THIS IS THE TITLE

by

Ima Author

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In Partial Fulfillment of the Requirements for the degree of

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To graduate students

ACKNOWLEDGMENTS

Purdue University's Engineering Computer Network (now part of Purdue IT) and Graduate School helped fund PurdueThesis development.

PREFACE

This is the preface.

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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. IMPORTANT—READ THIS FIRST

Be sure to sign up for the PurdueThesis mailing list[4] to learn of important changes to or get help with PurdueThesis.

I suggest you do not make any changes to the `PurdueThesis.cls` file. Put any changes in the `thesis.tex` file if you can. That way you will not need to add your customizations when a new version of `PurdueThesis.cls` is released.

2. INTRODUCTION

2.1 Typographic Conventions

The following typographic conventions are used in this document. These conventions were influenced by [5–7]. There are no quotes in the typographic conventions.

Emph, *FirstTime*, and *Title*

Emphasized material, terms used for the first time, and titles are typset in italics. Here are some examples: Emphasis: You *must* do this. First Time Use: An *ekayak* is an electric kayak. Title: He read *The Grapes of Wrath* and watched *Citizen Kane*.

Keyboard Keys

Keyboard keys look like keyboard keys. Control+A means press the Control key and A key at the same time. A B means press the A key and then press the B key.

`Literal Element`

Literal elements are typeet in a typewriter font. 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

Menus are typeset as arrows pointing to the right. For exmaple, to make sure smooth scrolling is on go to Edit › Settings and make sure the `Use smooth scrolling` checkbox is checked.

Placeholder

Placeholders are typset in a slanted font. Placeholders need to replaced with real input.

`shell command`

Shell commands are typset in a bold typewriter font. Shell commands are typed on the command line by the user.

2.2 Writing in English Information

2.2.1 Don't use redundant acronyms

Don't use redundant acronyms [8–15] like the following in formal writing:

Table 2.1. Redundant Acronyms

Redundant Acronym	Corresponding Phrase
% APR	percent Annual Percentage Rate
ABS system	Antilock Braking System system
AC current	Alternating Current current
ACT test	American College Test test
ADD disorder	Attention Deficit Disorder disorder
AIDS syndrome	Acquired Immune Deficiency Syndrome syndrome
AM modulation	Amplitude Modulation modulation
APL language	A Programming Language languge
APR rate	Annual Percentage Rate rate
ATM machine	Automated Teller Machine machine
BASIC code	Beginner's All-Purpose Symbolic Instruction Code code
CAD design	Computer-Aided Design design
CD disc	Compact Disc disc
CNN news network	Cable News Network news network
COBOL language	Common Business-Oriented Language language
DC Comics	Detective Comics Comics
DC current	Direct Current current
DVD disk	Digital Versatile Disk disk
DMZ zone	DeMilitarized Zone zone
FOD damage	Foreign Object Damage damage
GIF format	Graphics Interchange Format format [16]
GMT time	Greenwich Mean Time time [17]
GPS system	Global Positioning System system [18]
GOP party	Grand Old Party party [19]
GRE exam	Graduate Record Examination exam [20]
HIV virus	Human Immunodeficiency Virus virus [21]
HTML language	HyperText Markup Language language [22]
IRA account	Individual Retirement Account account [21]
ISBN number	International Standard Book Number number
ISDN network	Integrated Services Digital Network network
LAN network	Local Area Network network
LCD display	Liquid Crystal Display display
LED diode	Light Emitting Diode diode
LEM module	Lunar Excursion Module module

continued on next page

Table 2.1. *continued*

Redundant Acronym	Corresponding Phrase
MLB baseball	Major League Baseball baseball [23]
MIDI interface	Musical Instrument Digital Interface interface
MLS soccer	Major League Soccer soccer [23]
NATO organization	North Atlantic Treaty Organization organization
NPR radio	National Public Radio radio
OPEC countries	Organization of Petroleum Exporting Countries countries
PAC committee	Political Action Committee committee
PC computer	Personal Computer computer
PDF format	Portable Document Format format [24]
PIN number	Personal Identification Number number
RAM memory	Random-Access Memory memory
SSN number	Social Security Number number [25]
TCP-IP protocol	Transmission Control Protocol/Internet Protocol protocol
UPC code	Universal Product Code code
UL laboratories	Underwriters Laboratories laboratories
VAT tax	Value Added Tax tax
VHF frequency	Very High Frequency frequency
VIN number	Vehicle Identification Number number

I sometimes use FBI (Federal Bureau of Investigation) as an adjective, e.g., 'an FBI investigation'.

The SAT (SAT in not an acronym) is a standardized test [26].

2.2.2 Logical punctuation

I use logical punctuation [27]:

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.

2.2.3 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.

2.2.4 Modern pronouns

I don't use modern pronouns in this document but if I did I'd use the LambdaMoo "spivak" (1991) [28] variant of gender-neutral pronouns. (Hmm... thinking machines are coming. People are anthropocentric [29]. There may be resistance to using traditional human pronouns for machines that think. I wonder if using tradutional pronouns for mostly-meatbag lifeforms and spivak pronouns for mostly non-meatbag lifeforms would make sense.)

Variant	**Subject**	**Object**	**Possessive adjective**	**Posessive pronoun**	**Reflexive**
Masculine	he said	I saw him	his leg hurt	that is his	he hurt himself
Feminine	she said	I saw her	her leg hurt	that is hers	she hurt herself
LambdaMoo "spivak" (1991)	e said	I saw em	eir leg hurt	that is eirs	e hurt emself

2.3 The software used

Prof. Donald Knuth of Stanford University wrote the *TEX* typesetting system for the creation of beautiful books—and especially for books that contain lots of mathematics [30, page v]. He wasn't happy with the quality of the typesetting in his multi-volume *The Art of Computer Programming*. TEX was first released in 1978. TEX-related systems are not 'What You See Is What You Get' (WYSIWYG) systems. Documents are created in an ordinary text editor and processed by a program to make the output. This is a nice feature

because one can concentrate on the content of the document instead of the appearance of the document.

Dr. Leslie Lamport extended TEX using TEX's programming language to make the easier-to-use *LATEX*. It was first released in 1984. The LATEX Project [31] now handles LATEX development.

LuaLATEX is a dialect of LATEX with features that make it easier to use for programming.

TEX Live [32] is a free TEX software distribution that contains all of the above software and more. This document was created using TEX Live. TEX Live is available for Linux, Unix, and Windows. *MacTEX* is a TEX Live-based system for Apple MacOS computers. *Overleaf* is a TEX Live-based system to run TEX on the web.

PurdueThesis (*PuTh* for short—rhymes with tooth) uses LuaLATEX to make it easier to do Purdue theses, dissertations, etc. This template demonstrates how to use PurdueThesis. PurdueThesis is intended to support all Purdue campuses, programs, and graduate degrees. I only support this software using TEX Live.

Figure 2.1 shows the LuaLATEX system flowchart. *Overleaf* [33] uses latexmk [34] to run `biblatex`, `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 [35] wrote a formatting manual [36] and Microsoft Word templates [37] for Purdue theses, etc.

2.4 LATEX-related information

2.4.1 Input reading rules

LATEX uses the following rules when reading input:

- Spaces at the beginning of a line are ignored.
- % starts a comment. The % and everything after it on that line are ignored. Type \ % to print a '%'.
- Enter is equivalent to a space.

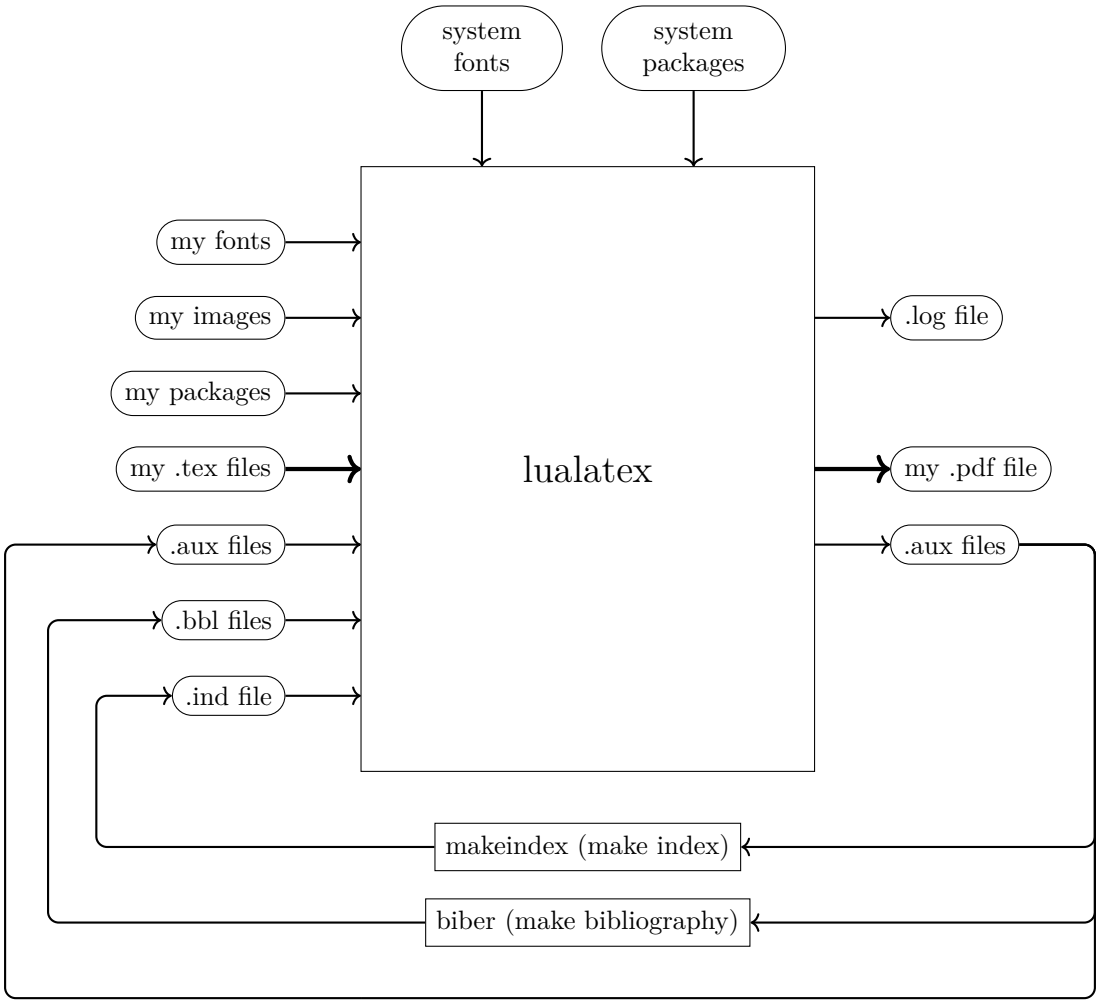

Figure 2.1. LuaLaTeX System Flowchart

- Enter Enter (a blank line) ends a paragraph.

- Typing multiple spaces works the same as one space.

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

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

2.5 Filenames

There are several different name styles for file names:

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 operating 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.

2.6 Special input characters

These input characters are special:

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

Type

```
\#   \$   \%   \&   $\backslash$   \char'136   \_   \{   \}   \char'176
```

to get this output

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

2.7 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.

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.

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.)

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

2.8 Five kinds of dashes

There are five kinds of dashes

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 [38].

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 [39] is used for

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 [40] is used for

--- (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".

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

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

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 MISCELLANEOUS

This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine. This was published in Mad Magazine.

This chapter is used to test miscellaneous stuff.

(5.1) This is a covexample test. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

(5.2) This is a covexamples test. This is the first item. This is the first item. This is the first item. This is the first item. This is the first item.

(5.3) This is the secord item.
This is the second item.

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

Proposition 5.0.3. 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 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. This is an example of normal text.

Theorem 5.0.4. 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.

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. This is an example of normal text.

6. TEST 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]".

`\cite{t001}` gives "[5]".

`\cite{t002}` gives "[6]".

`\cite{t003}` gives "[7]".

`\cite{t004}` gives "[8]".

`\cite{t005}` gives "[9]".

`\cite{t006}` gives "[10]".

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A. ABOUT THE APPENDICES

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

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

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

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

```
\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.
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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.

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

A.3 Text math

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

    α, β, and γ

I'd input the line like this

    α,~β, and~γ

where the ~ is a tie that ties together what's before and after it on the same line of the output [30, 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?

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

B. ACCESSIBILITY

```
\chapter{ACCESSIBILITY}
\ix{accessibility//Accessibility appendix}
```

Accessibility is the design of products, devices, services, vehicles, or environments so as to be usable by people with disabilities. [41]

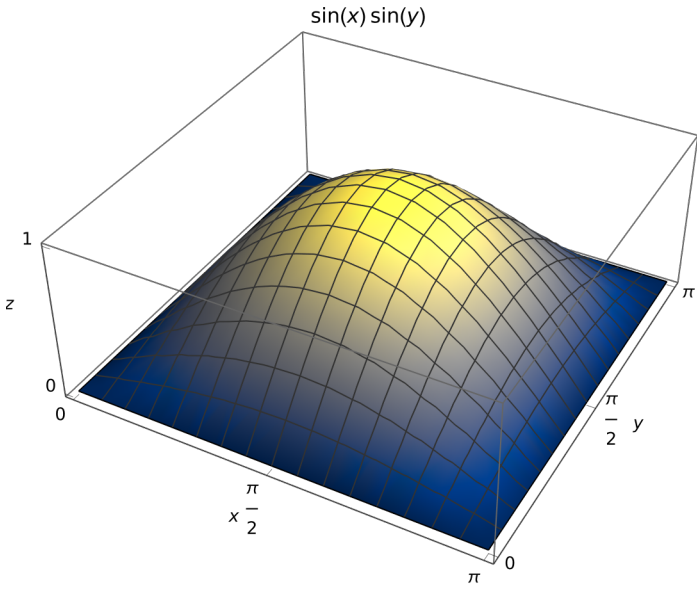
```

Accessibility is the design of products,
devices,
services,
vehicles,
or environments
so as to be usable by people with disabilities.
\cite{wikipedia-accessibility}
```

Please use the cividis colormap for accessibility unless there is a good reason not to.

B.1 Color

Color vision deficiency (CVD) affects more than 4% of the population and leads to a different visual perception of colors. The cividis colormap is optimal for viewing by those with or without CVD [42]. The *Cividis Mathematica Example Notebook* [43] and *Cividis Mathematica Example Notebook PDF file* [44] contain the Mathematica code used to produce this cividis example:




```


\section{Color}

Color vision deficiency (CVD) affects more than 4\% of the population
and leads to a different visual perception of colors.
The cividis%
```

```
\ix{cividis colormap}
colormap is optimal
for viewing
by those with or without CVD
\cite{nunez2018}.
The
\citetitle{senn2022}
\cite{senn2022}
and
\citetitle{senn2022b}
\cite{senn2022b}
contain the Mathematica code used to produce this cividis example:\\[\baselineskip]
\includegraphics{gr-cividis.pdf}
```

B.2 PDF file

The LaTeX Project [31] is working on making tagged and accessible PDF files with LaTeX [45]. It was not finished as of December 23, 2022.

```


\section{PDF file}

The \LaTeXLogo\ Project
\cite{thelatexproject2023}
is working on making tagged
and accessible PDF files with \LaTeXLogo\ %
\cite{mittlebach2022}.
It was not finished as of December 23, 2022.
```

C. 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:

Description	Color
done or waiting on someone else	black
high priority or easy to do	red
low priority	blue
not prioritized yet	gray

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

C.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 headings spacing? Reported by Anita Adams Sale on 2021-03-17.

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

BUG 8. Use, for example, `Last Accessed: yyyy-mm-dd.` urldate in bibliography. Reported by Mark Senn on 2021-04-19.

BUG 13. Headings containing a SmallCaps font do not work. Reported by Javad (Nima) Darivandpour on 2021-06-29. See T.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.

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. 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. 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.

BUG 24. Add `A Dissertation Proposal` document type. Add `A Thesis Proposal` document type. Reported by Mark Senn on 2022-12-20.

BUG 25. Dissertations and theses should continue to have *Month year* where *Month* is `August`, `December`, or `May`. For everything except dissertations and theses allow *Month year* or *Month day*`,` *year* dates where *Month* is any month. Reported by Mark Senn on 2022-12-20.

BUG 26. Complete `HOW TO DEBUG LaTeX PROBLEMS` chapter. Reported by Mark Senn on 2023-01-11.

BUG 28. Move `\addbibresource` from `PurdueThesis.cls` to `thesis.tex` to be more user friendly. Reported by Panos Manganaris on 2023-06-15.

BUG 29. Main biblioography and chapter bibliography should be indented the same amount. Reported by Panos Manganaris on 2023-06-15.

BUG 30. Main bibliography and chapter bibliography should both be flush with the left margin. Reported by Mark Senn on 2023-06-19.

BUG 31. There needs to be way to put a list of publications in a publications section. Reported by Panos Manganaris on 2023-06-14. Mark Senn is working on a way to do that using `keywords = {publication}` in a BibLaTeX `.bib` file entry.

BUG 33. Create Color Vision Deficiency (CVD) Accessible Line Graphs.
IEEE Author Center <ieee-author-center@deliver.ieee.org> wrote on 2024-03-20:

> Approximately 1 in 12 men and 1 in 200 women have color vision deficiency. It is highly likely that someone reading your article may have difficulty distinguishing between red and green, blue and green, or yellow and red. The following tips will help you communicate better with those readers.
>
> - Use both color and shape to convey the same meaning; for example, solid and dashed lines or different fill patterns can help readers understand the figure without relying solely on color
> - Each line of your line graph should be a thick line with a unique data point symbol. Contrast different elements of the figure with both color and brightness
> - Connect the data label to the data line rather than relying on a color key
>
> A quick way to evaluate your figure is to print it out in greyscale and see if it can still be interpreted correctly; if not, use some of these tips to more effectively communicate with all readers.

Lisa Renee Williams <will2922@purdue.edu> of the Graduate School wrote on 2024-03-21:

> I think this is a wonderful idea and am in support of including information within the template to provide students the opportunity to use CVD.

BUG 34. Implement `\begin{chapterabstract}` and `\end{chapterabstract}` for abstracts within chapters. Maybe rename this `paperabstract`?
Reported by Mark Senn on 2024-04-09.

BUG 36. Improve the order of thesis parts error message to indicate that not all parts listed are required. Reported by Mark Senn on 2022-09-21.

BUG 37. Check the spacing after all chapter and non-chapter headings for consistency. Reported by Mark Senn on 2020-02-28.

BUG 38. Add short caption info to documentation. See Shortening captions for a list of illustrations for a suggestion regarding this. To do this in LaTeX do

```
\caption[short caption]{long caption}
```

Reported by Mark Senn on 2023-12-08.

C.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. 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.

C.3 These bugs have been answered, fixed, or rejected

BUG 2. List of Figures indented ≈¼ inch more than List of Tables. Reported by Anita Adams Sale on 2021-03-17. 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. Adam Behnke sent me the solution to this problem on 2023-03-27.

BUG 3. Use "Last Accessed: dd/mm/yy." urldate in bibliography. Reported by Priyank Kalgaonkar on 2021-04-06. Answered by Mark Senn on 2022-02-27.

The United States uses mm/dd/yy and other countries use dd/mm/yy [46]. I recommend using what your bibliography style defines or the unambiguous ISO 8601 standard yyyy-mm-dd [47].

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. Tested ok on 2021-05-31.

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. Tested ok on 2022-10-18 using

```
alias g=grep
g -P '^\s*\\begin{tabular}' *.tex | g -Pv '^.*?:\s*\\begin{tabular}{@{}.*?@{}}'
```

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. Answered by Mark Senn on 2022-10-18.

The "IEEE Reference Guide" [48, page 12] specifies that `vol.` and `no.` should be used. You are the only one that has requested this. I'm not going to change anything because of that. I like the succinct "**23** (**1**)" format but am not going to implement it because not everyone will know those are the journal volume and number.

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. Answered by Mark Senn on 2022-10-18.

The "IEEE Reference Guide" [48, page 5] specifies that `Ed.` for a single editor and `Eds.` for multiple editors be used.

You are the only one that has requested this. I'm not going to change anything because of that.

But, if you put the current ieee.bbx file in the same directory as your thesis and change `editor = Ed\adddot` to `editor = editor\adddot` and `editors = Eds\adddot` to `editors = editors\adddot` it may do what you want. Email `latex@ecn.purdue.edu` if you need the current ieee.bbx file. I have not tested this answer.

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.

BUG 22. `\H{o}` works in pdfLaTeX but does not work in LuaLaTeX. Reported by Raymond Polak III on 2022-10-28. Use `\H{o}` to get ő in the text. Use `\ZZH{o}` to get ő in the bibliography. Tested ok on 2023-03-27.

BUG 23. The `Department of Human Development and Family Studies` was renamed to `Department of Human Development and Family Science`. Reported by Mark Senn on 2022-12-03. Fixed on 2024-06-12.

BUG 27. The figures in subsections L.5.2 and L.5.3 are

Color	On Operating Sytem	Using
color	macOS 12.6.2	Firefox 108.0.2 (64-bit)
color	Ubuntu 22.04 LTS	evince (GNOME Document Viewer 42.3)
black and white	Ubuntu 22.04 LTS	Firefox 108.0.2 (64-bit)

Reported by Mark Senn on 2023-01-11. Use software that will show the colors correctly.

BUG 32. The first two pages of the thesis (the title page and the graduate school statement of committee approval) should have a top margin of 1 1/2 in. Reported by Lisa Williams on 2023-12-08. Fixed on 2024-02-07. Tested ok on 2024-02-07.

BUG 35. Is there an easy way of dividing the thesis into multiple parts?
Asked by Vahid Tac on 2024-05-29. Thesis Help (Lisa Williams) <thesishelp@purdue.edu> wrote on 2024-06-04 "Since it is not part of the thesis structure in Purdue policies, we do not want parts. . . ".

D. CHECK MARGINS

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

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

is a sentence. This is a sentence.

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

E. 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.
```

E.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.

