line: State & state transition matrix
        \node (A_k-2)         {$\cdots$};           &
        \node (x_k-1) [state] {$\mathbf{x}_{k-1}$}; &
        \node (A_k-1) [matrx] {$\mathbf{A}$};       &
        \node (x_k)   [state] {$\mathbf{x}_k$};     &
        \node (A_k)   [matrx] {$\mathbf{A}$};       &
        \node (x_k+1) [state] {$\mathbf{x}_{k+1}$}; &
        \node (A_k+1)         {$\cdots$};           \\
        % Fourth line: Measurement noise & measurement matrix
        \node (v_k-1) [noise] {$\mathbf{v}_{k-1}$}; &
        \node (H_k-1) [matrx] {$\mathbf{H}$};       &
        \node (v_k)   [noise] {$\mathbf{v}_k$};     &
        \node (H_k)   [matrx] {$\mathbf{H}$};       &
        \node (v_k+1) [noise] {$\mathbf{v}_{k+1}$}; &
        \node (H_k+1) [matrx] {$\mathbf{H}$};       &
        \\
        % Fifth line: Measurement
        &
        \node (z_k-1) [measurement] {$\mathbf{z}_{k-1}$}; &
        &
        \node (z_k)   [measurement] {$\mathbf{z}_k$};     &
        &
        \node (z_k+1) [measurement] {$\mathbf{z}_{k+1}$}; &
        \\
    };
```

```
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}
```

Y. LINGUISTICS

linguistics ⇒ Linguistics appendix

See WIKIBOOKS LaTeX/Linguistics [157] or google for the information you need.

The doulossil font [158] is a TrueType font. Version 0.1 on September 21, 2020 claimed "it has characters that are not in other TeX IPA fonts".

```
\chapter{LINGUISTICS}
\ix{linguistics//Linguistics appendix}

See WIKIBOOKS \LaTeX/Linguistics \cite{wikibooks-latex-linguistics}
or google for the information you need.

The doulossil font
\cite{tambe2020}
is a TrueType font.
Version 0.1 on September 21, 2020 claimed
``it has characters that are not in other TeX IPA fonts''.
```

Y.1 Demonstrate the example and examples environments

The example and examples environment are defined in the covington [159] package.

Demonstrate the example environment:

(Y.1)

This is an example. This is an example.

Demonstrate the examples environment:

(Y.2)

First example.

(Y.3)

Second example.

```


\section{Demonstrate the example and examples environments}

The example and examples environment
are defined
in the covington
\cite{covington2021}
package.

Demonstrate the example environment:
\begin{example}
  This is an example.
  This is an example.
\end{example}

Demonstrate the examples environment:
\begin{examples}
  \item First example.
  \item Second example.
\end{examples}
```

Z. MATHEMATICS

mathematics ⇒ Mathematics appendix

PurdueThesis loads the AMSmath package [160] to do mathematics.

```
\chapter{MATHEMATICS}
\ix{mathematics//Mathematics appendix}

\PurdueThesisLogo\ loads the \AMSmathLogo\ package
\cite{amslatex3project2019}
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:

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

```
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:
\begin{equation}
  a = b + c
\end{equation}
```

Z.1 Standard Functions

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

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

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

```
\newpage

\section{Standard Functions}

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

% The "@{\hspace*{\parindent}}" indents the table
% the same amount as a paragraph.
\begin{tabular}{@{\hspace*{\parindent}}llll@{}}
  \verb+\arccos+& \verb+\csc+& \verb+\ker+&    \verb+\min+\\
  \verb+\arcsin+& \verb+\deg+& \verb+\lg+&     \verb+\Pr+\\
  \verb+\arctan+& \verb+\det+& \verb+\lim+&    \verb+\sec+\\
  \verb+\arg+&    \verb+\dim+& \verb+\liminf+& \verb+\sin+\\
  \verb+\cos+&    \verb+\exp+& \verb+\limsup+& \verb+\sinh+\\
  \verb+\cosh+&   \verb+\gcd+& \verb+\ln+&     \verb+\sup+\\
  \verb+\cot+&    \verb+\hom+& \verb+\log+&    \verb+\tan+\\
  \verb+\coth+&   \verb+\inf+& \verb+\max+&    \verb+\tanh+\\
\end{tabular}
\ix
{%
  arccos//arcsin//arctan//arg//cos//cosh//cot//coth%
  //csc//deg//det//dim//exp//gcd//hom//inf%
  //ker//lg//lim//liminf//limsup//ln//log//max%
  //min//Pr//sec//sin//sinh//sup//tan//tanh%
}
\index{\verb+\arccos+} \index{\verb+\arcsin+} \index{\verb+\arctan+} \index{\verb+\arg+}
\index{\verb+\cos+} \index{\verb+\cosh+} \index{\verb+\cot+} \index{\verb+\coth+}
\index{\verb+\csc+} \index{\verb+\deg+} \index{\verb+\det+} \index{\verb+\dim+}
\index{\verb+\exp+} \index{\verb+\gcd+} \index{\verb+\hom+} \index{\verb+\inf+}
\index{\verb+\ker+} \index{\verb+\lg+} \index{\verb+\lim+} \index{\verb+\liminf+}
\index{\verb+\limsup+} \index{\verb+\ln+} \index{\verb+\log+} \index{\verb+\max+}
\index{\verb+\min+} \index{\verb+\Pr+} \index{\verb+\sec+} \index{\verb+\sin+}
\index{\verb+\sinh+} \index{\verb+\sup+} \index{\verb+\tan+} \index{\verb+\tanh+}
```

