

Possible Organization for Writing a Thesis including a L^AT_EX Framework and
Examples

by

A Graduate Advisor

B.Sc., University of WhoKnowsWhere, 2053

M.Sc., University of AnotherOne, 2054

A Dissertation Submitted in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the Department of Whichever

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Supervisory Committee

Dr. R. Supervisor Main, Supervisor
(Department of Same As Candidate)

Dr. M. Member One, Departmental Member
(Department of Same As Candidate)

Dr. Member Two, Departmental Member
(Department of Same As Candidate)

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ABSTRACT

This document is a possible Latex framework for a thesis or dissertation at UVic. It should work in the Windows, Mac and Unix environments. The content is based on the experience of one supervisor and graduate advisor. It explains the organization that can help write a thesis, especially in a scientific environment where the research contains experimental results as well. There is no claim that this is the *best* or *only* way to structure such a document. Yet in the majority of cases it serves extremely well as a sound basis which can be customized according to the requirements of the members of the supervisory committee and the topic of research. Additionally some examples on using L^AT_EX are included as a bonus for beginners.

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I believe I know the only cure, which is to make one's centre of life inside of one's self, not selfishly or excludingly, but with a kind of unassailable serenity-to decorate one's inner house so richly that one is content there, glad to welcome any one who wants to come and stay, but happy all the same in the hours when one is inevitably alone.

Edith Wharton

DEDICATION

Just hoping this is useful!

Chapter 1

Introduction

The main goal of this document was to set up competently the Latex framework for a thesis document at UVic, with all the assorted details of front pages, numbering and so on. In order to present such a template to other users, the content has been filled from the guidelines of an experienced graduate advisor and supervisor on how to write a thesis in the first place.

The Latex framework given in these files should work in the Windows, Mac and Unix environments. In Windows, the development environment is MikTeX, available as a free download from the web page at *miktex.org*. Miktex includes all the tools for L^AT_EX, without a convenient editor. I have been using *WinEdt* which is still the best as far as working in a well integrated manner with MikTeX, even if one has to pay a small price. *WinEdt* is available from *winedt.com*. The corresponding package for the Mac is MacTeX, available from *www.tug.org/mactex*. Please note that in the actual file with the L^AT_EXcode there are extra local comments referring to small differences between platforms. This is especially crucial for the insertion of figures of any type (see also Chapter 3).

The package *BibTex* is used for the automatic bibliography and it is incorporated in the MikTeX package. The style of bibliography exemplified in this document is the "plain" one, most often used in science theses. This is shown by the entry *plain* in the *bibliographystyle* command which can be found in the top file, namely *mainthesisUVIC.tex*. Substitute the appropriate bibliography style for your needs by finding the correct parameter. In order to help you there is a PDF file entitled: "InformationOnBibliographyStyles.pdf" in the same folder as the top file *mainthesisUVIC.tex*.

The title pages are correctly formatted according to the guidelines. However the superset is given here as a template for a Ph.D. dissertation and adjustments must

be made for a Master's thesis accordingly.

When presented with the task of having to write a large document reporting on the work done for the thesis portion of a graduate degree most people have anxiety attacks. It seems that the research work has been done, probably with great competence, yet one feels totally lost on how to approach the writing part - unless of course one is a writer to start with. While I am not at all the expert, I have experience both in writing documents and in supervising many graduate students. I have developed a simple enough structure which guides me and my students most of the times fairly well. We then customize it for different audiences and situations. The content of this pseudo mini thesis summarizes the structure I use.

This document, however, is *not at all* a Latex manual. There are a few examples sprinkled here and there of various commands. However no explanations or full examples are given for how to use Latex itself. That is most certainly left to the user!

Starting at the very beginning, my first step is to set up the formatting framework before the content itself, just like the frame of a building is the sustaining structure. By having the content only in bullet points which can be moved and changed at will I can have a whole document which will always compile and be ready for presentation. I ask my student to prepare mock chapters which contains only these bulleted lists to be used for discussion. The bulleted list I had for this chapter is as follows:

1. State the dual purpose of this document (just mention briefly);
2. State what this document is not (just mention);
3. Describe what I think should go in the Introduction in general;
4. Describe what I think should not go in the "Introduction" chapter in general;
5. Describe the structure of the document.

When the writing for a chapter is particularly long, it might be better to have some, if not all, sections in separate files. It makes it a lot easier to find possible errors in Latex as well, since the command to input a file for a separate section can always be commented out. When looking at the *.tex* file itself for this introduction chapter you will notice that there are 2 sections, namely "How to Start an Introduction" and "Is a Review of All previous Work Necessary Here?" which are included as separate files, immediately following this paragraph.

1.1 How to Start an Introduction

What is the difference between an "Introduction" and the "Background" for a thesis? Should they be together? What about the review of the work from other people?

These are important questions which must be discussed between a student and the supervisor.

My view is that the introduction should be exactly that: a short introduction, not the history of the problem, its content and all its solutions to date. One major ingredient *must* be a marketing angle, such that the reader becomes deeply motivated to continue on with the rest of the document. When I referee an article I usually read the abstract, the introduction and the conclusion. At that point I expect to be able to state to someone else what the work is about, what seems to be the new advancement and how interesting I think it will be to read the rest.

