1 Introduction

As the title suggests, this document isn’t a comprehensive guide to thesis writing. Instead it is a collection of random pieces of advice that I would have liked to have been told before I began writing my first thesis. I think most of the advice is applicable to students writing theses in all fields of quantitative sciences and engineering. However, none of what follows has been rigorously tested — everything presented is my uninformed opinion and I’m sure would have benefitted me, but perhaps may be less helpful to others. *Caveat emptor*, and good luck!

2 Strategies for Thesis Writing

Students who begin writing their first thesis often make a critical mistake: they start putting down words immediately, without first planning their thesis. You should plan first. Make a high-level outline. Once this is done, go through each chapter and add subsections. I recommend that you then go through each chapter and add your figures or placeholders for figures. I used this technique when I wrote my Master’s theses, and I found that it made writing much easier: the bulk of the writing I needed to do was just that for describing each figure. By deciding first on what figures you will include, you will have compiled a list of figures that you still need to create. If you begin by preparing most of your figures, you’ll reduce your chances of being surprised by missing data later on.

Write your “background” chapter last. The reason for this is quite simple: it’s very easy to spend an enormous amount of time writing this chapter, and leaving it until you’re done with everything else makes sure that if you spend too much time on it, the presentation of your actual work won’t suffer consequently. It’s very tempting to make your review of background material a comprehensive tutorial of your field, because it’s fun to write and you get to look up and learn new and interesting things as you go.

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1 UCT ECE B.Sc. 2006; EE, CS M.Sc. 2008. Please feel free to send comments and corrections to pmcmahon@stanford.edu.
along. In contrast, presenting your results is much more difficult: typically by the time
you begin writing up, you know so much more about your work than the average reader
of your thesis will, that it’s a daunting prospect considering how best to coherently
present everything you’ve done in the best light possible. Don’t use your background
chapter to delay writing the meat of your thesis!

Write! At some point, you have to stop doing experiments. It’s tempting to keep work-
ing on your experiments because there are always extra things you can try. However,
at some point (typically at least one month before your thesis handin deadline) you
have to transition from doing experiments and analysis to writing up. As you write,
there will be times when you need to “quickly” do some extra work when preparing a
figure, or a table of results, but you should resist the temptation to do anything more
that isn’t absolutely necessary. Your readers would much rather read a well-written
account of your \( N - 4 \) weeks of research in your thesis than a rushed and sloppy account
of \( N - 2 \) weeks of work (where \( N \) is the total duration of your thesis in weeks). Your
thesis report is likely the only means your reader will have to evaluate your work, so
make sure your writeup reflects the same dedication to quality that you put into your
research!

Until you start writing up, you won’t know what data or knowledge you’re missing,
so starting your writeup early will help you avoid a rush before your deadline. It’s
very annoying discovering a week before you need to hand in that you forgot to run
an experiment with some set of parameters, and you don’t have enough time to do
it with just a few days left. At best, you may have to submit your thesis with some
graphs missing data points, and at worst the missing data points would have com-
pletely changed your conclusions. Either way, this is undesirable and can be avoided
if you find out well in advance of your handin date that you need more data.

### 3 The Structure and Style of Theses

The best way to learn about appropriate style for thesis writing is to read some theses.
(See the next section for suggested reading.) Academic style is quite different from all
other forms of writing, even report writing, that you’ve likely seen before starting your
research. It takes a while to get used to. During your thesis, you should have read
many academic papers from journals and conferences — these are typically written in
a style very similar to that which is appropriate for theses.

There is some room for creativity in structuring one’s thesis, but good theses usually
have the same basic divisions and flow:

- **Introduction** – \( \sim 10 \) pages. Explain the purpose of the thesis.
• **Background** (Related Work) – ~20 pages. Provide a summary of the subfield you’re working in, to provide some context for the reader to put your work in. Discuss related work done by other researchers, and explain how yours relates to it.

• **Experimental Design** – 20-30 pages. Explain the specific problems you set out to solve, and describe the design of your experiments.