Z.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}.
$a_{\text{max}} \ge a_{\text{min}}$ should always be true.
The temperature in the attic is t_{attic}.

```
\newpage

\section{English Words in Math}

English words in math should be in a roman font like this:\\
Let the maximum value of \(a\) be \(a_\text{max}\).\\
\(a_\text{max} \ge a_\text{min}\) should always be true.\\
The temperature in the attic is \(t_\text{attic}\).
```

Z.3 Text Math

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

```
\section{Text Math}

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

Z.4 Displayed Equations

Do not use `$$` to start or end displayed math like TeX uses [161].

The AMSmath package provides a number of additional displayed equation structures beyond the ones provided in basic LaTeX. The augmented set includes [162]:

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

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

```
\section{Displayed Equations}

Do not use \verb+$$+ to start or end displayed math like \TeX\ uses
\cite{gratzer2016}.

```

```
The \AMSmathLogo\ package provides a number
of additional displayed equation structures
beyond the ones provided in basic \LaTeX.
The augmented set includes
\cite{amslatex3project2019b}:

\hbox to\hsize{%
  \hss
  \begin{tabular}{@{}ll@{}}
    \toprule
    \bfseries Environment& \bfseries Used for\\
    \midrule
    \tt equation& used for single equations\\
    \tt multline& split single equations over multiple lines\\
    \tt gather& collect but do not align multiple equations\\
    \tt align& align multiple equations\\
    \tt alignat& aligns multiple equations at multiple places\\
    \tt flalign& aligns multiple equations at multiple places on full length lines\\
    \tt split& split a single equation over multiple lines\\
    \bottomrule
  \end{tabular}%
  \hss
}

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

Z.4.1 `equation` environment

The `equation` environment is used for single equations.

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

```

\subsection{\texttt{equation} environment}

The \verb+equation+ environment is used for single equations.

\begin{equation}
  E = mc^2
\end{equation}
```

The `equation*` environment does single, unnumbered equations.

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

```

The \verb+equation*+ environment does single, unnumbered equations.

\begin{equation*}
  a = b_0c + \frac12 de^2 + {\textstyle \frac12} fg^2
    + h_1 + h_2 + \cdots + h_n
    \qquad \text{for \(c \ne d\) and \(g < \infty\)}
\end{equation*}
```

Greene [163] wrote For #PiDay, one of the coolest formulae for today's honoree:

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

```

\textcite{greene-2021-03-14}
wrote
% \begin{quotation}
  For
  \href{https://twitter.com/hashtag/PiDay?src=hashtag\_click\#PiDay}{\#PiDay},
  one of the coolest formulae for today's honoree:
  \[
    \frac 1\pi
    =
    \frac {\sqrt8} {9801}
    \sum_{n=0}^\infty
    \frac  {(4n!) (1103+26390n)}  {(n!)^4 396^{4n}}
  \]
% \end{quotation}
```

International standard ISO 80000-2:2019 [164] states that e, i, j, and π should appear as e, i, j and $\mathbf{\pi}$ 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

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

```

International standard ISO 80000-2:2019
\cite{iso8000022019}
states that $\mit e$,~$\mit i$,~$\mit j$,
and $\itpi$ 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
\begin{equation*}
  e^{i\pi} + 1 = 0.
\end{equation*}
```

Here's a simple formula relating e, i, $\mathbf{\pi}$, and ϕ, the golden ratio

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

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.

```

Here's a simple formula relating $e$,~$i$,~$\pi$, and~$\phi$,
the golden ratio
\begin{equation}
  e^{i\pi} + 2\phi = \sqrt 5.
\end{equation}
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.
```

International standard ISO 80000-2:2019 [164] states that the "d" in math differentials should be typeset as "d". So,

$$\text{use } \int x\,\mathrm{d}x \qquad \text{instead of } \int x\,dx$$

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

The formula for Bekenstein-Hawking entropy:

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

```
The formula for Bekenstein-Hawking entropy:

\begin{equation*}
  S_\text{BH}
  =
  \frac A {4L_P^2}
  = \frac {c^3A} {4G\hbar}
\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:

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