E.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.
```

F. CITATIONS AND REFERENCES

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

In your thesis try to cite only original sources like articles and books. If possible, don‘t use encyclopedias and Wikipedia. [49]

```

In your thesis try to cite only original sources like articles
and books.
If possible,
don‘t use encyclopedias and Wikipedia.
\cite{citing-wikipedia}
```

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.
```

F.1 Citations

```


\section{Citations}
```

This @online entry does not have a date but has a urldate: [50].
“Diameters of point sets” by Paul Erdős [51] was published in 1992.
For LaTeX answers I refer to [52] and then to [53] or [54]. [54] is an update to [55].

```
This @online entry does not have a date
but has a urldate:
\cite{engineering}.

\citetitle{erdos1992}
by Paul Erd\H os
\cite{erdos1992}
was published in
\citeyear{erdos1992}.

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     = {{Neil A.~Armstrong} Worked for {NASA}},
  url       = {https://bogus.com/bogus.html},
  urldate   = {2020-10-27},
  version   = {1.0},
}
```

```
1
2  Here is an example .bib file entry:
3
4  {\footnotesize
5  \begin{verbatim}
6  @misc{example2020,
7    address   = {Imaginaryville, Indiana},
8    author    = {Andrew Anteater and Bertha Bear and Charles Cheetah and Davida Deer
9                 and Ethan Eagle},
10   date      = {2020-10-27},
11   doi       = {00.0000/000-0-000-00000-0},
12   editor    = {Mark Senn},
13   edition   = {2},
14   isbn      = {{000\FigureDash 0\FigureDash 000\FigureDash 00000\FigureDash 0}},
15   publisher = {Bogus International Publishing Company},
16   title     = {{Neil A.~Armstrong} Worked for {NASA}},
17   url       = {https://bogus.com/bogus.html},
18   urldate   = {2020-10-27},
19   version   = {1.0},
20 }
21 \end{verbatim}
22 }
```

Below are some example `ieee` style BibLaTeX citations.

(Different citation styles may give different results, for example, in the `apa` style, `\cite{example2020}` gives "Anteater et al., 2020" and `\parencite{example2020}` gives "(Anteater et al., 2020)". See [56] for more information. I'll document all the citation styles that PurdueThesis uses based on how `\ZZinstitution`, `\ZZcampus`, and `\ZZprogram` are set later.)

Input	Output
\cite{example2020}	[57]
\cite*{example2020}	[57]
\citeauthor{example2020}	Anteater *et al.*
\citeauthor*{example2020}	Anteater *et al.*
\citedate{example2020}	Oct. 27, 2020
\citetitle{example2020}	*John Doe is not employed by NASA*
\citetitle*{example2020}	*John Doe is not employed by NASA*
\citeurl{example2020}	https://bogus.com/bogus.html
\citeyear{example2020}	2020
\parencite{example2020}	[57]
\textcite{example2020}	Anteater *et al.* [57]

```

Below are some example |ieee| style \BibLaTeXLogo\ citations.

(%
  Different citation styles may give different results,
  for example,
  in the |apa| style,\\
  |\cite{example2020}|
  gives
  ``Anteater et al., 2020''
  and
  |\parencite{example2020}|
  gives
  ``(Anteater et al., 2020)''.
  See
  \cite{apa-style-examples}
  for more information.
  I'll document all the citation styles
  that \PurdueThesisLogo\ uses based on how
  |\ZZinstitution|,
  |\ZZcampus|,
  and |\ZZprogram| are set later.%
)

\begin{inlinetable}
  \begin{tabular}{@{}ll@{}}
    \toprule
    \textbf{Input}&                   \textbf{Output}\\
    \midrule
    \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}\\
    \bottomrule
  \end{tabular}
\end{inlinetable}
```

G. COMMON MISTAKES

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

G.1 Headings

Farkas [58, 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}
```

G.2 Mathematics

G.2.1 Put a little extra horizontal space before dx

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

G.3 Text

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

G.3.1 e.g.,

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

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

G.3.2 "et al." is an abbreviation

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

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

```
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}
```

G.3.3 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.3.4 ldots

Use "1, 2, . . . , 10" instead of 1, 2, ..., 10"

```

\subsection{ldots}

Use ``1, 2, \ldots, 10''
instead of 1, 2, ..., 10''
```

G.3.5 text math subscripts

If you are using an English word as a math subscript or subsubscript typeset it in a roman font like this '$x_{\max}$' instead of 'x_{max}'.

```

\subsection{text math subscripts}

If you are using an English word
as a math subscript or subsubscript
typeset it in a roman font like this
`\(x_\text{max}\)'
instead of
`\(x_{max}\)'.
```

G.3.6 ties

Change the space in ‘Dr. ’, ‘Fig. ’, ‘Mr. ’, ‘Mrs. ’, ‘Mx. ’, ‘Prof. ’, etc., to ‘∼’ so the period will only be followed by one space and, for example, ‘Dr.’ and ‘Smith’ will be tied together so they won’t be split over two lines.

```
1
2  \subsection{ties}
3
4  Change the space in
5  ‘Dr. ’, ‘Fig. ’, ‘Mr. ’, ‘Mrs. ’, ‘Mx. ’, ‘Prof. ’, etc.,
6  to ‘\(\sim\)’ so the period will only be followed by one
7  space and, for example, ‘Dr.’ and ‘Smith’ will be tied
8  together so they won’t be split over two lines.
```

H. 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.
```

I. DEPRECATED SOFTWARE

Deprecated means [59]

> to withdraw official support for or discourage the use of (something, such as a software product) in favor of a newer or better alternative.

The following software is deprecated for use with PurdueThesis. Read the "Details" or "Used For" columns below for more information.

```
\chapter{DEPRECATED SOFTWARE}

Deprecated means
\cite{merriam-webster-deprecated}
\begin{quote}
  to withdraw official support for or discourage the use of
  (something, such as a software product)
  in favor of a newer or better alternative.
\end{quote}

The following software is deprecated for use with \PurdueThesisLogo.
Read the ``Details''
or ``Used For''
columns below for more information.
```

I.1 Bibliography Software

Software Name	Details
Mendeley	If you don't currently use Mendeley and are thinking about using Mendeley just for your thesis I suggest that you do not do it. It may cause more problems than it solves. You can type the data needed for your bibliography directly into .bib files.

```


\section{Bibliography Software}

\noindent
\begin{tabularx}{\textwidth}{@{}lX@{}}
  \toprule
  \bf Software Name& \bf Details\\
  \midrule
  Mendeley&
    If you don't currently use Mendeley
    and are thinking about using Mendeley just for your thesis
    I suggest that you do not do it.
    It may cause more problems than it solves.
    You can type the data needed for your bibliography
    directly into .bib files.\\
  \bottomrule
\end{tabularx}
```

I.2 Packages

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

Do not use these packages—they are not compatible with PurdueThesis.

Package Name	**Used 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.
glossaries	Used to make glossaries. Do not load this package, it is not compatible with PurdueThesis. See the `front.tex` file for haw to make a glossary.
glossary	For glossararies. This package is deprecated. Do not load this package. See `glossaries`.
subfig	For subfigures. This package is deprecated. Do not load this package. See page 85 for how to do subfigures.
subfigure	For subfigures. This package is deprecated. Do not load this package. See page 85 for how to do subfigures.

```
1
2
3  \section{Packages}
4
5  The
6  |\usepackage{|\Place{packagename}|}|
7  command is used to load a package.
8
9  Do not use these packages---they are not compatible with \PurdueThesisLogo.\\
10
11 \noindent
12 \begin{tabularx}{\textwidth}{@{}lX@{}}
13   \toprule
14   \bf Package Name& \bf Used For\\
15   \midrule
16   babel&
17     Translating ``Table of Contents'', etc\@. to foreign languages.
18     Reported by Danushka Menikkumbura.
19     Send email to \verb+latex@ecn.purdue.edu+ if you need to
20     typset multiple languages in your thesis.\\
21   caption&
22     Used to customize captions.
23     Do not load this package, it is not compatible with \PurdueThesisLogo.\\
24   glossaries&
25     Used to make glossaries.
26     Do not load this package, it is not compatible with \PurdueThesisLogo.
27     See the \verb+front.tex+ file for haw to make a glossary.\\
28   glossary&
29     For glossararies.
30     This package is deprecated.
31     Do not load this package.
32     See \verb+glossaries+.\\
33       subfig&
34     For subfigures.
35     This package is deprecated.
36     Do not load this package.
37     See page \pageref{pa:subfigures} for how to do subfigures.\\
38   subfigure&
39     For subfigures.
```

```
40      This package is deprecated.
41      Do not load this package.
42      See page \pageref{pa:subfigures} for how to do subfigures.\\
43    \bottomrule
44  \end{tabularx}
```

J. 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.

```

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

This is the figure.

Figure J.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}
```

```
\begin{sidewaysfigure}[ht]
  \setbox0=\hbox{%
    \noindent
    This is the second figure in this appendix.
    This is the second figure in this appendix.
    This is%
  }
  \dimen0=\wd0
  \hbox to \textwidth{\hss\box0\hss}
  \textwidth=\dimen0
  \advance\textwidth by 1truein
  \caption{%
    This is the caption for the second figure.
    This is the caption for the second figure.
    This is the caption for the second figure.%
  }
\end{sidewaysfigure}
```

This is the second figure in this appendix. This is the second figure in this appendix. This is

Figure J.2. This is the caption for the second figure. This is the caption for the second figure. This is the caption for the second figure.

```
1
2  \begin{sidewaysfigure}[ht]
3    \setbox0=\hbox{\noindent \includegraphics[width=8truein]{gr-plot.pdf}}
4    \dimen0=\wd0
5    \hbox to \textwidth{\hss\box0\hss}
6    \textwidth=\dimen0
7    \advance\textwidth by 1truein
8    \caption{
9      This is the caption for the third figure.
10     This is the caption for the third figure.
11     This is the caption for the third figure.%
12   }
13 \end{sidewaysfigure}
```

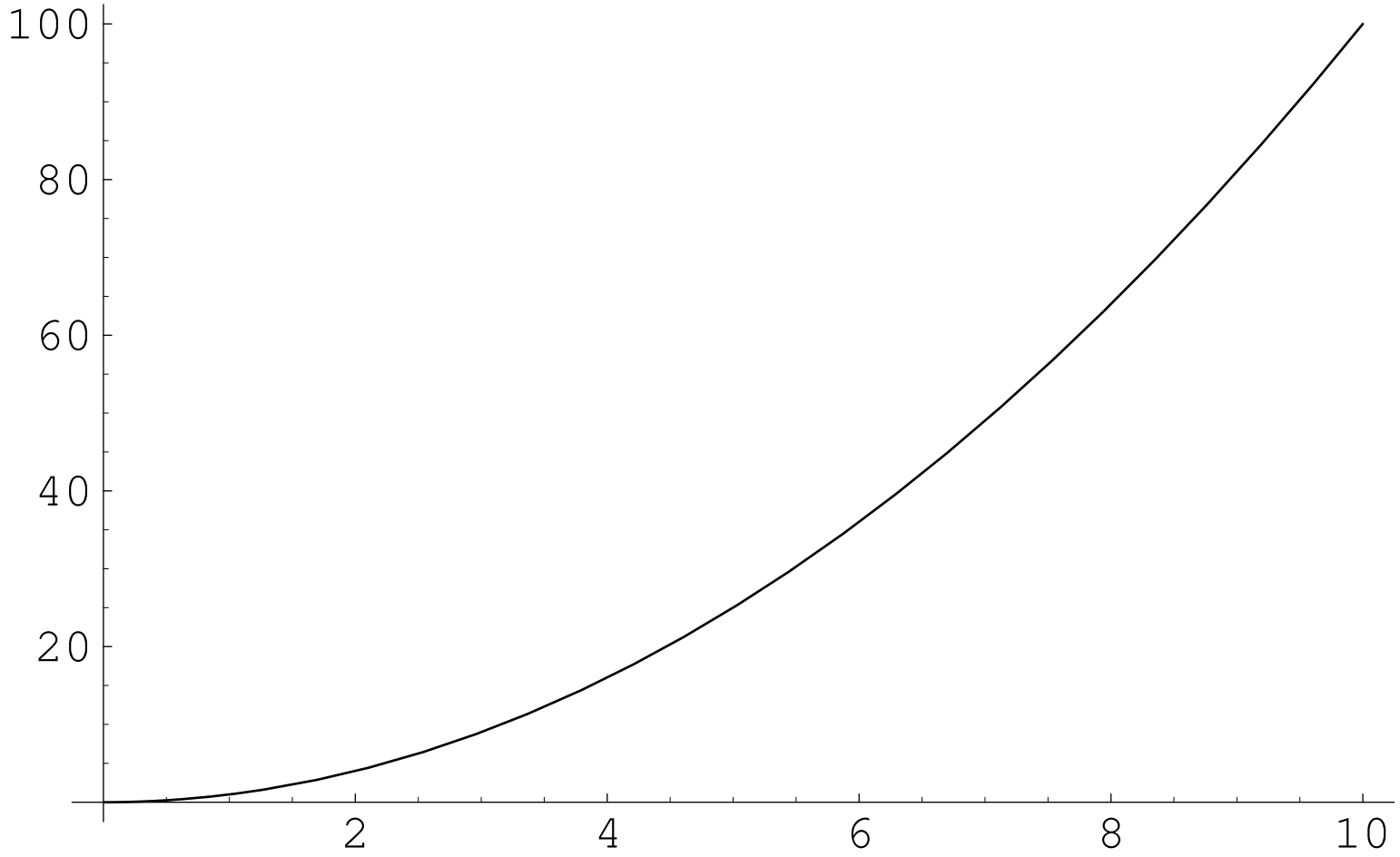


Figure J.3. This is the caption for the third figure. This is the caption for the third figure. This is the caption for the third figure.

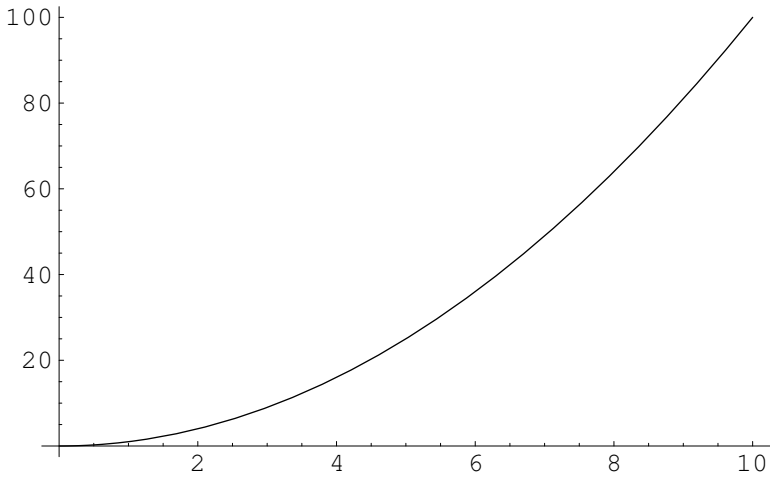


Figure J.4. By default figures are not centered. This is a long caption to demonstrate that captions are single spaced. This is a long caption to demonstrate that captions are single spaced.

```
\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}
```

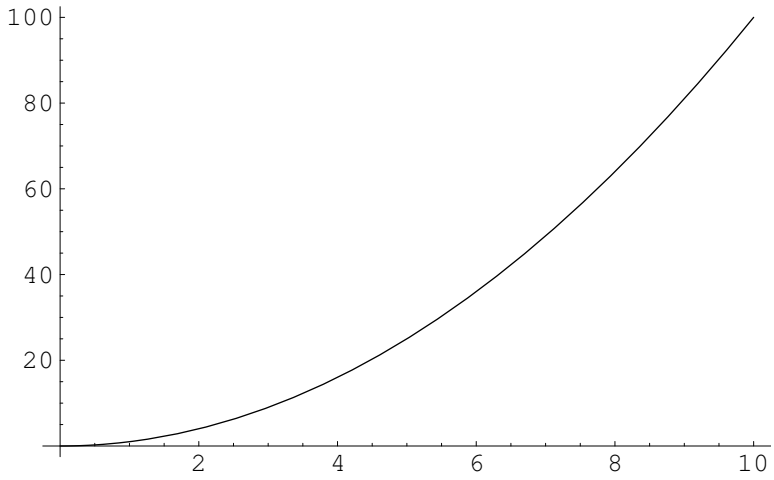


Figure J.5. Use `\centering` to center figures.

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

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

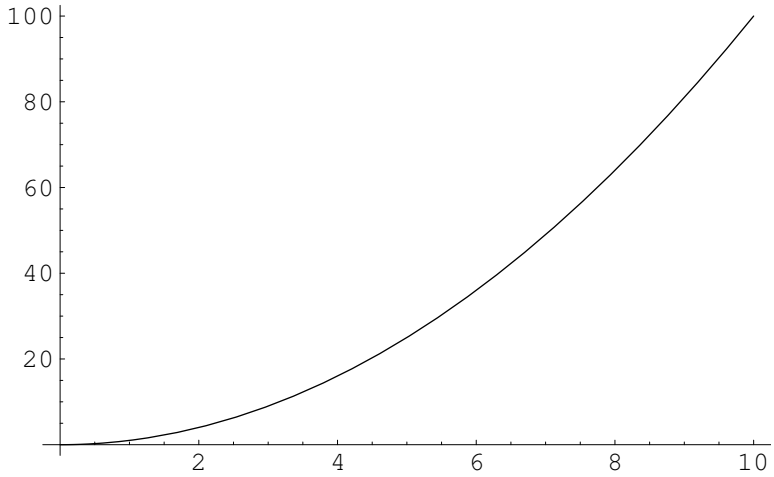


Figure J.6. This is another figuure.

```
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.

```

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

First subfigure. (a) First subcaption.

Second subfigure. (b) Second subcaption.

Figure J.7. This figure has two subfigures arranged horizontally.

```

  % 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 J.8. This figure has two subfigures arranged vertically.