My main statement about the introduction is: *"keep it short and write it last"*. The main features should be as follows:

1. 3-4 pages at most;
2. Start with a VERY short statement of the problem (2-3 sentences) - the problem should be stated, not described, as there will be a whole chapter for that;
3. State why the problem is important, its impact, how well it has been studied recently, its application (3 sentences) - this should be again a brief motivation, leaving a full impact description to later in the document;
4. Give a sketch of the new approach - there will be a whole chapter with all the details, now just impress the reader about what is the new approach, just as you would do if your boss asked you at work during an elevator ride;
5. Sketch the main new ideas of the new approach - again briefly, just get the reader interested;
6. Give a short statement regarding the results, nothing too elaborate, but certainly you should blow your horn and make sure that the reader is intrigued;
7. Interspersed in all the writing above do not forget the marketing angle, trying to suggest forcefully why the reader should keep reading;
8. Give an outline of what is to come in the organization of the thesis overall - you will find one below for this document.

Finally the strong suggestion is write the introduction chapter last. It will be faster, you will know what to say as the rest is already there, and the abstract, introduction and conclusion will be a mirror and complement of each other. You may well ask where to start writing your thesis. My view is included in the organization below.

1.2 Is a Review of All Previous Work Necessary Here?

Many people like to place in the introductory chapter a review of the work from everybody else on the same problem. I find this utterly boring and counter-productive. If I am an expert in the field I probably know all this and could even write it better, so the last thing I want to read at the beginning is a history of research. If I am not an expert in the field, I would prefer to read up all the details of the problem itself and understand its context before I can even take in any ideas of what others have done.

Secondly, often when talking about the work of others one includes a bit judgment on it. This may be necessary, as the pivot of the new work may indeed be that there was an open problem left unsolved by the other researchers. Yet it is hard not to sound negative, to describe the work of others stating that their solution did not include some important part without denigrating. If one of those researchers is a reader and perhaps an examiner, they do not want to start reading by being told that their own work is inadequate.

I suggest a general summary of no more than 3-4 paragraphs of the work in the area with references, just to give the impact of the importance of the problems to be solved. Use then a "just-in-time" approach, where the relevant work of another researcher is described when needed in a particular step of the exposition of the problem or of the new solution. I normally place a much more extensive review of the work of others after I have presented my solution and the results of my experimental or formal proof work, so that I can analyze and compare effectively without boring repetitions and without writing a literature review on a subject. Many good articles in journals follow this scheme and most grant organization ask for a literature review to be included at the end of an application. First they want to be impressed with the proposal for new work!

A similar logic should be applied to background knowledge and definitions. This is especially true in a scientific thesis where often one find a whole set of mathematical definitions lumped together in chapter 1, yet not used until chapter 6, by which time the reader has completely forgotten it and needs to shuffle back with irritation. Use again a "just-in-time" approach and give definitions and explanations locally, the first time they are needed.

1.3 My Claims

Something must be new in this work, no matter how small, since you are getting a graduate degree for it! Tell me about it clearly and succinctly right now, just as you did in the abstract. Make an impact here. How about something like the following box:

I am citing Ref. [2].

I make *four* claims which my dissertation validates:

My new algorithm to solve the problem of doing nothing include these important new features whose practical applicability can be proved both formally and empirically:

1. first feature;
2. second feature;
3. everything is much easier to understand, and therefore, easier to implement correctly.

Claim 1 and claim 2 are *quantitative* - they will be proven by experiment.

Claim 3 is *qualitative* - they will be demonstrated by argument.

1.3.1 The Importance of My Claims

Some very important positive consequences arise from the validation of the above claims. It is these consequences that comprise a significant positive contribution to research in the field of whatever the field is.

Claim 1 implies that:

1. Something profound which applies to:

- something excellent;
- something important.

2. Something else just as profound.

Claim 2 implies that:

- Repeat as above if necessary and useful.

The consequence of claim 3 is that:

- There must be something good coming out of all this work!

1.4 Agenda

This section provides a map of the dissertation to show the reader where and how it validates the claims previously made. Here is where I am also presenting my own style of organization which may be totally different from what your supervisor thinks. However, trust me, this is a good solid beginning for a structure. Your supervisor may ask you to change it, but will still appreciate what you have! For each of the chapters below I also give a short summary of what the main focus should be and then I expand on it a bit within the chapter itself.

Chapter 1 contains a statement of the claims which will be proved by this dissertation followed by an overview of the structure of the document itself.

Chapter 2 describes in details the open problem which is to be tackled together with its context, its impact and the overall motivation for the research overall.

Chapter 3 gives the new research, its methodology, the algorithms involved, the new solution, the new work done. Formal proofs and arguments are made here. This is the first of the two contributions expected in a thesis for a graduate degree.

Chapter 4 is where the experiments and the methodology for them is fully described. The first part includes all details of how the empirical side of the research has been conducted. Note that not every thesis has this empirical portion.

Chapter 5 includes the evaluation of the data presented above and the comparisons with the work of others, to show how much better the new approach is. This is the second of the two contributions expected in a thesis for a graduate degree. Note that this part could be consolidated into the chapter above.

Chapter 6 contains a restatement of the claims and results of the dissertation. It also enumerates avenues of future work for further development of the concept and its applications.

The list above is not complete. Chapter 3 actually includes a lot more, as I could not resist placing in it a few L^AT_EXexamples to help you along. This document is not a primer for L^AT_EX, but there is no harm done in giving a little help.

