This is the Name of my Thesis

by

Your Full Name

B.A., College of Hard Knocks, 2020

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Faculty of the Graduate School of the

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Doctor of Philosophy

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Committee Members:

Marie Curie, Chair

Isaac Newton

Albert Einstein

Name, Your Full (Ph.D., Rocket Science)

This is the Name of my Thesis

Thesis directed by Professor Marie Curie

Often the abstract will be long enough to require more than one page, in which case the macro `\OnePageChapter` should *not* be used.

But this one isn't, so it should.

Dedication

For whom it may concern.

Acknowledgements

Here's where you acknowledge folks who helped. But keep it short, i.e., no more than one page, as required by the Grad School Specifications.

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Chapter 1

Introduction

If you want your figures to look good, generate them to be the exact size that they'll be in the final PDF—often measured in points (or inches). For example, set the width to whatever you provide to `\includegraphis[width=XX]{...}`. In addition, set the font family and size to match. Here are reference values:

Full width images: `\textwidth` 469.75499pt

Font sizes:

`\scriptsize` 8pt

`\footnotesize` 9pt

`\small` 10pt

`\normalsize` 10.95pt ← ***The size of body and caption text***

`\large` 12pt

`\Huge` 24.88pt

Font family: cmr

The font family probably reads "cmr", which stands for Computer Modern Roman, which is the default font in LaTeX. You may be able to download this font and use it in other software when generating figures. Better yet, when using Python, instruct matplotlib to render all text using LaTeX.

This sample document illustrates how to use the `thesis` class, originally written by John P. Weiss. Some requirements of the Graduate School are written into that file; page size, line spacing, appropriate placement of captions for tables and figures, etc. Revisions by Hongcheng Ni make it possible to use the (optional) `\usepackage{hyperref}` command to enable internal hyperlinks in the final PDF document. The latest version, by Giaco Corsiglia, includes various other improvements—and has updated this sample file. Footnotes and references work as follows. The work presented here[1] is an extension of Lao [2] and Lao et al. [3], fictional references that are in the bibliographic

[1] Footnotes are handled neatly by LaTeX.

source file `bibliography.bib`. You should type citations like this: `word~\cite{ref}`. Include the tilde character instead of a normal space so that the bracketed reference doesn't awkwardly wrap onto a new line.

Figures work well, too. Figure 1.1 shows an image from a PDF file imported into this document using the `graphicx` package. The command `\usepackage{graphicx}`, which appears near the very top of the main LaTeX file, reads in this package which defines the `\includegraphics{}` macro. See Figure 1.2 for an example with sub-figures.

Notice the use of the `\cref{...}` commands in the previous paragraph. This is an enhanced version of the `\ref{...}` command that allows you to avoid typing "Figure..." or "Equation..." everywhere. Check out the documentation here.

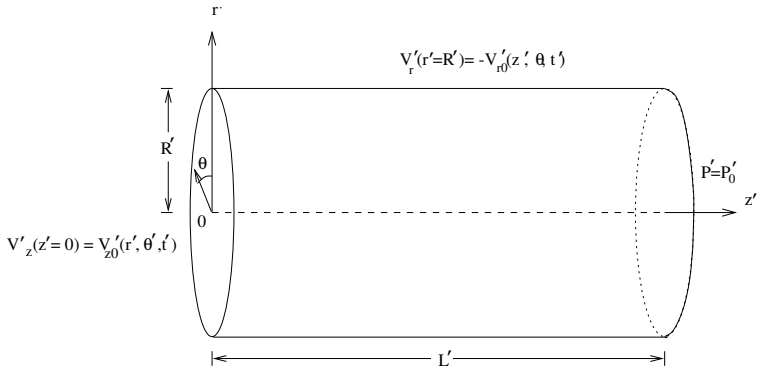


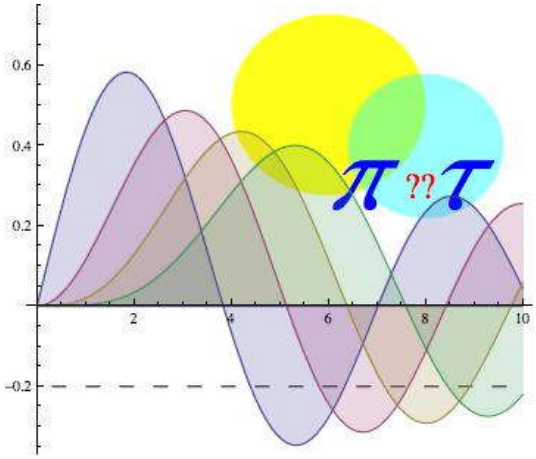
Figure 1.1: Look ma, a figure! This is the extended caption—but the short version of the caption provided in square brackets will be used in the list of figures at the start of the thesis. This caption is displayed below the figure.

