Possible Organization for Writing a Thesis including a LaTeXFramework 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)

Dr. Outside Member, Outside Member
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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 LaTeXare included as a bonus for beginners.

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I would like to thank:

my cat, Star Trek, and the weather, for supporting me in the low moments.

Supervisor Main, for mentoring, support, encouragement, and patience.

Grant Organization Name, for funding me with a Scholarship.

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 term *Trojan Horse* or *Trojan* has become a modern metaphor for a deception where by an unsuspecting victim welcomes a foe into an otherwise safe environment. [10] Though modern civilization rarely has need for large walls we are similarly surrounded. Not by stone and mortar but by the technology we so heavily rely on. These days it is more common to come across a piece of equipment with some form of computer in it than without. They provide us entertainment, education, security, monitor our health, grow our food and more. Our reliance make us susceptible to their compromise. Since the dawn of the computer we have dealt with software threats; we are almost as good as protecting ourselves against them as they are at attacking us. In recent years a new incarnation of danger has emerged; in hardware. In this new arena of attack and defend those who seek to defend are far behind.

1.1 Motivation

In the summer of 2007 an Israeli military action referred to as Operation Orchard commenced. A group of F-15I Ra'am fighter jets from the Israeli Air Force 69th Squadron took off to attack a suspected nuclear reactor in neighboring Syria. In the flight path was a Syrian radar station which boasted 'state-of-the-art' aircraft detection and neutralization technology. The Israeli war planes were able to approach and destroy the installation undetected. Though never proven it is commonly accepted that the detection mechanism was deactivated by a back-door circuit inserted into the radar system. [7] In 2011 over 1300 cases were reported to the Electronic Resellers Association International (ERAI) of modified ICs and the occurrence has been going

up. [1] Integrated Circuits (IC) are a large part of modern life yet it is easy to forget that they drive virtually every piece of technology used today. Ensuring their ICs run our devices as expected is vital in the digital era. Since their discovery there has been concerted effort to detect hardware trojans. [4]

1.2 Contributions

1.3 Organization

Chapter 2

Hardware Trojans

2.1 Background

Integrated Circuits (IC) are continuously decreasing in size whilst increasing in complexity. These trends require ever more people and sophisticated means of manufacture which in turn creates security vulnerabilities. Products developed by semiconductor companies generally compromised in one of two ways. First, due to the complexity it is rare for a product to be managed within a single company. Frequently, steps in the production-chain are outsourced. It is within these 'third-party' contributors that products can be maliciously modified. Secondly, for various reasons, employees of trusted contributors have been known to make modifications. [2] These modifications are known as hardware Trojans. ICs are an integral part of every facet of the modern world. Proper application of a Trojan can provide information, control of mechanical systems, surveillance and more to an unauthorized party.

2.2 Topology

The discussion, detection and evaluation of hardware trojans requires a comprehensive means of description. Several hardware trojan taxonomies have been proposed [3, 6, 8, 9]. In [9], trojans were organized based solely on their activation mechanisms. A taxonomy based on the location, activation and action of a trojan was presented in [6], [3]. However, these approaches do not consider the manufacturing process. Another taxonomy was proposed in [8] which employs five categories: insertion, abstraction, activation, effect, and location. While this is more extensive than