Chapter 2

Theory

The **Standard Model of Particle Physics (SM)** is a quantized relativistic field theory that describes all known elementary particles, as well as their interactions via three of the four known fundamental forces. It has been tested extremely rigorously since its development in the 1960s and 1970s, and in every case its predictions have held true. The final piece of the puzzle fell into place in 2012 with the experimental verification of the existence of the Higgs Boson in 2012. (cite <https://www.sciencedirect.com/science/article/pii/S037026931200857X>).

Despite its success, however, the SM is considered an incomplete theory. It does not describe the interaction of matter via the fourth fundamental force, gravity, nor does it account for the existence of *dark matter* in our universe, or the asymmetry between the observed amounts matter and anti-matter. These shortcomings provide motivation to extend the SM by searching beyond it for new phenomena.

This chapter will provide a short overview of the SM theory, before describing some of the deficiencies that motivate extending it.

2.1 The Standard Model

2.1.1 The Particles

The elementary particles of the Standard Model are shown in Figure 2.1. They can be categorized into two groups: *fermions* and *bosons*. *Fermions* carry half-integer spin, and constitute the matter that surrounds us. For each fermion there also exists a corresponding anti-particle with an opposite electric charge. In this document anti-particles will be denoted either by the charge (e.g. e vs. e^-) or by a bar overhead

e.g. (t vs. \bar{t}). The fermions can be further divided into two groups: *leptons* and *quarks*. *Leptons*, the most familiar of which is the electron, interact via the weak force and, if electrically charged, the electromagnetic force. They come in three flavour generations, each of which has a neutral particle (*neutrino*) and a charged fermion with charge -1. Unlike leptons, which regularly exist freely, *quarks* exist mostly in bound states called *hadrons*, the most well-know of which are the proton and neutron composed of (u, u, d) and (u, d, d) quarks respectively. Like leptons, quarks come in three generations, each of which has a pair of particles with electric charges $+2/3$ and $-1/3$. They interact via all three forces of the standard model: strong, weak, and electromagnetic.

mass charge spin	$\approx 2.2 \text{ MeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ u up	$\approx 1.28 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ c charm	$\approx 173.1 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ t top	0 0 1 g gluon	$\approx 124.97 \text{ GeV}/c^2$ 0 0 0 H higgs
QUARKS	$\approx 4.7 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ d down	$\approx 96 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ s strange	$\approx 4.18 \text{ GeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ b bottom	0 0 1 γ photon	SCALAR BOSONS
LEPTONS	$\approx 0.511 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ e electron	$\approx 105.66 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ μ muon	$\approx 1.7768 \text{ GeV}/c^2$ -1 $\frac{1}{2}$ τ tau	$\approx 91.19 \text{ GeV}/c^2$ 0 1 Z Z boson	GAUGE BOSONS VECTOR BOSONS
	$< 1.0 \text{ eV}/c^2$ 0 $\frac{1}{2}$ ν_e electron neutrino	$< 0.17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ ν_μ muon neutrino	$< 18.2 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ ν_τ tau neutrino	$\approx 80.39 \text{ GeV}/c^2$ ± 1 1 W W boson	

Figure 2.1: The elementary particles of the Standard Model

Bosons carry integer spin, and mediate the forces via which particles interact. Massless *gluons* and *photons* as well as massive W and Z bosons are spin-1 vector bosons, while the Higgs Boson is a spin-0 scalar boson. The massive W and Z vector bosons are the carriers of the weak force, the photon carries the electromagnetic force, and the gluons carry the strong force binding quarks. Along with interacting with fermions via exchange, bosons are also able to interact among themselves. W bosons are able to directly interact with both Z bosons and photons, as well as self-interacting. Gluons can also self-interact, but Z bosons and photons cannot. The

Higgs boson interacts with all massive particles, including self-interaction, and it is via their interaction with the Higgs field that massive bosons obtain their mass.

2.1.2 Quantum Electrodynamics (QED)

Quantum Electrodynamics (QED) is a quantum field theory of electrodynamics and the electromagnetic force. It describes the interaction of electrically charged particles via the exchange of photons. Mathematically, QED is an abelian (commutative) gauge theory with the gauge group $U(1)$. The fundamental interactions of the theory are: the emission or absorption of a single photon by a charged particle and the creation or annihilation of a pair of charged particles. These interactions can all be represented by various orientations of the Feynman vertex shown in Figure .

2.1.3 Weak Interactions

The weak force, in contrast to the electromagnetic force, is mediated by the exchange of massive vector bosons W^+ , W^- , and Z . Owing to the charge of the W bosons, and the fact in contrast to the electromagnetic force neutral fermions also interact via the weak force, there are many more possible fundamental interactions. Figure shows the vertices corresponding three such interactions: Fermions interacting with the Z boson in a similar vertex to that of Figure shown in (a), a charged lepton and neutrino interacting with a W boson shown in (b), and a quark-antiquark pair interacting with a W boson shown in (c).

At high energy scales, the aforementioned electromagnetic force and the weak force unify to become the electroweak interaction. Glashow, Salam, and Weinberg's theory unites to two forces into a single $U(1) \otimes SU(2)$ gauge theory.

