University of Cape Town

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I know the meaning of plagiarism and declare that all of the work in the dissertation, save for that which is properly acknowledged, is my own.

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Abstract

The abstract should be a one or two paragraph summary of your paper. It is meant to sell your paper to interested buyers.

Contents

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Nomenclature

1 Acronyms

A ..... Amperes

AC ..... Alternating Current

ADC ..... Analogue to Digital Converter

API ..... Application Programmer's Interface

ARM ..... Advanced RISC Machine

ASIC ..... Application Specific Integrated Circuit

AXI ..... Advanced Extensible Interface

BAR ..... Base Address Register

BCD ..... Binary-Coded Decimal

Bd ..... Baud, in symbols per second

CFAR ..... Constant False Alarm Rate

CMOS ..... Complimentary Metal-Oxide Semiconductor

CPLD ..... Complex Programmable Logic Device

dBm ..... Deci-Bell, relative to 1 mW

DC ..... Direct Current

DDC ..... Digital Down Converter

DDS ..... Direct Digital Synthesis

DMA ..... Direct Memory Access

DSP ..... Digital Signal Processor (or processing)

EDA ..... Electronic Design Automation

FIFO ..... First-in, First-out (queue)

FIR ..... Finite Impulse Response

FMC ..... FPGA Mezzanine Card

FPGA ..... Field Programmable Gate Array

FSM ..... Finite State Machine

GUI ..... Graphical User Interface

HDL ..... Hardware Description Language

HPS ..... Hard Processor System

HSTL ..... High Speed Transfer Logic

I/O ..... Inputs/Outputs

I^2C ..... Inter-IC

IC ..... Integrated Circuit

IDE ..... Integrated Development Environment

LE ..... Logic Element

LSb ..... Least Significant Bit

LSB ..... Least Significant Byte

LUT ..... Look-Up Table

LVCMOS ..... Low Voltage Complementary Metal Oxide Semiconductor

LVDS ..... Low Voltage Differential Signalling

LVPECL ..... Low Voltage Positive Emitter Coupled Logic

LVTTL ..... Low Voltage Transistor-Transistor Logic

MIMO ..... Multiple Input Multiple Output

MISO ..... Master Input / Slave Output

MOSI ..... Master Output / Slave Input

MSb ..... Most Significant Bit

MSB ..... Most Significant Byte

MSI ..... Message Signalled Interrupt

NCO ..... Numerically Controlled Oscillator

NTP ..... Network Time Protocol

PC ..... Personal Computer

PCB ..... Printed Circuit Board

PCI ..... Peripheral Component Interconnect

PCIe ..... PCI Express

PLL ..... Phase Locked Loop

PPDS ..... Point-to-Point Differential Signalling

PRF ..... Pulse Repetition Frequency

PRI ..... Pulse Repetition Interval

PSU ..... Power Supply Unit

RADAR ..... Radio-Assisted Direction and Ranging

REST ..... Representational State Transfer

RF ..... Radio Frequency

RISC ..... Reduced Instruction Set Computer

RMS ..... Root Mean Square

RPM ..... Revolutions per Minute

RSDS ..... Reduced Swing Differential Signalling

SI ..... Système International d'Unités

SoC ..... System On Chip

SPI ..... Serial Peripheral Interface

SSTL ..... Stub Series Terminated Logic

TCP ..... Transmission Control Protocol

TTL ..... Transistor-Transistor Logic

UART ..... Universal Asynchronous Receiver Transmitter

UDP ..... User Datagram Protocol

UFM ..... User Flash Memory

URL ..... Uniform Resource Locator

V ..... Voltage

VHDL ..... VLSI HDL

VLSI ..... Very Large-Scale Integration

XML ..... eXtensible Markup Language

2 Terminology

Developer	FPGA firmware developer, using any firmware development tool.
Device	The specific target FPGA.
Megafunction	A target-specific module, typically generated from within the vendor IDE, after the Altera nomenclature.
Module	Akin to a Verilog module; i.e. unit of digital circuit that has ports to the outside world and can exist at any level of the design hierarchy.
Object file	An intermediary file used in the ALCHA compilation process. It is the reult of compiling a single translation unit and describes a collection of objects.
Peripheral	Any device, external to the FPGA, that interfaces directly with the FPGA.
Platform	The platform that the ALCHA compiler runs on, including operating system and computer hardware.
Target	The platform ALCHA is compiling to, including FPGA, PCB, peripherals and vendor IDE.
Translation unit	Akin to a C language translation unit, i.e. a collection of source files and headers that translate to a single object file
User	The developer who is using ALCHA to develop FPGA firmware.
Vendor	The FPGA manufacturer.