```

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


```

```
% 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}


```

```
% 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 J.9. This figure has four parts.

```
8         {First subcaption.\label{sf:four-parts-a}}
9         [2in]%
10        {\bfseries First subfigure.}%
11      \hskip 0.5truein
12      \subcaptionbox
13        {Second subcaption.\label{sf:four-parts-b}}
14        [2in]%
15        {\bfseries Second subfigure.}%
16      \vspace*{\baselineskip}
17      \subcaptionbox
18        {Third subcaption.\label{sf:four-parts-c}}
19        [2in]%
20        {\bfseries Third subfigure.}%
21      \hskip 0.5truein
22      \subcaptionbox
23        {Fourth subcaption.\label{sf:four-parts-d}}
24        [2in]%
25        {\bfseries Fourth subfigure.}%
26    \caption{This figure has four parts.}
27    \label{fi:four-parts}
28  \end{figure}
29  \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.

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

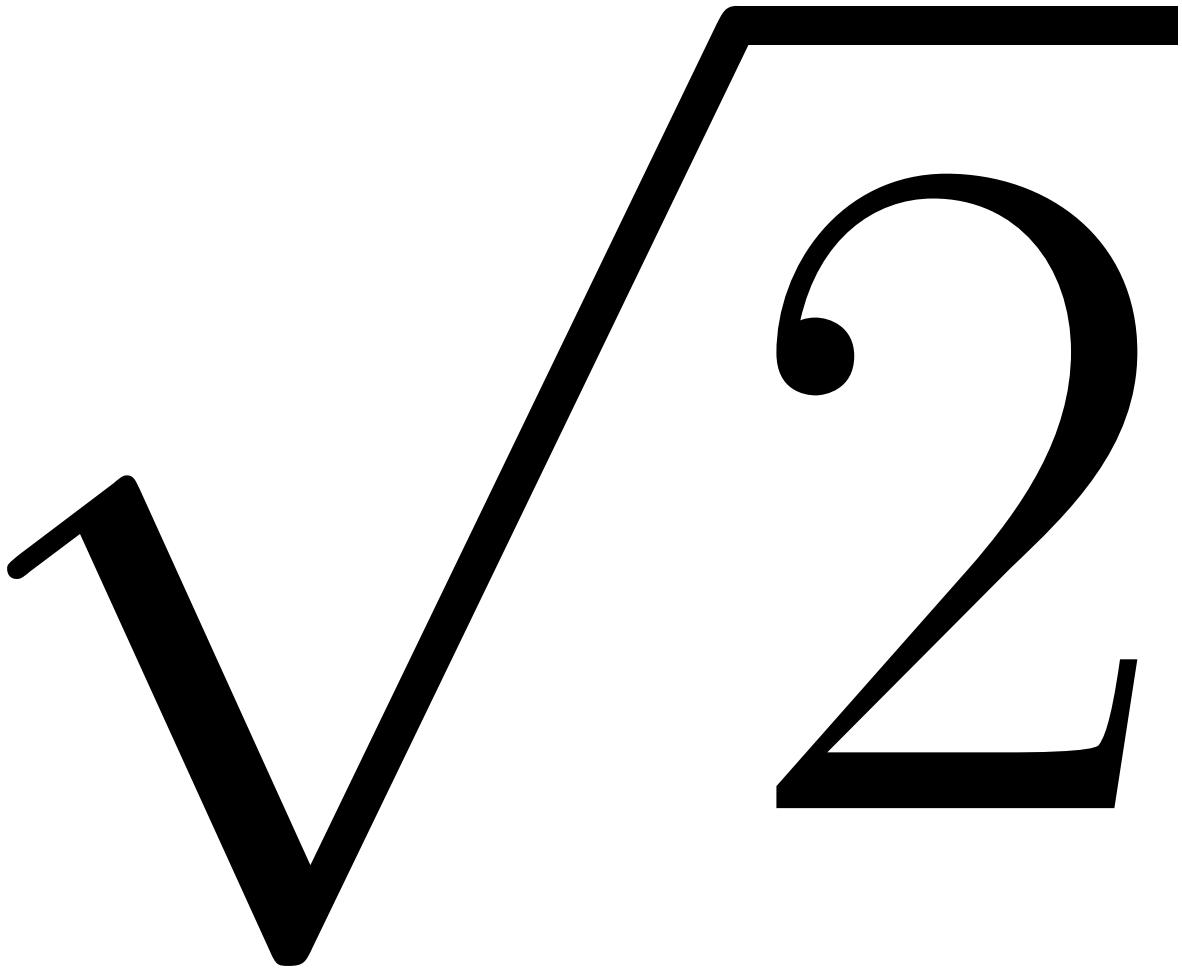


Figure J.10. A big "$\sqrt{2}$". LaTeX can make output big enough for T-shirts or posters. Square roots are printed with space before them, I put some negative horizontal space before this one to center it.

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

This is the figure.

Figure J.11. 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 J.12. Test figure 1 of 20.

Figure J.13. Test figure 2 of 20.

Figure J.14. Test figure 3 of 20.

Figure J.15. Test figure 4 of 20.

Figure J.16. Test figure 5 of 20.

Figure J.17. Test figure 6 of 20.

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

Figure J.18. Test figure 7 of 20.

Figure J.19. Test figure 8 of 20.

Figure J.20. Test figure 9 of 20.

Figure J.21. Test figure 10 of 20.

Figure J.22. Test figure 11 of 20.

Figure J.23. Test figure 12 of 20.

Figure J.24. Test figure 13 of 20.

```
16    \includegraphics[scale=0.5]{gr-metapost-tally-02.pdf}
17    \caption{Test figure 2 of 20.}
18    \label{fi:2of20}
19  \end{figure}
20
21  \begin{figure}[ht]
22    \centering
23    \includegraphics[scale=0.5]{gr-metapost-tally-03.pdf}
24    \caption{Test figure 3 of 20.}
25    \label{fi:3of20}
26  \end{figure}
27
28  \begin{figure}[ht]
29    \centering
30    \includegraphics[scale=0.5]{gr-metapost-tally-04.pdf}
31    \caption{Test figure 4 of 20.}
32    \label{fi:4of20}
33  \end{figure}
```

Figure J.25. Test figure 14 of 20.

Figure J.26. Test figure 15 of 20.

Figure J.27. Test figure 16 of 20.

Figure J.28. Test figure 17 of 20.

Figure J.29. Test figure 18 of 20.

Figure J.30. Test figure 19 of 20.

Figure J.31. 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}
```

```
52    \caption{Test figure 7 of 20.}
53    \label{fi:7of20centered7}
54  \end{figure}
55
56  \begin{figure}[ht]
57    \centering
58    \includegraphics[scale=0.5]{gr-metapost-tally-08.pdf}
59    \caption{Test figure 8 of 20.}
60    \label{fi:8of20}
61  \end{figure}
62
63  \begin{figure}[ht]
64    \centering
65    \includegraphics[scale=0.5]{gr-metapost-tally-09.pdf}
66    \caption{Test figure 9 of 20.}
67    \label{fi:9of20}
68  \end{figure}
69
70  \begin{figure}[ht]
71    \centering
72    \includegraphics[scale=0.5]{gr-metapost-tally-10.pdf}
73    \caption{Test figure 10 of 20.}
74    \label{fi:10of20}
75  \end{figure}
76
77  \begin{figure}[ht]
78    \centering
79    \includegraphics[scale=0.5]{gr-metapost-tally-11.pdf}
80    \caption{Test figure 11 of 20.}
81    \label{fi:11of20}
82  \end{figure}
83
84  \begin{figure}[ht]
85    \centering
86    \includegraphics[scale=0.5]{gr-metapost-tally-12.pdf}
87    \caption{Test figure 12 of 20.}
88    \label{fi:12of20}
89  \end{figure}
90
91  \begin{figure}[ht]
92    \centering
93    \includegraphics[scale=0.5]{gr-metapost-tally-13.pdf}
94    \caption{Test figure 13 of 20.}
95    \label{fi:13of20}
96  \end{figure}
97
98  \begin{figure}[ht]
99    \centering
100   \includegraphics[scale=0.5]{gr-metapost-tally-14.pdf}
101   \caption{Test figure 14 of 20.}
102   \label{fi:14of20}
103 \end{figure}
104
105 \begin{figure}[ht]
106   \centering
107   \includegraphics[scale=0.5]{gr-metapost-tally-15.pdf}
108   \caption{Test figure 15 of 20.}
109   \label{fi:15of20}
110 \end{figure}
111
112 \begin{figure}[ht]
113   \centering
114   \includegraphics[scale=0.5]{gr-metapost-tally-16.pdf}
115   \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}
```

K. FREQUENTLY ASKED QUESTIONS

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

Description	Color
done or waiting on someone else	black
high priority or easy to do	red
low priority	blue
not prioritized yet	gray

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

K.1 These questions need to be answered

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

K.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

```
$a | b$
```

(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

References

FAQ 4. I have an `@online{...` reference with no `date = {...}` and "()" gets printed in the references around where the date would go. How can I prevent the "()" from getting printed. Asked by Pratith Narasimha Shenai on 2023-07-15
A: Use `@online[*]{...` instead of `@online{...`. I don't know why this works.

K.3.1 Appendix

FAQ 3. Label Appendix/Appendices with APPENDIX. Asked by Panos Manganaris on 2023-06-16. **A:** Mark Jaeger, former Manager of the Thesis and Dissertation Office, wrote and said that the most important thing in a thesis was "consistency, consistency, consistency".

For consistency,

- Chapters aren't labeled with "CHAPTER" so Appendix/Appendices aren't labeled with "APPENDIX".
- Chapters are listed as 1, 2, ... and appendices are listed as A, B, ... in the Table of Contents.

Contemporary usage is to not label chapters or appendices see MIT theses [60, 61], Stanford theses [62, 63], and TEX/LATEXdocumentation [30, 52, 64].

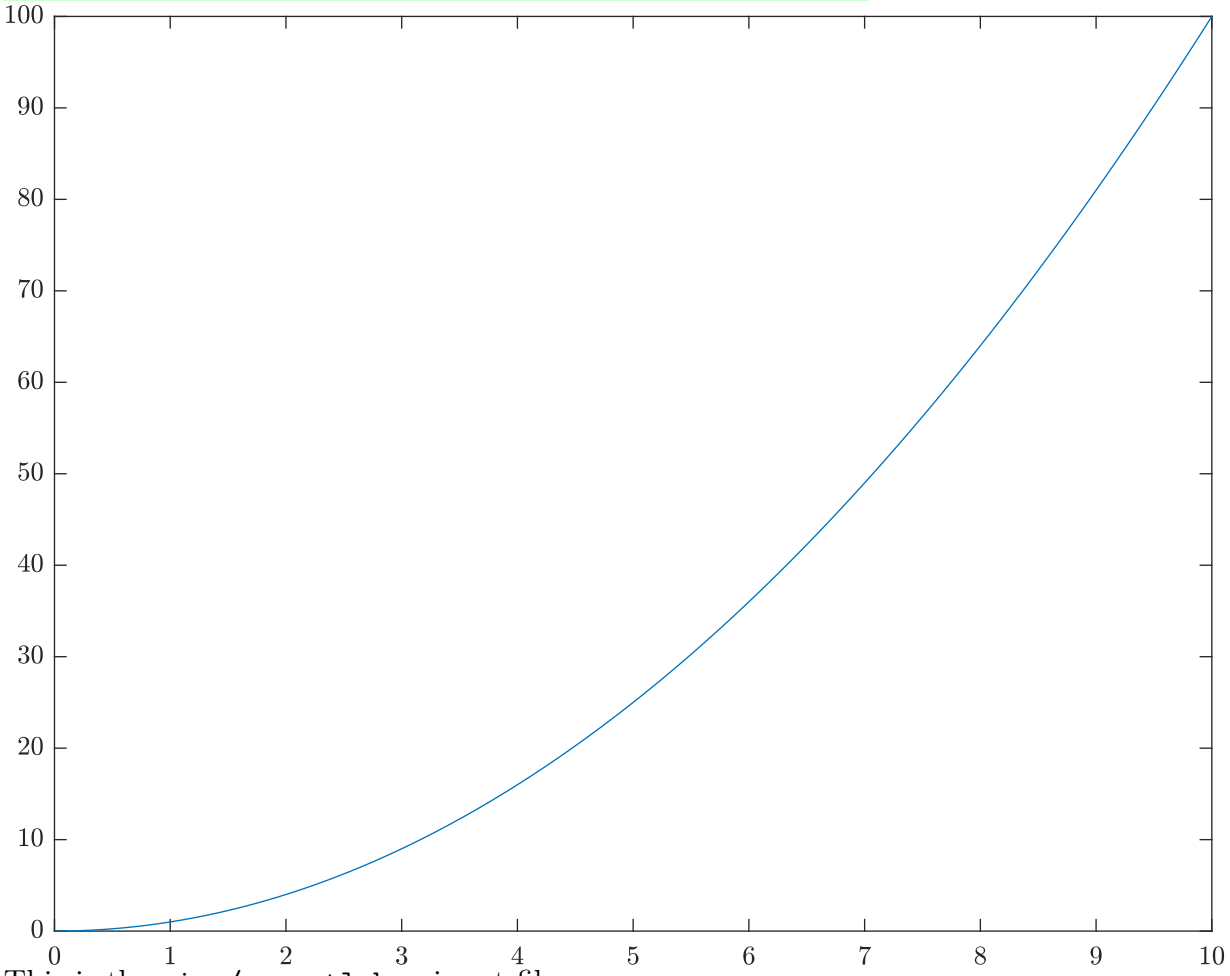
L. GRAPHICS

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.
```

L.1 MATLAB programming language

By default, MATLAB supports a subset of TeX markup [65].



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
```

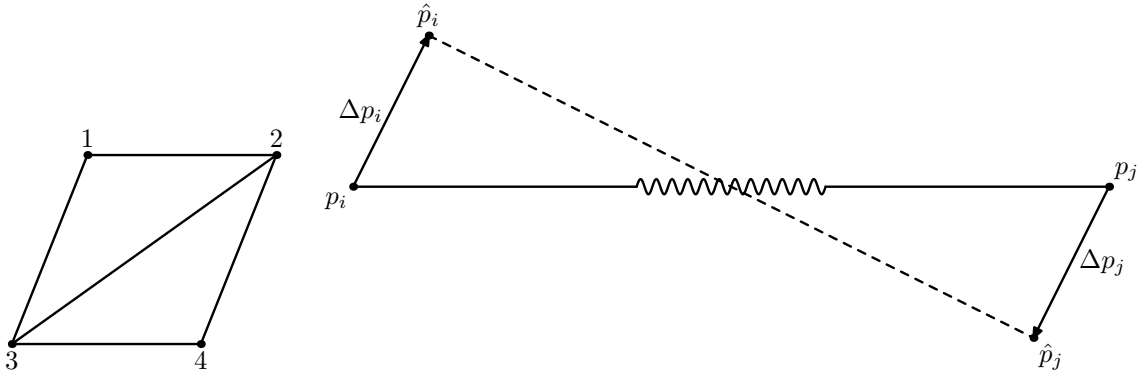
```
%     https://www.mathworks.com/matlabcentral/answers/346436-how-to-use-latex-interpreter-for-xticklabels
% Do axis labels using LaTeX.
set(groot, 'defaultAxesTickLabelInterpreter', 'latex');
% Do legends using LaTeX.
set(groot, 'defaultLegendInterpreter', 'latex');
% Do text using LaTeX.
set(groot,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

L.2 METAPOST programming language

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
```

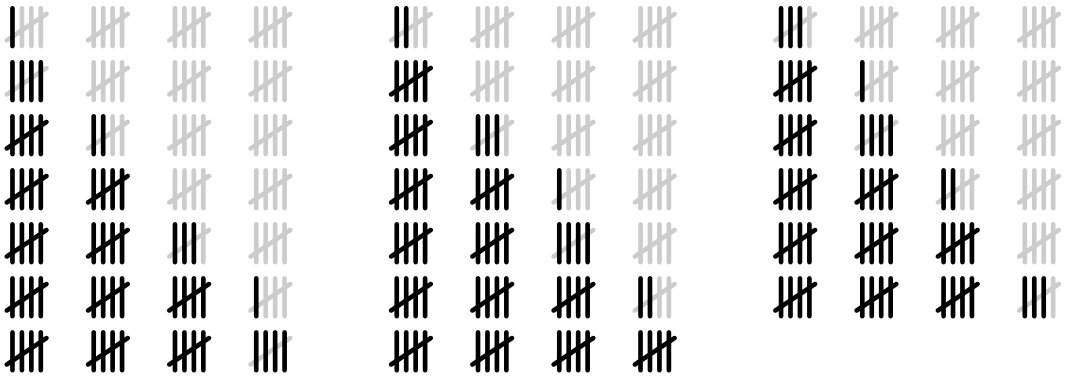
to run MetaPost and make `gr-metapost-kim-1.pdf` and `gr-metapost-kim-2.pdf`, and move them to the graphics subfolder.

```

\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 |gr-metapost-kim-1.pdf|
and |gr-metapost-kim-2.pdf|,
and move them to the graphics subfolder.
```

L.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:
```

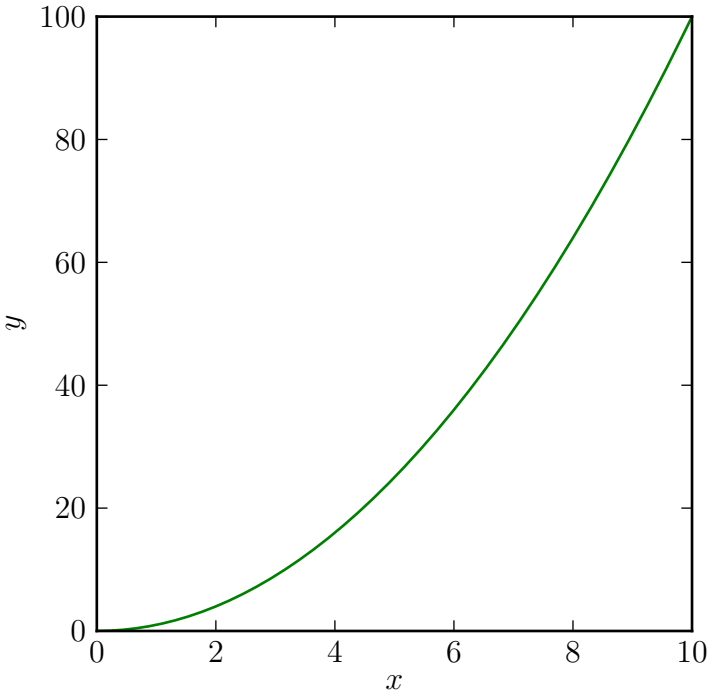
```
65
66      beginfig(i);
67
68          % Define pen---this must go between beginfig and endfig.
69          pen mypen;
70          mypen = pencircle scaled 3.5;
71          pickup mypen;
72
73          % Draw gray tally marks.
74          for j = i+1 upto n:
75              draw p[j] withcolor 0.8white;
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
```

L.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    2023-08-31    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
```

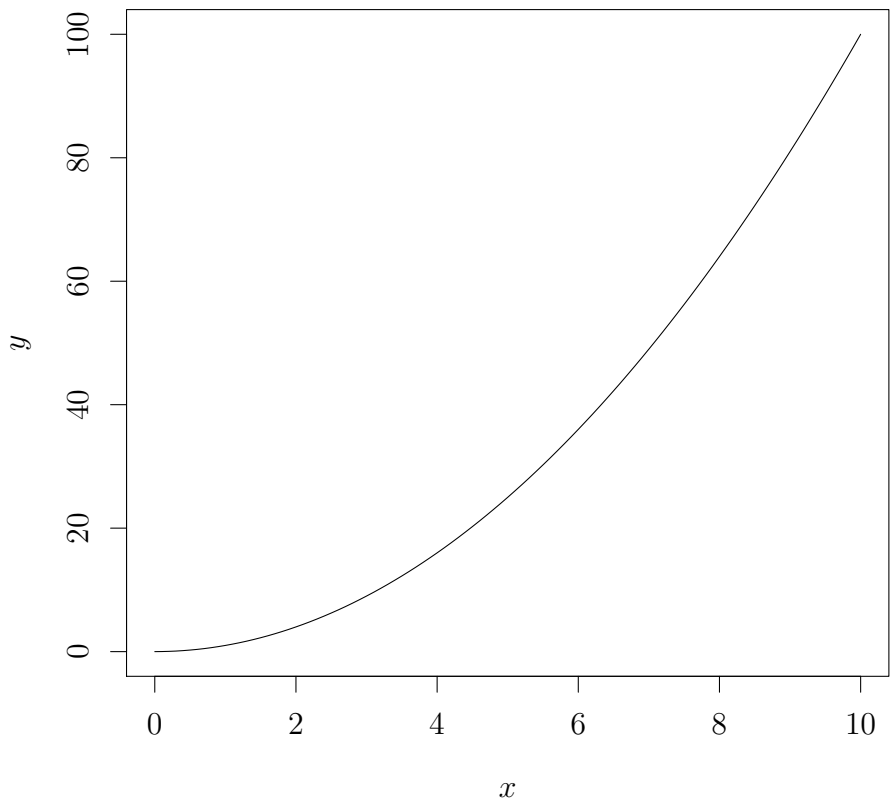
```
21
22  # From
23  # https://stackoverflow.com/questions/2801882/generating-a-png-with-matplotlib-when-display-is-undefined
24  #     # Force matplotlib to not use any Xwindows backend.
25  #     matplotlib.use('Agg')
26  mpl.use('Agg')
27
28  import matplotlib.pyplot as plt
29
30  plt.figure(figsize=(4,4))
31
32  import numpy as np
33
34  x = [ ]
35  y = [ ]
36  for i in range(0,1001):
37      x.append(i / 100.0)
38      y.append((i/100.0) ** 2)
39
40  # Normally, there is extra space to the left, right, top, and bottom
41  # of plotted data in a graph.  This gets rid of that space.
42  plt.autoscale(enable=None, tight=True)
43
44  plt.plot(x, y, 'g')
45
46  plt.xlabel('$x$')
47  plt.ylabel('$y$')
48
49  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.

