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"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Design and Innovation)

Signature: ……
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Date: ……

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THE IMPLEMENTATION OF DESIGN FOR RELIABILITY IN PRODUCT DEVELOPMENT

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering (Design and Innovation)

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MAY 2012

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledge"

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DEDICATED TO MY LOVED ONES

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ACKNOWLEDGEMENT

I owe a debt of thanks to all whose time, concern and efforts were given during the process of finishing the experiment and producing this report. Thus, my heartfelt gratitude is extended to my supervisor, Mdm Asriana Binti Ibrahim for giving me the guidance and support throughout this project. Their experience in topics related to this project has given me a boost of confidence in conducting my analysis. Without them, I would never achieve what I have meant to complete.

A special note of thanks is also due to my beloved parents; Ahmad Fuad Bin Jaafar and Habsah Binti Ahmad and also my dearest friends who have always been helping and praying for my success. Without them, I could never have the spirit to complete this project such as that I have now.

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ABSTRACT

Nowadays, product reliability is very important in product development. Reliability of a product ensures that customer satisfied with the product by meet customer requirement and demands. Design for Reliability is one of ways to improve product reliability. In implementing Design for Reliability on product, method and research steps should be carried out. This report writing contains several chapters that will covers all important aspects related in implementing Design for Reliability on product development. The first chapter is an introduction to the study which includes the problem statement, objectives and scope of the relevant discipline of study and will be referred to throughout this research. The second chapter is a description of the theory and the results of previous studies ever conducted in relation to the study of Design for Reliability. Elements of Design for Reliability needed in improving product reliability also stated clearly and detailed based on previous study. The next chapter is related to the actual composing technique or perhaps methodology found in the research. In this section, some with the methods used are described in detail. The finding has also been stated in the process so that appropriate data selection can be done.

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ABSTRAK

Pada masa kini, kebolehupayaan produk adalah sangat penting dalam pembagunan produk. Kebolehupayaan produk memastikan pelanggan berpuas hati dengan produk yang memenuhi keperluan dan permintaan pelanggan. Rekabentuk untuk kebolehupayaan adalah salah satu cara untuk meningkatkan kebolehupayaan produk. Dalam melaksanakan rekabentuk untuk kebolehupayaan produk, beberapa kaedah dan langkah-langkah penyelidikan perlu dijalankan. Laporan ini mengandungi beberapa bab yang akan meliputi semua aspek penting yang berkaitan dengan perlaksanakan rekabentuk untuk kebolehupayaan dalam pembangunan produk. Bab pertama merupakan pengenalan kepada kajian meliputi pernyataan masalah, objektif dan skop kajian yang berkaitan dengan seluruh kajian ini. Bab kedua ialah berkenaan teori dan hasil kajian ilmiah yang pernah dijalankan sebelum ini berhubung dengan kajian rekabentuk untuk kebolehupayaan. Ciri-ciri dalam rekabentuk untuk kebolehupayaan yang diperlukan untuk meningkatkan kebolehupayaan produk juga dinyatakan dengan jelas dan terperinci berdasarkan kajian sebelum ini. Bab seterusnya adalah berkaitan dengan teknik kajian dan metodologi yang terdapat dalam penyelidikan. Dalam seksyen ini, kaedah-kaedah yang telah dan akan digunakan diterangkan secara terperinci. Dapatan data juga telah dinyatakan dalam proses ini supaya pemilihan data yang sesuai boleh dilakukan.

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TABLE OF CONTENTS

CHAPTER	TITLE		PAGE
	DECLARATION		**ii**
	DEDICATION		**iii**
	ACKNOWLEDGEMENT		**iv**
	ABSTRACT		**v**
	ABSTRAK		**vi**
	TABLE OF CONTENTS		**vii**
	LIST OF FIGURES		**x**
	LIST OF TABLES		**xii**
	LIST OF ABBREVIATIONS		**xiii**
	LIST OF APPENDICES		**xiv**
1	**INTRODUCTION**		
	1.0	General Introduction	1
	1.1	Problem Statement	2
	1.2	Objective	3
	1.3	Scope	3
2	**LITERATURE REVIEW**		
	2.0	Introduction	5
	2.1	Reliability	6
		2.1.1 Need of Reliability in Product Design	6
		2.1.2 Product Reliability	7
	2.2	Design for Reliability	9