Chapter 1

Introduction

1.1 Preamble Concerning Use of Latex

If you are new to LaTeX, I would suggest reading [2]. If you want to use Microsoft Word (or one of its many clones), you can download the official IEEE conference template from [3]. The TA and tutors can provide LaTeX support. Use Word at your own risk.

The introduction is where you set the scene. Here you reference other, related work, as well as a summary relating to how you improve upon said work [4]. In the sense of the practical reports, the introduction will summarise the experiment the practical is all about.

As a general rule of thumb, keep the introduction to the first column and don't put any sub-sections into it.

Remember that, for bibliography citations to work, you have to include running BibTeX in the compile chain. My TeXstudio [5] compile chain for "Build & View" is

```
txs:///bibtex | txs:///pdflatex |
txs:///bibtex | txs:///pdflatex |
txs:///view-pdf-internal
```

1.2 Drafting Markup

When the template is in draft mode, you can use various helper macros, as illustrated below:

When compiled with `\Draftfalse`, the content of these macros are removed from the output, except something that needs to be rephrased.

1.3 Introduction Advice

Introduction Funnel - a general guide

The introduction, and especially the first paragraph, is a key part of your thesis or dissertation. First impressions matter! This comment goes together with the abstract, but in a way the start of the introduction is in a may setting an even more important first impression (as examiners know that an abstract is often a short piece that is highly polished and possibly not entirely representative of the quality that will appear later.)

You want to start off with a "fantastic opening paragraph" and the lead-in to the topic (I call this the "once upon a time" part of the thesis, which is setting the scene for your 'story'... I mean study). I suggest the use of the "funnel approach" that is illustrated below.

For introducing your dissertation, you essentially want to start broad and then focus in, getting to the main point of the focus. When you've got all the way to the scope, which explains some of the lower level details of e.g. specific context(s) of focus or aspects of exclusion, then one can transition (on something of a new tack) to explaining the outline of the dissertation, what chapters will follow and a brief summary of these, but without giving too much interesting points and findings away in these summaries of the chapters.

```
-----------------------
\ (start on Ch1 Into) /
 \    Background     /
 |      Terms       |  (optional)
 \  Problem Desc   /  (general problem -- may want to jump into objectives)
  \   Objective   /
   \  Spec Probs /    (specific problems to study)
    \ Questions /     (this is the research question you need to answer)
     \   ToR   /      (i.e. Terms of reference, requirements, function, getting very specific)
      \ Scope /       (discussing details of specific nitty gritty focus, things to leave out etc)
       | DiP |        (DIssemination Plan; optional - but highly recommended)
        -----         (you kind of close off with the disemination plan, which is ulitimately
        |   |         the delivery of your work to the wider audience)
        -----
       /     \        Then you can go on with (a somewhat different theme)
      /       \       that is the structure of the thesis
```

```
  / Overview\
 / of Thesis \
/             \
|(end of Intro)|
----------------
```

Chapter 2

Literature Review

2.1 Suggested Approach

As with suggestions provided concerning the Introduction, in which a funnel type of approach was suggested, essentially going from broader issues to more specific ones, a similar approach can be highly effective for the literature review. A literature review is one of the most difficult chapters to write, and particularly when it comes to deciding what should – and should not – be provided. Often students provide too much, and go into an excessive amount of detail, on things covered in the literature review. A guiding principle is demonstrating your awareness of the field and related works that are (or could) guide your work, are important to consider (eg. standards) or that you are building upon. You do not really want to have a literature review that are essentially recreating lecture notes or summaries on the theory; certainly in some case you do need brief recaps of techniques or theories (especially with references to direct the reader to resources where they can touch up on their understanding of the issues covered) – MSc student in particularly are likely going to need advice from their supervisor in making an effective choice of what should be, and should not be, recapped in the literature review.

The Figure 2.1 provides an illustration of a suggested "funnel structure" around which you could build your literature review. This structure should work for either BSc, MSc or PhD and the difference between them (e.g. BSc towards PhD) is the scale, scope, complexity and novelty of these. For example, a BSc will be small scale (often just a very specific gap in knowledge, if any; it might be more a build and test rather than a finding something to fill a knowledge gap) and not so complex and might not even have any novelty. A MSc would be a bit larger in scale (but not too much), more complex (likely more things happening and

more complicated connections between these) and hopefully (but not necessarily) having some novelty (for a MSc it could just be using a different platform e.g. a Raspberry Pi instead of an Arduino to trial an embedded solution). A PhD is of course quite a step up from a MSc in terms of scope, complexity, and certainly is needed to be proven a novel contribution in that it has added new knowledge (i.e. filled a non-trivial gap in the research literature).

