



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DESIGN OPTIMIZATION AND FABRICATE OF HAND FREE LEG  
BRACE TO IMPROVE CONVENTIONAL CRUTCHES**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering (Automotive Technology) with Honours.

by

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**2019**

**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

Tajuk: Design Optimization And Fabricate Hand Free Leg Brace To Improve  
Conventional Crutches

Sesi Pengajian: 2019/2020

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I hereby, declared this report entitled Design Optimization And Fabricate Hand Free Leg Brace To Improve Conventional Crutches is the results of my own research except as cited in references.

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# APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

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## ABSTRAK

Tongkat adalah alat atau peralatan yang membantu orang kurang upaya atau kecederaan kaki bawah yang menampung berat mereka dari kaki ke tongkat bergantung pada peranti dan jenis tongkat. Tongkat telah digunakan lebih dari 500 tahun yang lalu dan reka bentuk dan revolusi telah berubah tetapi fungsi itu masih sama. Berdasarkan sejarah tongkat ia dicipta sejak Perang Saudara pada tahun 1861-1865 dan orang pertama yang membuat tongkat adalah Emile Shlick pada tahun 1917. Terdapat beberapa jenis tongkat seperti tongkat auxillary, tongkat lengan bawah, tongkat lengan lutut dan lebih daripada itu. Pada asasnya tongkat konvensional sangat terkenal kerana reka bentuknya yang mudah dan kos pengeluaran yang lebih rendah. Tetapi tongkat konvensional tidak mencukupi untuk memuaskan pesakit terutama pada keselesaan mereka dan kesan sampingan apabila digunakan dalam jangka panjang. Oleh itu, terdapat hampir 100 kajian mengenai tongkat konvensional dan kebanyakan fokus kajian terhadap keselesaan dan untuk mengurangkan kesan sampingan tongkat konvensional. Kadangkala, kebanyakan kecederaan boleh menjadi lebih serius kerana salah cara menggunakan tongkat dan menggunakannya untuk jangka masa panjang. Oleh itu, dalam projek ini adalah satu alternatif untuk meningkatkan tongkat konvensional agar lebih selesa dan boleh dipercayai. Selain itu, dalam projek ini akan memperkenalkan teknologi baru yang boleh digunakan oleh pesakit dengan menyokong pesakit tanpa menggunakan kedua-dua tangan mereka. Projek ini telah menghasilkan tongkat bebas tangan yang membantu pesakit lebih santai dan tenang dengan menggunakan tongkat bebas tangan serta mengurangkan kesakitan mereka. Lebih daripada itu, manfaat tongkat tangan bebas adalah untuk membenarkan kaki bebas membengkok pada lutut mereka semasa berjalan dan juga membolehkan pesakit untuk menjalankan senaman otot walaupun ketidakupayaan mereka. Dalam pengeluaran satu item, ia perlu mempertimbangkan beberapa faktor seperti kos dan keselamatan faktor untuk mengelakkan kesilapan dalam reka bentuk dan pembuatan. Kemudian, untuk menjayakan projek ini, ujian analitik atau pengoptimuman perlu diperolehi di mana reka bentuk itu berkemampuan berfungsi dengan parameter yang sesuai yang telah ditetapkan menggunakan perisian kejuruteraan Solid Work. Tujuan pengoptimuman adalah meningkatkan prestasi, penjimatan bahan, kekuatan, dan meningkatkan faktor keselamatan sebelum membuat produk. Dalam projek ini juga meliputi proses untuk kualiti pengeluaran yang tinggi, berdaya saing dan mampu bekerja di bawah parameter negara.

