

The Theory of Soap Bubbles

THESIS

Submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

by

Candide, ou l'Optimisme

Under the Supervision of

Prof. Pangloss

and Co-supervision of

François-Marie Arouet *Voltaire*



BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

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Certificate

This is to certify that the thesis entitled '**The Theory of Soap Bubbles**' and submitted by **CANDIDE ou l'OPTIMISME**, ID.No. **20**PH******* for award of Ph.D. of the Institute embodies original work done by her under our supervision.

Signature of the Supervisor	:	
Name in capital letters	:	Prof. PANGLOSS
Designation	:	PROFESSOR
Date	:	31 February 2099
Signature of the Co-supervisor	:	
Name in capital letters	:	FRANÇOIS-MARIE AROUET <i>VOLTAIRE</i>
Designation	:	French Enlightenment writer, historian, and philosopher, famous for his wit, his advocacy of freedom of religion, freedom of speech, and separation of church and state
Date	:	31 February 1757

Declaration

I, Candide, ou l'Optimisme, declare that this thesis titled, 'The Theory of Soap Bubbles', submitted by me under the supervision of Prof. Pangloss and François-Marie Arouet *Voltaire* is a bonafide research work. I also declare that it has not been submitted previously in part or in full to this University or any other University or Institution for award of any degree.

Signature of the student :
Name of the student : **CANDIDE ou l'OPTIMISME**
ID number of the student : **20**PH*******
Date :

Abstract

In this thesis, we talk about soap bubbles in a hollow manner with as much substance as the soap bubbles hold.

Acknowledgements

I am grateful to ABDN for this template that I could easily adapt. I am grateful to Voltaire for the quote, "*Superstition sets the whole world in flames; philosophy quenches them*"; for making the quote, "*I disapprove of what you say, but I will defend to the death your right to say it*" popular; and for giving the pejorative *panglossian* to the world.

Candide, ou l'Optimisme

September 1779

Contents

Abstract	iii
Acknowledgements	iv
List of Figures	vii
List of Tables	ix
List of Symbols	xi
1 Introduction	1
1.1 Usage Guide	1
2 Usage of this Thesis Template	2
2.1 Preamble	2
2.1.1 Author etc.	3
2.2 The Actual Front of the Thesis	3
2.3 Other Stuff	3
3 Some Chapter	5
3.1 Chatter Begins	5
Appendix A	6
Bibliography	9
Index	11

List of Figures

3.1 An Example of Search and Objective Spaces	5
---	---

List of Tables

2.1	Table of Noncontents that produce Discontent	4
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List of Symbols

1. *MOEA* : Multiobjective Evolutionary Algorithm
2. *MOOP* : Multiobjective Optimization Problem
3. *MOP* : Multiobjective Optimization Problem
4. *DTLZ* : Deb-Thiele-Laumanns-Zitzler Benchmark Suite
5. \mathbb{P} : Probability
6. \mathbb{P}_0 : Uniform Distribution
7. \mathbb{E} : Expectation
8. μ : (Variously) Lebesgue measure, population size
9. ν : Lebesgue measure
10. \mathbb{X} : Search Space
11. f : Objective function (scalar or vector)
12. f_i : Components of a vector function
13. g, h : Special functions explained at the place of use
14. ω_n : Probability by \mathbb{P}_0 of the unit ball placed in \mathbb{X}
15. L : Lipschitz constant of f on \mathbb{X}
16. x^* : Global minimum
17. $m = f(x^*)$: Objective at global minimum
18. $a, a_t, a(x) = \frac{\omega_n(f(x)-f(x^*))^n}{L^n}$: The probability by \mathbb{P}_0 of the ball of radius $\frac{(f(x)-f(x^*))}{L}$ around x^*
19. $b, b_t, b(x) = \mathbb{P}_0\{y \in \mathbb{X} : f(y) \leq f(x)\}$: The probability by \mathbb{P}_0 of the space of better points than x
20. $\delta_t, \delta(x) = \frac{a(x)}{b(x)}$
21. $\delta = \inf_{x \in \mathbb{X}} \delta(x)$

Chapter 1

Introduction

Isoperimetry is generalization of the physics of soap bubbles. Concentration of measure explains why all the mass of soap bubbles is on their surface and nothing inside.

It is all hollow without substance.

If at all you want to read something useful, please see Roshi (1720)

1.1 Usage Guide

Actually, this template is not all that hollow. The real content is in Chapter 2.

Chapter 2

Usage of this Thesis Template

For BITS Goa PhD Scholars, this chapter describes how to use this template.

2.1 Preamble

In the thesis manuscript preamble, the following lines set up the document class and other paraphernalia:

```
\documentclass[PhD,cmmath]{bitsgoathesis}
\usepackage[round,colon,authoryear,sort&compress]{natbib}
\usepackage{ifthen}
\usepackage{graphicx}
\usepackage{amsmath}
\usepackage{imakeidx}
\usepackage[dvips]{hyperref}
\graphicspath{{images/}}

\setlength{\bibsep}{0pt}
\bibliographystyle{apalike}
\usepackage[T1]{fontenc}
% \usepackage[round]{natbib}
\usepackage{indentfirst}
\def\sffthing#1#2{\def#1{\mbox{{\small\normalfont\sffamily #2}}}}
\sffthing{\PP}{P}
\sffthing{\FF}{F}

\makeindex
```

Here, you can somewhat change the result by dropping or changing the parameters (PhD, cmmath) to the document class command. Other packages included will be optional, and their behaviour too you may want to change. Among them, `graphicx` is important for figures, `hyperref` for navigation in the soft copy pdf generated, `imakeidx` is for indexing. There is just one example of the use of `\index` given in the Intro chapter.