```
1  \section{Python programming language}
2  \ix{Python programming language}
3
4  \lightgreen{Python can be set up to use \LaTeX\ fonts.}
5
6  \includegraphics{gr-python2.pdf}
7
8  This is the |misc/gr-python2.py| input file:
9  \MyI{misc/gr-python2.py}
10
11 I typed, on Linux,
12 \Shell{./gr-python2.py}
13 in the |misc| subdirectory
14 to make the\\
15 |graphics/gr-python2.pdf| output file.
```

L.4 R programming language

R can be set up to use LaTeX fonts.



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.}
```

```
6
7  \input{gr-r.tex}
8
9  This is the |misc/gr-r.R| input file:
10 \MyI{misc/gr-r.R}
11
12 I typed, on Linux,
13 \Shell{R CMD BATCH gr-r}
14 in the |misc| subdirectory to make the |gr-r.tex| outfile file.
```

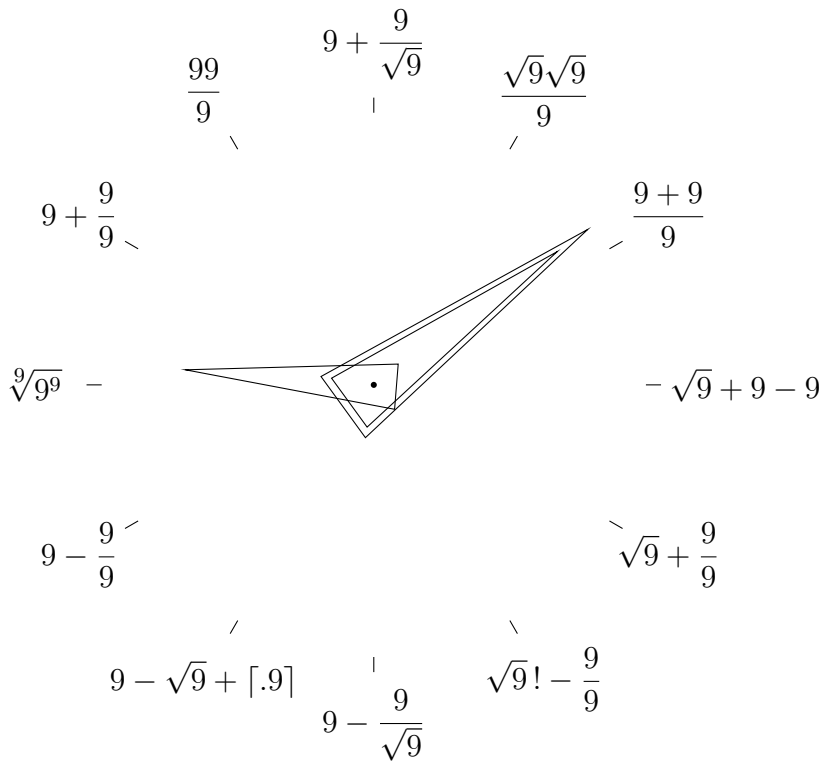
L.5 TikZ LaTeX package

TikZ uses LaTeX fonts.

```
1
2  \section{\TikZLogo\ \LaTeX\ package}
3  \index{TikZ@\TikZLogo\ \LaTeX\ package}
4  \todoindex{\TikZLogo\ \LaTeX\ package}
5
6  \lightgreen{\TikZLogo\ uses \LaTeX\ fonts.}
```

L.5.1 Clock example

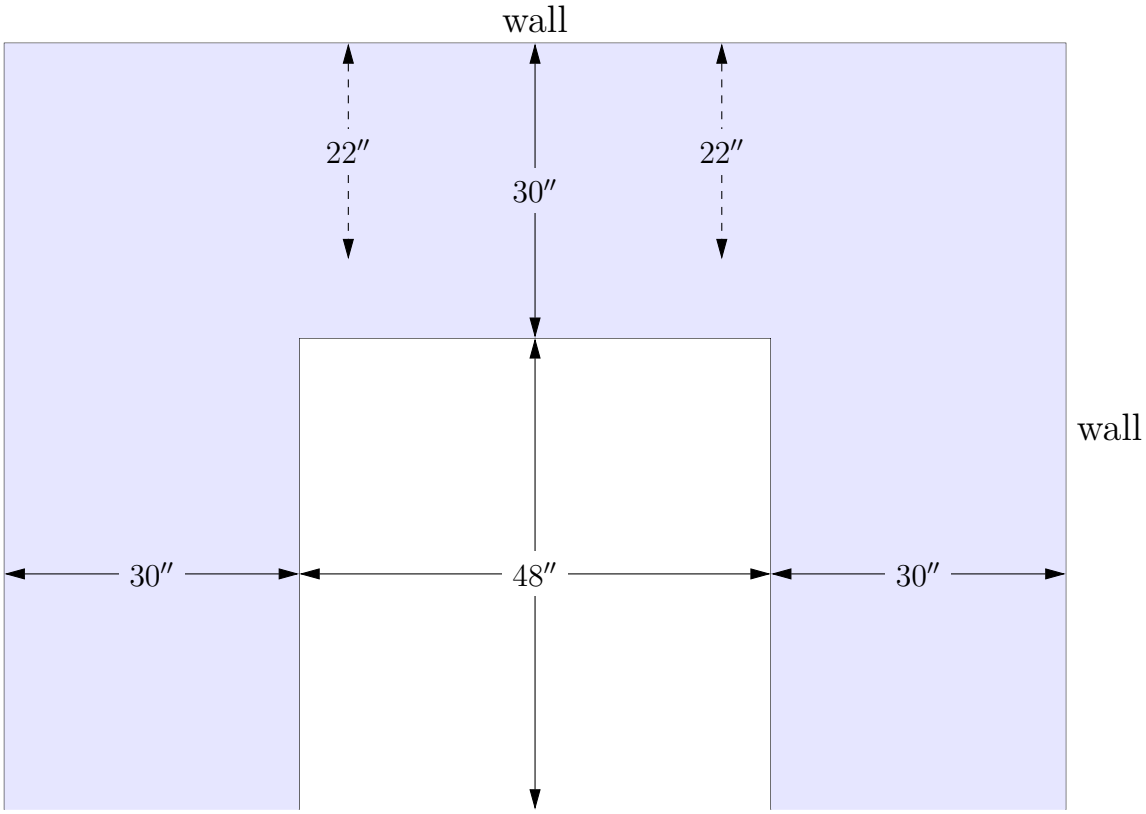
```
1
2  \subsection{Clock example}
3  \index{clock \TikZLogo\ example}
4  \todoindex{clock \TikZLogo\ example}
```




```
1
2  \index{TikZ@\TikZLogo}
```

```
3
4  \hbox to\textwidth{%
5    \hfil
6    % The idea for this clock was originally from a Google+ posting by Afamefuna ‘‘Ferdy’’ Ibeabuchia.
7    \begin{tikzpicture}
8      \def\CenterRadius{0.04cm}
9      \def\InnerTickRadius{3.6cm}
10     \def\OuterTickRadius{3.8cm}
11     % Make \LR be an abbreviation for \LabelRadius so the
12     % lines below will fit within the width of the page.
13     \def\LabelRadius{4.5cm}      \let\LR=\LabelRadius
14     \def\HourHandRadius{2.5cm}   \def\HourHandBase{0.3cm}
15     \def\MinuteHandRadius{3cm}   \def\MinuteHandBase{0.4cm}
16     \def\SecondHandRadius{3.5cm} \def\SecondHandBase{0.5cm}
17     \def\DS{\displaystyle}
18     \fill (0,0) circle (\CenterRadius);
19     \foreach \i in {0,30,...,330}
20     \draw (\i:\InnerTickRadius)--(\i:\OuterTickRadius);
21     \node at (  0:\LR) {$\DS \qquad \sqrt9 + 9 - 9$};        %  3
22     \node at ( 30:\LR) {$\DS \frac{9+9}9$};                  %  2
23     \node at ( 60:\LR) {$\DS \frac{\sqrt9\sqrt9}9$};         %  1
24     \node at ( 90:\LR) {$\DS 9 + \frac9{\sqrt9}$};           % 12
25     \node at (120:\LR) {$\DS \frac{99}9$};                   % 11
26     \node at (150:\LR) {$\DS 9 + \frac99$};                  % 10
27     \node at (180:\LR) {$\DS \sqrt[\scriptstyle 9]{9^9}$};   %  9
28     \node at (210:\LR) {$\DS 9 - \frac99$};                  %  8
29     \node at (240:\LR) {$\DS 9 - \sqrt9 + \lceil.9\rceil$};  %  7
30     \node at (270:\LR) {$\DS 9 - \frac9{\sqrt9}$};           %  6
31     \node at (300:\LR) {$\DS \sqrt9\,! - \frac99$};          %  5
32     \node at (330:\LR) {$\DS \sqrt9 + \frac99$};             %  4
33     % In the following
34     %   ABBREVIATION    DESCRIPTION
35     %   deg             degrees
36     %   min             minutes
37     %   sec             seconds
38     % for second hand:
39     %   (9 sec/60 sec) * 360 deg = 54 deg;
40     %   90 deg - 54 deg = 36 deg
41     \draw[rotate around={36:(0,0)}]
42       (-\SecondHandBase,\SecondHandBase) -- (\SecondHandRadius,0)
43         -- (-\SecondHandBase,-\SecondHandBase) -- cycle;
44     % for minute hand:
45     %   (9 min/60 min) * 360 deg = 54 deg;
46     %   90 deg - 54 deg = 36 deg
47    \draw[rotate around={36:(0,0)}]
48      (-\MinuteHandBase,\MinuteHandBase) -- (\MinuteHandRadius,0)
49        -- (-\MinuteHandBase,-\MinuteHandBase) -- cycle;
50     % for hour hand:
51     %   (9 min * (60 sec/1 min)) + 9 sec) / 3600 sec
52     %     = 549 sec / 3600 sec = 0.1525
53     %   The hour hand is 0.1525 of the way from 9:00 to 10:00.
54     %   Each hour is 30 degrees on the clock, so the hour hand
55     %   position is
56     %     30 deg * 0.1525 = 4.575 deg past 9:00
57     %   180 deg - 4.575 deg = 175.425 deg
58     \draw[rotate around={175.425:(0,0)}]
59       (-\HourHandBase,\HourHandBase) -- (\HourHandRadius,0)
60       -- (-\HourHandBase,-\HourHandBase) -- cycle;
61   \end{tikzpicture}
62   \hfil
63 }
```

L.5.2 counter example



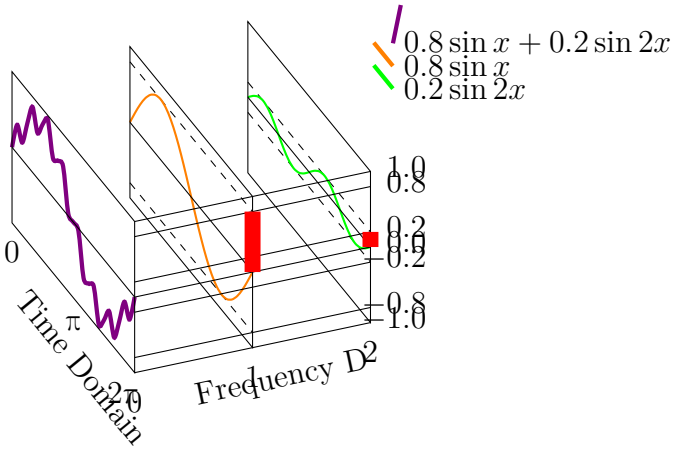

```
1
2  \newpage
3
4  \subsection{counter example}
5  \label{ss:counter-example}
6  \index{counter \TikZLogo\ example}
7  \todoindex{counter \TikZLogo\ example}
8
9  \begin{tikzpicture}[scale=0.13]
10   % Define points.
11   \coordinate   (p11) at (  0, 78);
12     \coordinate (p14) at ( 35, 78);
13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

```
      \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}
```

L.5.3 Fourier transform 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.")



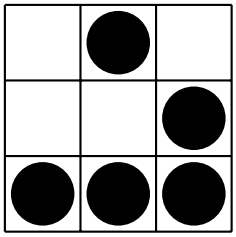

```
1
2  \subsection{Fourier transform example}
3  \label{ss:fourier-transform-example}
4  \index{Fourier transform \TikZLogo\ example}
5  \todoindex{Fourier transform \TikZLogo\ example}
6
7  The Fourier transform decomposes a function
8  into the frequencies that make it up.
9  The inverse Fourier transformation combines the contributions
10 of all the different frequencies to recover the original function.
11
12 (Mark Senn {\tt\char'074}mark@purdue.edu{\tt\char'076} wrote sales@aavos.be on 2021-09-03
13 to ask permission
14 to use
15 \href{https://aavos.eu/glossary/fourier-transform/}{Fourier transform}
16 as the starting point
17 for an example \TikZLogo\ figure.
18 Dominique Demurie {\tt\char'074}sales@aavos.be{\tt\char'076} replied
19 on 2021-09-06 with
20 ``I think it is not an original drawing from us either.
21 We had it for years on our website,
22 but I cannot remember where we got it from.
23 We don't mind you using it for a thesis.'')
24
25 % Run this with
26 %     pdflatex --shell-escape t
27 % That makes the t.table.* files.
28 %
29 % See
30 %     https://ctan.math.washington.edu/tex-archive/graphics/pgf/base/doc/pgfmanual.pdf
31 %     PAGE    TOPIC
32 %      655    decorations.text library to draw text
33 %     1221    animations
34 %
35 % for text decorations, which includes text along a path information.
36 % Also see
37 %     https://tex.stackexchange.com/questions/427454/tikz-3dplot-and-rotation-of-coordinates
38 %     https://tex.stackexchange.com/questions/67573/tikz-shift-and-rotate-in-3d
39 %     http://tug.ctan.org/graphics/pgf/contrib/tikz-3dplot/tikz-3dplot_documentation.pdf
40 %     https://tex.stackexchange.com/questions/45848/rotate-node-text-and-use-relative-positioning-in-tikz
41
42 % was scale = 2
43 \begin{tikzpicture}[domain=0:6.283185, rotate around y=-55, scale=1]
44
45   % total plot
46   \begin{scope}[canvas is xy plane at z=0]
```

```
47      \node[below=3pt] at (0,        -1) {0};
48      \node[below=3pt] at (3.141593, -1) {$\pi$};
49      \node[below=5pt] at (5.683185, -1) {$2\pi$};
50      \draw[ultra thick,color=violet] plot[id=total,smooth] function{0.8*sin(x)+0.2*sin(8*x)};
51      \draw[thin,color=black] (0,-1) -- (0,1) -- (6.283185,1) -- (6.283185,-1) -- cycle;
52      \draw[thin,color=black] (0,0) -- (6.283185,0);
53      \path[decorate,decoration={text along path,
54  % |\LARGE|
55        text={Time Domain}}] (0.1,-2) -- (6.283185,-2);
56      % $s(t)$
57    \end{scope}
58
59    % tall plot
60    \begin{scope}[canvas is xy plane at z=-1.5]
61      \draw[dashed] (0,0.8) -- (6.283185,0.8);
62      \draw[dashed] (0,-0.8) -- (6.283185,-0.8);
63      \draw[thick,color=orange] plot[id=tall,smooth] function{0.8*sin(x)};
64      \draw[thin,color=black] (0,-1) -- (0,1) -- (6.283185,1) -- (6.283185,-1) -- cycle;
65      \draw[thin,color=black] (0,0) -- (6.283185,0);
66    \end{scope}
67
68    % short plot
69    \begin{scope}[canvas is xy plane at z=-3.0]
70      \draw[dashed] (0, 0.2) -- (6.283185,  0.2);
71      \draw[dashed] (0,-0.2) -- (6.283185, -0.2);
72      \draw[thick,color=green] plot[id=short,smooth] function{0.2*sin(2*x)};
73      \draw[thin,color=black] (0,-1) -- (0,1) -- (6.283185,1) -- (6.283185,-1) -- cycle;
74      \draw[thin,color=black] (0,0) -- (6.283185,0);
75    \end{scope}
76
77    % frequency plot
78    \begin{scope}[canvas is zy plane at x=6.283185]
79      \node[below=3pt] at ( 0.0,-1) {0};
80      \node[below=3pt] at (-1.5,-1) {1};
81      \node[below=3pt] at (-3.0,-1) {2};
82      \draw[thin,color=black] (0,-1.0) -- (-3.0,-1.0);  \node[above=-9pt] at (-3.3,-1.0) {$-1.0$};
83      \draw[thin,color=black] (0,-0.8) -- (-3.0,-0.8);  \node[above=-9pt] at (-3.3,-0.8) {$-0.8$};
84      \draw[thin,color=black] (0,-0.2) -- (-3.0,-0.2);  \node[above=-9pt] at (-3.3,-0.2) {$-0.2$};
85      \draw[thin,color=black] (0, 0.0) -- (-3.0, 0.0);  \node[above=-9pt] at (-3.3, 0.0) {$\phantom-0.0$};
86      \draw[thin,color=black] (0, 0.2) -- (-3.0, 0.2);  \node[above=-9pt] at (-3.3, 0.2) {$\phantom-0.2$};
87      \draw[thin,color=black] (0, 0.8) -- (-3.0, 0.8);  \node[above=-9pt] at (-3.3, 0.8) {$\phantom-0.8$};
88      \draw[thin,color=black] (0, 1.0) -- (-3.0, 1.0);  \node[above=-9pt] at (-3.3, 1.0) {$\phantom-1.0$};
89      \draw[line width=6pt,color=red] (-1.5,0) -- (-1.5,0.8);
90      \draw[line width=6pt,color=red] (-3.0,0) -- (-3.0,0.2);
91      \path[decorate,decoration={text along path,
92  % |\LARGE|
93        text={Frequency Domain}}] (-0.8,-1.6) -- (-3.0,-1.6);
94      % $S(\omega)$
95    \end{scope}
96
97    %% legend
98    %% Wolfram Language code:
99    %%     In[1]:= ry[theta_] :=
100   %%     {
101   %%         {Cos[theta Degree],  0, Sin[theta Degree]},
102   %%         {0,                  1, 0},
103   %%         {-Sin[theta Degree], 0, Cos[theta Degree]}
104   %%     }
105   %%
106   %%     ry[55] . {Pi, 0.7, -3.5}
107   %%     # Out[] = {-1.06509, 0.7, -4.58096}
108   %%     ry[55] . {(3/4)Pi, 0.7, -3.5}
109   %%     # Out[] = {-1.51557, 0.7, -3.9376}
110
```

```
    \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}
```

L.5.4 Glider example

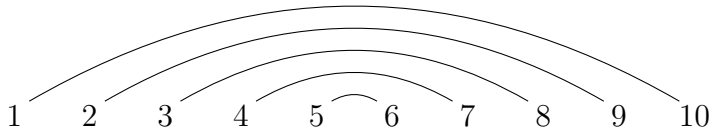
The glider is a pattern from the Game of Life, and it's used as an emblem representing the hacker community.