1.1 Lists in `thesis` class

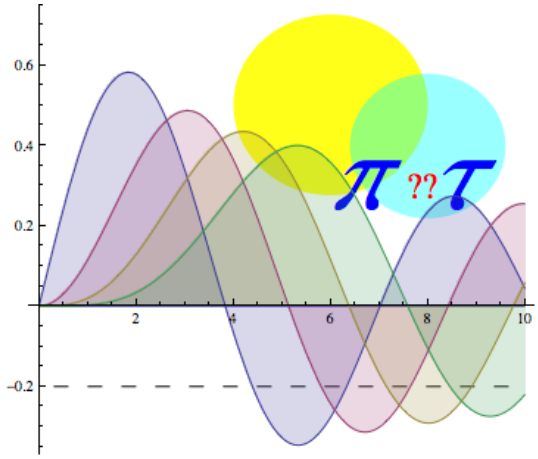
In `thesis` class (for Colorado University), lists are defined so that nested lists will be numbered or marked appropriately. First, an itemized (non-enumerated) list prefaces each item with a bullet. Nested itemized list use asterisks, then dashes, then dots. These lists are typed between the `\begin{itemize}` and `\end{itemize}` commands.

- This is "itemized" item A.

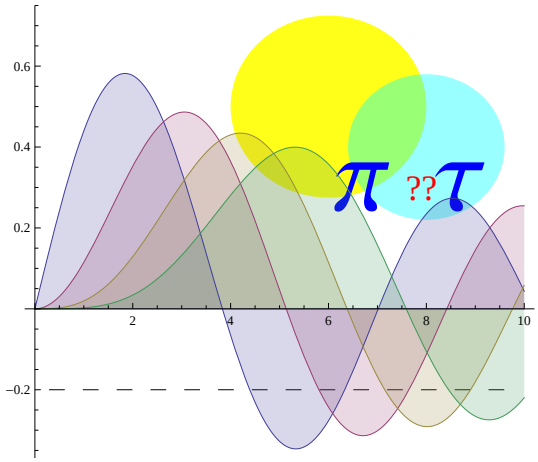
Figure 1.2: This caption is above the figure. This figure has sub-figures! Notice in the source that each sub-figure has its own `label` so that each can be referenced independently.



(a) JPEG version. You should never use the JPEG format unless you're including an actual photograph.



(b) PNG version. If you must use a bitmap format, prefer PNG to JPEG.



(c) PDF version. Obviously better than the other formats for generated graphics.

- This is “itemized” item B.
- This is “itemized” item C.
  - This is “itemized” subitem A.
    - This is “itemized” subsubitem A.
      - This is “itemized” subsubsubitem A.
    - This is “itemized” subsubitem B.
  - This is “itemized” subitem B.
- This is “itemized” item D.

Enumerated lists use the commands `\begin{enumerate}` and `\end{enumerate}`, and nested enumerations appear like this.

(1) This is “enumerated” item A.

(2) This is “enumerated” item B.

(3) This is “enumerated” item C.

  (a) This is “enumerated” subitem A.

    (i) This is “enumerated” subsubitem A.

      (i.a) This is “enumerated” subsubsubitem A.

    (ii) This is “enumerated” subsubitem B.

  (b) This is “enumerated” subitem B.

(4) This is “enumerated” item D.

Table 1.1: Here is an example of a table with its own footnotes. Don't use the `\footnote` macro if you don't want the footnotes at the bottom of the page. Also, note that in a thesis the caption goes *above* a table, unlike figures. (Well, so the original version of the document said—but my thesis showed captions under the tables.)
You should try using the `tabularx` command, instead of just `tabular`. In addition, check out the documentation for `booktabs`.
Note there are no vertical lines in this table and few horizontal lines, too. Plus, we've stretched the table to be the full text width, which is how Physical Review does it. Much nicer.