2.1.1 Author etc.

In this sample, information of the candidate and other culprits was given as commands in the preamble:

```
\newcommand{\candidatename}{Candide} % GIVE THE CANDIDATE NAME HERE
\newcommand{\candidatenamecap}{CANDIDE}
\newcommand{\candidno}{20**PH*****}
\newcommand{\thesistitle}{The Theory of Soap Bubbles} % GIVE THE THESIS TITLE HERE
\newcommand{\supername}{Prof. Pangloss} % all such irrelevant information ...
\newcommand{\supernamecap}{Prof. PANGLOSS}
\newcommand{\superdesig}{PROFESSOR}
\newcommand{\cosupername}{Fran\c{c}ois-Marie Arouet \textit{Voltaire}}
\newcommand{\cosupernamecap}{FRAN\c{C}OIS-MARIE AROUET \textit{VOLTAIRE}}
\newcommand{\cosuperdesig}{French Enlightenment writer, historian, and philosopher\ \ famous}
```

Of course, you can and need to change this according to relevant facts, your taste and the least fixed point of the intersection of collective interpretations of the ARD's website and described formats.

2.2 The Actual Front of the Thesis

Beginning with

```
\begin{document}
\frontmatter
```

that tells the \LaTeX compiler to set up its initial stuff, we give the required title page, certificate page and the main culprit's confession in `FrontMatter.tex`. It uses the commands created for the culprits' information mentioned above.

Earlier, I had made some clumsy pdfs from the doc formats on the constantly updated ARD website. Thanks to V. Sreejith and Shubhangi Gawli, this \LaTeX ed version is here. Without the certificate the thesis is hollower than soap bubbles, so fill the fields accurately.

2.3 Other Stuff

Ultimately soap bubbles are empty, yet we want them to show reflections of the outside world and even some rainbow colours. Therefore, some of the things that go into this whole bubble are depicted in Table 2.1.

Element	Mode	Anchoring
Abstract	<code>\begin{abstract}</code> abstract contents ... <code>\end{abstract}</code>	None
Acknowledgements	<code>\chapter*{Acknowledgements}</code>	<code>\part*{\addcontentsline{toc}{chapter}{Acknowledgements}}</code>
Table of Contents	<code>\tableofcontents</code>	None
List of Figures	<code>\listoffigures</code>	<code>\part*{\addcontentsline{toc}{chapter}{List of Figures}}</code>
List of Tables	<code>\listoftables</code>	<i>Similar</i>
List of Symbols	<code>\chapter{List of Symbols}</code>	Automatic
Chapters	Somehow	Automatic
Appendices	appendix	Below the intestine <code>\part*{\addcontentsline{toc}{chapter}{Appendix A}}</code>
Your bio	<code>\chapter*</code>	Automatic
Guide's bio	<code>\chapter*</code>	Automatic
Bibliography needs	<code>\bibliography{biblbabl}</code> <code>\bibliographystyle{apalike}</code> Choose your style	<code>\part*{\addcontentsline{toc}{chapter}{Bibliography}}</code> in preamble
Index needs needs	<code>\printindex</code> <code>\makeindex</code> imakeidx package	<code>\part*{\addcontentsline{toc}{chapter}{Index}}</code> in preamble in preamble

Table 2.1: Table of Noncontents that produce Discontent

Chapter 3

Some Chapter

With some chatter.

3.1 Chatter Begins

When soap bubbles burst, they make no sound, nor a splash. A perfect dilbertian(Adams, 1997) or calvin-like (see Figure 3.1) existence!

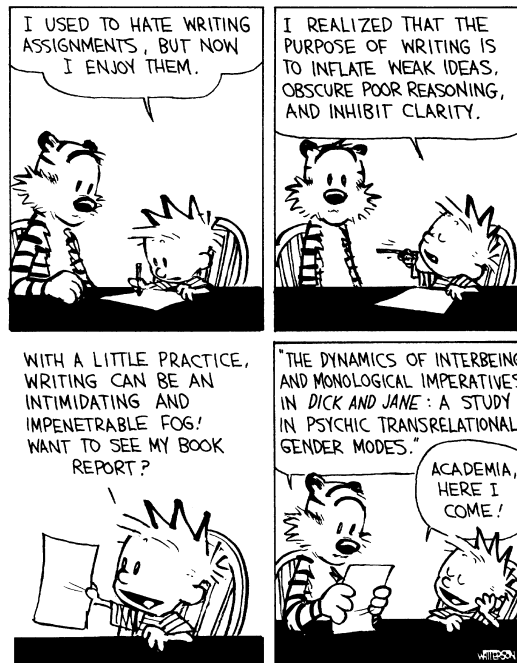


Figure 3.1: An Example of Search and Objective Spaces

Biodata of the Candidate

Name: Some Name

List of Publications

1 Some publication

Biodata of the Supervisor

Name: Some Other Name

List of Publications

1 Some publication, maybe with the candidate as a co-author or the first author

Bibliography

Adams, S. (1997). *The Dilbert Principle*. Boxtree Ltd.

Roshi, J. S. (1720). *How to Create and Burst Soap Bubbles*. PITS, Bilani, INDIA.

Index

substance, 1