The parts of the literature review funnel structure are explained briefly in the points below. Note that you do not really want to just use these bullet points for the names of the subheadings of you lit review, you need to think a bit more about what would be suitable heading names and sequencing of these. These tips are only suggestions to help you think about how to construct you literature review and should not be considered a prescribed structure or method to use (theses do tend to be quite unique, there is not really one method that would works for all cases, generally it is built through a process of reviewing what others have done, writing and reworking the document).

- Intro: Start with explaining how the approach to the lit review and its structure.
- Locate: Entry to the top funnel, outlining what you will cover. Start drilling down, the field, broad theories. Cover significant aspects of main thinking/trends you are plugging in to.
- Gap(s): Ideally bring the discussion towards a point that you identify gaps in research or areas that need further investigation.
- Targeted gap: Of the various gaps identified indicate which one(s) you will focus on in this project (for BSc/MSc probably just one gap; PhD may have more but not too many).
- Focus of approach Get into the more specific issues, techniques that will be used to solve the problem and review these theories/methods/tools. At the same time you may cover a few 'alternate approaches' that could inspire your approach or what you are learning from to refine the approach you have chosen, learning from past attempts or similar types of investigation (they obviously don't need to be trying to do the same thing but some relation/relevance to your project).
- Selection / Details: At this part you get into more specifics of potential development tool or library you planning to use and why. This can be handled fairly easily, e.g. doing brief literature surveys, e.g. web searches, on what are the most popular tools. Could expanded by describing a methodology to use for selecting these tools, the result of this could be tables showing the tool/library options, their pros and cons*. The tool rated best could be the one to choose in the project.