Wave form	S (kVA)	P (kW)	Q^* (kVAr)	$D^\dagger$ (kVAd)
Figure 1.3a	25.48	25.00	-2.82	4.03
Figure 1.3c	25.11	18.02	-9.75	14.52
Table 2.1	24.98	22.26	9.19	6.64
Table 1.1	23.48	15.00	6.59	16.82
Figure 2.1	24.64	22.81	-0.44	9.3

*kVAr means reactive power.
†kVAd means distortion power.

Chapter 2

Mathematical Formulation

The objective of this fake thesis document is to demonstrate a multitude of LaTeX features as well as features specific to the thesis class. We start by giving one short formula, and one big hairy multi-line formula (one of the non-dimensional Navier-Stokes equations):

$$A = \pi r^2 \tag{2.1}$$

$$\begin{aligned}
\rho\left[\frac{DV_r}{Dt} - M\epsilon^2\frac{V_\theta^2}{r}\right] &= -\frac{\delta^2}{\gamma\ M}\frac{\partial P}{\partial r} + \frac{M\ \delta^2}{Re}\left\{2\frac{\partial}{\partial r}\left[\mu\left(\frac{\partial V_r}{\partial r} - \frac{1}{3}\nabla\cdot\overline{\mathbf{V}}\right)\right]\right. \\
&+\frac{1}{r}\frac{\partial}{\partial\theta}\left[\mu\left(\frac{1}{r}\frac{\partial V_r}{\partial\theta} + \epsilon\frac{\partial V_\theta}{\partial r} - \epsilon\frac{V_\theta}{r}\right)\right] \\
&+\frac{\partial}{\partial z}\left[\mu\left(\frac{1}{\delta^2}\frac{\partial V_r}{\partial z} + \frac{\partial V_z}{\partial r}\right)\right] \\
&\left.+2\ \frac{\mu}{r}\left[\frac{\partial V_r}{\partial r} - \frac{\epsilon}{r}\frac{\partial V_\theta}{\partial\theta} - \frac{V_r}{r}\right]\right\},
\end{aligned} \tag{2.2}$$

2.1 Explanation of equations

The latter equation is non-dimensionalized using the following definitions:

$$r = \frac{r'}{R'}, \quad z = \frac{z'}{L'}, \quad t = \frac{t'}{t'_a}, \quad \kappa = \frac{\kappa'}{\kappa'_0}, \quad \mu = \frac{\mu'}{\mu'_0}, \quad C_V = \frac{C'_V}{C'_{V0}},$$

where P_0' is the initial static pressure in the cylinder, and ρ_0' and T_0' are the density and temperature of the fluid being injected from the sidewall.

Here is an example of using the macros `\singlespacing` and `\doublespacing`:

This paragraph was preceded by the command `\singlespacing`. See the Specifications of the Grad School for instructions about when single spacing is appropriate in a thesis.

And now, here is an example of using the macros `\begin{singlespace}` and `\end{singlespace}`; another way to get single-spacing:

Two cases are studied in the present work which differ only in the boundary conditions. Each different boundary condition model a different source of instability. The boundary of the first case consists of a steady, axisymmetric sidewall radial velocity boundary and a time-dependent, non-axisymmetric endwall axial velocity boundary. The second case is studied with a fixed impermeable axial velocity along the endwall and a combination axisymmetric steady and non-axisymmetric unsteady radial velocity along the sidewall.

You may want to use a table produced by some other software, such as Excel, rather than try to do it using LaTeXmacros. If the table is saved/printed to a PDF file, then it can be displayed using the `\includegraphics` macro inside a `table` environment:

Some of the boundary conditions are:

$$z = 0; \qquad V_z = \begin{cases} 0, & t \le 0 \\ \widetilde{F}_{zw}(r,\theta,t), & t > 0 \end{cases} \tag{2.3}$$

$$z = 0; \qquad V_\theta = V_r = 0 \tag{2.4}$$

$$r = 0; \qquad P, \rho, T, V_r, V_\theta, V_z \text{ finite}, \tag{2.5}$$

$$r = 1; \qquad V_r = F_{rws}(z), \tag{2.6}$$

$$r = 1; \qquad V_z = V_\theta = 0, \tag{2.7}$$

and solutions must be periodic in θ.

