DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo for the degree of Masters Science has not previously been submitted by me for a degree at this or any other university, that it is my own work in design and execution, and that all material contained therein has been duly acknowledged.

Signed:_______________

Date:__________________
ACKNOWLEDGMENTS

I would like to acknowledge all the people who contributed in advising and assisting me while working on this project. I thank my supervisors Prof. M A Lesaoana and Prof. V S S Yadavalli for their guidance, valuable comments, patience and their all time accessibility in supervising this dissertation through its various phases.

The financial assistance of the National Research Foundation (NRF) in conjunction with the University of Limpopo, towards this research is hereby acknowledged.

Special thanks go to my mother, Thorometjane and my sister Ngaoanaphokwane for their financial assistance throughout my school life. To my lovely wife, Precious and my little girl, Tumelo, I affably thank you for the encouragement, patience and all time support.

Above all, I give glory to Almighty God who is able.
This study is focused on the scheduling of minibus (taxi) transport between the City of Polokwane and Mankweng Township in the Limpopo province of South Africa. New formulations of integer programming for taxi timetabling problems were presented. The problem is modeled as a single link transit. Hard and soft constraints have been identified.

The main objective of the study is to design the best schedule that minimizes the waiting time of passengers and provides better service to the public for taxi transport on the aforementioned link.

In this study the proposed solution methods managed to produce a timetable with a non-conflicting set of taxis and no consecutive assignment of one taxi to the trips within a duration time (total time traveled on a return trip between two locations). Local search algorithms such as the Genetic Algorithm are used in the research, mainly due to its flexibility and power to produce the best solution to the timetabling problems. The algorithm starts with a population of a feasible search space. Two operators: mutations and crossovers, were designed in such a way that they do not produce infeasible offspring.
# Table of contents

DECLARATION……………………………………………………………………………. I
ACKNOWLEDGEMENTS………………………………………………………………….. II
ABSTRACT……………………………………………………………………………….. III
ACRONYMNS……………………………………………………………………………… IV
TABLE OF CONTENTS…………………………………………………………………… IV
LIST OF FIGURES…………………………………………………………………………. V
APPENDICES……………………………………………………………………………… V

## CHAPTER 1 ………………………………………………………………………………… 1
INTRODUCTION……………………………………………………………………………… 1
1.1 Introduction……………………………………………………………………………… 1
1.2 Geography………………………………………………………………………………… 3
1.3 Problem statement……………………………………………………………………… 5
1.4 Objective Function…………………………………………………………………….. 10
1.5 Preliminary data……………………………………………………………………….. 10
1.6 Organization of the report…………………………………………………………….. 13

## CHAPTER 2 ………………………………………………………………………………… 14
LITERATURE REVIEW…………………………………………………………………… 14
2.1 Introduction……………………………………………………………………………… 15
2.2 Timetabling problem…………………………………………………………………… 15
2.2.1 Hard and Soft constraints………………………………………………………….. 15
2.2.2 Feasible solution or timetable……………………………………………………… 16
2.3 University timetabling problems .......................... 20
2.3.1 University course timetabling problems .................. 21
2.3.2 University examination timetabling problems .... 25
2.4 Public Transport Scheduling problems .................... 28
2.5 Solution techniques of university timetabling .......... 34

CHAPTER 3 ........................................................................................................ 45
SCHEDULING MODEL: AN APPLICATION .......................... 45
3.1 Introduction ......................................................... 46
3.2 Application of University Timetabling problem .......... 46
  3.2.1 Problem situation ....................................... 46
  3.2.2 Taxi timetabling ........................................... 48
  3.2.3 The hard constraints ................................. 50
  3.2.4 The soft constraints ................................. 51
  3.2.5 The objective function ............................... 52
  3.2.6 Evaluation of the feasible schedule .............. 53
3.3 Mathematical programming model ......................... 54
  3.3.1 Assumptions ............................................. 54
  3.3.2 Definitions ............................................. 55
  3.3.3 Notations .............................................. 56

CHAPTER 4 ........................................................................................................ 60
ANALYSIS OF THE MODEL .................................................. 60
4.1 Computational experiments and results ................ 61

CHAPTER 5 ........................................................................................................ 64
CONCLUSION ........................................................................................... 64
REFERENCES ............................................................................................ 67
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBD:</td>
<td>Central Business District.</td>
</tr>
<tr>
<td>UL:</td>
<td>University of Limpopo.</td>
</tr>
<tr>
<td>GMTA:</td>
<td>Greater Mankweng Taxi Association.</td>
</tr>
<tr>
<td>UTP:</td>
<td>University Timetabling Problem.</td>
</tr>
<tr>
<td>CTP:</td>
<td>Course Timetabling Problem.</td>
</tr>
<tr>
<td>ETP:</td>
<td>Examination Timetabling Problem.</td>
</tr>
<tr>
<td>GA:</td>
<td>Genetic Algorithm</td>
</tr>
<tr>
<td>SA:</td>
<td>Simulated Annealing</td>
</tr>
<tr>
<td>TS:</td>
<td>Tabu Search.</td>
</tr>
<tr>
<td>TTP:</td>
<td>Train Timetabling Problem.</td>
</tr>
<tr>
<td>VTP:</td>
<td>Vehicle Timetabling Problem.</td>
</tr>
<tr>
<td>VSP:</td>
<td>Vehicle Scheduling Problem.</td>
</tr>
<tr>
<td>ATP:</td>
<td>Airline Timetabling Problem.</td>
</tr>
<tr>
<td>BSP:</td>
<td>Bus Scheduling Problem.</td>
</tr>
<tr>
<td>BCSP:</td>
<td>Bus Crew Scheduling Problem.</td>
</tr>
<tr>
<td>RCP:</td>
<td>Robust Colouring Problem.</td>
</tr>
<tr>
<td>IP:</td>
<td>Integer Programming</td>
</tr>
<tr>
<td>SPP:</td>
<td>Set Partitioning Problem</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

1. Figure 1.1: The South Africa map(unit: km). 4
2. Figure 1.2: The Limpopo provincial map(unit: km). 6
3. Figure 1.3: Estimated number of passengers transported daily between Mankweng and Polokwane. 12
4. Figure 1.4: Number of accidents according to the factors. 13
5. Figure 2.1: The classes in the general timetabling model. 19
6. Figure 3.1: A vehicle block development. 48
7. Figure 3.2: Estimated number of passengers transported daily. 49
8. Figure 3.3: Scheduling and rescheduling of timetable. 50
9. Figure 4.1: The objective function for instance of 30 trips. 62
10. Figure 4.2: The objective function for instance of 50 trips. 63

### APPENDICES

1. Appendix 1: A structured questionnaire for preliminary data. 73