```
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 \verb+equation*+ environment,
note the spacing before the large close parenthesis:

\begin{equation*}
  \frac ab
    = ab^{-1}
    % Parens are the wrong size.
    = (\sqrt{\frac ab})^2
    % Parens are the right size but closing paren is too close to radical.
    = \left( \sqrt\frac ab \right)^2
    % Parens are right size but a negative thin space puts closing paren on top of radical.
    = \left( \sqrt\frac ab \!\right)^2
    % Parens are right size but a thin space puts closing paren too close to radical.
    = \left( \sqrt\frac ab \,\right)^2
    % Parens are right size but a medium space puts closing paren too close to radical.
    = \left( \sqrt\frac ab \:\right)^2
    % Parens are right size and I think a thick space looks the best.
    = \left( \sqrt\frac ab \;\right)^2
\end{equation*}
```

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

```

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

$$x \mod 2 = \begin{cases} 0 & \text{if } x \text{ is even} \\ 1 & \text{if } x \text{ is odd} \end{cases} \tag{Z.4}$$

```

\begin{equation}
  x \mod 2 =
  \begin{cases}
    0& \text{if $x$ is even}\\
    1& \text{if $x$ is odd}\\
  \end{cases}
\end{equation}
```

The first six derivatives of distance are velocity, acceleration, jerk, snap, crackle, and pop [165].

$$\text{distance derivitives} = \begin{cases} x = \text{distance} & = vt \\ v = \text{velocity} & = \frac{\mathrm{d}x}{\mathrm{d}t} \\ a = \text{acceleration} & = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2x}{\mathrm{d}t^2} \\ j = \text{jerk} & = \frac{\mathrm{d}a}{\mathrm{d}t} = \frac{\mathrm{d}^2v}{\mathrm{d}t^2} = \frac{\mathrm{d}^3x}{\mathrm{d}t^3} \\ s = \text{snap} & = \frac{\mathrm{d}j}{\mathrm{d}t} = \frac{\mathrm{d}^2a}{\mathrm{d}t^2} = \frac{\mathrm{d}^3v}{\mathrm{d}t^3} = \frac{\mathrm{d}^4x}{\mathrm{d}t^4} \\ c = \text{crackle} & = \frac{\mathrm{d}s}{\mathrm{d}t} = \frac{\mathrm{d}^2j}{\mathrm{d}t^2} = \frac{\mathrm{d}^3a}{\mathrm{d}t^3} = \frac{\mathrm{d}^4v}{\mathrm{d}t^4} = \frac{\mathrm{d}^5x}{\mathrm{d}t^5} \\ p = \text{pop} & = \frac{\mathrm{d}c}{\mathrm{d}t} = \frac{\mathrm{d}^2s}{\mathrm{d}t^2} = \frac{\mathrm{d}^3j}{\mathrm{d}t^3} = \frac{\mathrm{d}^4a}{\mathrm{d}t^4} = \frac{\mathrm{d}^5v}{\mathrm{d}t^5} = \frac{\mathrm{d}^6x}{\mathrm{d}t^6} \end{cases} \tag{Z.5}$$

```

The first six derivatives of distance are velocity, acceleration, jerk, snap, crackle,
and pop
\cite{reid2013}.

\begin{equation}
  % Every array element should be in \displaystyle (a big font).
  \AtBeginEnvironment{array}{\everymath{\displaystyle}}
  % Set space between columns to zero, use {} = ... to add a little space before the = "by hand".
  \arraycolsep = 0pt
  \text{distance derivitives} = \left\{\ %
    \begin{array}{llllllll}
      % I'm formatting the first 4 lines different from the last 3 so this will fit on one page.
      x&      {}=\text{distance}&     {}=vt\\[2pt]
```

```
      v&     {}=\text{velocity}&     {}=\frac{\di x}{\di t}\\[9pt]
      a&     {}=\text{acceleration}& {}=\frac{\di v}{\di t}& {}=\frac{\di^2x}{\di t^2}\\[9pt]
      \mit j& {}=\text{jerk}&        {}=\frac{\di a}{\di t}& {}=\frac{\di^2v}{\di t^2}&
        {}=\frac{\di^3x}{\di t^3}\\[9pt]
      s
        & {}=\text{snap}
        & {}=\frac{\di \mit j}{\di t}
        & {}=\frac{\di^2a}{\di t^2}
        & {}=\frac{\di^3v}{\di t^3}
        & {}=\frac{\di^4x}{\di t^4}\\[9pt]
      c
        & {}=\text{crackle}
        & {}=\frac{\di s}{\di t}
        & {}=\frac{\di^2\mit j}{\di t^2}
        & {}=\frac{\di^3a}{\di t^3}
        & {}=\frac{\di^4v}{\di t^4}
        & {}=\frac{\di^5x}{\di t^5}\\[9pt]
      p
        & {}=\text{pop}
        & {}=\frac{\di c}{\di t}
        & {}=\frac{\di^2s}{\di t^2}
        & {}=\frac{\di^3\mit j}{\di t^3}
        & {}=\frac{\di^4a}{\di t^4}
        & {}=\frac{\di^5v}{\di t^5}
        & {}=\frac{\di^6x}{\di t^6}
    \end{array}
  \right.
\end{equation}
```