```

  \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}
```

L.5.5 Sum of 1 to n example

What is the sum of 1 to n?
Pair the numbers 1 and 10, 2 and 9, ... :



So

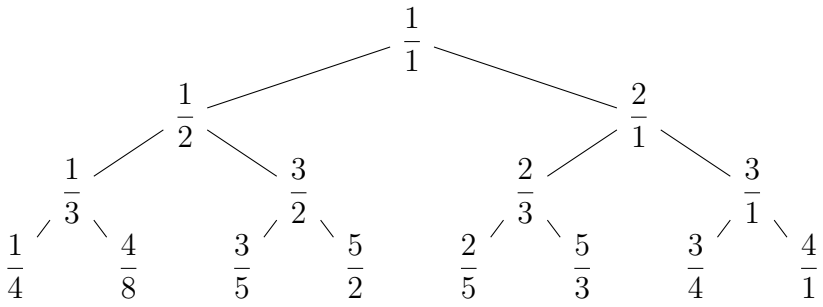
$$\begin{aligned}\sum_{1}^{n} &= \text{how many pairs of numbers} \times \text{the sum of each pair} \\ &= \left(\frac{n}{2}\right)(n+1) \\ &= \frac{n(n+1)}{2}\end{aligned} \tag{L.1}$$

This also works if n is an odd number. (The famous mathematician Gauss reportedly added the numbers 1–100 quickly in 1784 but the best reference I could find [66, page 3–4] did not state which method he used.)

```
1
2  % If you use the silence package change
3  \subsection{Sum of 1 to \(n\) example}
4  % to
5  %     \subsection{Sum of 1 to $n$ example}
6  % to avoid having the silence package apparently go into an infinite
7  % loop.
8  % \ix{sum of 1 to \(n\)}
9
10 What is the sum of \(1 \text{ to } n\)?
11
12 Pair the numbers 1 and 10, 2 and 9, \ldots\,:
13
14 \hbox to\textwidth{%
15   \hss  % horizontal stretch or shrink as needed
16   \vspace*{0.25in}
17   % Curves leave a node at a 30 degree angle
18   % and enter a node at a 150 degree angle.
19   \begin{tikzpicture}[out=30,in=150]
20     \node at  (1,0)  {1};
21     \node at  (2,0)  {2};
22     \node at  (3,0)  {3};
23     \node at  (4,0)  {4};
24     \node at  (5,0)  {5};
25     \node at  (6,0)  {6};
26     \node at  (7,0)  {7};
27     \node at  (8,0)  {8};
28     \node at  (9,0)  {9};
29     \node at (10,0) {10};
30     \draw (1.2, 0.2) to (9.8, 0.2)
31           (2.2, 0.2) to (8.8, 0.2)
32           (3.2, 0.2) to (7.8, 0.2)
33           (4.2, 0.2) to (6.8, 0.2)
34           (5.2, 0.2) to (5.8, 0.2);
35   \end{tikzpicture}%
36   \hss
37 }
38
```

```
So
\begin{align}
  % Since i is interpreted as a constant and is an upright font by default
  % I'm using {\mit i} so it is in a math italic font.
  \sum_1^n &= \text{how many pairs of numbers}
    \times \text{the sum of each pair}\nonumber\\
  &= \left(\frac n 2\right) (n+1)\nonumber\\
  &= \frac {n (n+1)} 2
\end{align}
This also works if \(n\) is an odd number.
(The famous mathematician Gauss reportedly added
the numbers~1--100 quickly in~1784
but the best reference I could find
\cite[page 3--4]{waltershausen1856}
did not state which method he used.)
```

L.5.6 Tree example



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

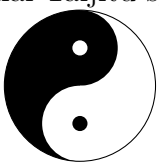
with additional conditions	has	with value
(none)	left child	$\frac{n}{n+d}$
(none)	right child	$\frac{n+d}{d}$
$n < d$	parent	$\frac{n}{d-n}$
$n = d$	no parent	(not applicable)
$n > d$	parent	$\frac{n-d}{d}$

```
1
2   \newpage
3
4   \subsection{Tree example}
5   \ix{???, ???}
6   \index{tree \TikZLogo\ example}
7   \todoindex{tree \TikZLogo\ example}
8
9   {
10    \def\f#1#2{$\displaystyle\frac #1#2$}
11    \begin{tikzpicture}%
12    [%
13      level 1/.style={sibling distance=60mm},
14      level 2/.style={sibling distance=30mm},
15      level 3/.style={sibling distance=15mm}
16    ]
17      \node {\f 11}
18        child {node {$\displaystyle\frac 12$}
19          child {node {\f 13}
20            child {node {\f 14}}
21            child {node {\f 48}}
22          }
23          child {node {\f 32}
24            child {node {\f 35}}
25            child {node {\f 52}}
26          }
27        }
28        child {node {\f 21}
29          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}
  }
```

L.5.7 Yin and yang example

This Yin and yang example was done by Thomas G. Kristensen [67]. This is the "traditional Taijitu symbol from Chinese philosophy".

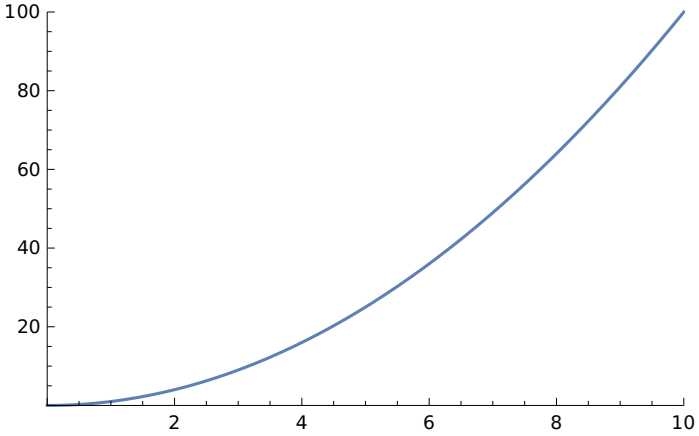


```


  \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}
```

L.6 Wolfram Language (Mathematica uses this)

Wolfram Language can be set up to use LaTeX fonts.



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

```
1   (*
2       MaTeX is a Wolfram Language package to use LaTeX fonts in
3       Wolfram Language graphics.  See
4           http://szhorvat.net/pelican/latex-typesetting-in-mathematica.html
5       for instructions on how to use MaTeX.
6   *)
7
8   (* Install MaTeX. *)
9   ResourceFunction["MaTeXInstall"][];
10
11  (* Load MaTeX. *)
12  <<MaTeX`;
13
14  latexStyle = {FontFamily->"Latin Modern Roman", FontSize->10};
15
16  g = Graphics[
17    Plot[x^2,
18      {x,0,10},
19      BaseStyle->latexStyle,
20      PlotRange->{{0,10},{0,100}}
21    ]
22  ];
23  I
24  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.

```
1
2   \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.
```

M. HOW TO DEBUG LaTeX PROBLEMS

```
\chapter
  [HOW TO DEBUG LATEX PROBLEMS]%
  {HOW TO DEBUG \LaTeX\ PROBLEMS}
\ix{debugging \LaTeX//How to Debug \LaTeXLogo\ Problems appendix}
```

Add more content here.

```

Add more content here.
\todoerror{add more content here}
```

In LuaLaTeX error messages, the `l` in, for example, `l.987` means `line`. `l.987` means `line 987`.

`! Undefined control sequence. l.`*line_number* `\`*command*`}`

The *command* on *line_number* of the current file does not exist. It may be misspelled.

N. 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.

```

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

A Manual for the Preparation of [Purdue] Graduate Theses [36]

> Parts of this are out of date.
>
> Thesis Help <thesishelp@purdue.edu> wrote on March 20, 2023:
>
> > Please look for current information on the *Templates* web page [68].

```

\noindent
\textbf{A Manual for the Preparation of [Purdue] Graduate Theses}
\cite{thesis2017}

\begin{quote}
  Parts of this are out of date.

  Thesis Help \(<\)thesishelp@purdue.edu\(>\) wrote on March 20, 2023:
  \begin{quote}
    Please look for current information on the
    \citetitle{thesisanddissertationofficeb}
    web page
    \cite{thesisanddissertationofficeb}.
  \end{quote}
\end{quote}
```

Purdue Online Writing Lab, IEEE Reference List [69]

> 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 [70, page 2].

```

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

\begin{quote}
  The IEEE
  (The world's largest technical professional organization
  for the advancement
```

```
10    of technology)
11    has changed their references format from,
12    for example,
13
14    \noindent
15    \begin{tabular}{@{}ll@{}}
16    \noalign{\vspace*{6pt}}
17      [1]& W. K. Chen, Linear Networks and Systems. Belmont, CA: Wadsworth Press,\\
18      \multispan{2}{2003.\hfil}\\
19    \noalign{\vspace*{6pt}}
20    \noalign{\noindent to}
21    \noalign{\vspace*{6pt}}
22      [1]& W. K. Chen, Linear Networks and Systems. Belmont, CA: Wadsworth Press,\\
23      & 2003.\hfil\\
24    \noalign{\vspace*{6pt}}
25    \end{tabular}
26    See
27    \cite[page~2]{ieeedataport}.
28  \end{quote}
```

O. 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`	CTAN
`\LaTeXLogo`	LaTeX
`\LuaLaTeXLogo`	LuaLaTeX
`\METAFONTLogo`	METAFONT
`\METAPOSTLogo`	METAPOST
`\MetaPostLogo`	MetaPost
`\NonCalligraphicAMSLaTeXLogo`	AMS-LaTeX
`\PurdueThesisLogo`	PurdueThesis
`\PuThLogo`	PuTh
`\siunitxLogo`	siunitx
`\TeXLogo`	TeX
`\TeXLiveLogo`	TeX Live
`\TikZLogo`	Ti*k*Z
`\TEXUsersGroupLogo`	TeX Users Group
`\TUGboatLogo`	*TUGboat*

```
\chapter{LOGOS}

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

\begin{tabular}{@{}ll@{}}
  \toprule
  \bfseries Input& \bfseries Output\\
  \midrule
  % From thesis.tex
  %     \newcommand{\tabularspace}{\noalign{\vspace*{2pt}}}
  % \tabularspace
  |\AMSmathLogo|& \AMSmathLogo\\[2pt]
  |\BibLaTeXLogo|& \BibLaTeXLogo\\[2pt]
  |\BiberLogo|& \BiberLogo\\[2pt]
  |\CalligraphicAMSLaTeXLogo|& \CalligraphicAMSLaTeXLogo\\[2pt]
  |\CircuiTikZLogo|& \CircuiTikZLogo\\[2pt]
  |\CTANLogo|& \CTANLogo\\[2pt]
  |\LaTeXLogo|& \LaTeXLogo\\[2pt]
  |\LuaLaTeXLogo|& \LuaLaTeXLogo\\[2pt]
  |\METAFONTLogo|& \METAFONTLogo\\[2pt]
  |\METAPOSTLogo|& \METAPOSTLogo\\[2pt]
  |\MetaPostLogo|& \MetaPostLogo\\[2pt]
  |\NonCalligraphicAMSLaTeXLogo|& \NonCalligraphicAMSLaTeXLogo\\[2pt]
  |\PurdueThesisLogo|& \PurdueThesisLogo\\[2pt]
```

```
    |\PuThLogo|& \PuThLogo\\[2pt]
    |\siunitxLogo|& \siunitxLogo\\[2pt]
    |\TeXLogo|& \TeXLogo\\[2pt]
    |\TeXLiveLogo|& \TeXLiveLogo\\[2pt]
    |\TikZLogo|& \TikZLogo\\[2pt]
    |\TEXUsersGroupLogo|& \TeXUsersGroupLogo\\[2pt]
    |\TUGboatLogo|& \TUGboatLogo\\[2pt]
    \bottomrule
  \end{tabular}
```

P. NUMBERS AND UNITS

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

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

The PurdueThesis documentclass uses the siunitx [71] package with some extra definitions in the puthesis.cls file to do numbers and units.

```

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

The \PurdueThesisLogo\ documentclass
uses the siunitx \cite{wright2024} package
with some extra definitions in the puthesis.cls file
to do numbers and units.
```

P.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}`	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}
```

P.2 Unit Examples

```

\section{Unit Examples}
```

See page 129 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}
```

P.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*}
```

P.4 Binary Prefixes

```

\section{Binary Prefixes}
```

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

```

The
|\kibi|\ldots|\yobi|
commands are defined immediately after the
|\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}
```

P.5 Decimal Prefixes

```

\section{Decimal Prefixes}
```

Power	Prefix	Symbol	Command	Comment
−30	quecto	q	`\si{\quecto}`	
−27	ronto	r	`\si{\quecto}`	
−24	yocto	y	`\si{\yocto}`	
−21	zepto	z	`\si{\zepto}`	
−18	atto	a	`\si{\atto}`	
−15	femto	f	`\si{\femto}`	
−12	pico	p	`\si{\pico}`	
−9	nano	n	`\si{\nano}`	
−6	micro	µ	`\si{\micro}`	
−3	milli	m	`\si{\milla}`	
−2	centi	c	`\si{\centi}`	
−1	deci	d	`\si{\deci}`	
1	deca	da	`\si{\deca}`	
1	deka	da	`\si{\deka}`	same as `\si{\deca}`
2	hecto	h	`\si{\hecto}`	
3	kilo	k	`\si{\kilo}`	
6	mega	M	`\si{\mega}`	
9	giga	G	`\si{\giga}`	
12	tera	T	`\si{\tera}`	
15	peta	P	`\si{\peta}`	
18	exa	E	`\si{\exa}`	
21	zetta	Z	`\si{\zetta}`	
24	yotta	Y	`\si{\yotta}`	
27	ronna	R	`\si{\ronna}`	
30	quetta	Q	`\si{\quetta}`	

```

\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
    -30& quecto& \unit{\quecto\nounit}& \verb+\si{\quecto}+\\
    -27& ronto&  \unit{\ronto\nounit}&  \verb+\si{\quecto}+\\
    -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}+\\
     27& ronna&  \unit{\ronna\nounit}&  \verb+\si{\ronna}+\\
     30& quetta& \unit{\quetta\nounit}& \verb+\si{\quetta}+\\
  \end{tabular}
```

P.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}
```

P.7 Complete List of Units

```

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

Table P.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}`	10^{-12} A
nanoampere	″	nA	`\si{\nA}`	10^{-9} A
microampere	″	µA	`\si{\uA}`	10^{-6} A
milliampere	″	mA	`\si{\mA}`	10^{-3} A
kiloampere	″	kA	`\si{\kA}`	10^{3} A
arcminute	plane angle	′	`\si{\arcmin}`	1/60°
arcsecond	plane angle	″	`\si{\arcsec}`	1/60′
astronomical unit	length	au	`\si{\au}`	mean earth to sun distance
bar	pressure	bar	`\si{\bar}`	10^{-5} Pa

continued on next page

Table P.1. *continued*

Name	Unit Of	Symbol	Command	Is equal to
millibar	″	mbar	`\si{\mbar}`	10^{-3} bar
barn	area	b	`\si{\b}`	$10^{-28}\,\mathrm{m}^2$
becquerel	radioactivity	Bq	`\si{\Bq}`	one radioactive decay per second
bel	sound intensity	B	`\si{\B}`	10 decibels
decibel	″	dB	`\si{\dB}`	10^{-1} B
bohr	length	a_0	`\si{\bohr}`	distance between nucleus and electron in hydrogen atom
bushel	quantity	bu	`\si{\bu}`	see [72]
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	°	`\si{\degree}`	1/360 of a cicle
degree Celsius	temperature	°C	`\si{\celsius}`	xxx
electron mass	mass	m_e	`\si{\em}`	xxx
electronvolt	energy	eV	`\si{\eV}`	xxx
millielectronvolt	″	meV	`\si{meV}`	10^{-3} eV
kiloelectronvolt	″	keV	`\si{keV}`	10^{3} eV
megaelectronvolt	″	MeV	`\si{MeV}`	10^{6} eV
gigaelectronvolt	″	GeV	`\si{\GeV}`	10^{9} eV
teraelectronvolt	″	TeV	`\si{\TeV}`	10^{12} eV
elementary charge	electrical charge	e	`\si{\ec}`	$\approx 1.6 \times 10^{19}$ C
farad	electrical capacitance	F	`\si{\F}`	$\mathrm{s}^4\,\mathrm{A}^2\,\mathrm{m}^{-2}\,\mathrm{kg}^{-1}$
femtofarad	″	fF	`\si{\fF}`	10^{-15} F

continued on next page

Table P.1. *continued*

Name	Unit Of	Symbol	Command	Is equal to
picofarad	″	pF	`\si{\pF}`	10^{-12} F
foot	length	ft	`\si{\ft}`	0.3048 m
gray	absorbed dose of ionizing radiation	Gy	`\si{\Gy}`	J kg^{-1}
hartree	energy used in molecular orbital calculations	E_h	`\si{\hartree}`	xxx
hectare	area	ha	`\si{\ha}`	10^4 m^2
henry	electrical inductance	H	`\si{\H}`	kg m^2 s^{-2} A^{-2}
hertz	frequency	Hz	`\si{\Hz}`	s^{-1}
millihertz	″	mHz	`\si{\mHz}`	10^{-3} Hz
kilohertz	″	kHz	`\si{\kHz}`	10^3 Hz
megahertz	″	MHz	`\si{\MHz}`	10^6 Hz
gigahertz	″	GHz	`\si{\GHz}`	10^9 Hz
terahertz	″	THz	`\si{\THz}`	10^{12} Hz
horsepower	power	hp	`\si{\hp}`	≈745.7 W, see [73] for details
hour	time	h	`\si{\h}`	3600 s
inch	length	in	`\si{\in}`	25.4 mm
joule	work or energy	J	`\si{\J}`	kg m^2 s^{-2}
microjoule	″	µJ	`\si{\uJ}`	10^{-6} J
millijoule	″	mJ	`\si{\mJ}`	10^{-3} J
kilojoule	″	kJ	`\si{\kJ}`	10^3 J
megajoule	″	MJ	`\si{\MJ}`	10^6 J
katal	catalytic activity	kat	`\si{\kat}`	mol s^{-1}
kelvin	thermodynamic temperature	K	`\si{\K}`	(SI base unit)
kilogram	mass	kg	`\si{\kg}`	(SI base unit)
femtogram	″	fg	`\si{\fg}`	10^{-15} g

continued on next page

Table P.1. *continued*

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

continued on next page

Table P.1. *continued*

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

continued on next page

Table P.1. *continued*

Name	Unit Of	Symbol	Command	Is equal to
millisecond	″	ms	`\si{\ms}`	$10^{-3}\,\mathrm{s}$
siemens	conductance	S	`\si{\S}`	$\mathrm{kg^{-1}\,m^{-2}\,s^{3}\,A^{2}}$
sievert	dosage of ionizing radiation	Sv	`\si{\Sv}`	$\mathrm{m^{2}\,s^{-2}}$
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}`	$1\,\mathrm{m^{2}\,m^{-2}}$
tesla	magnetic flux density	T	`\si{\T}`	$\mathrm{kg\,s^{-2}\,A^{-1}}$
metric ton	mass	t	`\si{\t}`	$10^{3}\,\mathrm{kg}$
volt	electrical potential difference	V	`\si{\V}`	$\mathrm{kg\,m^{2}\,s^{-3}\,A^{-1}}$
picovolt	″	pV	`\si{\pV}`	$10^{-12}\,\mathrm{V}$
nanovolt	″	nV	`\si{\nV}`	$10^{-9}\,\mathrm{V}$
microvolt	″	µV	`\si{\uV}`	$10^{-6}\,\mathrm{V}$
millivolt	″	mV	`\si{\mV}`	$10^{-3}\,\mathrm{V}$
kilovolt	″	kV	`\si{\kV}`	$10^{3}\,\mathrm{V}$
watt	power	W	`\si{\W}`	$\mathrm{kg\,m^{2}\,s^{-3}}$
microwatt	″	µW	`\si{\uW}`	$10^{-6}\,\mathrm{W}$
milliwatt	″	mW	`\si{\mW}`	$10^{-3}\,\mathrm{W}$
kilowatt	″	kW	`\si{\kW}`	$10^{3}\,\mathrm{W}$
megawatt	″	MW	`\si{\MW}`	$10^{6}\,\mathrm{W}$
gigawatt	″	GW	`\si{\GW}`	$10^{9}\,\mathrm{W}$
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},
```

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

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

Q. RESOURCES

Books:

- *LaTeX Beginner's Guide*, second edition, [74].

From the IEEE Author Center [75]

- The "IEEE Editorial Style Manual for Authors" [76] contains a formal set of editorial guidelines.
- "Editing Mathematics" [77] illustrates how to do mathematics.
- The IEEE Reference Guide [48] outlines how to cite references.

Colleges and Universities:

- IUPUI: *THESIS/DISSERTATION Formatting Guidelines & Deposit Procedures IUPUI* [78] is out-of-date. See *Thesis and Dissertation Office* [79].
- Purdue: *Thesis and Dissertation Office* [79]

Question and Answer site:

- TeX – LaTeX Stack Exchange is a question and answer site for users of TeX, LaTeX, and related typesetting systems [80].