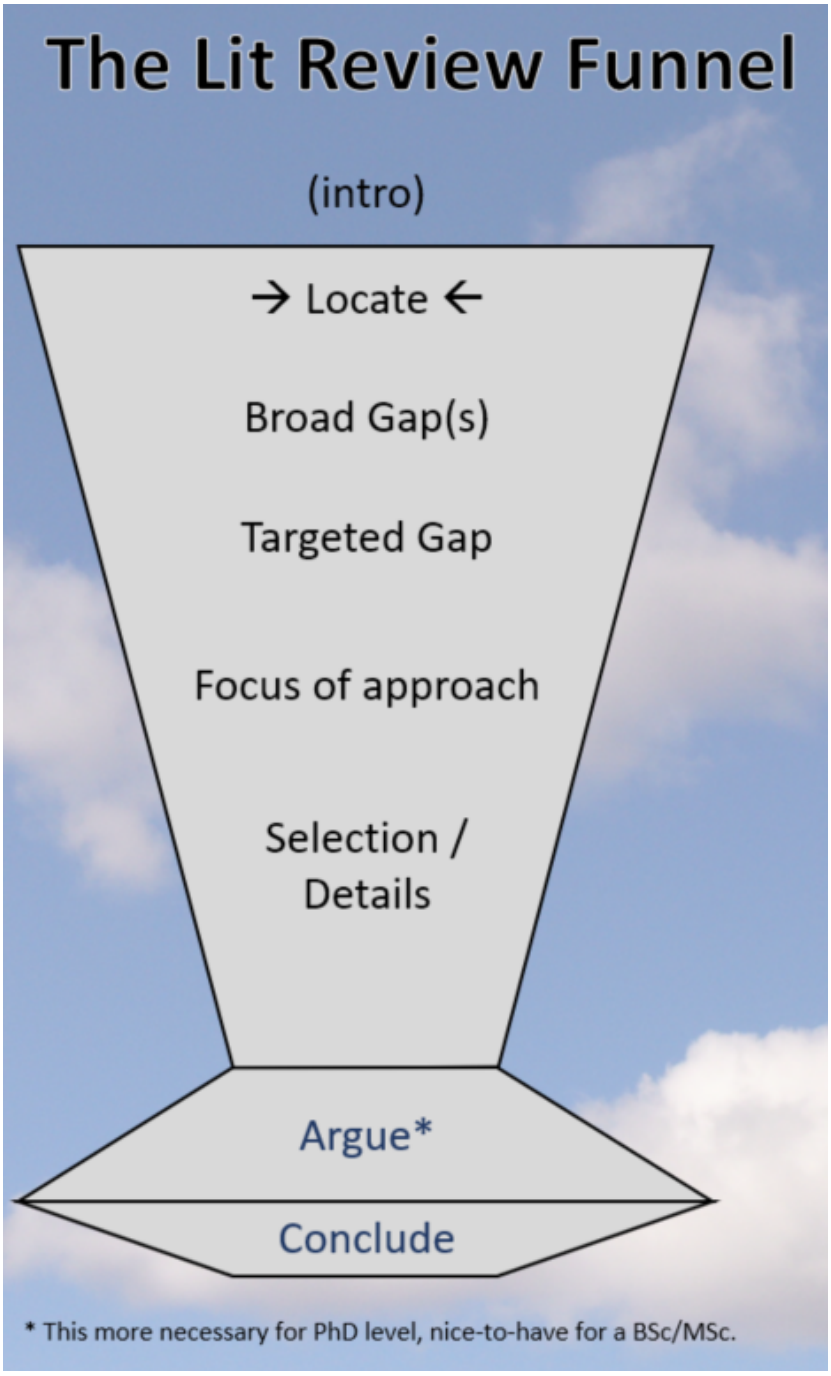

Figure 2.1: Literature review funnel structure

- Argue: Nice-to-haves (emphasising 'the researcher' and research benefits) Broaden out with argument, identifying new knowledge needed, how this research investigation will contribute new understanding. This part depends on space availability*.
- Conclude/Summary: Definitely, try to close in some elegant way. Could be done with a short summary of key observations/gaps and useful theories/methods you'll build on. For an e.g. PhD proposal in particular you could end it by justifying (reaffirming the need for) this research.
- *: items marked by asterisk are more necessary for PhD level, but still a nice-to-have for a BSc/MSc dissertation.

Chapter 3

Methodology

In this section you should describe the method followed in your research project, which for an engineering case is typically the development and experimentation of the system that is developed to solve a problem together with how testing of the system was carried out to show that it indeed solved the problem or at least to what extent it solved the problem (note that, yes, unfortunately it is sometimes not possible to provide an effective solution – it may be too expensive or take to long to solve properly – but even then it can still be considered a contribution of knowledge and still have some value as a research investigation.).

Methodology vs Design: A vitally important terminology consideration is to realize that methodology is not the same as design. This is a common confusion amongst students who have not done a research project or written a thesis before. This short explanation should suffice to ensure you understand the difference:

- Methodology: this describes how you are going to go about doing the research project. It describes the main high-level steps (or phases) of the project. It does not detail design or pieces of your design. You should not need any block diagrams in the design.
- Design: this is what you have built (or are going to build). It includes diagrams, system block diagram, flow charts, pseudocode/algorithms, schematics, etc. Generally, in a computing-related project, it will end off with implementation details (actual code snippets). These implementation details, depending on how much there are of them, may be better placed in a separate Implementation chapter. Similarly, you might decide to have a separate Integration chapter if there are a lot of pieces that takes quite a bit of explaining and diagrams to describe how they connect and work together.

3.1 Experiment Procedure

Furthermore, include detail relating to the experiment itself: what did you do, in what order was this done, why was this done, etc. What are you trying to prove / disprove? You can include hypotheses, such as presented in Hypothesis H0 below.

Hypothesis H0: All scientific papers contain hypotheses. An hypothesis is generally not longer than a single paragraph, but the command does support multiple paragraphs if required.

Chapter 4

Design

4.1 Hardware

Include detail such as the hardware used. It's generally a good idea to include a block diagram at this point, such as the one presented in Fig. 4.1. This figure was drawn in InkScape [6]. When you want to import an InkScape figure (SVG format) into LaTeX, simply save it to PDF (use the drawing extents as the media box area) and include the figure.

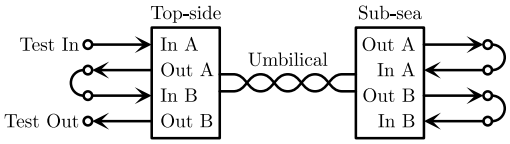

Fig. 4.1. Test setup used to test the implementation [1].