Z.4.2 `multline` environment

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

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

```

\subsection{\texttt{multline} environment}

The \verb+multline+ environment is used
to split single equations over multiple lines.

\begin{multline}
  S = 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{multline}
```

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

```
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}
```

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

```
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}
```

Z.4.3 `gather` environment

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

$$a = b + c + d + \mathrm{e} + f + g + h + \mathrm{i} + \mathrm{j} + k + l \tag{Z.9}$$

$$m = n + o + p + q + r + s + t + u + v + w + x + y + z \tag{Z.10}$$

```

\subsection{\texttt{gather} environment}

The \verb+gather+ environment collects but does not align multiple equations.

\begin{gather}
  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{gather}
```

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

```

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

$$\alpha = \beta + \gamma + \delta + \eta$$
$$\theta = \iota + \kappa + \lambda + \mu + \nu + \rho + \tau$$

```
\begin{gather*}
  \alpha = \beta + \gamma + \delta + \eta\\
  \theta = \iota + \kappa + \lambda + \mu + \nu + \rho + \tau
\end{gather*}
```

$$x_{\mathrm{min}} + x_{\mathrm{max}} \le \sum_{\mathrm{i}=1}^{n} x_{\mathrm{i}} \tag{Z.12}$$
$$x_{\mathrm{min}} + x_{\mathrm{max}} = \sum_{\mathrm{i}=1}^{n} x_{\mathrm{i}} - \sum_{\mathrm{i}=2}^{n-1} x_{\mathrm{i}} \quad \text{if } x \text{ is sorted} \tag{Z.13}$$
$$x_{\mathrm{min}} \le \left(\sum_{\mathrm{i}=1}^{n} x_{\mathrm{i}} \right) / n \tag{Z.14}$$

```

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

Z.4.4 `align` environment

The `align` environment aligns multiple equations.

$$a = b + c + d \tag{Z.15}$$
$$\mathrm{e} = f + g + h + \mathrm{i} + \mathrm{j} \tag{Z.16}$$

```
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

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{Z.17}$$

```
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 [166]:

quadratic formula

$$
\begin{aligned}
ax^2 + bx + c &= 0 \\
ax^2 + bx &= -c \\
x^2 + \frac{b}{a}x &= -\frac{c}{a} \\
x^2 + \frac{b}{a}x + \frac{b^2}{4a^2} &= \frac{b^2}{4a^2} - \frac{c}{a} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{c}{a} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{4ac}{4a^2} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2 - 4ac}{4a^2} \\
\sqrt{\left(x + \frac{b}{2a}\right)^2} &= \sqrt{\left(\frac{b^2 - 4ac}{4a^2}\right)} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{\sqrt{4a^2}} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{2a} \\
x &= -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} \\
x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\end{aligned}
\tag{Z.18}
\tag{Z.19}
$$

```
1
2  Quadratic formula proof
3  \cite{khan2018}:
4  \ix{quadratic formula}
5
6  % The align environment requires the amsmath package.
7  % Use \addtolength{\jot}{6pt} to increase the space between rows in an amsmath multi-line math formula.
8  % That's not done here so everything will fit on one page.
9  \begin{align}
10   ax^2 + bx + c &= 0\\
11   ax^2 + bx &= -c\notag\\
12   % The "\," adds a thinspace of horizontal space.
13   x^2 + \frac ba\,x &= -\frac ca\notag\\
14   x^2 + \frac ba\,x + \frac{b^2}{4a^2} &= \frac{b^2}{4a^2} - \frac ca\notag\\
15   \left(x + \frac b{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac ca\notag\\
16   \left(x + \frac b{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{4ac}{4a^2}\notag\\
17   \left(x + \frac b{2a}\right)^2 &= \frac{b^2-4ac}{4a^2}\notag\\
18   \sqrt{\left(x + \frac b{2a}\right)^2}
19     &= \sqrt{\left(\frac{b^2-4ac}{4a^2}\right)}\notag\\
20   x + \frac b{2a} &= \pm \frac{\sqrt{\,b^2-4ac}}{\sqrt{4a^2}}\notag\\
21   x + \frac b{2a} &= \pm \frac{\sqrt{\,b^2-4ac}}{2a}\notag\\
22   x &= - \frac b{2a} \pm \frac{\sqrt{\,b^2-4ac}}{2a}\notag\\
23   x &= \frac{-b \pm \sqrt{\,b^2-4ac}}{2a}
24 \end{align}
```

Z.4.5 `alignat` environment

alignat environment

The `alignat` environment aligns multiple equations at multiple places.

$$\begin{aligned} a &= b & &\text{set } a & &\text{(Z.20)}\\ c &= d & &\text{you guessed it, set } c\\ g &= h & &\text{and finally, set } g & &\text{(Z.21)} \end{aligned}$$