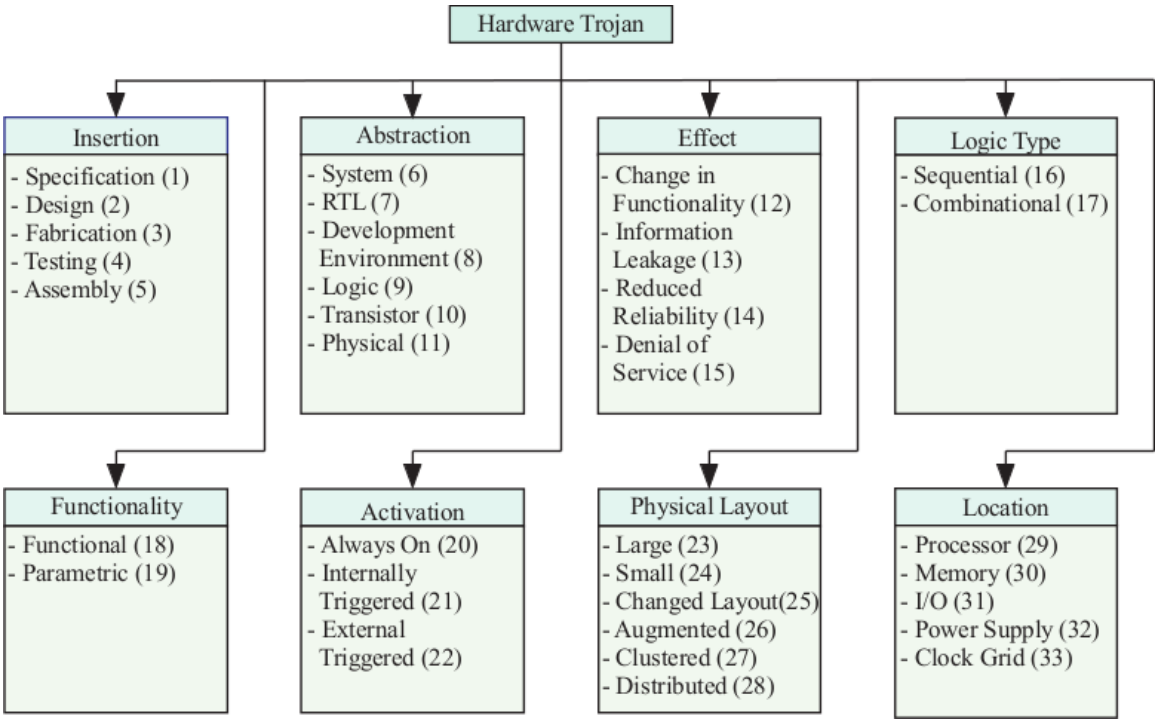

Figure 2.1: The thirty-three attributes of the hardware trojan taxonomy in [5].

previous approaches, it fails to account for the physical characteristics of a trojan. An additional taxonomy was proposed in [5] which considers all attributes a hardware trojan may posses. This taxonomy is the most comprehensive and was selected as the means of description for this work. It is comprised of thirty-three attributes organized into eight categories as shown in Fig. 2.1. These categories can be arranged into the following four levels as indicated in Fig. 2.2.

1. The **insertion** (chip life-cycle) level/category comprises the attributes pertaining to the IC production stages.

2. The **abstraction** level/category corresponds to where in the IC abstraction the trojan is introduced.

3. The **properties** level comprises the behavior and physical characteristics of the trojan.

4. The **location** level/category corresponds to the location of the trojan in the IC.

The properties level consists of the following categories.

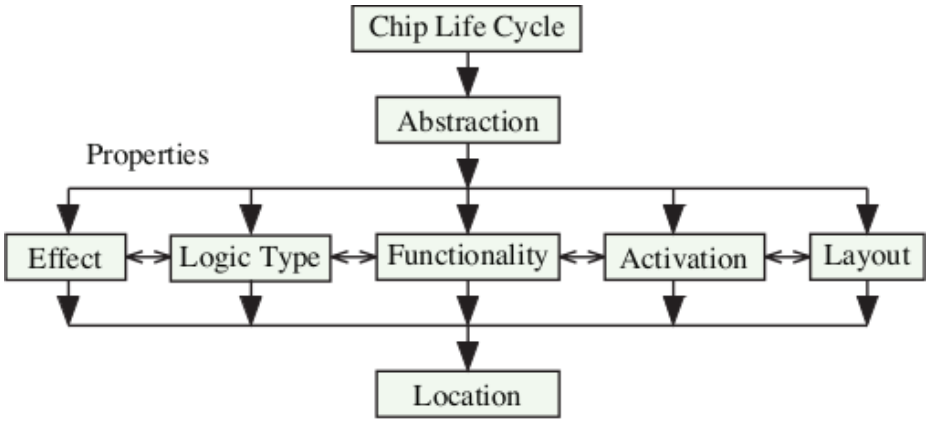

Figure 2.2: The hardware trojan levels [5].

- The **effect** describes the disruption or effect a trojan has on the system.
- The **logic type** is the circuit logic that triggers the trojan, either combinational or sequential.
- The **functionality** differentiates between trojans which are functional or parametric.
- The **activation** differentiates between trojans which are always on or triggered.
- The **layout** is based on the physical characteristics of the trojan.

The relationships between the trojan attributes shown in Fig. 2.1 can described using a matrix $\mathbf{R}$ [5]. Entry $r(i,j)$ in $\mathbf{R}$ indicates whether or not attribute i can lead to attribute j. For example, $r(2,3) = 1$ indicates that design (attribute 2) can lead to fabrication (attribute 3). This implies that if an IC can be compromised during the design phase (attribute 2), it may influence the fabrication phase (attribute 3).

The matrix $\mathbf{R}$ is divided into sub matrices as follows

$$\mathbf{R} = \begin{bmatrix} \mathbf{R_1} & \mathbf{R_{12}} & 0 & 0 \\ 0 & \mathbf{R_2} & \mathbf{R_{23}} & 0 \\ 0 & 0 & \mathbf{R_3} & \mathbf{R_{34}} \\ 0 & 0 & 0 & \mathbf{R_4} \end{bmatrix}$$