• **Results and Analysis** – 20-30 pages. Present your results, and provide analysis of them.

• **Conclusion** – ~5 pages. Summarize what you did, what worked and what didn’t. Discuss potential future work that may fill gaps in your work, or approaches that seem promising to overcome problems you encountered but that you weren’t able to tackle.

• **Appendices** – Include any material that would break the flow of the main body of your thesis in appendices. For example, appendices often include presentation of non-essential data; long proofs; elaborations of ideas for future work; code listings or other “methods” information (circuit designs and suchlike), and other documentation such as user guides.

The structure and style of a good thesis typically looks very different to what is taught in “professional communication” classes in many universities. This is unsurprising: in most cases, professional communication lecturers are neither scientists nor engineers, and have never written a scientific document, let alone a science or engineering thesis. No wonder their advice is ill-suited for science or engineering writing! Any grammar lessons that one obtains in professional communications classes are advantageous, but I recommend that you ignore everything else that they teach about report writing.

If your thesis is mathematical, then I can recommend a guide to mathematical writing co-authored by Donald Knuth. Stanford offered a course in 1987, “Mathematical Writing”, that was co-taught by Prof. Knuth, and a transcript of the course was released as a technical report that makes for very pleasant reading. There are many excellent ‘before’ and ‘after’ examples; the course is packed with practical advice to make your writing easier to understand.


4 **Examples of Outstanding Theses**

• University of California, Berkeley David J. Sakrison Memorial Prize for a Ph.D. Thesis (2005): ‘Limits on Efficient Computation in the Physical World’ (Scott Aaronson). This is the gold standard by which all theory theses should be measured — it is a very fun read, contains excellent overviews of background material,
and clearly explains all the results that were obtained.


- MIT Ph.D. Thesis (2001): "Photonic Crystals: From Theory to Practice" (Steven G. Johnson). This thesis is the gold standard for all physical sciences and engineering theses. It is witty, but gives the reader a very serious and intuitive introduction to the subject matter, placing the achieved results in context in a very effective manner.

  URL: [http://hdl.handle.net/1721.1/8644](http://hdl.handle.net/1721.1/8644)

Meeting the high standards set by Aaronson’s and Johnson’s theses is not a realistic goal for most of us (although it is good to know what superstars of thesis writing can achieve). The following theses are also examples of great style and structure, and are somewhat more conventional than the gold standards. I have tried to pick out theses from several different areas.

- University of California, Berkeley M.S. Thesis (2008): "RDLC2: The RAMP Model, Compiler & Description Language" (Greg Gibeling). This is an outstanding Master’s thesis that provides a very clear and comprehensive coverage of the material.


  URL: [http://www.ri.cmu.edu/publication_view.html?pub_id=5825](http://www.ri.cmu.edu/publication_view.html?pub_id=5825)


  URL: [http://hdl.handle.net/1721.1/41255](http://hdl.handle.net/1721.1/41255)

- American Physical Society Atomic, Molecular or Optical Physics Dissertation Award (2005): “Ultracold Bosonic Atoms in Optical Lattices” (Ana Maria Rey).

  URL: [http://hdl.handle.net/1721.1/1903/1802](http://hdl.handle.net/1721.1/1903/1802)

2Besides Prof. Johnson’s work in computational methods for investigating photonic crystals, he is also known for creating the Fastest Fourier Transform in the West (FFTW). He has co-authored an outstanding textbook on photonic crystals that is available for free online as an e-book, and is another superb example of technical writing. URL: [http://ab-initio.mit.edu/book/photonic-crystals-book.pdf](http://ab-initio.mit.edu/book/photonic-crystals-book.pdf)
• MIT George M. Sprowls Award for Outstanding Ph.D. Thesis (1999): ‘Mostly-
Static Decentralized Information Flow Control’ (Andrew Myers).
URL: http://hdl.handle.net/1721.1/16717