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,

$$\begin{aligned} a &= b & &\text{set } a & &\text{(Z.22)}\\ c &= d & &\text{you guessed it, set } c\\ g &= h & &\text{and finally, set } g & &\text{(Z.23)} \end{aligned}$$

alignat environment

Do whatever works best for you.

```

 \subsection{\texttt{alignat} environment}
 \index{\verb+\begin{aligo}+@\verb+\begin{alignat}+}
 \ix{alignat environment}

The \verb+alignat+ environment aligns multiple equations at multiple places.
\begin{alignat}{2}
  a &= b& \qquad\qquad& \text{set $a$}\\
  c &= d& &            \text{you guessed it, set $c$}\notag\\
  g &= h& &            \text{and finally, set $g$}
\end{alignat}
\index{\verb+\begin{aligo}+@\verb+\begin{alignat}+}
\ix{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,
\begin{alignat}{2}
  a
    &= b
    & \qquad\qquad
    & \text{set $a$}\\
  c
    &= d
    &
    &\text{you guessed it, set $c$}\notag\\
  g
    &= h
    &
    &\text{and finally, set $g$}
\end{alignat}
\index{\verb+\begin{aligo}+@\verb+\begin{alignat}+}
\ix{alignat environment}

Do whatever works best for you.

```

Quadratic formula proof [166]:

$$
\begin{aligned}
ax^2 + bx + c &= 0 && \text{subtract } c \\
ax^2 + bx &= -c && \text{divide by } a \\
x^2 + \frac{b}{a}x &= -\frac{c}{a} && \text{add } \frac{b^2}{4a^2} \\
x^2 + \frac{b}{a}x + \frac{b^2}{4a^2} &= \frac{b^2}{4a^2} - \frac{c}{a} && \text{factor left hand side} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{c}{a} && \text{multiply right-most term by } \frac{4a}{4a} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{4ac}{4a^2} && \text{use common denominator} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2 - 4ac}{4a^2} && \text{take square root of each side} \\
\sqrt{\left(x + \frac{b}{2a}\right)^2} &= \sqrt{\left(\frac{b^2 - 4ac}{4a^2}\right)} && \text{compute square root of each side} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{\sqrt{4a^2}} && \text{simplify right hand denominator} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{2a} && \text{subtract } \frac{b}{2a} \text{ from each side} \\
x &= -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} && \text{use common denominator} \\
x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} &&
\end{aligned}
\tag{Z.24}
\tag{Z.25}
$$

```
1
2  Quadratic formula proof
3  \cite{khan2018}:
4
5  % Make changes to \jot be local to the group that starts on the next line.
6  {
7    % Increase distance between lines by 6pt.
8    \addtolength{\jot}{6pt}
9    \begin{alignat}{2}
10     ax^2 + bx + c
11       &= 0
12       &
13       &\text{subtract $c$}\\
14     ax^2 + bx
```

```
      &= -c
      &
      &\text{divide by $a$}\notag\\
    % The "\," adds a thinspace of horizontal space.
    x^2 + \frac ba\,x
      &= -\frac ca
      &
      &\text{add $\displaystyle\frac{b^2}{4a^2}$}\notag\\
    x^2+\frac ba\,x+\frac{b^2}{4a^2}
      &= \frac{b^2}{4a^2}-\frac ca
      &
      &\text{factor left hand side}\notag\\
    \left(x+\frac b{2a}\right)^2
      &= \frac{b^2}{4a^2}-\frac ca
      &
      &\text{multiply right-most term by $\displaystyle\frac{4a}{4a}$}\notag\\
    \left(x + \frac b{2a}\right)^2
      &= \frac{b^2}{4a^2}-\frac{4ac}{4a^2}
      &
      &\text{use common denominator}\notag\\
    \left(x + \frac b{2a}\right)^2
      &= \frac{b^2-4ac}{4a^2}
      &
      &\text{take square root of each side}\notag\\
    \sqrt{\left(x + \frac b{2a}\right)^2}
      &= \sqrt{\left(\frac{b^2-4ac}{4a^2}\right)}
      &
      &\text{compute square root of each side}\notag\\
    x + \frac b{2a}
      &= \pm \frac{\sqrt{\,b^2-4ac}}{\sqrt{4a^2}}
      &
      &\text{simplify right hand denominator}\notag\\
    x + \frac b{2a}
      &= \pm \frac{\sqrt{\,b^2-4ac}}{2a}
      &
      &\text{subtract $\displaystyle\frac b{2a}$ from each side}\notag\\
    x
      &= -\frac b{2a} \pm \frac{\sqrt{\,b^2-4ac}}{2a}
      &\qquad
      &\text{use common denominator}\notag\\
    x
      &= \frac{-b \pm \sqrt{\,b^2-4ac}}{2a}
  \end{alignat}
}
```