```
\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
    \citetitle{ieee-editorial-style-manual-for-authors}
    \cite{ieee-editorial-style-manual-for-authors}
    contains a formal set of editorial guidelines.
  \item
    \citetitle{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
Colleges and Universities:
```

```
\begin{itemize}
  \item
    IUPUI:
    \citetitle{thesisdissertationiupui}
    \cite{thesisdissertationiupui}
    is out-of-date.
    See
    \citetitle{thesisanddissertationoffice}
    \cite{thesisanddissertationoffice}.
  \item
    Purdue:
    \citetitle{thesisanddissertationoffice}
    \cite{thesisanddissertationoffice}
\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}
```

R. TABLES

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

Here is a really simple table. I was greatly influenced by Herbert Voss' following ideas on typsetting tables [81]: Use `\toprule`, `\midrule`, and `\bottomrule`. Don't have blank horizontal space to the left or right of body of table.

Table R.1. The first three American Presidents.

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

```

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 R.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

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

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

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

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

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

Here is a more complicated table.

Table R.4. C Bitwise Operators

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

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

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

Table R.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

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

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

Table R.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 R.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	
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make this three pages long	
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make this three pages long	
make this three pages long	
make this three pages long	

continued on next page

Table R.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	
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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}\\
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\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}\\
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  \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}\\
\end{longtable}
```

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

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

Number	Name
1	George Washington
2	John Adams
3	Thomas Jefferson

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

Note Name	Computed f_0 (Hz)	Live Guitar Test 1 Measured f_0 (Hz)	Live Guitar Test 1 % Error	Live Guitar Test 1 Accuracy Range (¢)	Live Guitar Test 2 Measured f_0 (Hz)	Live Guitar Test 2 % Error	Live Guitar Test 2 Accuracy Range (¢)	Live Guitar Test 3 Measured f_0 (Hz)	Live Guitar Test 3 % Error	Live Guitar Test 3 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 R.11. First tally table. Use this method. I think it is the simplest.

```
\begin{table}[ht]%
  \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 R.12. Second tally table. Don't use this method. The method used in the first tally table is easier to understand.

```
\begin{table}[ht]
  \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 R.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
```

S. SPECIAL CHARACTERS

```
\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}+}
```

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

T.1 Apostrophes

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

```

\section{Apostrophes}

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

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

T.2 Cite long title

Cite a reference with a very, very, very, ... long title [82].

```

\section{Cite long title}

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

T.3 Footnote

This is a footnote[1]

```

\section{Footnote}

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

[1] ↑This is a footnote.

T.4 PurdueThesis Logo

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

```
\section{\PurdueThesisLogo\ Logo}

\begin{tabular}{@{}lll@{}}
  \bfseries Input&     \bfseries Output&  \bfseries Comment\\
  |PurdueThesis|&      PurdueThesis&      just ordinary text\\
  |\PurdueThesisLogo|& \PurdueThesisLogo& PurdueThesis logo, less space between\\
                     &                  & |P|--|u|, |e|--|T|, and |T|--|h|\\
  |PuTh|&              PuTh&              just ordinary text\\
  |\PuThLogo|&         \PuThLogo&         PuTh abbreviation logo, less space between\\
                     &                  & |P|--|u|, |u|--|T|, and |T|--|h|\\
\end{tabular}
```

T.5 Section headings with SmallCaps font

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

This does not work:

```
\section{Section with {\protect\scshape SmallCaps}}
```

use

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

instead.

```
\section{Section headings with {\protect\scshape SmallCaps} font}
\label{section-headings-with-smallcaps-font}

Section headings with |{\protect\scshape SmallCaps}| don't work.%
\todoerror{Section headings with {\protect\scshape SmallCaps} don't work.}

\mbox{}

\todowarn{Putting this section in a VerbatimOut environment
  caused a ``'! LaTeX Error: Float(s) lost.'' error.}

This does not work:
```

```
\begin{verbatim}
  \section{Section with {\protect\scshape SmallCaps}}
\end{verbatim}
use
\begin{verbatim}
  \section
    [Section with {\protect\scshape SmallCaps}]%
    {Section with S{\protect\scriptsize MALL}C{\protect\scriptsize APS}}
\end{verbatim}
instead.
```

T.6 To-do notes

Make a todo comment.
The Purdue football game is at noon tomorrow.

$$\sum_{1}^{n} = 1 + 2 + \cdots + n - 1$$

```


\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.}

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

These lower-case Greek characters should be used in math mode:

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

T.7 Figure Captions

This is a paragraph.

```


\paragraph{This is a paragraph.}



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

This is the figure.

Figure T.1. This is the long caption. This is the long caption. This is the long caption. This is the long caption. This is the long caption. This is the long caption. This is the long caption. This is the long caption.

```
4       This is the figure.
5     \caption[A short caption for the list of figures.]{%
6       This is the long caption.  This is the long caption.
7       This is the long caption.  This is the long caption.
8       This is the long caption.  This is the long caption.
9       This is the long caption.  This is the long caption.%
10    }
11  \end{figure}
```

```
\chapter{TEXT}

\ix{Text appendix}
```

U. TEXT

U.1 Color

The soul package [83] 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 [84] 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.
```

U.2 Description, enumerate, and itemize environments

The first example:

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

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

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

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

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

```
1
2  % The \sentence command is also defined in the convington package
3  % so I'll comment this one out.  I don't think this sentence
4  % command is used.
5  % \newcommand\sentence[1]{\MyRepeat{This is a sentence.  }{#1}}
6
7  \section{Description, enumerate, and itemize environments}
8  \ix{description environment//enumerate environment//itemize environment}
9  \index{\verb+\begin{description}+}
10 \index{\verb+\begin{enumerate}+}
11 \index{\verb+\begin{itemize}+}
12
13 The first example:
14
15 \begin{description}
16   \item[elephant]
17     \MyRepeat{This is the elephant item of a description environment. }{3}
18   \item[frog]
19     \MyRepeat{This is the frog item of a description environment. }{3}
20 \end{description}
21
22 \begin{enumerate}
23   \item
24     \MyRepeat{This is the first item of an enumerate environment. }{3}
25   \item
26     \MyRepeat{This is the second item of an enumerate environment. }{3}
27 \end{enumerate}
28
29 \begin{itemize}
30   \item
31     \MyRepeat{This is the first item of an itemize environment. }{3}
32   \item
33     \MyRepeat{This is the second item of an itemize environment. }{3}
34 \end{itemize}
```

The second example:

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

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

U.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 U.1. This is the caption.
This is the listing.

Listing U.2. A Pascal Program

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

```
13
14  \begin{ZZlisting}
15    \caption{A Pascal Program}
16    \begin{CenteredBox}
17      \begin{lstlisting}
18  for i:=maxint to 0 do
19  begin
20      { do nothing }
21  end;
22  Write('Case insensitive.');
23  WritE('Pascal keywords.');
24      \end{lstlisting}
25    \end{CenteredBox}
26  \end{ZZlisting}
```

U.4 Frenchspacing

DON'T USE THIS: As far as I know I'm the only one that uses this crazy format. The `\frenchspacing` `\nonfrenchspacing` command puts approximately one two spaces after sentences. The default is `\nonfrenchspacing`.

BETTER [85]: The `\frenchspacing` (`\nonfrenchspacing`) command puts approximately one (two) spaces after sentences. The default is `\nonfrenchspacing`.

BEST [86]: 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.

```
1
2
3  \section{Frenchspacing}%
4  \ix{frenchspacing//nonfrenchspacing}
5  \index{\verb+\frenchspacing+}
6  \index{\verb+\nonfrenchspacing+}
7
8  {\small DON'T USE THIS:}
9  As far as I know I'm the only one
```

```
that uses this crazy format.
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 default\\[2pt]
is |\nonfrenchspacing|.

{\small BETTER} \cite{kris2014}:
The
|\frenchspacing| (|\nonfrenchspacing|)
command puts approximately
one (two)
spaces after sentences.
The default is |\nonfrenchspacing|.

{\small BEST} \cite{cms17-slashes-to-signify-alternatives}:
The
|\frenchspacing|/|\nonfrenchspacing|
command puts approximately
one/two
spaces after sentences.
The 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.
```

U.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 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. 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}
```

U.6 Words

irregardless is a nonstandard word that means regardless. Use *regardless* instead [87].

out of date / out-of-date means "outmoded, obsolete". [88].

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 [89]. Also see [88].

In the context of writing about out-of-date software you may want to use "deprecated" [59] instead.

start-up / start-up company means a fledgling business enterprise [90]. I would use the more modern *startup* and only use *company* if not clear from the context.

peace out means "goodbye" [91]

```


\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{oed-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}
```

V. ASTRONOMY

```
\chapter{ASTRONOMY}
\ix{astronomy//Astronomy appendix}

\ix{astronomy}

```

W. BIOLOGY

```
\chapter{BIOLOGY}

\ix{Biology appendix}
```

X. CHEMISTRY

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

\ix{chemistry}
\ix{Chemistry appendix}

```

X.1 Chemical Diagrams

The chemplants package [92] 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.
```

X.2 Chemical Equations

The mhchem Bundle [93] 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 [94, starting at 5:25] claims this equation

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

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:

$$\underset{\text{human fat}}{\ce{C55H104O6}} + \underset{\text{oxygen}}{\ce{78O2}} \longrightarrow \underset{\text{carbon dioxide}}{\ce{55CO2}} + \underset{\text{water}}{\ce{52H2O}} + \underset{\text{body heat, moving, thinking, growing}}{\text{energy}}$$

```
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:

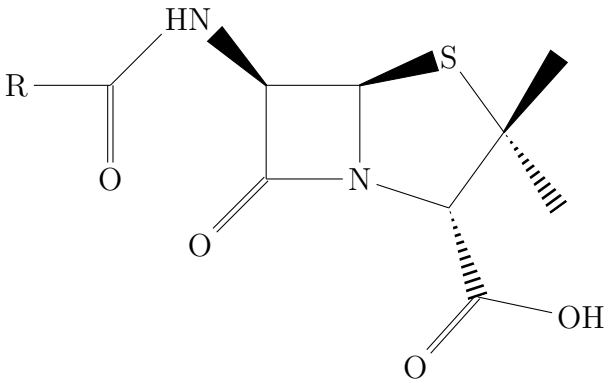
$$\overset{\text{kg}}{\underset{\text{human fat}}{\ce{C55H104O6}}} + \overset{\text{kg}}{\underset{\text{oxygen}}{\ce{78O2}}} \longrightarrow \overset{\text{kg}}{\underset{\text{carbon dioxide}}{\ce{55CO2}}} + \overset{\text{kg}}{\underset{\text{water}}{\ce{52H2O}}} + \overset{\text{calories}\\ \text{kJ}}{\underset{\text{body heat, moving, thinking, growing}}{\text{energy}}}$$

```
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}
```

X.3 Chemical Figures

Below is an example of how to use the chemfig package [95].
Here is the chemical figure for Penicillin [95, 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>)--)
}
```

X.4 Chemical Schemes

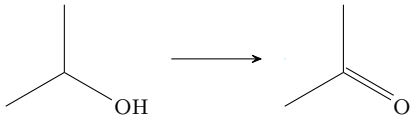
Below are some examples of how to do schemes.

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

This is the first scheme.

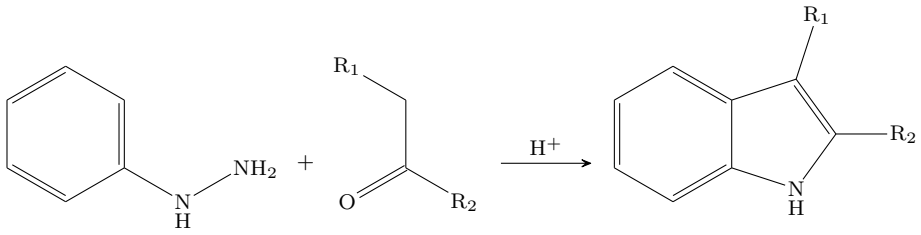
```
\newpage
\section{Chemical Schemes}

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 X.2. This is the second scheme caption.



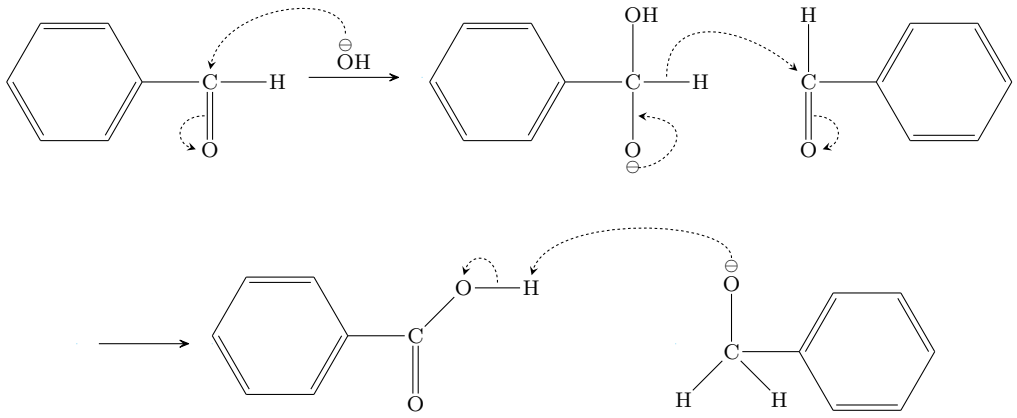

```
\begin{scheme}[ht]
  \caption{This is the second scheme caption.}
  \vspace*{6pt}
  \begin{center}
    % Next line was added to make scheme a little smaller.
    \scriptsize\setchemfig{bond offset=1pt,atom sep=3em,compound sep=6em}
    \schemestart
      \chemfig{-[:30](-[2])-[:-30]OH}
      \arrow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

Scheme X.3. The Fischer indole synthesis [95, 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 X.4. The Cannizzaro reaction [95, 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}
```

Y. COMPUTER SCIENCE

The cryptocode package [96] is used to typeset pseudocode, algorithms, and protocols.

```
\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.
```

Y.1 Protocol examples

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

This is the first protocol.

Protocol Y.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}
```

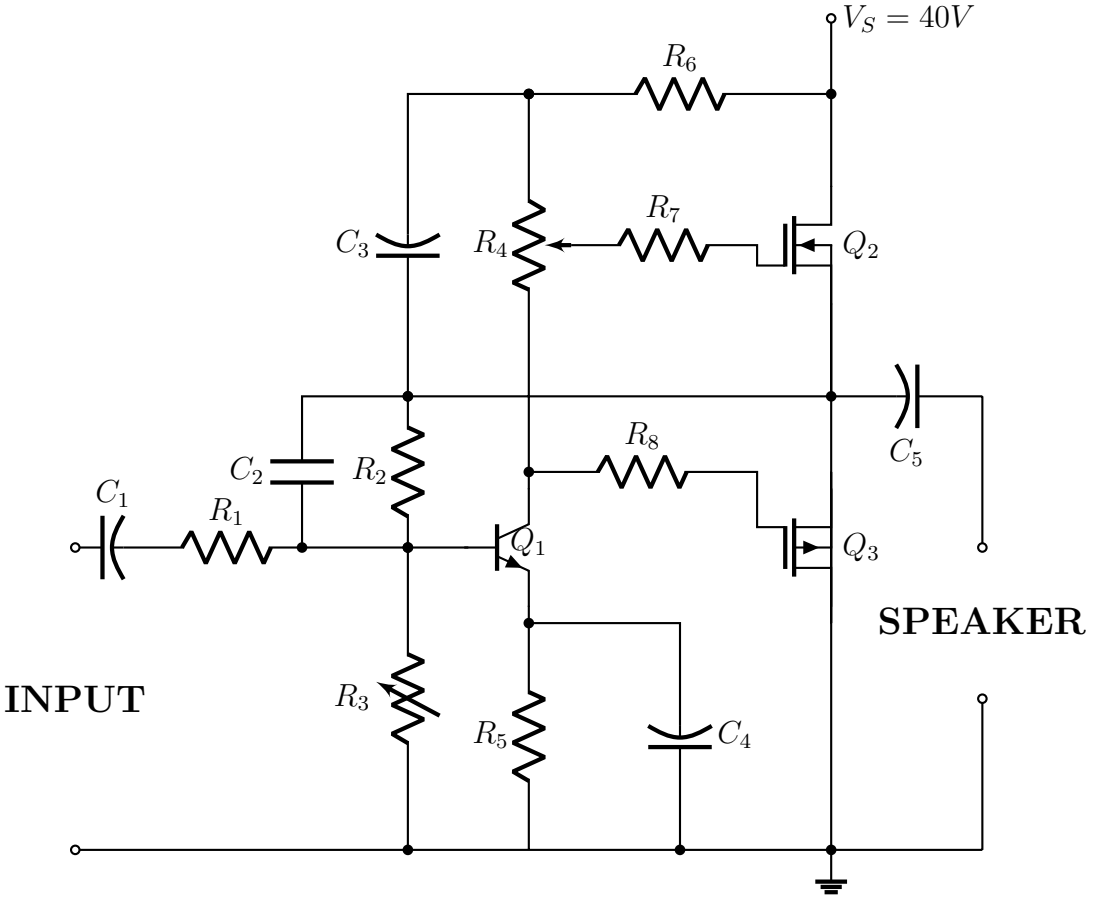
Z. ELECTRICAL ENGINEERING

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

Z.1 Amplifiers

```


\section{Amplifiers}
```

This 18 W MOSFET amplifier with npn transistor was done by Ramón Jaramillo [97]. This example make uses the CircuiTi*k*Z [98] and siunitx packages.




```
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
```

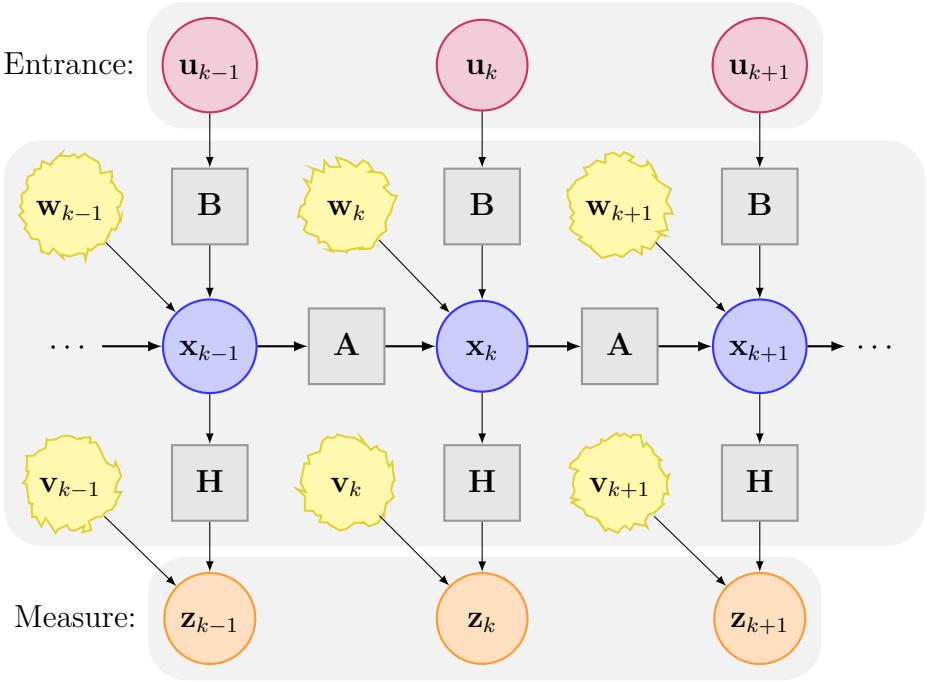
```
    (0,1) node[]{\large{\textbf{INPUT}}}
    % Connection of passive components
    (5,0) node[ground]{} node[circ](4.5,0){}
    (0,2) to [cC, l=$C_1$, o-] (0.5,2)
    to [R,l=$R_1$,](1.5,2)
    to node[short]{}(2.6,2)
    (1.5,2) to [C, l=$C_2$, *-] (1.5,3) -| (5,3)
    (2.2,2) to [R, l=$R_2$, *-*] (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}
```

Z.2 Kalman Filter System Model

This Kalman filter system model was done by Burkart Lingner [99].