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	2.2.1	Redundancy	9
	2.2.2	Durability	11
	2.2.3	Simplicity	11
	2.2.4	Safety Product	12
	2.2.5	The Bathtub Curve	12
2.3	Introduction to Wheelchair		14
	2.3.1	Manual Wheelchair	14
	2.3.2	Basic standard manual wheelchair	15
	2.3.3	The Components of Manual Wheelchair	16
	2.3.4	Wheelchair Common Material	18
	2.3.5	Failures on Manual Wheelchair	19
2.4	Computer Aided Three-dimensional Interactive Application (CATIA)		20
	2.4.1	CATIA Approach	21
3	**METHODOLOGY**		
3.0	Introduction		22
3.1	Methodology Diagram		22
3.2	Gantt Chart		23
3.3	Data Collection		24
	3.3.1	Conceptual of Selection and Concept Design	24
	3.3.2	Embodiment Diagram	25
	3.3.3	Detail Design	25
	3.3.4	Analysis	26
4	**RESULT AND ANALYSIS**		
4.0	Introduction		27
4.1	Concept of selection		28
	4.1.1	Weight Decision Matrix	28
4.2	Detail Design		33
	4.2.1	FOSHAN Standard Wheelchair 18” design	33

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			4.2.1.1 Bill of Materials for FOSHAN Standard Wheelchair 18”	38
		4.2.2	FOSHAN Standard Wheelchair 18” with the implementation of Design for Reliability	39
			4.2.2.1 Bill of Materials for FOSHAN Standard Wheelchair 18” with the implementation of Design for Reliability	42
	4.3	Analysis		43
		4.3.1	Screw M6	44
		4.3.2	Snap Fit	47
5	**DISCUSSION**			
	5.0	Introduction		50
	5.1	Elements of Design for Reliability		50
	5.2	Comparison		52
	5.3	Comparison Analysis		54
6	**CONCLUSION AND RECOMMENDATION**			
	6.0	Conclusion		56
	6.1	Recommendation		57
7	**REFERENCES**			58
8	**APPENDIX**			61

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LIST OF FIGURE

NO	TITLE	PAGES
1.1	FOSHAN Standard Wheelchair 18”	2
2.2	Graph Reliability versus Time	8
2.3	The Bathtub Curve	13
2.4	First Folding Metal Wheelchair	14
2.5	Standard Manual Wheelchair	15
2.6	Illustration of failures occurring on rehabilitation wheelchairs during fatigue testing	20
3.7	Flowchart for Study Planning	23
4.8	FOSHAN Standard Wheelchair 18”	34
4.9	Sketch of FOSHAN Standard Wheelchair 18” with dimension	34
4.10	Complete design of FOSHAN Standard Wheelchair 18”	35
4.11	Main Frame in FOSHAN Standard Wheelchair 18”	36
4.12	Cylindrical Steel in FOSHAN Standard Wheelchair 18”	37
4.13	Screw M6 in FOSHAN Standard Wheelchair 18”	37
4.14	Main Frame in FOSHAN Standard Wheelchair 18”	40
4.15	Rectangular Steel in FOSHAN Standard Wheelchair 18”	41
4.16	Snap fit for FOSHAN Standard Wheelchair 18”	41
4.17	Maximum and Minimum Stress (von-mises) for screw M6	45
4.18	Total deformation for screw M6	45
4.19	Safety Factor for Screw M6	46
4.20	Graph of Life Cycle for Screw M6	46
4.21	Maximum and Minimum Stress (von-Mises) for Snap fit	47
4.22	Total Deformation for Snap fit	48

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4.23	Safety Factor for Snap fit	48
4.24	Graph of Life Cycle for Snap fit	59

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LIST OF TABLE

NO	TITLE	PAGES
4.1	Weight Decision Matrix Scale and Description	28
4.2	Weight Decision Matrix for Elements and Components Selection	30
4.3	Bill of Materials for FOSHAN Standard Wheelchair 18"	39
4.4	Bill of Material for FOSHAN Standard Wheelchair 18" with the Implementation of Design for Reliability	43
5.5	Differences between FOSHAN Standard Wheelchair 18" and FOSHAN Standard Wheelchair 18" with DfR Implementation	53
5.6	Comparison analysis between Screw M6 and Snap Fit	54