Verb+Begin-Ocurly-flalign-Ccurly+

falign environment

Z.4.6 `flalign` environment

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

$$a = b \qquad\qquad u = v \quad \text{(Z.26)}$$
$$c = d \qquad\qquad m = n \qquad\qquad w = x$$
$$g = h \qquad\qquad y = z \quad \text{(Z.27)}$$

```

\index{\verb+\begin{flalign}+}
```

```
\todoindex{Verb+Begin-Ocurly-flalign-Ccurly+}
\ix{falign environment}
\subsection{\texttt{flalign} environment}

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

\begin{flalign}
  a &= b&   &   & u &= v\\
  c &= d& m &= n& w &= x\notag\\
  g &= h&   &   & y &= z
\end{flalign}
```

Verb+Begin-Ocurly-split-Ccurly+

split environment

Z.4.7 `split` environment

The `split` environment ???.

```

\index{\verb+\begin{split}+}
\todoindex{Verb+Begin-Ocurly-split-Ccurly+}
\ix{split environment}
\subsection{\texttt{split} environment}

The \verb+split+ environment ???.
```

Verb+Begin-Ocurly-split-Ccurly+

split environment

Z.5 Theorem-like environments

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

```
\section{Theorem-like environments}

These theorem-like environments are defined
in the amsthm package or in\\  % break line here so we don't go past right margin
\verb+PurdueThesis.cls+.
```

Verb+Begin-Ocurly-definition-Ccurly+

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

definition environment

Verb+Begin-Ocurly-observation-Ccurly+

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

observation environment

Verb+Begin-Ocurly-proof-Ccurly+

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

proof environment

Verb+Begin-Ocurly-proposition-Ccurly+

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

proposition environment

Verb+Begin-Ocurly-theorem-Ccurly+

theorem environment

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

```

\index{\verb+\begin{definition}+}
\todoindex{Verb+Begin-Ocurly-definition-Ccurly+}
\ix{definition environment}
\begin{definition}
  This is an example definition.
  This is an example definition.
  This is an example definition.
  This is an example definition.
  This is an example definition.
\end{definition}

\index{\verb+\begin{observation}+}
\todoindex{Verb+Begin-Ocurly-observation-Ccurly+}
\ix{observation environment}
\begin{observation}
  This is an example observation.
  This is an example observation.
  This is an example observation.
  This is an example observation.
  This is an example observation.
\end{observation}

\index{\verb+\begin{proof}+}
\todoindex{Verb+Begin-Ocurly-proof-Ccurly+}
\ix{proof environment}
\begin{proof}
  This is an example proof.
  This is an example proof.
  This is an example proof.
  If \(a = b\) and \(b = c\) then \(a = c\).
\end{proof}

\index{\verb+\begin{proposition}+}
\todoindex{Verb+Begin-Ocurly-proposition-Ccurly+}
\ix{proposition environment}
\begin{proposition}
  This is an example proposition.
  This is an example proposition.
  This is an example proposition.
  This is an example proposition.
  This is an example proposition.
\end{proposition}

\index{\verb+\begin{theorem}+}
\todoindex{Verb+Begin-Ocurly-theorem-Ccurly+}
\ix{theorem environment}
\begin{theorem}
  This is an example theorem.
  This is an example theorem.
  This is an example theorem.
  This is an example theorem.
  This is an example theorem.
\end{theorem}
```

Z.6 Examples

Z.6.1 Bayes' Theorem

Bayes' Theorem

Bayes' Theorem [167]:

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

```
1
2
3  \section{Examples}
4
5  \subsection{Bayes' Theorem}
6  \ix{Bayes' Theorem}
7
8  Bayes' Theorem
9  \cite{bayes}:
10
11 {
12   \UndefineShortVerb{\|}
13 \[
14   \text{P}(\text A|\text B)
15     % The "\," puts a thin horizontal space there, 1/6 of an "em".
16     % An "em" is roughly the width of a lowercase "m".
17     = \frac{\text P(\text B|\text A)\,\text P(\text A)}{\text P(\text B)}
18 \]
19 }
```

Z.6.2 Nicomachus's theorem

Nicomachus's theorem

Nicomachus's theorem [168] states that the sum of the first n cubes is the square of the nth triangular number. That is,

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

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
6  \cite{wikipedia-nicomachus}
7  states that
8  the sum of the first~$n$ cubes is the square of the~$n$th triangular number.
9  That is,
10 \[
11   1^3 + 2^3 + 3^3 + \cdots + n^3 = (1 + 2 + 3 + \cdots + 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.
```

Z.6.3 Prime Number Theorem

Prime Number Theorem

Li [169] suggested using a functional equation from the Prime Number Theorem proof as an example:

$$\int_1^x \sum_{p\le u} \left\lfloor \frac{\log u}{\log p} \right\rfloor \log p \, \mathrm{d}u = \frac{1}{2\pi \mathrm{i}} \int_{c-\mathrm{i}\infty}^{c+\mathrm{i}\infty} \frac{x^{s+1}}{s(s+1)} \left(-\frac{\zeta'(s)}{\zeta(s)} \right) \mathrm{d}s \tag{Z.28}$$