2.1.4 Quantum Chromodynamics (QCD)

Quantum Chromodynamics (QCD) is the theory describing the strong interaction between gluons and quarks. It is again a gauge theory, this time with the $SU(3)$ symmetry group. There are three colour charges associated with this group, which are carried by both quarks and gluons. Each of the 8 gluons carries a unique colour charge and anti colour charge pair, while quarks carry a single colour charge. Because they carry colour charge, gluons are able to both interact with quarks and self-interact.

This gives rise to several possible interaction vertices in the theory, some of which are shown in Figure .

2.1.5 The Higgs Boson

Electroweak theory alone does not contain a mechanism to provide particles with mass. This contrasts with the observed reality that all fermions as well as W and Z bosons are in fact massive. If the lagrangian of these theories were to contain mass terms, they would lose their gauge invariance and the standard model would not be renormalizable. Instead, these particles acquire their mass through the *Higgs Mechanism*.

A new "Higgs Field" Φ is introduced, with a Lagrangian which can be written as:

$$L_{Higgs} = (D_\mu \Phi)^\dagger D^\mu \Phi + V(\Phi)$$

Where D_μ is the gauge covariant derivative of the electroweak theory. In order for the Lagrangian to remain gauge invariant the Higgs potential $V(\Phi)$ must take the form:

$$V(\Phi) = \mu^2 \Phi + \lambda \Phi^4$$

where λ and Φ are free parameters. Λ is forced to be greater than 0 by requiring that the potential have a stable minimum. This leads the potential to have two different possible shapes given the sign of μ^2 , shown in Figure .

1. $\mu^2 > 0$: The trivial case of a parabolic potential with a minimum at $\Phi = 0$ arises.
2. $\mu^2 < 0$: A potential with a minimum at:

$$|\Phi| = v = \sqrt{\frac{\mu^2}{\lambda}}$$

arises, where v is known as the vacuum expectation value. This minimum is occupied by infinitely degenerate states. This is the case that gives rise to the Higgs mechanism.

In the second case, the ground states occupying the minimum are not equivalent under gauge transformation, which breaks the Electroweak gauge symmetry. The

masses of particles are then determined by the strength of their coupling to the Higgs field.

2.2 Beyond the Standard Model

While the Standard Model as described above has proven extremely robust through precise experimental testing. There are, however, many remaining questions in physics that cannot be answered within its confines. Some of those not further explored in this thesis include: whether or not there is a quantum theory of gravity that can tie it to the SM, the exact value of the neutrino masses and whether they are Majorana particles (their own antiparticles), and what the cause is of the matter-antimatter asymmetry in the universe. The fact that these questions are unanswered in the standard model tells us we must search deeper, and test beyond its limits.

2.2.1 Dark Matter

Another currently open question is the nature of dark matter. Astrophysical observations including the dynamics of galaxy clusters (cite Zwick) and rotational curves of galaxies (cite <https://ui.adsabs.harvard.edu/abs/1980ApJ...238..471R/abstract>) are not explained under Einstein's theory of gravitation by visible matter alone. Several theories have arisen over time to explain this discrepancy, including that Einstein's theory is not correct at galactic scales, or that these galaxies contain ordinary matter that is somehow unobservable to us.

Most evidence, however, points to the existence of a new type of matter that interacts gravitationally but not electromagnetically with ordinary matter. Perhaps the most clear evidence for this theory comes from observations of the bullet cluster (cite <https://arxiv.org/pdf/astro-ph/0608407.pdf>), a pair of colliding clusters of galaxies. In such a scenario, with some normal matter and some dark matter in each cluster, the matter would collide and interact, slowing it down, while the dark matter would pass through largely undisturbed. In the case of the bullet cluster, this separation is observed when comparing the distribution of mass in the galaxies measured by gravitational lensing and the distribution of normal matter in the form of galaxy plasma, measured as emitted x-ray radiation. Figure shows the observed separation, with gravitational density in blue and x-ray density in pink.

2.2.2 Dark Higgs Boson Model

This work involves a search for dark matter produced in association with a new hypothetical scalar "dark Higgs" boson s *Add footnote - s is not strange quark*. In this model the dark matter particle χ is a majorana fermion, who's mass is generated by a Higgs mechanism in the dark sector. This also generates the new s particle. If the mass of s is less than that of χ then the relic density is set by the process $\chi\chi \rightarrow ss$, followed by the decay of s to standard model particles. The addition of a further particle, such as a massive Z' boson allows this model to be probed at a collider.

The model proposes that the dark matter particle χ obtains its mass from the vacuum expectation value (vev) w of a new Higgs field S . A new $U(1)'$ gauge group is proposed, under which S carries a charge q_s . As a result, the vev w of S breaks the gauge symmetry, and through this mechanism the mass of the corresponding Z' boson is generated. Additionally, the dark matter particle χ couples axially to the Z' boson, allowing all particles in the new dark sector to interact. This gives rise to the renormalizable interaction Lagrangian:

$$L_\chi = \text{Lagrangian}$$

2.3 not me

Here is where you tell me what is the problem you have been working on for the past few months (or years). I want all the details and you should not be timid about being too tutorial, except that you do not want to cross the line towards writing a textbook. However consider carefully that *communication* implies conveying ideas to other people, while *effective communication* occurs when your message is clearly understood. Remember that your audience must understand your message before they can agree with you.