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LIST OF ABBREVIATIONS

CATIA	Computer Aided Three-dimensional Interactive Application
CAD	Computer Aided Data
ANSYS	Analysis System

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LIST OF APPENDICES

NO	TITLE
A	Flow Chart
B	Gantt Chart Semester 1
C	Gantt Chart Semester 2
D	Drafting Sheet of FOSHAN Standard Wheelchair 18”
E	Drafting Sheet of M6 Screw
F	Drafting Sheet of Snap Fit

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CHAPTER 1

INTRODUCTION

1.0 GENERAL INTRODUCTION

Reliability engineering is definitely an engineering area that handles the research, evaluation, as well as life-cycle administration of reliability: the ability of the system or aspect of performs its required features under mentioned conditions for any specified time period. Product reliability is an important product attribute because customer satisfaction. High reliability is mandatory requirement for customer satisfaction. Company nowadays built the company's reputation by relates high reliability with their product. The more reliable a product is, the more company will have favorable reputation. Design for Reliability (DFR), will be an emerging constraint that represents the procedure of designing reliability into design. This discipline can improve product reliability by implementing its design elements on product development.

A wheelchair is known as a chair through wheels, designed as being a replacement designed for walking. This product is used by people with disabilities. This disability means people whom walking are difficult or impossible due to illness, injury and others. As a product, wheelchair is designed to able functioning well in helping disabilities people. To be able functioning well, a product must not have failure or defects that can disturb its functionality. Products that have high reliability are able to

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functioning well in some period of time, and its quality is higher than product that does not count heavily on reliability.

Figure 1.1: FOSHAN Standard Wheelchair 18"
(Source: The Medical Healthcare Superstore Maycare, 2012)

1.1 PROBLEM STATEMENT

While a reliable product may not dramatically affect customer satisfaction in a positive manner, an unreliable product will negatively affect customer satisfaction severely. Thus high reliability is a mandatory requirement for customer satisfaction. Certain product such as wheelchair has problems while operating or moving. Those problems that interfere with the function can reduce its reliability. Manual wheelchair is a product that should have the capability to function properly as an assistant to people with disabilities in everyday work. But some types of manual wheelchairs face difficulties in functioning properly. This problem will affect users confidence in the abilities of wheelchair to help them move or do work. Most of the problems occurred because the design of manual wheelchair components.

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Here stated the problems faced by some users using manual wheelchair. Users can easily injure themselves by pushing the hand rim with their hand to propel the manual wheelchair. This is because hand rim designed and attached to the wheel. So, when pushing the manual wheelchair users accidently touching the moving wheel that have sharp edge. Example of other problems that can be known is brake for the wheel does not work properly. This will cause the wheelchair to move while users want to be in static conditions. Manual wheelchair tires that using pneumatic tires are susceptible to flats and the manual wheelchair cannot moves.

1.2 OBJECTIVE

Manual wheelchair has an important role in order to help disable people to allow a greater mobility by decreasing their limitations of travel. The main objective of this project and research is to implement one of the elements of Design for Reliability (DfR) on FOSHAN Standard Wheelchair 18". The other objectives of this research are

i. To study the implementation of Design for Reliability on FOSHAN Standard Wheelchair 18"
ii. To evaluate the new component design of FOSHAN Standard Wheelchair 18".

1.3 SCOPE

i. Case Study

   A manual wheelchair has been selected as a case study of this project. The critical components of manual wheelchair was chooses to be applied one of the Design for Reliability elements.

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ii. Design Tool

Through this project, Computer Aided Three-dimensional Interactive Application known as CATIA will be used as a design tool in implementing elements of Design for Reliability (DfR) on this manual wheelchair.

iii. Element of Evaluation

Analysis on existing and new product design will be done using ANSYS 13.0.