```

\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}
%%%%
%%%% \usepackage{lmodern}        % font definition
```

Figure Z.1. Kalman filter system model



```
%%%% \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] {$\mathbf{z}_{k+1}$}; &
        \\
    };

    % 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}
```

AA. LINGUISTICS

See WIKIBOOKS LaTeX/Linguistics [100] or google for the information you need.

The doulossil font [101] 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''.
```

AA.1 Demonstrate the example and examples environments

The example and examples environment are defined in the covington [102] package.
Demonstrate the example environment:

Example AA.1.1. This is an example. This is an example.

Demonstrate the examples environment:

(AA.1) First example.

(AA.2) 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}
```

AB. MATHEMATICS

PurdueThesis loads the AMSmath package [103] 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 interspersed with text. For example, this is text math: $a = b + c$. Display math is not interspersed with text. For example, this is display math:

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

```
There are two types of mathematics in \LaTeXLogo.
Text math is interspersed with text.
For example,
this is text math: \(a = b + c\).
Display math is not interspersed with text.
For example,
this is display math:
\begin{equation}
  a = b + c
\end{equation}
```

AB.1 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 `\(` and `\)` [104].

```


\section{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 \LaTeXLogo\ can give better error messages
if you use |\(|
and |\)|
\cite{meckes2010}.
```

AB.2 Display Math

Use one of the below environments to start and end display math. Some people use `$$` to start and end displayed math but LaTeX doesn't officially support `$$` [105].

```
\section{Display Math}

Use one of the below environments to start and end display math.
Some people use |$$|
to start and end displayed math
but \LaTeXLogo\ doesn't officially support |$$|
\cite{alpert2010}.
```

AB.2.1 Displayed Equations

Do not use $$ to start or end displayed math like TEX uses [106].

The AMSmath package provides a number of additional displayed equation structures beyond the ones provided in basic LATEX. The augmented set includes [107]:

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.

```
\subsection{Displayed Equations}

Do not use
|$$|
to start or end displayed math like \TeXLogo\ uses
\cite{gratzer2016}.
\todoerror{add page number to reference}

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

`equation` environment

The `equation` environment is used for single equations.

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

```

  \subsubsection{\texttt{equation} environment}

  The
  |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
  |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 [108] 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}
```

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
|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*}
```

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

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

$$x \mod 2 = \begin{cases} 0 & \text{if } x \text{ is even} \\ 1 & \text{if } x \text{ is odd} \end{cases} \tag{AB.3}$$

The first six derivatives of distance are velocity, acceleration, jerk, snap, crackle, and pop [109].

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

\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]
```

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

```
      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}
```

`multline` environment

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

$$S = a + b + c + d + \mathrm{e} + f + g + h + \mathrm{i} + \mathrm{j} + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z \quad \text{(AB.5)}$$

```

\subsubsection{\texttt{multline} environment}

The
|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}
```

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

```
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}
```

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

```
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}
```

`gather` environment

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

$$a = b + c + d + \mathrm{e} + f + g + h + \mathrm{i} + \mathrm{j} + k + l \tag{AB.8}$$

$$m = n + o + p + q + r + s + t + u + v + w + x + y + z \tag{AB.9}$$

```

\subsubsection{\texttt{gather} environment}

The
|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}
```

$$
\begin{gather}
a = b + c + d + \mathrm{e} + f + g + h + \mathrm{i} + \mathrm{j} + k + l\\
m = n + o + p + q + r + s + t + u + v + w + x + y + z
\end{gather}
\tag{AB.10}
$$

```

\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}
```

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

```

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

$$
\begin{gather}
x_{\mathrm{min}} + x_{\mathrm{max}} \le \sum_{\mathrm{i}=1}^{n} x_{\mathrm{i}} \tag{AB.11}\\
x_{\mathrm{min}} + x_{\mathrm{max}} = \sum_{\mathrm{i}=1}^{n} x_{\mathrm{i}} - \sum_{\mathrm{i}=2}^{n-1} x_{\mathrm{i}} \quad \text{if } x \text{ is sorted} \tag{AB.12}\\
x_{\mathrm{min}} \le \left(\sum_{\mathrm{i}=1}^{n} x_{\mathrm{i}} \right) / n \tag{AB.13}
\end{gather}
$$

```

\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}
```

`align` environment

The `align` environment aligns multiple equations.

$$a = b + c + d \tag{AB.14}$$
$$\mathrm{e} = f + g + h + \mathrm{i} + \mathrm{j} \tag{AB.15}$$

```
\subsubsection{\texttt{align} environment}

The
|align|
environment aligns multiple equations.

\begin{align}
  a &= b + c + d\\
  e &= f + g + h + i + j
\end{align}
```

$$\begin{aligned} x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\ x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \end{aligned} \tag{AB.16}$$

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

Quadratic formula proof [110]:

$$
\begin{aligned}
ax^2 + bx + c &= 0 \\
ax^2 + bx &= -c \\
x^2 + \frac{b}{a}\,x &= -\frac{c}{a} \\
x^2 + \frac{b}{a}\,x + \frac{b^2}{4a^2} &= \frac{b^2}{4a^2} - \frac{c}{a} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{c}{a} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{4ac}{4a^2} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2 - 4ac}{4a^2} \\
\sqrt{\left(x + \frac{b}{2a}\right)^2} &= \sqrt{\left(\frac{b^2 - 4ac}{4a^2}\right)} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{\sqrt{4a^2}} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{2a} \\
x &= -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} \\
x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\end{aligned}
\tag{AB.17}
\tag{AB.18}
$$

```
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}
```

`alignat` environment

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

$$a = b \qquad \text{set } a \tag{AB.19}$$
$$c = d \qquad \text{you guessed it, set } c$$
$$g = h \qquad \text{and finally, set } g \tag{AB.20}$$

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

$$a = b \qquad \text{set } a \tag{AB.21}$$
$$c = d \qquad \text{you guessed it, set } c$$
$$g = h \qquad \text{and finally, set } g \tag{AB.22}$$

Do whatever works best for you.

```
1
2  \subsubsection{\texttt{alignat} environment}
3  \index{\verb+\begin{aligo}+@\verb+\begin{alignat}+}
4  \ix{alignat environment}
5
6  The
7  |alignat|
8  environment aligns multiple equations at multiple places.
9  \begin{alignat}{2}
10   a &= b& \qquad\qquad& \text{set \(a\)}\\
11   c &= d& &             \text{you guessed it, set \(c\)}\notag\\
12   g &= h& &             \text{and finally, set \(g\)}
13 \end{alignat}
14 \index{\verb+\begin{aligo}+@\verb+\begin{alignat}+}
15 \ix{alignat environment}
16
17 I like to align input columns on the input if possible
18 and will sometimes use windows over~250 characters wide to do so.
19 If that won't work I sometimes do,
20 for example,
21 \begin{alignat}{2}
22   a
23     &= b
24     & \qquad\qquad
25     & \text{set \(a\)}\\
26   c
27     &= d
28     &
29     &\text{you guessed it, set \(c\)}\notag\\
30   g
31     &= h
32     &
33     &\text{and finally, set \(g\)}
34 \end{alignat}
35 \index{\verb+\begin{aligo}+@\verb+\begin{alignat}+}
36 \ix{alignat environment}
37
```

```
Do whatever works best for you.

```

Quadratic formula proof [110]:

$$
\begin{aligned}
ax^2 + bx + c &= 0 && \text{subtract } c \\
ax^2 + bx &= -c && \text{divide by } a \\
x^2 + \frac{b}{a}x &= -\frac{c}{a} && \text{add } \frac{b^2}{4a^2} \\
x^2 + \frac{b}{a}x + \frac{b^2}{4a^2} &= \frac{b^2}{4a^2} - \frac{c}{a} && \text{factor left hand side} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{c}{a} && \text{multiply right-most term by } \frac{4a}{4a} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2}{4a^2} - \frac{4ac}{4a^2} && \text{use common denominator} \\
\left(x + \frac{b}{2a}\right)^2 &= \frac{b^2 - 4ac}{4a^2} && \text{take square root of each side} \\
\sqrt{\left(x + \frac{b}{2a}\right)^2} &= \sqrt{\left(\frac{b^2 - 4ac}{4a^2}\right)} && \text{compute square root of each side} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{\sqrt{4a^2}} && \text{simplify right hand denominator} \\
x + \frac{b}{2a} &= \pm\frac{\sqrt{b^2 - 4ac}}{2a} && \text{subtract } \frac{b}{2a} \text{ from each side} \\
x &= -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} && \text{use common denominator} \\
x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\end{aligned}
\tag{AB.23, AB.24}
$$

```

Quadratic formula proof
\cite{khan2018}:

% Make changes to \jot be local to the group that starts on the next line.
{
  % Increase distance between lines by 6pt.
  \addtolength{\jot}{6pt}
  \begin{alignat}{2}
    ax^2 + bx + c
```

```
      &= 0
      &
      &\text{subtract \(c\)}\\
    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}
}
```

`flalign` environment

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

$$a = b \qquad m = n \qquad u = v \quad \text{(AB.25)}$$
$$c = d \qquad\qquad\qquad w = x$$
$$g = h \qquad\qquad\qquad y = z \quad \text{(AB.26)}$$

```
1
2  \index{\verb+\begin{flalign}+}
3  \todoindex{Verb+Begin-Ocurly-flalign-Ccurly+}
4  \ix{falign environment}
5  \subsubsection{\texttt{flalign} environment}
6
7  The
8  |flalign|
9  environment aligns multiple equations at multiple places
10 on full length lines.
11
12 \begin{flalign}
13   a &= b&   &   & u &= v\\
14   c &= d& m &= n& w &= x\notag\\
15   g &= h&   &   & y &= z
16 \end{flalign}
```

`split` environment

The `split` environment ???.

```
1
2  \index{\verb+\begin{split}+}
3  \todoindex{Verb+Begin-Ocurly-split-Ccurly+}
4  \ix{split environment}
5  \subsubsection{\texttt{split} environment}
6
7  The
8  |split|
9  environment ???.
10 \index{\verb+\begin{split}+}
11 \todoindex{Verb+Begin-Ocurly-split-Ccurly+}
12 \ix{split environment}
13
14
```

AB.3 Use the Following in Text or Display Math

The following constructs can be used in text or display math.

```
\newpage
\section{Use the Following in Text or Display Math}

The following constructs can be used in text or display math.
```

AB.3.1 Breaking Lines

This information is based on information from ISO 80000-2 [111, page 2]:

> If an expression or equation must be split into two or more lines, place the line breaks immediately before one of the symbols $=$, $+$, $-$, $\times$, $/$, $\pm$, $\mp$, etc.

Examples:

The alternating sum of the first 20 prime numbers is $2 - 3 + 5 - 7 + 11 - 13 + 17 - 19 + 23 - 29 + 31 - 37 + 41 - 43 + 47 - 53 + 59 - 61 + 67 - 71$.

$$\begin{aligned} s = {} & 2 - 3 + 5 - 7 + 11 - 13 + 17 - 19 + 23 - 29 \\ & + 31 - 37 + 41 - 43 + 47 - 53 + 59 - 61 + 67 - 71 \end{aligned}$$

```
\subsection{Breaking Lines}

This information is based on information from ISO 80000-2
\cite[page 2]{iso80000-2}:
\begin{quote}
  If an expression or equation must be split into two or more lines,
  place the line breaks immediately before one of the symbols
  \(=\),
  \(+\),
  \(-\),
  \(\times\),
  \(/\),
  \(\pm\),
  \(\mp\),
  etc.
\end{quote}

Examples:

The alternating sum of the first 20 prime numbers is
\(2 - 3 + 5 - 7 + 11 - 13 + 17 - 19\\+ 23 - 29 + 31 - 37 + 41 - 43 + 47 -53 + 59 - 61 + 67 - 71\).
\begin{align}
  s = {} & 2 - 3 + 5 - 7 + 11 - 13 + 17 - 19 + 23 - 29\nonumber\\
         & + 31 - 37 + 41 - 43 + 47 -53 + 59 - 61 + 67 - 71\nonumber
\end{align}
```

AB.3.2 Constants, etc., should be in an upright font

This information is based on information in ISO 80000-2 [111, page 1]:

- The constants e, i, j, and π should be typeset in an upright font as e, i, j and π. Example: $\mathrm{e}^{\mathrm{i}\pi} + 1 = 0$.
- The ordinary derivative operator d should be typeset in an upright font as 'd'. Example: $\int 2x\,\mathrm{d}x = x^2 + C$.
- The partial derivative operator ∂ should be typeset in an upright font as ∂. Example: $\displaystyle \frac{\partial f}{\partial x} = f_x = \lim_{h\to 0} \frac{f(x+h,y) - f(x,y)}{h} = \lim_{h\to 0} \frac{f(x+h,y) - f(x,y)}{h}$.

```
1
2  \subsection{Constants, etc., should be in an upright font}
3
4  This information is based on information
5  in ISO 80000-2
6  \cite[page 1]{iso80000-2}:
7  \begin{itemize}
8    \item
9      The constants \(\mit e\),~\(\mit i\),~\(\mit j\), and~\(\itpi\)
10     should be typeset in an upright font as \(e\),~\(i\),~\(j\) and~\(\pi\).\\
11     Example: \(\displaystyle e^{i\pi} + 1 = 0\).
12   \item
13     The ordinary derivative operator \(d\)
14     should be typeset in an upright font as '\(\mathrm{d}\)'.\\
15     Example: \(\displaystyle \int 2x\di x = x^2 + C\).
16   \item
17     The partial derivative operator \(\partial\)
18     should be typeset in an upright font as \(\pa\).
19     Example:
20     \(
21       \displaystyle
22       \frac {\pa f} {\pa x}
23       =
24       f_x
25       =
26       \lim_{h\to 0}
27       \frac {f(x + h,y) - f(x,y)} {h}
28       =
29       \lim\nolimits_{h\to 0}
30       \frac {f(x + h,y) - f(x,y)} {h}
31     \).
32 \end{itemize}
```

The `thesis.tex` file sets up the first capability above with

```
% Follow ISO 80000-2:2019
%     o   put e, i, j, and pi in upright font automatically
%     o   use, for example, "\di x" to get "\,mathrm{d}\/x"
\usepackage{pa-mismath}
  % Put e, i, j, and pi in upright font automatically.
  % Comment the corresponding line to not put the symbol in an upright font.
  \enumber
  \inumber
  \jnumber
  \pinumber
  % With the four lines above not commented out, to typeset math italic e,
  % i, j, and pi use
  %     \mathit e
  %     \mathit i
  %     \mathit j
  %     \itpi
```

```
\newpage
The |thesis.tex| file sets up the first capability above with
\begin{verbatim}
% Follow ISO 80000-2:2019
%     o   put e, i, j, and pi in upright font automatically
%     o   use, for example, "\di x" to get "\,mathrm{d}\/x"
\usepackage{pa-mismath}
  % Put e, i, j, and pi in upright font automatically.
  % Comment the corresponding line to not put the symbol in an upright font.
  \enumber
  \inumber
  \jnumber
  \pinumber
  % With the four lines above not commented out, to typeset math italic e,
  % i, j, and pi use
  %     \mathit e
  %     \mathit i
  %     \mathit j
  %     \itpi
\end{verbatim}
```

AB.3.3 English Words

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}.

```
\subsection{English Words}

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 \(t_\text{attic}\).
```

AB.3.4 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
```

```
\subsection{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+}
```

AB.3.5 Matrices

From ISO 80000-2 [111, page 18]:

> Matrices are usually written with boldface italic capital letters and their elements with italic lower case letters, but other typefaces may be used.

Example: Let $\boldsymbol{M}$ be a 3×3 matrix:

$$\boldsymbol{M} = \begin{pmatrix} m_{1,1} & m_{1,2} & m_{1,3} \\ m_{2,1} & m_{2,2} & m_{2,3} \\ m_{3,1} & m_{3,2} & m_{3,3} \end{pmatrix} = \begin{pmatrix} a & b & c \\ d & e & f \\ g & h & i \end{pmatrix}$$

```
1
2  \subsection{Matrices}
3
4  From ISO 80000-2
5  \cite[page 18]{iso80000-2}:
6  \begin{quotation}
7    Matrices are usually written with boldface italic capital letters
8    and their elements with italic lower case letters,
9    but other typefaces may be used.
10   \todoerror{Double check this quote.}
11 \end{quotation}
12
13 Example:
14 Let \(\bm{M}\) be a \(3 \times 3\) matrix:
15 \begin{equation*}
16   \bm{M}
17   =
18   \left(
19     \begin{array}{ccc}
20       m_{1,1}& m_{1,2}& m_{1,3}\\
21       m_{2,1}& m_{2,2}& m_{2,3}\\
22       m_{3,1}& m_{3,2}& m_{3,3}\\
23     \end{array}
24   \right)
25   =
26   \left(
27       % If your thesis.tex is set up to assume, for example, 'e' is a constant
28       % and typeset in an upright font, use '\mit e' to typeset 'e' in a math
29       % italic font.
30     \begin{array}{ccc}
31       a& b& c\\
32       d& \mit e& f\\
33       g& h& \mit i\\
34     \end{array}
35   \right)
36 \end{equation*}
```

AB.3.6 Sets

Use $\mathbb{N}$ for the natural numbers.
Use $\mathbb{R}$ for the real numbers.
Use $\mathbb{Z}$ for the integers.
The Cartesian product of $\mathbf{A}$ and $\mathbf{B}$ is $\mathbf{A} \times \mathbf{B} = \{(a, b) \mid a \in \mathbf{A} \text{ and } b \in \mathbf{B}\}$.
The intersection of $\mathbf{A}$ and $\mathbf{B}$ is $\mathbf{A} \cap \mathbf{B} = \{x \mid x \in \mathbf{A} \text{ and } x \in \mathbf{B}\}$.
The union of $\mathbf{A}$ and $\mathbf{B}$ is $\mathbf{A} \cup \mathbf{B} = \{x \mid x \in \mathbf{A} \text{ and } x \in \mathbf{B}\}$.

```
1
2  \subsection{Sets}
3
4  % Make \newcommand local to { ... }.
5  {
```

```
  % \St is short for my set.
  \newcommand{\Se}[1]{\ensuremath{\mathbf #1}}
  % \St is short for suchthat.
  \newcommand{\St}{\mid}
  \noindent
  Use \(\mathbb{N}\) for the natural numbers.
  \index{natural numbers}\\
  Use \(\mathbb{R}\) for the real numbers.
  \index{real numbers}\\
  Use \(\mathbb{Z}\) for the integers.
  \index{integers}\\
  The Cartesian product\index{\verb+\times+}\index{Cartesian product}
  of \Se A and \Se B is
  \(\Se A \times \Se B = \{(a,b) \St a \in \Se A \text{ and } b \in \Se B\}\).\\
  The intersection\index{\verb+\cap+}\index{intersection}
  of \Se A and \Se B is
  \(\Se A \cap \Se B = \{ x \St x \in \Se A \text{ and } x \in \Se B\}\).\\
  The union\index{\verb+\cup+}\index{union}
  of \Se A and \Se B is
  \(\Se A \cup \Se B = \{ x \St x \in \Se A \text{ and } x \in \Se B\}\).
}
```