Ask yourself: *who is your audience?* You might think of your supervisor who knows everything and you want to impress with your knowledge. I think instead of the graduate students who will be reading this thesis which is, after all, a property of the university. It is published as a university technical report so that others may learn by reading it. Then teach them! Be a bit tutorial. Even the expert external examiner will be impressed by your clarity of exposition if he or she does not need to

read paragraphs twice in order to understand - something which people with PhDs and big egos find particularly irritating.

On the other hand, do not go too far and give trivial definitions from concepts learned in a 3rd year undergraduate courses, else you might find yourself in trouble when having to remember the details during an oral examination.

My approach is to put everything necessary to make clarity for the problem the main goal of this chapter, assuming an intelligent and well prepared reader who already has a Bachelor degree in an appropriate subject.

Once I understand the problem clearly and its nuances (it may not be what I expected after all), I also need to know why the problem is important, what its impact is and what its application, if any. Here you are free to elaborate and write as much as you think is necessary to avoid the examination doubt that you have a brilliant new solution to a trivial and unimportant issue.

I suggest reading various books on how to do research and set up problems. The best for me was "The Craft of Research" by Wayne Booth [3], which can be found in the main library at Q180.55 M4B66. From there I have transferred to my writing a fairly simple structure for talking about the topic of the research, with the question to be asked and its motivation and significance. It goes as follows:

1. *I am trying to learn about (working on, studying...)*
2. *because I want to find out....*
3. *in order to understand...*

Another way of looking at this is to ask the *what*, *why* and *where*, starting from a *setting* of the problem with a first point A, stating what the *goal* is at point B and having an *action link* between the two which will encompass your new solution. As surprising as this may be to some of you, I found reading a book from Microsoft very useful: "Beyond Bullet Points: Using Microsoft Office PowerPoint 2007 to Create Presentations That Inform" [1]. The goal of the book is to improve presentations with Power Point, but there is a lot that can be transferred towards *effective communication* for a thesis.

In summary, my view of the second chapter on "*The Problem to be solved*" is as follows:

1. *Not* all the background and definitions (boring!) - use instead just-in-time explanations as needed in every context as it comes up;

2. Motivation in depth;
3. Tutorial high level explanation, where it is important to choose the right pitch: who is the audience? who are you teaching here?
4. Make it exciting, make it current, make it important - why do I want to keep reading?
5. Should you list here the solutions from other researchers? I think not, list instead the different facets of the problems that other researchers have attacked.
6. A taxonomy can be extremely useful to place your problem and its particular special features within the perfect context of the overall area, as you need to make sure that the reader understands perfectly what you are trying to solve.

Chapter 3

The New Approach and Solution

This is where you go all out and tell us all about your new discovery and research related to the problem in the previous chapter. No arrogant sweeping statements which cannot be fully justified, but no false modesty either. You must impress your reader that you have accomplished something.

Simply summarized, this chapter should be comprised of at least two main sections, each with appropriate subsections. The first section should describe:

- what the new approach is;
- what is really totally new;
- what is incrementally new;
- what you built upon.

The second part should describe fully how the new approach works, both with the overall theoretical exposition (e.g. an algorithm) and with as many examples as necessary for clarity. Remember that if the reader does not understand fully, you will get a lot of questions and doubts. Good examples, good figures, good diagrams with super clear tutorial explanations can be a joy to read and make even a small contribution appear to be more impressive. Are you afraid that if you are too tutorial your work will not seem as deep and difficult? Only shallow people will make such a superficial evaluation, have trust instead in the wisdom of your supervisory committee.

Use at least one good example throughout, and even better if this is one of the examples you used in Chapter 2 to describe the original problem.

By the way, this would be the first chapter I would write. This is what I know best right now, as I just finished working on it. It is clear to me and on the tip of my fingers. Start with your strengths! The second chapter I would write is the next one about the experiments, followed closely by chapter 2 describing the problem. It may not seem intuitive to you, but it works and it is the most productive way I ever found to finish a document.

3.1 Some L^AT_EX Examples

A Latex document is composed of two parts: the Preamble, and the Document Body. The *Preamble* is the site for inclusion of all document set up commands: definition of new commands, inclusion of prebuilt packages, template declaration, etc. The *Body* is where the document content is placed.

3.1.1 Preamble

The Preamble refers to the input which precedes the documents contents. It is the area where the author determines the general template for the document using the `\documentclass[options]{doc style}` command. For example, `\documentclass[11pt]{article}` declares that a document will follow the *article* document class, and have 11pt font.

If the document requires support of any library packages they must be included in the preamble using the `\usepackage{package name}` command. For example, `\usepackage{graphicx}` is the command needed to include the *graphicx* package.

3.1.2 Document Body

The document body is the area which follows the Preamble. It is defined by the `\begin{document}` and `\end{document}` commands. The content of a Latex document is declared in the document body. Input which appears after the `\end{document}` command is ignored.

3.2 How to Number Pages

To number the pages of a document use the `\pagenumbering{style}` command. Numbering is defined in the documents preamble. There are several different *styles* to choose from.

Numbering Style	Output
<code>\pagenumbering{arabic}</code>	1, 2, 3, ...
<code>\pagenumbering{roman}</code>	i, ii, iii, ...
<code>\pagenumbering{alph}</code>	a, b, c, ...
<code>\pagenumbering{Roman}</code>	I, II, III, ...
<code>\pagenumbering{Alph}</code>	A, B, C, ...