```

\subsection{Prime Number Theorem}
\ix{Prime Number Theorem}

\textcite{li2013}
suggested using a functional equation
from the Prime Number Theorem proof
as an example:
\begin{equation}
  \int_1^x
    \sum_{p\le u}
    \left\lfloor\frac{\log u}{\log p}\right\rfloor
    \log p
    \,\text{d}u
    =
    \frac1{2\pi i}
    \int_{c-i\infty}^{c+i\infty}
    \frac{x^{s+1}}{s(s+1)}
    \left(-\frac{\zeta'(s)}{\zeta(s)}\right)
    \text{d}s
\end{equation}
```

Z.6.4 Quantum Mechanics

Quantum Mechanics

Greene [170] 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.

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

```

\subsection{Quantum Mechanics}
\ix{Quantum Mechanics}

\textcite{greene-2021-04-04}
wrote
\ix{Greene, Brian Randolph}
\begin{quotation}
```

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

    \[
      \langle x_f,t_f \vert x,t_{\mathit i} \rangle
      =
      \sum_{\text p \in \text{paths}} e^{\mathit iS(\text p) \si{\planckbar}}
    \]
  \end{quotation}
```

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

yourlazyphysicist [171] wrote "I have the following definition of the space-time coordinates":

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

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

```
\subsection{Question in String Theory / Mass of States / Number Operator}


\textcite{yourlazyphysicist2017}
wrote
``I have the following definition of the space-time coordinates'':

\newcommand{\fpt}{{4\pi T}}
\newcommand{\oh}{\frac12}
\newcommand{\snnz}{\sum_{n\ne0}}
\newcommand{\tms}{\tau - \sigma}
\newcommand{\tps}{\tau + \sigma}
\begin{align}
    \text{closed string: }&
        \begin{cases}
            \displaystyle
            X^\mu_R
                = \oh x^\mu
                + \frac1\fpt (\tms) p^\mu
                + \frac i{\sqrt\fpt} \snnz \frac1n \alpha^\mu_n e^{-in(\tms)},\\
            \displaystyle
            X^\mu_L
                = \oh x^\mu
                + \frac1\fpt (\tps) p^\mu
                + \frac i{\sqrt\fpt} \snnz \frac1n \tilde\alpha^\mu_n e^{-in(\tps)}.
        \end{cases}\\[6pt]
    \text{open string: }&
        \begin{cases}
            \displaystyle
```

```
                X^\mu_N
                    = x^\mu
                    + \frac1{\pi T}p^\mu\tau
                    + \frac i{\sqrt{\pi T}} \snnz \frac1n \alpha^\mu_n e^{-in\tau} \cos(n\sigma),\\
                \displaystyle
                X^\mu_D
                    = x^\mu
                    + \frac i{\sqrt{\pi T}} \snnz \frac1n \alpha^\mu_n e^{-in\tau} \sin(n\sigma).
            \end{cases}
    \end{align}
```

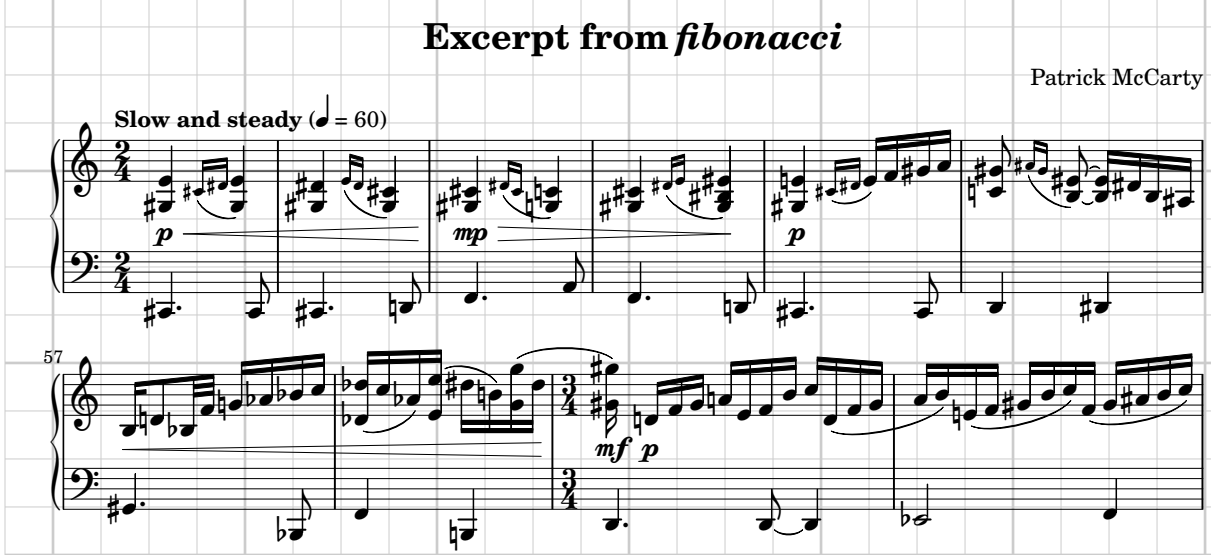
AA. MUSIC

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 [172] and put it in a `fib.ly` file.
- Ran `lilypond fib.ly` and got the following `fib.pdf` file:

LilyPond music typesetting software



Music engraving by LilyPond 2.22.0—www.lilypond.org

```
\chapter{MUSIC}
\ix{music//Music appendix}

To get the following printed music score I did the following steps.
\begin{itemize}
  \item
     Get the ‘‘Example of LilyPond input file’’
     from the Wikipedia LilyPond page
     \cite{wikipedia-lilypond}
     and put it in a \verb+fib.ly+ file.
  \item
     Ran \verb+lilypond fib.ly+ and got the following \verb+fib.pdf+ file:
\end{itemize}
\ix{LilyPond music typesetting software}

\noindent \includegraphics[scale=0.77]{gr-fib.pdf}
```

VITA

[Put a brief autobiographical sketch here.]

PUBLICATION(S)

publication environment ⇒ publications environment

The following is based on information in [173]–[175].

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}
```

INDEX

COLOPHON

colophon

This is the colophon. The colophon describes how a document was produced [176].

This document was compiled using PurdueThesis 2022-10-05 on 2022-10-13 at 09:40:45 with

Control Sequence	Value
INPUT	
\ZZinstitution	Purdue University
\ZZcampus	West Lafayette
\ZZprogram	Electrical and Computer Engineering
\ZZdegree	Doctor of Philosophy
\ZZauthor	Ima Student
\ZZdocument	A Dissertation
\ZZgraduation	December 2022
\ZZtitle	This is the Title
\ZZshowcolophon	true
\ZZshowdiagonalline	true
\ZZshowgridlines	true
\ZZshowmarginlines	false
\ZZshowtimestamp	true
\ZZtodonotes	wide
SHORTENED (for debugging)	
\ZZins	pu
\ZZcam	wl
\ZZpro	ece
\ZZdeg	phd
DERIVED (for debugging)	
\ZZinscam	pu-wl
\ZZinscampro	pu-wl-ece
\ZZinscamprodeg	pu-wl-ece-phd
COMPUTED	

```
\chapter*{COLOPHON}
\label{ap:colophon}

\ix{colophon}

This is the colophon.
The colophon describes how a document was produced
\cite{diggypod-colophon}.

This document was compiled using \PurdueThesisVersion\ on \ZZDateRun\ at \ZZTimeRun\ with\\
\begin{tabular}{@{}ll@{}}
  \noalign{\vspace*{6pt}}
  \toprule
```

```
14    \bf Control Sequence& \bf Value\\
15    \midrule
16    \multicolumn{2}{@{}l}{INPUT\hfil}\\
17    \verb+\ZZinstitution+& \ZZinstitution\\
18    \verb+\ZZcampus+& \ZZcampus\\
19    \verb+\ZZprogram+& \ZZprogram\\
20    \verb+\ZZdegree+& \ZZdegree\\
21    \verb+\ZZauthor+& \ZZauthor\\
22    \verb+\ZZdocument+& \ZZdocument\\
23    \verb+\ZZgraduation+& \ZZgraduation\\
24    \verb+\ZZtitle+& \ZZtitle\\
25    \noalign{\vspace*{6pt}}
26    \verb+\ZZshowcolophon+& \ZZshowcolophon\\
27    \verb+\ZZshowdiagonalline+& \ZZshowdiagonalline\\
28    \verb+\ZZshowgridlines+& \ZZshowgridlines\\
29    \verb+\ZZshowmarginlines+& \ZZshowmarginlines\\
30    \verb+\ZZshowtimestamp+& \ZZshowtimestamp\\
31    \verb+\ZZtodonotes+& \ZZtodonotes\\
32    \noalign{\vspace*{12pt}}
33    \multicolumn{2}{@{}l}{SHORTENED (for debugging)\hfil}\\
34    \verb+\ZZins+& \ZZins\\
35    \verb+\ZZcam+& \ZZcam\\
36    \verb+\ZZpro+& \ZZpro\\
37    \verb+\ZZdeg+& \ZZdeg\\
38    \noalign{\vspace*{12pt}}
39    \multicolumn{2}{@{}l}{DERIVED (for debugging)\hfil}\\
40    \verb+\ZZinscam+& \ZZinscam\\
41    \verb+\ZZinscampro+& \ZZinscampro\\
42    \verb+\ZZinscamprodeg+& \ZZinscamprodeg\\
43    \noalign{\vspace*{12pt}}
44    \multicolumn{2}{@{}l}{COMPUTED\hfil}\\
45    \bottomrule
46    \end{tabular}
```