AB.4 Theorem-like environments

The `ntheorem` package is used instead of `amsthm` so the counter for a theorem-like construct can be overridden by the user. See [112, pages 4–5] and below for how to do this.

```


\section{Theorem-like environments}

The |ntheorem| package\index{ntheorem package}
is used instead of |amsthm|\index{amsthm package}
so the counter
for a theorem-like construct
can be overridden by the user.
See
\cite[pages 4--5]{may2011}
and below
for how to do this.
```

By default all theorem-like constructs:

acknowledgment	assertion	assumption	axiom	case	claim
conclusion	condition	conjecture	corollary	criterion	definition
example	exercise	hypothesis	lemma	notation	note
observation	problem	proof	property	proposition	question
remark	summary	theorem			

use the same counter.

```

By default all theorem-like constructs:\\[6pt]
\begin{tabular}{@{\hspace*{2\parindent}}llllll@{}}
acknowledgment& assertion&  assumption& axiom&      case&        claim\\
conclusion&     condition&  conjecture& corollary&  criterion&   definition\\
example&        exercise&   hypothesis& lemma&     notation&    note\\
observation&    problem&    proof&      property&   proposition& question\\
```

```
remark&         summary&    theorem\\
\end{tabular}
\mbox{}\\[6pt]
use the same counter.
```

From PurdueThesis.cls:

```
\usepackage[amsthm]{ntheorem}
  % From example 31 of https://math.mit.edu/~poonen/papers/writing.pdf
  %     Use a single numbering system for all theorems, lemmas, etc.,
  %     instead of having both a Theorem 1.1 and a Lemma 1.1 in the
  %     same paper. This makes statements easier to find[...]
  % For example,
  %     \newtheorem{lemma}[theorem]{Lemma}
  % makes lemma use the theorem counter.
  \theoremstyle{plain}
  \newtheorem{theorem}{Theorem}[section]
  \newtheorem{lemma}[theorem]{Lemma}
  [28 more lines]
```

To make, for example, lemma have its own counter put

```
\renewtheorem{lemma}{Lemma}[section]
```

in your thesis.tex file right after the `\begin{document}` statement.

```

From PurdueThesis.cls:
\begin{verbatim}
    \usepackage[amsthm]{ntheorem}
      % From example 31 of https://math.mit.edu/~poonen/papers/writing.pdf
      %     Use a single numbering system for all theorems, lemmas, etc.,
      %     instead of having both a Theorem 1.1 and a Lemma 1.1 in the
      %     same paper. This makes statements easier to find[...]
      % For example,
      %     \newtheorem{lemma}[theorem]{Lemma}
      % makes lemma use the theorem counter.
      \theoremstyle{plain}
      \newtheorem{theorem}{Theorem}[section]
      \newtheorem{lemma}[theorem]{Lemma}
      [28 more lines]
\end{verbatim}
To make,
for example,
lemma have its own counter put
\begin{verbatim}
    \renewtheorem{lemma}{Lemma}[section]
\end{verbatim}
in your thesis.tex file right after the |\begin{document}| statement.
```

Acknowledgment AB.4.1. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{acknowledgment}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{acknowledgment}
5  \index{\verb+\begin{acknowledgment}+}
6  \index{acknowledgment environment}
```

Assertion AB.4.2. *This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.*

```
1
2  \begin{assertion}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{assertion}
5  \index{\verb+\begin{assertion}+}
6  \index{assertion environment}
```

Assumption AB.4.3. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{assumption}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{assumption}
5  \index{\verb+\begin{assumption}+}
6  \index{assumption environment}
```

Axiom AB.4.4. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{axiom}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{axiom}
5  \index{\verb+\begin{axiom}+}
6  \index{axiom environment}
```

Claim AB.4.5. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{claim}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{claim}
5  \index{\verb+\begin{claim}+}
6  \index{claim}
```

Conclusion AB.4.6. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{conclusion}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{conclusion}
5  \index{\verb+\begin{conclusion}+}
6  \index{conclusion environment}
```

Condition AB.4.7. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{condition}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{condition}
5  \index{\verb+\begin{condition}+}
6  \index{condition environment}
```

Conjecture AB.4.8. *This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.*

```
1
2  \begin{conjecture}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{conjecture}
5  \index{\verb+\begin{conjecture}+}
6  \index{conjecture environment}
```

Corollary AB.4.9. *This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.*

```
1
2  \begin{corollary}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{corollary}
5  \index{\verb+\begin{corollary}+}
6  \index{corollary environment}
```

Criterion AB.4.10. *This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.*

```
1
2  \begin{criterion}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{criterion}
5  \index{\verb+\begin{criterion}+}
6  \index{criterion environment}
```

Definition AB.4.11. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{definition}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{definition}
5  \index{\verb+\begin{definition}+}
6  \index{definition environment}
```

Example AB.4.12. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{example}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{example}
5  \index{\verb+\begin{example}+}
6  \index{example environment}
```

Exercise AB.4.13. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{exercise}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{exercise}
5  \index{\verb+\begin{exercise}+}
6  \index{exercise environment}
```

Hypothesis AB.4.14. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
1
2  \begin{hypothesis}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{hypothesis}
5  \index{\verb+\begin{hypothesis}+}
6  \index{hypothesis environment}
```

Lemma AB.4.15. *This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.*

```
1
2  \begin{lemma}
3    \MyRepeat{This is a sentence.  }{5}
4  \end{lemma}
5  \index{\verb+\begin{lemma}+}
6  \index{lemma environment}
```

Notation AB.4.16. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{notation}
  \MyRepeat{This is a sentence.  }{5}
\end{notation}
\index{\verb+\begin{notation}+}
\index{notation environment}
```

Note AB.4.17. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{note}
  \MyRepeat{This is a sentence.  }{5}
\end{note}
\index{\verb+\begin{note}+}
\index{note environment}
```

Problem AB.4.18. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{problem}
  \MyRepeat{This is a sentence.  }{5}
\end{problem}
\index{\verb+\begin{problem}+}
\index{problem environment}
```

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.

```
\begin{proof}
  \MyRepeat{This is an example proof.  }{5}
\end{proof}
\index{\verb+\begin{proof}+}
\index{proof environment}
```

Property AB.4.19. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{property}
  \MyRepeat{This is a sentence.  }{5}
\end{property}
\index{\verb+\begin{property}+}
\index{property environment}
```

Proposition AB.4.20. *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.*

```
\begin{proposition}
  \MyRepeat{This is an example proposition.  }{5}
\end{proposition}
\index{\verb+\begin{proposition}+}
\index{proposition environment}
```

Question AB.4.21. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{question}
  \MyRepeat{This is a sentence.  }{5}
\end{question}
\index{\verb+\begin{question}+}
\index{question environment}
```

Remark AB.4.22. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{remark}
  \MyRepeat{This is a sentence.  }{5}
\end{remark}
\index{\verb+\begin{remark}+}
\index{remark environment}
```

Summary AB.4.23. This is a sentence. This is a sentence. This is a sentence. This is a sentence. This is a sentence.

```
\begin{summary}
  \MyRepeat{This is a sentence.  }{5}
\end{summary}
\index{\verb+\begin{summary}+}
\index{summary environment}
```

Theorem AB.4.24. *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.*

```
\begin{theorem}
  \MyRepeat{This is an example theorem.  }{5}
\end{theorem}
\index{\verb+\begin{theorem}+}
\index{theorem environment}
```

AB.5 Examples

AB.5.1 Bayes' Theorem

Bayes' Theorem [113] is

$$\mathrm{P}(\mathrm{A}|\mathrm{B}) = \frac{\mathrm{P}(\mathrm{B}|\mathrm{A})\,\mathrm{P}(\mathrm{A})}{\mathrm{P}(\mathrm{B})} \tag{AB.27}$$

```
1
2
3  \section{Examples}
4
5  \subsection{Bayes' Theorem}
6  \ix{Bayes' Theorem}
7  \ix{Bayes, Thomas}
8
9  Bayes' Theorem
10 \cite{bayes}
11 is
12 {
13   \UndefineShortVerb{\|}
14   \begin{equation}
15     \text{P}(\text A|\text B)
16     % The "\," puts a thin horizontal space there, 1/6 of an "em".
17     % An "em" is roughly the width of a lowercase "m".
18     = \frac{\text P(\text B|\text A)\,\text P(\text A)}{\text P(\text B)}
19   \end{equation}
20 }
```

AB.5.2 Euler's identity

Euler's identity [114] is

$$\mathrm{e}^{\mathrm{i}\pi} + 1 = 0. \tag{AB.28}$$

```
1
2  \subsection{Euler's identity}
3  \ix{Euler's identity}
4  \ix{Euler, Leonhard}
5
6  Euler's identity
7  \cite{eulers-identity}
8  is
9  \begin{equation}
10   e^{i\pi} + 1 = 0.
11 \end{equation}
```

AB.5.3 Fourier transform

ISO 80000-2 [111, page 25] recommends using $\mathcal{F}$ nfor the Fourier transform. The Fourier transform of f is $(\mathcal{F}f)(\omega) = \mathcal{F}(\omega) = \int_{-\infty}^{\infty} \mathrm{e}^{\mathrm{i}\omega t} f(t)\,\mathrm{d}t$.

```
1
2  \subsection{Fourier transform}
```

```
\ix{Fourier Transform}

ISO 80000-2
\cite[page 25]{iso80000-2}
recommends using
\(\Fourier\)
nfor the Fourier transform.
The Fourier transform of \(f\) is
\(
  \displaystyle
  (\Fourier f)(\omega)
  = \Fourier (\omega)
  = \int_{-\infty}^\infty e^{i\omega t} f(t) \di t
\).
```

AB.5.4 Laplace transform

ISO 80000-2 [111, page 25] recommends using $\mathcal{L}$ for the Laplace transform. The Laplace transform of s is $(\mathcal{L}f)(s) = \mathcal{L}(s) = \int_0^\infty \mathrm{e}^{-st} f(t)\,\mathrm{d}t$.

```

\subsection{Laplace transform}
\ix{Laplace Transform}

ISO 80000-2
\cite[page 25]{iso80000-2}
recommends using
\(\Laplace\)
for the Laplace transform.
The Laplace transform of \(s\) is
\(
  \displaystyle
  (\Laplace f)(s)
  = \Laplace(s)
  = \int_0^\infty e^{-st} f(t) \di t
\).
```

AB.5.5 Nicomachus's theorem

Nicomachus's theorem [115] states that the sum of the first n cubes is the square of the nth triangular number. That is,

$$1^3 + 2^3 + 3^3 + \cdots + n^3 = (1 + 2 + 3 + \cdots + n)^2. \tag{AB.29}$$

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.

```

\subsection{Nicomachus's theorem}
\ix{Nicomachus's theorem}
```

```
\ix{Nicomachus of Gerasa}
Nicomachus's theorem
\cite{wikipedia-nicomachus}
states that
the sum of the first~\(n\) cubes is the square of the~\(n\)th triangular number.
That is,
\begin{equation}
  1^3 + 2^3 + 3^3 + \cdots + n^3 = (1 + 2 + 3 + \cdots + n)^2.
\end{equation}
The same equation may be written more compactly using the mathematical notation for summation:
\begin{equation*}
  \sum_{k=1}^n k^3 = \left(\sum_{k=1}^n k\right)^2.
\end{equation*}
Also see the diagram on that web page.
```

AB.5.6 Prime Number Theorem

Li [116] suggested using a functional equation from the Prime Number Theorem proof as an example:

$$\int_1^x \sum_{p \le u} \left\lfloor \frac{\log u}{\log p} \right\rfloor \log p \, \mathrm{d}u = \frac{1}{2\pi \mathrm{i}} \int_{c-\mathrm{i}\infty}^{c+\mathrm{i}\infty} \frac{x^{s+1}}{s(s+1)} \left(-\frac{\zeta'(s)}{\zeta(s)} \right) \mathrm{d}s \tag{AB.30}$$

```

\subsection{Prime Number Theorem}
\ix{Prime Number Theorem}

\textcite{li2013}
\ix{Li, Henry}
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
    \di 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)
    \di s
\end{equation}
```

AB.5.7 Quantum Mechanics

Greene [117] wrote

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

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

```
\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.

  \[
    \langle x_f,t_f \mid x,t_{\mathit i} \rangle
    =
    \sum_{\text p \in \text{paths}} e^{\mathit iS(\text p) \si{\planckbar}}
  \]
\end{quotation}
```

AB.5.8 Question in String Theory / Mass of States / Number Operator

yourlazyphysicist [118] wrote "I have the following definition of the space-time coordinates":

$$\text{closed string:}\quad \begin{cases} X_R^\mu = \dfrac{1}{2}x^\mu + \dfrac{1}{4\pi T}(\tau-\sigma)p^\mu + \dfrac{\mathrm{i}}{\sqrt{4\pi T}}\displaystyle\sum_{n\neq 0}\frac{1}{n}\alpha_n^\mu \mathrm{e}^{-in(\tau-\sigma)}, \\ X_L^\mu = \dfrac{1}{2}x^\mu + \dfrac{1}{4\pi T}(\tau+\sigma)p^\mu + \dfrac{\mathrm{i}}{\sqrt{4\pi T}}\displaystyle\sum_{n\neq 0}\frac{1}{n}\tilde{\alpha}_n^\mu \mathrm{e}^{-in(\tau+\sigma)}. \end{cases} \tag{AB.31}$$

$$\text{open string:}\quad \begin{cases} X_N^\mu = x^\mu + \dfrac{1}{\pi T}p^\mu\tau + \dfrac{\mathrm{i}}{\sqrt{\pi T}}\displaystyle\sum_{n\neq 0}\frac{1}{n}\alpha_n^\mu \mathrm{e}^{-in\tau}\cos(n\sigma), \\ X_D^\mu = x^\mu + \dfrac{\mathrm{i}}{\sqrt{\pi T}}\displaystyle\sum_{n\neq 0}\frac{1}{n}\alpha_n^\mu \mathrm{e}^{-in\tau}\sin(n\sigma). \end{cases} \tag{AB.32}$$

```
\subsection{Question in String Theory / Mass of States / Number Operator}

\textcite{yourlazyphysicist2017}
wrote
``I have the following definition of the space-time coordinates'':
{
  % The following five definitions are local to inside the { ... }.
  \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}
}
```

AB.5.9 Willans' Formula

An Exact Formula for the Primes: Willans' Formula [119] is a good video about Willans' Formula by Eric Rowland:

$$n\text{th prime} = 1 + \sum_{i=1}^{2^n} \left\lfloor \left(\frac{n}{\sum_{j=1}^{i} \left\lfloor \left(\cos \pi \frac{(j-1)! + 1}{j} \right)^2 \right\rfloor} \right)^{1/n} \right\rfloor \tag{AB.33}$$

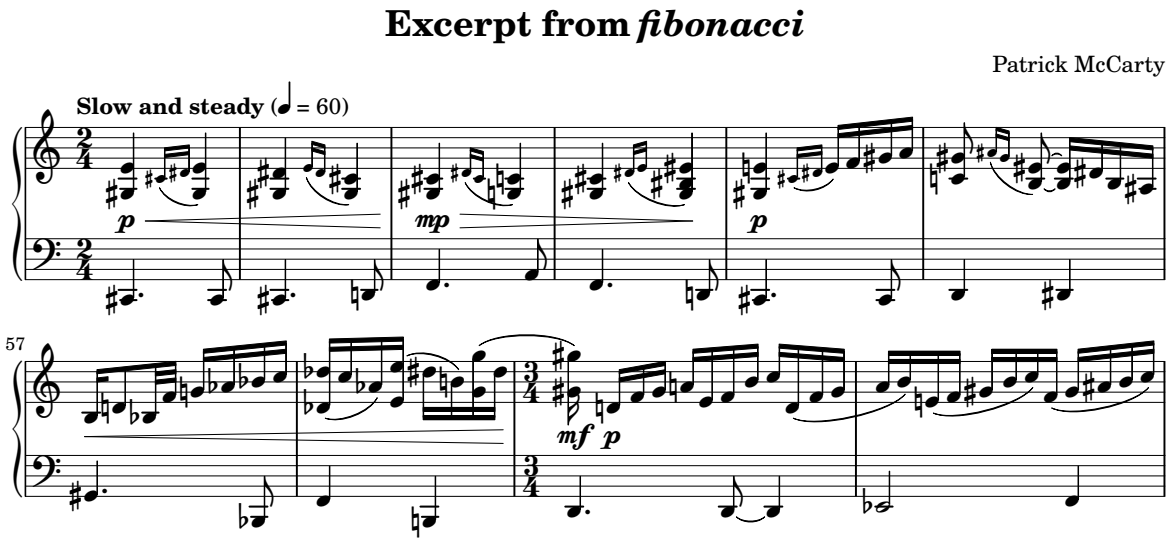
```

\subsection{Willans' Formula}

\citetitle{rowland2022}
\cite{rowland2022}
\ix{Willans, C. P.}
\ix{Rowland, Eric Samuel}
is a good video about Willans' Formula by Eric Rowland:

\begin{equation}
  % Typeset i and j in a math italic font for this equation only.
  \MathIt{i}
  \MathIt{j}
  \text{\(n\)th prime}
  =
  1
  +
  \sum_{i = 1}^{2^n}
  \left\lfloor
    \left(
      \frac
        n
        {
          \displaystyle  % so \sum limits are above and below and to make denominator bigger
          \sum_{j=1}^i
          \left\lfloor
```

```
27              \left(
28                % use \, for a tiny bit of horizontal space
29                \cos \pi \, \frac {(j-1)! + 1} j
30              \right)^2
31            \right\rfloor
32          }
33      \right)^{1/n}
34    \right\rfloor
35  \end{equation}
```

AC. MUSIC

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

- Get the “Example of LilyPond input file” from the Wikipedia LilyPond page [120] and put it in a `fib.ly` file.
- Run **`lilypond fib.ly`** to get the following `fib.pdf` file:



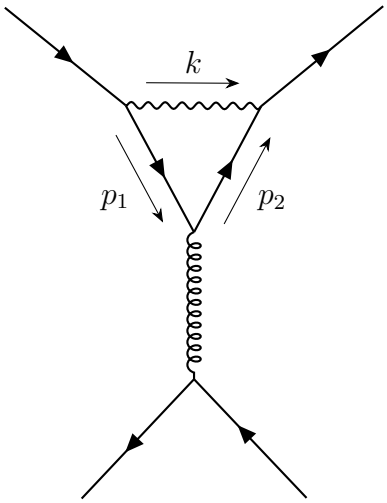

```
\chapter{MUSIC}
\ix{music//Music appendix}

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
    |fib.ly|
    file.
  \item
    Run \Shell{lilypond fib.ly} to get the following
    |fib.pdf|
    file:
\end{itemize}
\ix{LilyPond music typesetting software}

\noindent \includegraphics[scale=0.77]{gr-fib.pdf}
```

AD. PHYSICS

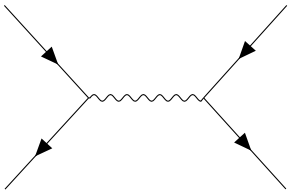
Feynman diagrams show what happens when elementary particles collide [121]. The Feynman diagrams below are from the *TikZ-Feynman: Feynman diagrams with TikZ* documentation [122]. **You must use `lualatex` instead of `pdflatex` to process documents that use the `tikz-feynman` package.**

The input in the documentation is different than here because a different random number generator is used [123]. I expect this to be corrected. In the meantime try replacing `vertical` with `vertical'` and/or switch some `fermion` to `anti fermion` lines [124].

```
\chapter{PHYSICS}
\ix{physics//Physics appendix}

Feynman diagrams\ix{Feynman diagram}
show what happens
when elementary particles collide
\cite{feynman-diagram}.
The Feynman diagrams below are from the
\citetitle{ellis2016} documentation \cite{ellis2016}.
\textbf{%
  You must use \texttt{lualatex} instead
  of \texttt{pdflatex}
  to process documents that use the \texttt{tikz-feynman} package.%
}

The input
in the documentation
is different than here because a different random number generator
is used \cite{menke2019}.
I expect this to be corrected.
In the meantime try replacing \texttt{vertical}
with \texttt{vertical'}
and/or switch some \texttt{fermion}
to \texttt{anti} \texttt{fermion} lines \cite{ellis2017}.
```




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



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

VITA

[Put a brief autobiographical sketch here.]

INDEX