Table 3.1: Page Numbering Styles

The numbering of pages for a thesis is, however, much more complex than for an article and, in fact, the *book* class has been adopted. Make changes to those settings only if you are really familiar with L^AT_EX.

3.3 How to Create a Title Page

A title page can be either on a separate page or integrated directly into the first page of the document. It is defined by three declarations, followed by the `\maketitle` command as illustrated below.

```
\title{Title of Paper}
\author{Author(s) of Paper}
\date{Publication Date}
\maketitle
```

The article document class defaults on an integrated title page. To make a separate title page, use the **titlepage** option with the `\documentclass[titlepage]{doc style}` command.

For this thesis style the title page has been completely formatted for you. Just insert the various names of people in the supervisory committee, the title, your name and so on in the location where the *dummy* entries exist right now and you will be done. I would suggest to avoid doing any other changes unless you are absolutely sure!

3.4 How to Create an Abstract

To create an abstract, place contents of abstract between the `\begin{abstract}` and `\end{abstract}` commands.

3.5 How to Create a Table of Contents

The `\tableofcontents` command automatically generates a table of contents from all section headers. The default behavior for the article document class is to produce an integrated table of contents. However, the document can be altered to generate the table of contents on a separate page using the `\newpage` command (see section Formatting Extras).

For this thesis template a special command has been added, namely the `\textTOCadd`. You can find it in the file *macros/style.tex*. It has to be explicitly called for an insertion into the Table of Contents and it is already in place appropriately for the existing sections and subsections.

3.6 How to Create Sections

Creating sections, subsections, and subsubsections is completed using the `\section{Section Name}`, `\subsection{Subsection Name}` and `\subsubsection{Subsubsection Name}` commands, respectively. Each sectional division is numerically labeled with respect to its placement in the section hierarchy. For example, this section was defined with the code:

```
\section{How to Create Sections}
Creating sections, subsections, and ...
```

It is useful to give a label using the `\label` command to a section or subsection if a reference to it is made, so that the reference will be automatically updated should the structure of the document change.

3.7 How to Create a List

Lists can be either enumerated, non enumerated, or descriptive. Each element of a list is termed an 'item'.

loc	Purpose
l	left justified column
r	right justified column
c	centered column
	vertical rule

Table 3.2: Table Example

1. enter the list environment with the `\begin{list style}` command.
2. define each item with the `\item` command for non-enumerated lists, or `\item[label]` for descriptive lists.
3. terminate list environment with the `\end{list style}` command.

3.8 How to Insert Tables, Figures, Captions, and Footnotes

The table and figure environments contain input blocks which cannot be split across pages. Rather than divide the input of either of these environments, the contents are relocated, or floated, to a location in the document which optimizes page layout with the surrounding document content.

3.8.1 Tables

Tables are created in the tabular environment. A single parameter is used to define the number of columns and item justification pertaining to each column. The single parameter is a combination of the following ones shown in Table 3.2.

`\` and `&` are used to define rows and columns, respectively. A table can either have the contents of its rows and columns lined or not. Each line used to construct the table must be individually specified, using `|` and `\hline` for vertical and horizontal lines, respectively.

Table 3.2 was generated with the following input:

```
\begin{center}
\begin{tabular}{|l|l|} \hline
l & left justified column \\ \hline
```

```

        r & right justified column  \\ \hline
        c & centered column          \\ \hline
        $|& & vertical rule          \\ \hline
\end{tabular}
\end{center}

```

You will want to include your table in the "List Of Tables" section at the beginning of your thesis. To do this you enclose the above table inside a table environment like so:

```

\begin{table}
  \begin{center}
    ...
  \end{center}
  \caption{Sentence describing table.}
  \label{unique:label}
\end{table}

```

The caption is the text that appears underneath the table. It should be short and precise. The label is a unique label that you can use to refer to the table within your document. You can use the `\ref{label}` to insert the table number into your text as in Table 3.2. In the example above you would use as in:

I am referring to Table `\ref{unique:label}`.

3.8.2 Figures

The first step to including an externally prepared image into a document, is to declare the `graphixs` package into the documents preamble. Integrating the image can be done using the figure environment. Enter and exit the figure environment with the `\begin{figure}[loc]` and `\end{figure}` commands, respectively. The *loc* dictates the placement of the included image, and can be any of the following:

h here: location in text where the environment appears

t top: top of the page

b bottom: bottom of the page

p page of floats: on a separate page with no text

For organizational purposes, it is best to have keep all figures in a folder together. I usually label the folder as "*Figures*" (with great creativity) and I placed it in the same directory as the topmost main *.tex* file. Include the image into the document with the `\includegraphics[dim]{path to image}` command. *dim* dictates the magnitude of the **height** or **width**. The image is scaled proportionally. An example and its resulting output follow below.

```
\begin{figure}[h]
  \centering
  \includegraphics[height = 1in]{LinuxPenguin.eps}
  \caption{The Linux Penguin}
\end{figure}
```

Why is the output for the figure not shown? Because inserting figures into L^AT_EX is not that simple and it is highly dependent on the system you are using together with the type of figure. This is not the place to dwell upon the inconsistencies which can make your life difficult. Suffice it to say that the original L^AT_EX and its tools was geared to accept *.eps* files for figures and it still maintains that expectation if one compiles using a *Latex to dvi to (pdf or ps)* series of commands. On the other hand, if one uses the *Latex to pdf* direct path, then files of other types are perfectly fine (e.g. *pdf, jpg, gif, etc.*).

