

UNIVERSITI TEKNOLOGI MARA

TECHNICAL REPORT

RULES OF SOLVING  $3 \times 3 \times 3$  RUBIK'S CUBE BASED ON  
PERMUTATION OF THE GROUP THEORY

P26S18

MAIZATUL ASYIRAH BINTI MAKHTAR  
NAIHIAH BINTI ABDULLAH  
NOOR HAFIZAN BINTI ZUL APANDI

BACHELOR OF SCIENCE (HONS.) MATHEMATICS  
FACULTY OF COMPUTER AND MATHEMATICAL SCIENCES

DECEMBER 2018

## **ACKNOWLEDGEMENTS**

First and foremost, we praise and thank Almighty Allah for giving us this opportunity, the patience and strength to complete this final year project. Next, we would like to express our gratitude and appreciation to those who help us in completing the research. A special thanks to our supervisor, Madam Nor Aishah Md Noh for her guidance, stimulating suggestions and constant encouragement throughout the research especially in writing this report. We are very thankful for her time that she spent in supervising us despite of her busy schedule and her guidance is immensely valuable for our study. We also would like to express our deepest thanks to Dr. Mat Salim, our final year project (MSP 660) lecturer for his necessary advices and guidance in getting a better report writing. It is such an honour to learn something that is very significant regarding the report writing. Finally, we would like to thank those who helped us either directly or indirectly towards finishing this study and we will strive to use the gained knowledge in the best possible way.

# TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES .....	iv
LIST OF TABLES.....	iv
ABSTRACT.....	vi
1.0 INTRODUCTION .....	1
1.1 Problem Statement .....	2
1.2 Objectives.....	2
1.3 Significance of the Study .....	3
1.4 Scope of the Project.....	3
1.5 Definition of Terms and Concepts .....	4
2.0 BACKGROUND THEORY AND LITERATURE REVIEW .....	6
2.1 Background Theory.....	6
2.1.1 Permutation.....	6
2.1.2 Permutation Multiplication .....	6
2.1.3 Groups.....	7
2.1.4 Permutation on Rubik's Cube.....	7
2.1.5 Lagrange Theorem .....	8
2.1.6 Commutator .....	9
2.1.7 Conjugation.....	9
2.1.8 Permutation Group in Solving Rubik's Cube.....	10
2.1.9 Cycle Notation.....	11
2.2 Literature Review.....	12
2.2.1 Pattern Database.....	12
2.2.2 Solving Rubik's Cube Manually.....	12
2.2.3 Solving Rubik's Cube Using Software.....	13
3.0 METHODOLOGY AND IMPLEMENTATION .....	15
3.1 Beginner's Solution in Solving Rubik's Cube Manually.....	17
3.2 Permutation of Rubik's Cube.....	17
3.3 Fridrich and Layer-by-Layer Method .....	17
3.4 Label the (3x3x3) Rubik's Cube .....	18
3.5 Involvement Area for Each Movement.....	19

3.6	Fix Movements Used in Solving The (3x3x3) Rubik's Cube Using the Multiplication Cycle of Permutation.....	19
3.7	Suggested Alternatives Techniques .....	27
3.7.1	Solving For White Cross.....	27
3.7.2	Solving For First Layer .....	32
3.7.3	Solving For Second Layer .....	36
3.7.4	Solving For Full Yellow .....	38
3.7.5	Solving To Get an Identity .....	42
3.8	Implementation.....	44
4.0	RESULT AND DISCUSSION .....	50
5.0	CONCLUSION AND RECOMMENDATION.....	53
	REFERENCES .....	54

## **ABSTRACT**

Permutation is a part of group theory which is a one-to-one function and onto (bijective function) that maps on the finite number of sets. Since the movement of Rubik's Cube is a one-to-one function, it uses permutation method to solve it from the shuffled state until it becomes identity. Rubik's Cube is not a puzzle that can be solved by sheer luck. Without knowing that there exist a simpler way in solving the Rubik's Cube, most people find it difficult and stressful. The objectives of this study is to generate the Rubik's Cube rules based on Fridrich and Layer-by-Layer method using groups of permutation in group theory. Besides that this study also aims to analyse the average total movements in solving Rubik's Cube using Maple software. The first phase of this research is suggesting two alternatives in solving Rubik's Cube for beginners which are based on Fridrich and Layer-by-Layer method. The final phase is to analyse the average total movements for both alternative 1 and 2. Concluded in this study, alternative 2 give the least movement required to solve the Rubik's Cube and help in reducing time consuming. This study will act as a fundamental programming to come out with an advanced system using mathematics software. It also provides an encouragement for the beginners to solve the Rubik's Cube in a higher level in terms of different sizes and shapes of Rubik's Cube.