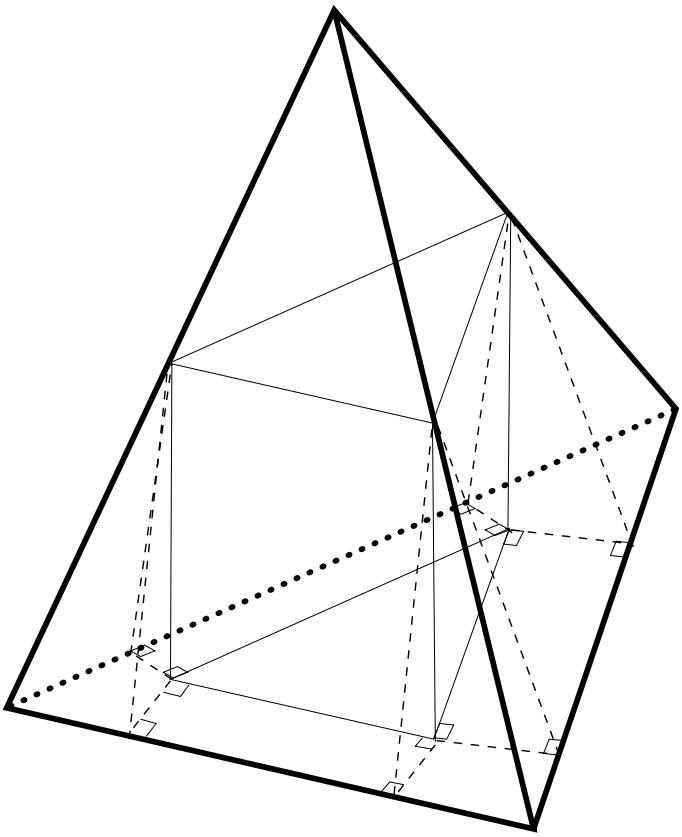


Figure 2.1: A triangular pyramid may be cut up as shown, to yield one top pyramid (with one-eighth the volume of the full pyramid), three bottom corner pyramids (which, when joined, are congruent to the top pyramid), three prisms along the bottom edges (the area of whose bottom faces total $B/2$) and the large central prism (volume = $(B/4)(h/2) = Bh/8$). The image, from PDF file "pyr.pdf", was read in using the `\includegraphics` command, from the `graphicx` package.

Table 2.1: This table wasn't constructed with LaTeX commands, but resides in PDF file `table.pdf` created by some other software. It's so ugly! Rendering your tables using LaTeX is probably better.

n	**n^2**	**n^3**	**n^4**	**n^7**	**n^{13}**
2	4	8	16	128	8192
3	9	27	81	2187	1594323
4	16	64	256	16384	67108864
5	25	125	625	78125	1220703125
6	36	216	1296	279936	13060694016
7	49	343	2401	823543	96889010407

If you don't believe this stuff, check out Mulick [4] and Baylor [1].

2.2 Yet another section

2.2.1 Just meaningless text to test lines per page

According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does

this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform? According to the Grad School specs. there should be 24–27 lines of print per page of a thesis. This should be true whether the font size is 10, 11, or 12. Count them up; does this document conform?

What is it? This is a labelled paragraph. The heading of the paragraph is emphasized. This is a labelled paragraph. The heading of the paragraph is emphasized.

2.2.2 This is a subsection

This is a subsection. Filler filler filler filler filler filler filler filler. Filler filler filler filler filler filler filler filler.

2.2.3 This is another subsection

This is another subsection. Filler filler filler filler filler filler filler filler. Filler filler filler filler filler filler filler filler.

This is paragraph number 2. It used a `\paragraph{}` header, which are always inlined (with extra space) and boldfaced.

This is the third paragraph of the subsection. Filler filler filler filler filler filler filler filler. Filler filler filler filler filler filler filler filler.

2.2.3.1 This is a subsubsection (1)

This is the first paragraph of the subsubsection. Whether it is numbered or inlined depends on the option selected at the beginning of the thesis.