4.2 Implementation

Also mention the implementation source code:

```
# You can include inline Matlab / Octave code
x = linspace(0, 2*pi, 1000);
y = sin(x);
plot(x, y); grid on;
```

Or you could turn it into a float: see listing 4.1. Floats are tables, figures and listings that appear at a different place than in the source code. This template is set up to put floats at

the top of the next column, as prescribed by the IEEE article specification.

```
__kernel void Multiply(
__global float* A, // Global input buffer
__global float* B, // Global input buffer
__global float* Y, // Global output buffer
const  int    N  // Global uniform
){
        const int i = get_global_id(0); // 1st dimension index
        const int j = get_global_id(1); // 2nd dimension index

        // Private variables
        int   k;
        float f = 0.0;

        // Kernel body
        for(k = 0; k < N; k++) f += A[i*N + k] * B[k*N + j];
        Y[i*N + j] = f;
}
```

Listing 4.1. OpenCL kernel to perform matrix multiplication

Only list what is relevant. Don't give too much detail - just enough to show what you've done. This template supports the following languages:

- Matlab (Octave)
- GLSL
- OpenCL
- Verilog
- VHDL
- TCL
- Python
- C++ (use the name 'Cpp')

Chapter 5

Experimentation

Chapter 6

Results

The results section is for presenting and discussing your findings. You can split it into subsections if the experiment has multiple sections or stages.

6.1 Figures

Include good quality graphs (see Fig. 6.1). These were produced by the Octave code presented in listings 6.1 and 6.2. You can play around with the `PaperSize` and `PaperPosition` variables to change the aspect ratio. An easy way to obtain more space on a paper is to use wide, flat figures, such as Fig. 6.2.

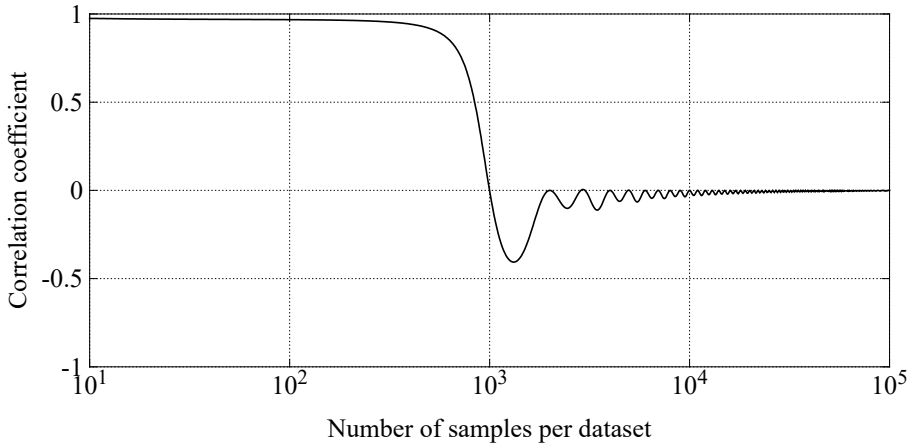

Fig. 6.1. The correlation coefficient as a function of sample count.

```
function FormatFig(X, Y, File);
  set(gcf, 'PaperUnits'      , 'inches');
  set(gcf, 'PaperOrientation', 'landscape');
  set(gcf, 'PaperSize'       ,       [8, 4]);
  set(gcf, 'PaperPosition'   , [0, 0, 8, 4]);

  set(gca, 'FontName', 'Times New Roman');
  set(gca, 'Position', [0.1 0.2 0.85 0.75]);

  xlabel(["\n" X]);
  ylabel([Y "\n\n"]);

  setenv("GSC", "GSC"); # Eliminates stupid warning
  print(...
    [File '.pdf'],...
    '-dpdf'...
  );
end
```

Listing 6.1. Octave function to format a figure and save it to a high quality PDF graph

```
figure;                                  # Create a new figure
# Some code to calculate the various variables to plot...
plot(N, r, 'k', 'linewidth', 4); grid on; # Plot the data
xlim([0 360]);                           # Limit the x range
ylim([-1 1]);                            # Limit the y range
set(gca, 'xtick', [0 90 180 270 360]);   # Set the x labels

FormatFig(...                            # Call the function with:
  'Phase shift [\circ]',...                    # The x title
  'Correlation coefficient',...                # The y title
  ['r_vs_N;_f=' num2str(f) ';_P=' num2str(P)]... # Format the file name
);
close all;                               # Close all open figures
```

