Thesis Template Created with a Little Help from Artifical Intelligence

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PhD Thesis

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Contents

Abstract

Writing a compelling abstract for a Ph.D. thesis requires conciseness, clarity, and the ability to convey the significance of your research. Here are some tips to help you craft an effective abstract. (1) Clearly State the Problem: Begin by clearly stating the problem or question your research addresses. Be concise and specific about the problem you are investigating. (2) Highlight the Objective: Clearly state the main objective of your research. What are you contributing to the field of study? Make it evident how your work fits into the broader context. (3) Provide a Brief Overview of Methods: Mention the key methods used in your research. Briefly explain the tools or frameworks you used to address the problem. However, avoid going into excessive detail. (4) Present Key Results: Summarize the main findings and results of your research. Highlight any breakthroughs, novel insights, or contributions your work has made to the field. (5) Contextualize the Significance: Communicate the significance and relevance of your research. Explain how your findings contribute to and address gaps in the field. (6) Use Concise and Accessible Language: Write in a clear, concise, and accessible language. Avoid unnecessary jargon that may be unclear to readers outside your specific subfield of study. Remember that the abstract serves as a short summary of your entire Ph.D. thesis. It provides readers with a quick overview of your research. Striking the right balance between conciseness and informativeness is key. Put your best foot forward without overstating your findings.

About the Author

When writing about yourself, highlight your academic background, research interests, accomplishments, and any relevant experiences. Here are some tips to help you craft an effective blurb. (1) Start with a Strong Opening: Begin with a concise and engaging statement that captures the reader's attention. For example, you might start with a brief description of your academic journey or research focus. (2) Highlight Your Academic Background: Provide a brief overview of your academic qualifications, including your degree(s) and any relevant academic honors or awards you have received. (3) Emphasize Your Research Interests: Clearly articulate your research interests and the topics you are passionate about. Briefly mention any specific areas of mathematics or related fields that you have focused on in your thesis work. (4) Showcase Your Accomplishments: Highlight any significant achievements or contributions you have made in your field. This could include publications, conference presentations, research projects, or collaborations. (5) Include Relevant Experiences: Mention any relevant academic or professional experiences that have shaped your research interests and expertise. This could include internships, research assistantships, teaching positions, or involvement in academic societies.

Chapter 1

Introduction

In the introduction, you should describe what your thesis is about, how the thesis is organised, and what the reader can expect as they read down through it. The most important aspect of the introduction is to set the context for the rest of the thesis. You should sign-post for the reader the most important parts of your work and where they appear in the document. In LaTeX, you should refer to sections, tables, and figures using commands rather than specifying a page or saying "the table below". The `ref` command will keep track of changes to the layout to the document. So, for example, I can just refer to Section 2 rather than worrying where that might move to in future. Note to refer to an item in the bibliography, you use the `cite` command, which should generally be placed after a `tilde(~)` rather than a space [1].

1.1 What Should be Included Here

The introduction chapter of a Ph.D. thesis serves as the gateway to your research and sets the stage for the reader to understand the context, significance, and objectives of your study. Here's a comprehensive guide on what to include in the introduction chapter.

Background and Context

Provide an overview of the broader field of study and the specific research area your thesis addresses. Discuss the historical background, key concepts, theories, and previous research relevant to your topic.

Research Problem and Motivation

Clearly articulate the research problem or question your thesis aims to address. Explain why this problem is significant and worthy of investigation. Discuss any gaps or limitations in existing literature that your research seeks to fill.

Objectives and Research Questions

State the objectives of your research and the specific research questions you seek to answer. These objectives should be clear, specific, and aligned with the overall purpose of your study.

Scope and Limitations

Define the scope of your research by outlining what is included and excluded from your study. Discuss any limitations or constraints that may impact the interpretation or generalizability of your findings.

Conceptual Framework or Theoretical Framework

If applicable, introduce the conceptual framework or theoretical framework that underpins your research. Explain the theoretical perspectives, models, or frameworks you will use to guide your analysis and interpretation.

Methodology

Provide an overview of the research methodology and approach you have adopted. Discuss the research design, data collection methods, analytical techniques, and any other procedures used to conduct your study.

Significance and Contributions

Clearly articulate the significance of your research and the potential contributions it makes to the field. Explain how your study advances knowledge, addresses gaps in the literature, or has practical implications.

Organizational Structure

Outline the structure of your thesis by briefly describing the contents of each chapter. Provide a roadmap that helps the reader navigate through your thesis

and understand the sequence of your argumentation.

Literature Review

While the main literature review may be presented in a separate chapter, briefly summarize the key literature that informs your research in the introduction. Highlight the most relevant theories, concepts, and empirical studies that provide context for your study.