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CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

A literature review is a step of compiling every data taken from all kind of research including journals, magazines, internet, any reference books or other kind of sources including having a survey, interviews and even taking seminar which is related to the chosen topic. Literature reviews are secondary sources, and as such, do not report any new or original experimental work. Most often associated with academic-oriented literature, such as a thesis, a literature review usually precedes a research proposal and results section. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area. A well-structured literature review is characterized by a logical flow of ideas; current and relevant references with consistent, appropriate referencing style; proper use of terminology; and an unbiased and comprehensive view of the previous research on the topic. This chapter will summarize on the details of the scope of project, any equipment used and technology and elements of analysis involved in the implementation of Design for Reliability (DfR) on manual folding wheelchair.

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2.1 RELIABILITY

Reliability is a measurement of the ability of a component or system to operate without failure in the service environment. It is expressed as the probability of the component functioning for a given time without failure. It is also expressed as a probability for example a reliability of 0.999 implies that there is probability of failure of 1 part in every 1000. According to Kuo & Zuo, 'Optimal Reliability Modeling' (2003), reliability is "a measure of how well a system meets its design objectives". According to Billinton & Allan, 'Reliability Evaluation of Engineering Systems: Concepts and Techniques' (1992), reliability is "the probability of a device (or product) performing its purpose adequately for the period of time intended under the operating conditions encountered". To be easily understood, reliability of a component or product is very important in product development to prevent failure of product functionality.

2.1.1 Need Of Reliability In Product Design (B. S. Dhillon, 1999)

We have seen many factors liable for the factor of consistency in solution design as well as product complication, insertion connected with reliability related-clauses with design technical specs, competition, awareness of cost efficiency, public desire, and way back when system breakdowns.

Even if we consider the increase in the product complexity with respect to parts alone, there has been a phenomenal growth of some products. For example, today a typical Boeing 747 jumbo jet airplane is made up of approximately 4.5 million parts, including fasteners. Even for relatively simpler products, there has been a significant increase in complexity with respect to parts. For example, in 1935 a farm tractor was made up of 1200 critical parts and in 1990 the number increased to around 2900.

With respect to cost effectiveness, many studies have indicated that the most effective for profit contribution is the involvement of reliability professionals with

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product designers. In fact, according to some experts, if it would cost $1 to rectify a design defect prior to the initial drafting release, the cost would increase to $10 after the final release, $100 at the prototype stage, $1000 at the pre-production stage, and $10,000 at the production stage. Nonetheless, various studies have revealed that design-related problems are generally the greatest causes for product failures. For example, a study performed by the U.S. Navy concerning electronic equipment failure causes attributed 43% of the failures to design, 30% to operation and maintenance, 20% to manufacturing, and 7% to miscellaneous factors. Well-publicized system failures such as those listed below may have also contributed to more serious consideration of reliability in product design:

i. Space Shuttle Challenger Disaster:
   This debacle occurred in 1986, in which all crew members lost their lives. The main reason for this disaster was design defects.
ii. Chernobyl Nuclear Reactor Explosion:
   This disaster also occurred in 1986, in the former Soviet Union, in which 31 lives were lost. This debacle was also the result of design defects.
iii. Point Pleasant Bridge Disaster:
   This bridge located on the West Virginia/Ohio border collapsed in 1967. The disaster resulted in the loss of 46 lives and its basic cause was the metal fatigue of a critical eye bar.

2.1.2 Product Reliability

Joaquín Coleff from Department of Economics, Universidad Carlos III de Madrid in his journal 'Product Reliability, Consumers' Complaints and Market Performance: The case of Consumers' Associations' published August, 2011 has stated that product reliability is defined by the probability that the product is defective. Reliability is extremely design-sensitive. Very slight changes to the design of a component can cause profound changes in reliability, which is why it is important to

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specify product reliability and maintainability targets before any design work is undertaken.

A more reliable product spends less of its time being maintained, so there is often a design trade-off between reliability and maintainability. Changes to the design of a component require early knowledge of the anticipated service life of the product, and the degree to which parts of the product are to be made replaceable. The relationship between failure and reliability is apparent from the definitions and it is stated explicitly later. A product which is more prone to failure than another could thus be said to be less reliable than the other.

In previous study, it is stated that reliability of a system or product decreasing as the time period increases (S.C. Agarwal, Mamta Sahani & Shikha Bansal, 2010).