Listing 6.2. Example of how to use the FormatFig function

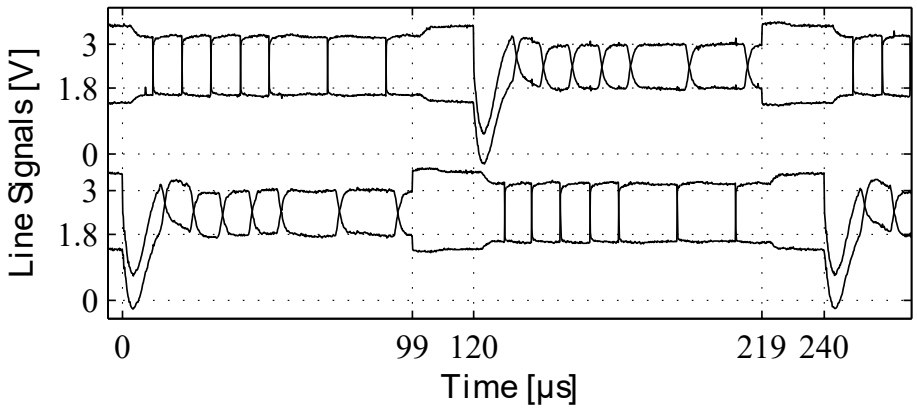

Fig. 6.2. Oscilloscope measurement showing physical line signals on both ends of a transmission line during master switch-over [1].

Always remember to include axes text, units and a meaningful caption in your graphs. When typing units, a µ sign has a tail! The letter "u" is not a valid unit prefix. When typing resistor values, use the Ω symbol.

6.2 Tables

Tables are often a convenient means by which to specify lists of parameters. An example table is presented in table 6.1. You can use Tablesgenerator to make your LaTeX tables.

TABLE 6.1

My Informative Table

Heading 1	**Heading 2**	**Heading 3**
Data	123	321
Data	456	654
Data	789	987

6.3 Pictures and Screen-shots

When you include screen-shots, pdfLaTeX supports JPG and PNG file formats. PNG is preferred for screen-shots, as it is a loss-less format. JPG is preferred for photos, as it results in a smaller file size. It's generally a good idea to resize photos (not screen-shots) to be no more that 300 dpi, in order to reduce file size. For 2-column article format papers, this translates to a maximum width of 1024. **Never change the aspect ratio of screen-shots and pictures!**

It is highly recommended to make use of the `\Figure` macro for figures. It puts all the formatting tweaks in one place, so that you don't need to update all the individual figure inclusion points when you want to do a styling update. The file name is used for the LaTeX label, such as "Fig. 6.3".

Fig. 6.3. An example image with custom scaling

Make sure to always use the best quality image possible. Use JPEG for photos, PNG for screen-shots and PDF (scalable vector graphics) for everything else. JPEG is lossy, but good for photos, whereas PNG is lossless and good for images with large areas of solid colour, as can be seen in Fig. 6.4.

(a) JPEG (b) PNG (c) SVG

Fig. 6.4. Comparison of various image format qualities

6.4 Maths

LaTeX has a very sophisticated maths rendering engine, as illustrated by equation 6.1. When talking about approximate answers, never use ± 54 V, as this implies "positive or negative 54 V". Use ≈ 54 V or ~ 54 V instead.

$$y = \int_0^\infty e^{x^2} \mathrm{dx} \tag{6.1}$$

Chapter 7

Conclusion

The conclusion should provide a summary of your findings. Many people only read the introduction and conclusion of a paper. They sometimes scan the tables and figures. If the conclusion hints at interesting findings, only then will they bother to read the whole paper.

You can also include work that you intend to do in future, such as ideas for further improvements, or to make the solution more accessible to the general user-base, etc.

Publishers often charge "overlength article charges" [7], so keep within the page limit. In EEE4084F we will simulate overlength fees by means of a mark reduction at 10% per page. Late submissions will be charged at 10% per day, or part thereof.

Bibliography

[1] J. Taylor and J. G. Hoole, "Robust Protocol for Sending Synchronisation Pulse and RS-232 Communication over Single Low Quality Twisted Pair Cable," in *Proceeding of ICIT*. Taiwan: IEEE, Mar. 2016.

[2] T. Oetiker, H. Partl, I. Hyna, and E. Schlegl, "The Not So Short Introduction to LaTeX 2_ε," https://tobi.oetiker.ch/lshort/lshort.pdf, Jul. 2015, version 5.05.

[3] "IEEE Conference Paper Templates," http://www.ieee.org/conferences_events/conferences/publishing/templates.html.

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Appendix A

Item 1

Appendix B

Item 2