Engage the Reader

Write in a clear, engaging, and concise manner to capture the reader's interest. Use compelling language and examples to draw the reader into the topic and motivate them to continue reading. Remember, the introduction chapter sets the tone for your entire thesis and should provide a comprehensive overview of your research topic, objectives, methodology, and significance. It should be well-structured, focused, and persuasive, laying the foundation for the reader to understand and appreciate the rest of your work.

Chapter 2

Literature

A comprehensive literature review is a critical component of any academic research, including a Ph.D. thesis. It serves several purposes, as follows.

Establishing Context

Provide background information on the topic of study to contextualize your research within existing knowledge and scholarship. Identify key concepts, theories, and methodologies relevant to your research.

Identifying Gaps and Opportunities

Identify gaps, inconsistencies, or contradictions in the existing literature that your research aims to address. Highlight areas where further research is needed or opportunities for innovation exist.

Synthesizing Previous Research

Summarize and synthesize findings from previous studies, organizing them thematically or chronologically. Evaluate the strengths and weaknesses of previous research methodologies, data sources, and analytical approaches.

Demonstrating Scholarly Engagement

Demonstrate your familiarity with the current state of research in your field and your ability to critically evaluate and synthesize existing literature. Es-

tablish your credibility as a researcher by showing that you are building upon established knowledge and contributing to ongoing scholarly conversations.

Supporting Methodological Choices

Justify your research methodology by explaining how it builds upon or diverges from previous approaches. Discuss the suitability of different research methods and theoretical frameworks for addressing your research questions.

Highlighting Significance and Contribution

Emphasize the significance of your research by showing how it fills a gap, extends existing knowledge, or offers new insights. Articulate the specific contribution your research makes to the field and how it advances scholarship.

Citing Sources Appropriately

Ensure that you accurately cite all sources consulted in your literature review according to the citation style guidelines required by your institution or discipline.

Maintaining Focus and Organization

Keep your literature review focused and well-organized, with clear sections or subsections devoted to different themes, theories, or methodologies. Provide transitions and connections between different sections to maintain coherence and flow.

Remaining Critical and Objective

Remain critical and objective in your evaluation of previous research, acknowledging both strengths and limitations. Avoid bias and strive to present a balanced and comprehensive overview of the literature.

Updating and Revising

Continuously update and revise your literature review as your research progresses and new relevant studies are published. Be open to incorporating feedback from peers, advisors, and reviewers to strengthen your literature review.

By including these elements in your literature review, you can effectively situate your research within the broader scholarly conversation, demonstrate your expertise in the field, and lay the groundwork for your own empirical investigation.

2.1 Maxwell's Equations

Maxwell's equations are a set of four fundamental equations that describe the behavior of electric and magnetic fields, as well as their interaction with matter. They are the cornerstone of classical electromagnetism and are essential for understanding a wide range of phenomena in physics and engineering.

Gauss's Law for Electricity

Gauss's Law for Electricity is one of the four fundamental equations in classical electromagnetism, formulated by Carl Friedrich Gauss. It describes the relationship between the electric flux through a closed surface and the electric charge enclosed within that surface. Mathematically, Gauss's Law for Electricity is expressed as:

$$\oint_S \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{\text{enc}}}{\varepsilon_0}$$

Here's an explanation of the key components of Gauss's Law for Electricity:

- $\oint_S$ represents a closed surface integral over a closed surface S. This means that we are summing the electric field ($\mathbf{E}$) over all infinitesimal areas ($d\mathbf{A}$) of the closed surface S.
- $\mathbf{E}$ is the electric field vector at each point on the surface. It represents the force experienced by a unit positive charge placed at that point.
- $d\mathbf{A}$ is a vector representing an infinitesimal area element of the surface. It is oriented perpendicular to the surface at each point.
- Q_{enc} is the total electric charge enclosed within the closed surface S. This includes the sum of all positive and negative charges within the enclosed region.
- ε_0 is the permittivity of free space, a fundamental constant in electromagnetism. It represents the ability of a material to permit the formation of an electric field in response to an applied electric field.

In simpler terms, Gauss's Law for Electricity states that the total electric flux through a closed surface is proportional to the total electric charge enclosed within that surface, with the constant of proportionality being the permittivity of free space. In other words, it quantifies how much electric field passes through a closed surface due to the presence of electric charges inside that surface.

Gauss's Law for Magnetism

Gauss's Law for Magnetism states that the magnetic flux through any closed surface is always zero. Mathematically, it is expressed as:

$$\oint_S \mathbf{B} \cdot d\mathbf{A} = 0$$

Here's an explanation of the key components of Gauss's Law for Magnetism:

- $\oint_S$ represents a closed surface integral over a closed surface S. This means that we are summing the magnetic field ($\mathbf{B}$) over all infinitesimal areas ($d\mathbf{A}$) of the closed surface S.
- $\mathbf{B}$ is the magnetic field vector at each point on the surface. Unlike electric fields, magnetic fields do not have sources or sinks (monopoles), so the magnetic flux through any closed surface is always zero.
- $d\mathbf{A}$ is a vector representing an infinitesimal area element of the surface. It is oriented perpendicular to the surface at each point.