By default, a `\subsubsection` heading is numbered and set off on a separate line, left-justified.

However. Using the `inlineh4` option, subsubsection headers are inlined. And using the `nonumh4` option suppresses numbering of the subsubsections. Together they make subsubsection headings just the same as paragraph headings.

2.2.3.2 This is another subsubsection (2)

Once again, whether its heading is numbered and/or inlined depends on the class options chosen at the start.

There is no "subsubsubsection" entity, and "subparagraph" gets no special treatment in *thesis* class.

2.3 The End

Finally, this is the end. The bibliography starts on the next page. Note how the `\hyperref` package (mentioned in Chapter 1) also makes hyperlinks from references (e.g., Mulick [4]) to entries in the bibliography.

References

[1] G. I. Baylor, "Up, up and away", Proc. Roy. Soc., London A **294**, 456 (1959) (Cited on p. 10).

[2] H. Lao, "Linear acoustic processes in rocket engines", PhD thesis (University of Colorado at Boulder, 1979) (Cited on p. 1).

[3] Q. Lao, M. N. Cassoy, and K. Kirkpatrick, "Acoustically generated vorticity from internal flow", J. Fluid Mechanics **2**, 122 (1996) (Cited on p. 1).

[4] F. C. Mulick, "Rotational axisymmetric mean flow and damping of acoustic waves in a solid propellant", AIAA J. **3**, 1062 (1964) (Cited on pp. 10, 12).

Appendix A

Fun animal facts

About appendices: Each appendix follow the same page-numbering rules as a regular chapter; the first page of a (multi-page) appendix is not numbered. Here are some facts about dogs!

(1) Dalmatians are born without spots! They are born with plain white coats with their first spots appearing after they are 1week old.

(2) Dogs sweat through their foot pads to help keep them cool. They also keep cool by panting.

(3) Greyhounds are the world's fastest dogs with the ability to reach up to 45 mph.

(4) Every dog has a unique nose print with no two alike.

(5) The Basenji, an African wolf dog, does not bark in a normal way but may yodel or scream when excited!

(6) Snoopy, from Charles M. Schultz's "Peanuts" comic strip, is a beagle.

(7) A dog's sense of smell is 1000 times greater than a human!

(8) Nine percent of dog owners will have a birthday party for their pet.

(9) Dogs have 28 baby teeth and 42 permanent teeth.

And here are some other animal facts:

(1) Fleas can jump 350 times its body length.

(2) Hummingbirds are the only birds that can fly backwards.

(3) Crocodiles cannot stick their tongue out.

(4) Starfish do not have a brain.

(5) Slugs have 4 noses.

(6) Only female mosquitoes bite.

(7) Polar bear skin is black!

(8) The only mammal capable of flight is the bat.

(9) A newborn kangaroo is the size of a lima bean.

I took these facts from animalmedical.org, which was the first Google search result for "list of fun facts about animals".

Appendix B

Ode to Spot

(Data, Stardate 1403827) (A one-page chapter — page must be numbered!) Throughout the ages, from Keats to Giorchamo, poets have composed "odes" to individuals who have had a profound effect upon their lives. In keeping with that tradition I have written my next poem . . . in honor of my cat. I call it. . . Ode. . . to Spot. (Shot of Geordi and Worf in audience, looking mystified at each other.)

> Felus cattus, is your taxonomic nomenclature
> an endothermic quadruped, carnivorous by nature?
> Your visual, olfactory, and auditory senses
> contribute to your hunting skills, and natural defenses.
> I find myself intrigued by your sub-vocal oscillations,
> a singular development of cat communications
> that obviates your basic hedonistic predilection
> for a rhythmic stroking of your fur to demonstrate affection.
> A tail is quite essential for your acrobatic talents;
> you would not be so agile if you lacked its counterbalance.
> And when not being utilized to aid in locomotion,
> It often serves to illustrate the state of your emotion.

(Commander Riker begins to applaud, until a glance from Counselor Troi brings him to a halt.) Commander Riker, you have anticipated my denouement. However, the sentiment is appreciated. I will continue.

> O Spot, the complex levels of behavior you display
> connote a fairly well-developed cognitive array.
> And though you are not sentient, Spot, and do not comprehend
> I nonetheless consider you a true and valued friend.