• MIT William A. Martin Memorial Thesis Award for an Outstanding Master’s
phylogeny and ortholog determination’ (Matthew D. Rasmussen).
URL: http://hdl.handle.net/1721.1/37921

• MIT William A. Martin Memorial Thesis Award for an Outstanding Master’s
Thesis in Computer Science (2005): ‘End-user programming for the Web’ (Michael
Bolin).
URL: http://hdl.handle.net/1721.1/33110

• MIT William A. Martin Memorial Thesis Award for an Outstanding Master’s
Wrapper Induction on the World Wide Web’ (Andrew W. Hogue).
URL: http://hdl.handle.net/1721.1/28406

• MIT William A. Martin Memorial Thesis Award for an Outstanding Master’s
Video’ (Nicholas Feamster).
URL: http://hdl.handle.net/1721.1/8570

• MIT M.S. Thesis (1993). ‘Robust, High-Speed Network Design for Large-Scale
Multiprocessing’ (Andre DeHon).
URL: http://hdl.handle.net/1721.1/6790

Computing’ (Andre DeHon).
URL: http://hdl.handle.net/1721.1/10637

• University of California, Berkeley Ph.D. Thesis (2001): ‘Decoherence, Control,
and Symmetry in Quantum Computers’ (Dave M. Bacon). This is another fun
thesis that demonstrates the possibility of presenting difficult, interesting material
in an engaging and entertaining fashion.

Many professional societies have thesis awards, and these can be a useful source for
finding other theses that have been recognized as excellent. For example, the American
Physical Society has AMO awards, and the Association for Computing Machinery has
a Doctoral Dissertation Award. The ACM award is given out annually to what is
deemed the best Ph.D. thesis in the world in Computer Science submitted in the past
year.

[3] Most often the winners are from MIT, UC Berkeley, Stanford, Carnegie Mellon, and the University
Theses need not have boring layout. If you are adventurous and would like some inspiration for unconventional layout, you can refer to the undisputed leader in thesis presentation:


5 Technical Tools

Take the time to learn \LaTeX — you won’t regret it! If you’re not very technically inclined, then you might like a WYSIWYG \TeX editor, such as [lyx](http://www.lyx.org). However, you get significant speed advantages from writing directly in \TeX markup. Another major advantage of writing raw \TeX is that you can focus on the content of your writing and worry about the layout later. When you see how your material is being presented in a WYSIWYG editor, it is very tempting to continually tweak the layout, which distracts you. With \TeX, you can write your text and then only worry about making the layout look just the way you want it to.

Cambridge University’s Engineering Department has a comprehensive collection of \TeX resources. I recommend you use this as your starting point; it has links to both Windows and Linux installation/usage instructions and both beginner and advanced \TeX tutorials. URL: [http://www.eng.cam.ac.uk/help/tpl/textprocessing/](http://www.eng.cam.ac.uk/help/tpl/textprocessing/)

Good figures are critical to a thesis. If you use unwieldy tools, you’ll become frustrated and undermine your work by producing subpar figures. The following software is useful for producing good-looking diagrams for theses:

- OmniGraffle (Mac OS; commercial) — hands down the best diagramming software available, but unfortunately restricted to Mac OS.

- Microsoft Office Visio (Windows; commercial) — the best option for Windows users who have free access to it. An unconvincing choice if you have to pay the retail price.

- Microsoft Office PowerPoint (Windows; commercial) — can be used to make appealing block diagrams, but is found wanting for anything more complicated.

*This thesis also includes a very accessible introduction to the field of radio pulsars, although it is unfortunately only available in Dutch. The main body of the thesis presents, in English, a very readable summary of each of the papers the author wrote during his studies.*
• InkScape (Windows/Linux; free) — not bad, but has many flaws. Quite possibly the best free diagramming tool.

Make sure you use vector image formats for your diagrams and graphs. For figures that are intrinsically in raster format (such as photographs of experimental setups, or image outputs of computer simulations), use the highest resolution images possible — few things create a worse first impression for a thesis reader than the appearance of pixelated images every few pages.