In summary, Gauss's Law for Magnetism implies that there are no magnetic monopoles (isolated north or south poles), and the magnetic flux through any closed surface is always zero, indicating that magnetic field lines neither start nor end but always form closed loops.

Faraday's Law of Induction

Faraday's Law of Induction describes how a changing magnetic field induces an electromotive force (EMF) and hence an electric current in a conducting loop. Mathematically, it is expressed as:

$$\oint_C \mathbf{E} \cdot d\boldsymbol{\ell} = -\frac{d\Phi_B}{dt}$$

Here's an explanation of the key components of Faraday's Law of Induction:

- $\oint_C$ represents a closed path integral around a closed loop C. This means that we are summing the electric field ($\mathbf{E}$) around the closed loop C.
- $\mathbf{E}$ is the induced electric field within the conducting loop. It is created by a changing magnetic flux through the loop according to Faraday's law.
- $d\boldsymbol{\ell}$ is a vector representing an infinitesimal displacement along the closed loop C.
- $d\Phi_B/dt$ represents the rate of change of magnetic flux (Φ_B) through the surface enclosed by the loop with respect to time. The negative sign indicates that the induced EMF and hence the induced electric field opposes the change in magnetic flux.

In summary, Faraday's Law of Induction states that a changing magnetic field induces an electric field and hence an electromotive force (EMF) in any closed conducting loop, producing an electric current in the loop. This phenomenon forms the basis of many practical devices, such as electric generators and transformers.

Ampere's Circuital Law (with Maxwell's addition)

Ampère's Circuital Law relates the magnetic field around a closed loop to the electric current passing through the loop. With Maxwell's addition, it accounts for the displacement current, which arises from changing electric fields. Mathematically, it is expressed as:

$$\oint_C \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 \left(I_{\text{enc}} + \varepsilon_0 \frac{d\Phi_E}{dt} \right)$$

Here's an explanation of the key components of Ampère's Circuital Law (with Maxwell's addition):

- $\oint_C$ represents a closed path integral around a closed loop C. This means that we are summing the magnetic field ($\mathbf{B}$) around the closed loop C.
- $\mathbf{B}$ is the magnetic field vector at each point along the closed loop C.
- $d\boldsymbol{\ell}$ is a vector representing an infinitesimal displacement along the closed loop C.
- μ_0 is the permeability of free space, a fundamental constant in electromagnetism.

- I_{enc} is the total current passing through the loop C. This includes both conduction current and displacement current.
- ε_0 is the permittivity of free space, another fundamental constant in electromagnetism.
- $\frac{d\Phi_E}{dt}$ represents the rate of change of electric flux (Φ_E) through the surface enclosed by the loop with respect to time. This gives rise to the displacement current, which is included in Ampère's law with Maxwell's addition.

In summary, Ampère's Circuital Law with Maxwell's addition states that the magnetic field around a closed loop is proportional to the total current passing through the loop, including both conduction current and displacement current arising from changing electric fields. This law plays a crucial role in understanding the behavior of electromagnetic fields in various physical systems.

Chapter 3

Methodology

You are expected to be methodical in your work, so that it could and can be reproduced and replicated by others to verify your results. If you are clear in your methodology, you will have a better chance of someone building on your work [2]. That will lead to more people being interested in what you have done, and will give you a higher profile. Remember that undergraduate students will sometimes do projects based on academic research, so it's a good idea to be explicit enough that they can easily replicate your results.

It is important that you demonstrate that you were methodical from the start. While it is tempting to play around with various algorithms or techniques before you really sit down to work. If you take five minutes beforehand to think through what you are about to do and write it down, you will quickly build up a portfolio of writing and results that can go into your thesis. There is often very little pracitcal difference between being methodical and playing around – it's largely in your attitude while you are doing the work.

Note that LaTeXhas a lot of nice functionality for creating various types of plots and diagrams. Check out the nice graphs in Figure 3.1.

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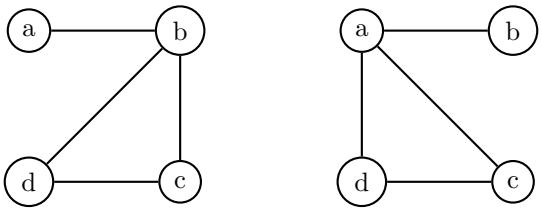

G_1 G_2

Figure 3.1: Nice pictures

3.1 Vector Spaces

A **vector space** V over a field $\mathbb{F}$ is a set equipped with two operations:

- Vector addition: $+ : V \times V \to V$, denoted as $(\mathbf{v}, \mathbf{w}) \mapsto \mathbf{v} + \mathbf{w}$.
- Scalar multiplication: $\cdot : \mathbb{F} \times V \to V$, denoted as $(\lambda, \mathbf{v}) \mapsto \lambda\mathbf{v}$.