$$\mathbf{R} =$$

A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	0	1	0	0	0	1	0	0	0	0	0																						
2	0	0	1	0	0	0	1	0	0	0	0																						
3	0	0	0	1	0	0	0	0	0	0	1																						
4	0	0	0	0	1	1	0	0	1	0	0																						
5	0	0	0	0	0	1	0	0	0	0	0																						
6						0	1	0	0	0	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0					
7						0	0	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	1	0	0	0	0					
8						0	0	0	1	0	0	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1					
9						0	0	0	0	1	0	1	0	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0					
10						0	0	0	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	1	0	1	1	0					
11						0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	0	0	1	1	1	1	1	1					
12												0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13												0	0	0	0	0	1	0	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1
14												0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1
15												0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1
16												1	0	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1
17												1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18												1	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19												0	1	1	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	1	1	1
20												1	1	1	1	0	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1
21												1	0	0	1	1	1	1	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1
22												1	1	0	1	1	1	1	0	0	0	0	0	1	0	1	1	0	1	1	1	1	1
23												1	0	0	1	1	1	1	0	1	1	0	0	0	1	1	1	1	1	1	0	0	0
24												1	1	1	1	0	1	1	1	1	1	1	0	0	0	1	1	0	1	1	1	1	1
25												1	0	0	1	1	1	1	0	1	0	0	1	0	0	1	1	0	1	1	1	1	1
26												1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
27												1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1
28												1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	1
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where $\mathbf{R_1}$, $\mathbf{R_2}$, $\mathbf{R_3}$ and $\mathbf{R_4}$ indicate the attribute relationships within a category. For example, $\mathbf{R_1}$ is given by

$$\mathbf{R_1} = \left[\begin{array}{c|ccccc} A & 1 & 2 & 3 & 4 & 5 \\ \hline 1 & 0 & 1 & 0 & 0 & 0 \\ 2 & 0 & 0 & 1 & 0 & 0 \\ 3 & 0 & 0 & 0 & 1 & 0 \\ 4 & 0 & 0 & 0 & 0 & 1 \\ 5 & 0 & 0 & 0 & 0 & 0 \end{array}\right]$$

Submatrix $\mathbf{R_{12}}$ relates the attributes of the insertion category to the attributes of the abstraction category. An example of this submatrix is

$$\mathbf{R_{12}} = \left[\begin{array}{c|cccccc} A & 6 & 7 & 8 & 9 & 10 & 11 \\ \hline 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 1 & 0 & 0 & 0 & 0 \\ 3 & 0 & 0 & 0 & 0 & 0 & 1 \\ 4 & 1 & 0 & 0 & 1 & 0 & 0 \\ 5 & 1 & 0 & 0 & 0 & 0 & 0 \end{array}\right]$$

2.3 Field Programmable Gate-Arrays (FPGA)

An IC belongs to one of two categories. An Application Specific Integrated Circuit (ASIC) or a Field Programmable Gate-Array (FPGA). An ASIC is manufactured once and is immutable; its hardware is permanently printed in silicon. FPGAs are reconfigurable. They are comprised of an array of Programmable Logic Devices (PLD). A PLD is a component whose functionality is dependent on a set of configuration options. Each PLD in and FPGA device receives a series of configuration instructions in the form of a binary message. A single FPGA can contain hundreds, or even thousands of PLDs, each of which can be one of hundreds of possible different types. The messages from all PLDs comprise the configuration Bitstream for the whole device. FPGA developers create processor designs using a programming language; the design is then downloaded or "configured" onto the device via the Bitstream. The design process is simpler and modifications can be made after manufacture. Because of this, FPGAs are becoming the IC of choice in larger scale productions however these same features increase their vulnerability.

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 LaTeX 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[11*pt*]{*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**
\pagenumbering{arabic}	1, 2, 3, ...
\pagenumbering{roman}	i, ii, iii, ...
\pagenumbering{alph}	a, b, c, ...
\pagenumbering{Roman}	I, II, III, ...
\pagenumbering{Alph}	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 LaTeX.

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 it's 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 LaTeXis 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 LaTeXand 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 footnote[1] 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**
\textit{Italic Characters}	*Italic Characters*
\textsl{Slanted Chartacters}	*Slanted Characters*
\textsc{Small Cap Characters}	Small Cap Characters
\textbf{Boldface characters}	**Boldface characters**
\textsf{Sans Serif Characters}	Sans Serif Characters
\texttt{Typewriter Characters}	`Typewriter Characters`

3.9.2 Type Size

The font size can be modified using the following commands.

Command	**Output**
\tiny{tiny font}	tiny font
\scriptsize{scriptsize font}	scriptsize font
\small{small font}	small font
\normalsize{normalsize font}	normalsize font
\large{large font}	large font
\Large{Large font}	Large font
\huge{huge font}	huge font
\Huge{Huge font}	Huge font

[1] this is a footnote

3.10 Math Mode

To incorperate 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`	`\ ( ...\ )`
`displaymath`	`displays an unnumbered formula`	`\ [ ...\ ]`
`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}
```
$$e \doteq mc^2 \tag{3.1}$$

3.11 Formatting Extras

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

Command	**Purpose**
`\hspace{`*len*`}`	`insert a horizontal space of length` *len*
`\vspace{`*len*`}`	`insert a vertical space of length` *len*
`\mbox{`*text*`}`	`ensure that` *text* `is not split over multiple lines`
`\\`	`new line`
`\newpage`	`start new page`
`\pagebreak`	`insert a page break`
`%`	`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 the 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 Masters 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!

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