If you are interested, look at the actual file for this section namely "sec_latexhelp.tex" and consider the set of lines commented out just above this paragraph. There are two examples of insertion of figures, the first with the *.eps* version and the second with the *.pdf* version of the same picture (of a penguin). Delete the comments from one of the two sets and use the appropriate tools.

To refer to a figure, the same approach used for tables should be used, namely a `\ref{label}` command which includes the unique identifier label for that figure, as in:

I am referring to Figure `\ref{unique:label}`.

3.8.3 Captions

Captions for tables and figures are created using the `\caption{caption goes here}`. Captions are automatically numbered with separate counters for tables and figures. `\caption{caption contents}` can only be used in the Figure or Table environment.

3.8.4 Footnotes

Footnotes are inserted with the `\footnote{footnote contents}` command. This footnote¹ is generated as follows:

...This footnote`\footnote{this is a footnote}` is generated...

3.9 How to Alter Font

3.9.1 Type Style

Roman Family is the default type style. The types style can be modified using the following commands.

Command	Output
<code>\textit{Italic Characters}</code>	<i>Italic Characters</i>
<code>\textsl{Slanted Chartacters}</code>	<i>Slanted Characters</i>
<code>\textsc{Small Cap Characters}</code>	SMALL CAP CHARACTERS
<code>\textbf{Boldface characters}</code>	Boldface characters
<code>\textsf{Sans Serif Characters}</code>	Sans Serif Characters
<code>\texttt{Typewriter Characters}</code>	Typewriter Characters

3.9.2 Type Size

The font size can be modified using the following commands.

Command	Output
<code>\tiny{tiny font}</code>	<small>tiny font</small>
<code>\scriptsize{scriptsize font}</code>	<small>scriptsize font</small>
<code>\small{small font}</code>	<small>small font</small>
<code>\normalsize{normalsize font}</code>	<small>normalsize font</small>
<code>\large{large font}</code>	large font
<code>\Large{Large font}</code>	Large font
<code>\huge{huge font}</code>	huge font
<code>\Huge{Huge font}</code>	Huge font

¹this is a footnote

3.10 Math Mode

To incorporate mathematical content into a document, Latex provides three different environments: Displaymath, Math, and Equation. Brief descriptions for each environment, and environment short cuts are displayed in the table below.

Environment	Function	Shortcut
math	displays an in-text formula	<code>\ (... \)</code>
displaymath	displays an unnumbered formula	<code>\ [... \]</code>
equation	displays a numbered formula	N/A

The following examples, using Einstein's famous $e \doteq mc^2$ equation, illustrate how to include a formula into a document.

...Einstein's famous `\(e \doteq mc^2 \)` equation, illustrate...

`\[e \doteq mc^2\]` $e \doteq mc^2$

`\begin{equation}`

`\doteq mc^2`

`\end{equation}` $e \doteq mc^2$ (3.1)

3.11 Formatting Extras

The following table illustrates some formatting tips for perfecting the layout of a Latex document.

Command	Purpose
<code>\hspace{len}</code>	insert a horizontal space of length <i>len</i>
<code>\vspace{len}</code>	insert a vertical space of length <i>len</i>
<code>\mbox{text}</code>	ensure that <i>text</i> is not split over multiple lines
<code>\\</code>	new line
<code>\newpage</code>	start new page
<code>\pagebreak</code>	insert a page break
<code>%</code>	precedes comments

Chapter 4

Experiments

Assuming you have some experimental results to support your claims this is where all the data is reported. There are a few issues you should consider before dumping a lot of stuff here, or it will lose its effectiveness.

First of all you must describe precisely the experimental setup and the benchmarks you used. In any scientific discipline an experimental result is only good if it is reproducible. To be reproducible then somebody else must have sufficient details of the setup to be able to obtain the same data. Thus the first section in this chapter is a super precise history of the decisions made towards experimentation, including mentions of the paths which became infeasible. The setup must be valid and thus your description of it must prove that it is indeed sound. At times, terrifying times, when writing this section, both supervisor and student realize belatedly that something is missing and more work needs to be done!

The second portion of this chapter is dedicated to the actual results. At least two issues arise here:

1. Should all the data be reported here or should some be placed in the Appendix?
2. Should this be an exposition of the raw facts and data or should it include its analysis and evaluation?

There are no definite answers here, but I follow a few rules.

Should all the data be reported here or should some be placed in the Appendix?

- If there is a large number of tables of data, it might be better to present here only a handful of the most significant ("best") results, leaving all the rest of the data in the Appendix with proper linkages, as it would make the chapter

so much more easily readable (not to mention limiting the struggle with a word processor for the proper placement of tables and text).

- Use an example throughout, call it a "case study" to make it sound better, so that all the data and results are somehow linked in their logic, and even better if this is one of the examples you used in Chapter 2 to describe the original problem.
- Highlight in some manner the important new data, for example the column of your execution speed where all the numbers are much smaller. Make the results highly easy to read!
- It is normally expected that data should be presented only in one form and not duplicated, that is, you are not supposed to include both a table of raw numbers and also its graphical representation from some wonderful Excel wizard. I tend to disagree. I would not wish to see every results repeated in this manner, but some crucial ones need to be seen in different manners, even with the same information content, in order to show their impact. One good trick is to place the more boring tables in the Appendix and use wonderful graphs in this chapter.
- This is the one chapter where I would splurge and use colour printing where necessary, as it makes an *enourmous* difference.