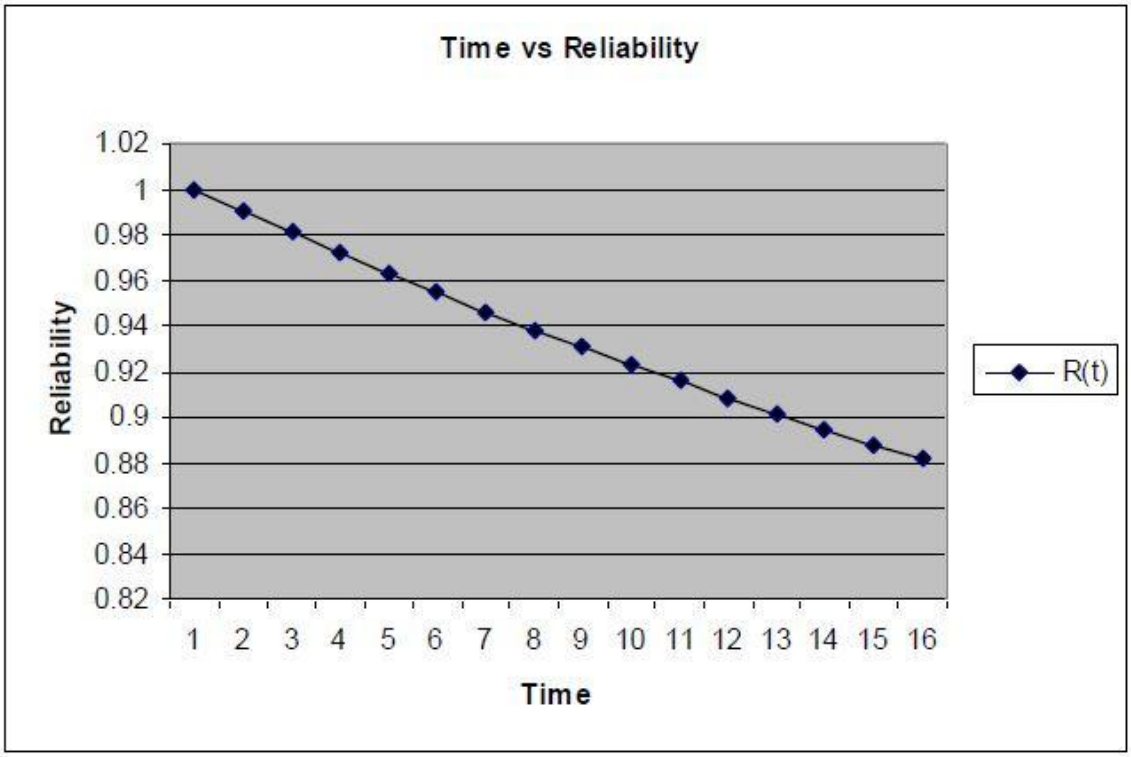

Figure 1.2: Graph Reliability versus Time

(Source: S.C. Agarwal, Mamta Sahani and Shikha Bansal, 2010)

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2.2 DESIGN FOR RELIABILITY

Design for Reliability also known as DfR is a method to design components or products to enhance the capability and reliability of the components or products from experiencing any failure to function. There are elements of Design for Reliability that is applied on products and its components to increase its reliability. It is important a product to have high reliability to ensure a longer life-cycle and prevent failure. Reliability is a measure of how the quality of a product is maintained over time. Quality here is usually in terms of satisfactory performance under stated set of operating conditions (David G. Ullman, 2001).

2.2.1 Redundancy

In engineering, redundancy is the duplication of critical components or functions of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe. The reason why this is the ultimate design choice is related to the fact that to provide absolute high confidence reliability evidence for new parts or items is often not possible or extremely expensive. By creating redundancy, together with a high level of failure monitoring and the avoidance of common cause failures, even a system with relative bad single channel (part) reliability, can be made highly reliable (mission reliability) on system level.

Reliability design can be an iterative method that begins with all the specification regarding reliability goals in keeping with cost and also performance targets. To attain performance targets, some product will need to have high trustworthiness which operating well. Redundancy is probably the most effective approaches to increase reliability. Redundant or perhaps multiple parts are performed concurrently in parallel unnecessary designs although the blended output just isn't required. Each component is derated and has its life increased by a longer-than –normal time because the existence of parallel paths may result in load sharing. Another method of increasing redundancy is to

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