These operations must satisfy the following properties for all $\mathbf{u}, \mathbf{v}, \mathbf{w} \in V$ and $\lambda, \mu \in \mathbb{F}$:

1. **Addition is commutative**: $\mathbf{u} + \mathbf{v} = \mathbf{v} + \mathbf{u}$.
2. **Addition is associative**: $(\mathbf{u} + \mathbf{v}) + \mathbf{w} = \mathbf{u} + (\mathbf{v} + \mathbf{w})$.
3. **Additive identity**: There exists a vector $\mathbf{0} \in V$ such that $\mathbf{v} + \mathbf{0} = \mathbf{v}$ for all $\mathbf{v} \in V$.
4. **Additive inverse**: For every vector $\mathbf{v} \in V$, there exists a vector $-\mathbf{v} \in V$ such that $\mathbf{v} + (-\mathbf{v}) = \mathbf{0}$.
5. **Scalar multiplication is distributive over vector addition**: $\lambda(\mathbf{v} + \mathbf{w}) = \lambda\mathbf{v} + \lambda\mathbf{w}$.
6. **Scalar multiplication is distributive over scalar addition**: $(\lambda + \mu)\mathbf{v} = \lambda\mathbf{v} + \mu\mathbf{v}$.
7. **Scalar multiplication is associative**: $(\lambda\mu)\mathbf{v} = \lambda(\mu\mathbf{v})$.
8. **Scalar multiplication identity**: $1 \cdot \mathbf{v} = \mathbf{v}$, where 1 is the multiplicative identity in $\mathbb{F}$.

3.2 Dirac Notation

Dirac notation, also known as bra-ket notation, is a powerful and concise mathematical notation used extensively in quantum mechanics. It was introduced by the physicist Paul Dirac and provides a convenient way to represent vectors, linear operators, and inner products in quantum mechanics. Here's a breakdown of the components of Dirac notation:

Ket notation $|\psi\rangle$: A ket is represented by a column vector enclosed within vertical bars. It represents a state vector in a complex vector space. For example, $|\psi\rangle$ could represent the state of a quantum system.

Bra notation $\langle\psi|$: A bra is represented by a row vector enclosed within angular brackets. It represents the complex conjugate transpose of a ket vector. If $|\psi\rangle$ represents a state vector, then $|\psi\rangle$ represents the corresponding bra vector.

Inner product ($\langle\psi \mid \psi\rangle$): The inner product of two vectors is represented by placing a bra vector on the left and a ket vector on the right, enclosed within angular brackets. It yields a complex number and is a measure of the "overlap" between the two vectors. In quantum mechanics, the inner product is used to calculate probabilities and to determine the expectation values of observables.

Outer product ($|\psi\rangle\langle\phi|$): The outer product of two vectors is represented by placing a ket vector on the left and a bra vector on the right. It results in a linear operator known as a ket-bra or dyad, which maps one vector to another. In quantum mechanics, outer products are used to represent quantum operators.

Operators ($A|\psi\rangle$): If A is a linear operator, its action on a ket vector $|\psi\rangle$ is represented by placing the operator to the left of the ket vector. This notation shows the result of applying the operator to the state vector.

Dirac notation offers several advantages:

Clarity and Conciseness: It provides a concise representation of complex mathematical objects, making expressions and calculations easier to write and understand.

Flexibility: It can be easily extended to represent complex operations and concepts in quantum mechanics, such as composite systems, entanglement, and measurement.

Computational Efficiency: Dirac notation simplifies many calculations in quantum mechanics, such as computing inner products, expectation values, and transition probabilities.

Overall, Dirac notation is a fundamental tool in quantum mechanics, enabling physicists to express and manipulate quantum states and operations in a clear and efficient manner.

Chapter 4

Prototypes

You might consider including a section describing your algorithm and code. The minted package is great for displaying short sections of code, as in Listing 4.1.

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# Ian McLoughlin, 2018-02-01
# Is it Tuesday?

import datetime

if datetime.datetime.today().weekday() == 1:
  print("Yay! It is Tuesday.")
else:
  print("Unfortunately it is not Tuesday.")
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Listing 4.1: Is it Tuesday?

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Chapter 5

Something interesting

You will sometimes, over the course of your research, find something particularly interesting. If you think it is worthy of a published paper in its own right, you can add a chapter about it.

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Figure 5.1: A table.

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Chapter 6

Conclusion

The conclusion generally summaries the thesis and suggest further work you would like to complete based on the work in your thesis.

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