Should this be an exposition of the raw facts and data or should it include its analysis and evaluation?

- Is the evaluation of the data really obvious? For example you have 10 tables to show that your chemical process is faster in development and gives purer material - you may simply need to highlight one column in each table and state the obvious.
- Most results are not that obvious even if they appear so. Moreover this is where you are comparing your *new* results to data from other people. I usually describe other people's work at this point and make comparisons. That is why I prefer to talk about the analysis and evaluation of the results in a separate chapter.
- There is absolutely no clear structure here which is best.

Chapter 5

Evaluation, Analysis and Comparisons

For a Master's research this chapter represents the critical part where **you** are truly evaluated to determine whether you should be given your degree. Even more so for a PhD. Consider carefully what the University calendar states regarding the expectations for a master's thesis, paraphrased here.

1. *A Master's thesis is an original lengthy essay.* The main implication here is that the essay is original, that is, it is completely newly written by you and does not contain any writings from others unless precisely quoted. Any paraphrased items must be cited.
2. *It must demonstrate that:*
 - students understand research methods;
 - students are capable to employ research methods;
 - students demonstrate command of the subject.
3. *The work may be based on:*
 - original data;
 - original exercise from scholarly literature;
 - data by others.
4. *The work must show that:*

- appropriate research methods have been used;
- appropriate methods of critical analysis supplied.

5. *The work must contain:*

- evidence of some new contribution;
- evidence of a new perspective on existing knowledge.

Only the last point uses the attribute *new* and it refers almost entirely to giving a new perspective and analysis, even if based on data from others. This truly implies that this current chapter on evaluation and analysis of results is the most important and must be written with care. You are demonstrating here that, even if given data and methods from others, your skills of critical judgment and analysis are now at the level that you can give professional evaluations.

Things are slightly different for a PhD. According to the Graduate Calendar: *a doctoral dissertation must embody original work and constitute a significant contribution to knowledge in the candidate's field of study. It should contain evidence of broad knowledge of the relevant literature, and should demonstrate a critical understanding of the works of scholars closely related to the subject of the dissertation. Material embodied in the dissertation should, in the opinion of scholars in the field, merit publication.*

The general form and style of dissertations may differ from department to department, but all dissertations shall be presented in a form which constitutes an integrated submission. The dissertation may include materials already published by the candidate, whether alone or in conjunction with others. Previously published materials must be integrated into the dissertation while at the same time distinguishing the student's own work from the work of other researchers. At the final oral examination, the doctoral candidate is responsible for the entire content of the dissertation. This includes those portions of co-authored papers which comprise part of the dissertation.

The second paragraph makes it clear that one must emphasize what is new and different from others, without arrogance, yet without being too subtle either. The first paragraph implies that for a PhD it is required that one approached an important open problem and gave a new solution altogether, making chapters 3, 4, 5 all part of the body of research being evaluated. In fact at times even the problem may be entirely new, thus including chapter 2 in the examination. This is in contrast to a Master's degree where the minimum requirement is for chapter 5 to be original.

Chapter 6

Conclusions

My first rule for this chapter is to avoid finishing it with a section talking about future work. It may seem logical, yet it also appears to give a list of all items which remain undone! It is not the best way psychologically.

This chapter should contain a mirror of the introduction, where a summary of the *extraordinary* new results and their wonderful attributes should be stated first, followed by an executive summary of how this new solution was arrived at. Consider the practical fact that this chapter will be read quickly at the beginning of a review (thus it needs to provide a strong impact) and then again in depth at the very end, perhaps a few days after the details of the previous 3 chapters have been somehow forgotten. Reinforcement of the positive is the key strategy here, without of course blowing hot air.

One other consideration is that some people like to join the chapter containing the analysis with the only with conclusions. This can indeed work very well in certain topics.

Finally, the conclusions do not appear only in this chapter. This sample mini thesis lacks a feature which I regard as absolutely necessary, namely a short paragraph at the end of each chapter giving a brief summary of what was presented together with a one sentence preview as to what might expect the connection to be with the next chapter(s). You are writing a story, the *story of your wonderful research work*. A story needs a line connecting all its parts and you are responsible for these linkages.

Appendix A

Additional Information

This is a good place to put tables, lots of results, perhaps all the data compiled in the experiments. By avoiding putting all the results inside the chapters themselves, the whole thing may become much more readable and the various tables can be linked to appropriately.

The main purpose of an Appendix however should be to take care of the future readers and researchers. This implies listing all the housekeeping facts needed to continue the research. For example: where is the raw data stored? where is the software used? which version of which operating system or library or experimental equipment was used and where can it be accessed again?

Ask yourself: if you were given this thesis to read with the goal that you will be expanding the research presented here, what would you like to have as housekeeping information and what do you need? Be kind to the future graduate students and to your supervisor who will be the one stuck in the middle trying to find where all the stuff was left!

Bibliography

- [1] Cliff Atkinson. *Beyond Bullet Points: Using Microsoft Office PowerPoint 2007 to Create Presentations That Inform*. Microsoft Press, 2008.
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