## ABSTRACT

Crutches is a device or assist tools that help disabilities people or lower leg injury that transfer their weight from leg to the crutches depend on their device and types of crutches. Crutches was been used almost over 500 years ago and the design and revolution has been change but the function it still same. Based on history crutches are created since Civil War at 1861-1865 and the first person that created the crutches is Emile Shlick at 1917. There are have several types of crutches such as auxiliary crutches, forearm crutches, knee crutches and more than that. Basically conventional crutches are very familiar because of it simple design and the lower cost of production. But conventional crutches not enough satisfy the patients especially on their comfortable and the side effect when long term used. So there are almost over 100 study about to improve the conventional study and most of the study focus on comfortable and to reduce side effect of conventional crutches. Sometimes, most of injury can be more serious cause of wrong step or ways using the crutches and used it for long term. So in this project is one alternative that to improve the conventional crutches to more comfortable and reliable. Beside that, on this project will introduce a new technology that crutches able to support the patient without using both of their hands. This project has been fabricate of the hand free crutches that helps the patients more relax and restful by using hand free crutches of reduce their amount of pain. More than that, the benefit of hand free crutches is to allow the leg free to bend at their knee during walking and also allowing the patients to exercise the muscle even their in disabilities. In the production of one item, it need to consider a several factor such as cost and safety of factor to avoid error in design and fabricate. Then, for successfully of this project, analytic test or optimization need to obtain where the design should capable working with the predetermined parameter bu using Solid Work engineering software. The purpose of optimization is to increase performance, material saving, strength, and increase safety of factor of the design before fabricate the product. In this project also covers the process for the high quality of production, competitive and able to work under state parameter.

## **DEDICATION**

This project and research work is dedicated to my beloved parents and all families for their enthusiastic caring throughout my life, my loving siblings, my supervisor and also my friends for their encouragement and ideas support.



## **ACKNOWLEDGEMENT**

I would like to express my deepest appreciate to the people who support me to finish this report. Firstly, special thanks to my final year project supervisor, En Azman Bin Ibrahim because has given guidance and advice to finish my report very well and not forget to En Rafi Bin Omar because provide additional information and assist me to allow use SLS 3D Print. Special appreciate also to the other lecture that give extra knowledge and idea to improve my writing and also to the panel that help me to improve my presentation skill and my report. Then special thanks to my parent that give me encouragement while finish my task during this project establish. Lastly thanks to my housemate that will assist me in giving ideas and support me to complete this project.

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# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

kg	-	Kilogram
Cm	-	Centimeter
Mm	-	Millimeter
Nm	-	newton meter
F	-	Force
V	-	Velocity
$\sigma$	-	Stress
E	-	Modulus Young
M <sup>3</sup>	-	Meter Cube
<i>l</i>	-	Length
Ø	-	Diameter
%	-	Percent
Min	-	Minimum
Max	-	Maximum
SoF	-	Safety Factor
RM	-	Ringgit Malaysia
OD	-	Outside Diameter
MPa		Mega pas

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

A crutch is an assist device mobility that help disabilities people or lower limb injuries by transfers their weight from the legs to the upper body. Based on LeBlanc study, crutches have been used for over 5,000 years but it not to much change either their design and characteristic (LeBlanc, Carlson, & Nauenberg, 1993). There have been numerous technology to modify the design of the standard axillary crutch to the advancement of Canadian crutches which some of there use combination of axillary bolsters and elbow bolsters; spring-loaded bolsters; and rocker-bottom bolsters. However, the designs from the modify have not successfully marketed to crutch users generated not much interest.

It is important to create a more viable, secure, and comfortable crutch for disabilities people. The benefits of developing a more viable crutches are not constrained to a walking and standing, but it help them for do daily activities. Crutches are utilized by numerous individuals including amputees, paraplegics, individuals with broken bones, individuals with torn tendons and numerous others. (Adriana Segura, McNair Scholar, Penn State, 2012).

Most disabilities people or lower limb injury are request to be comfortably use crutches and it importance especially in standing and walking that allow for improved growth of bone, improved circulation of blood, reduced bladder infections and reduced pressure lesions (Shortell, Kucer, Neeley, & LeBlanc,2001). The crutches helps people with disabilities or lower limb injuries to be able freely move around and do their daily life.

However, conventional crutches have some of problems for the crutch user and sometimes the more disadvantages rather than a benefit. Besides that, conventional axillary crutches may effect vibration forces to the wrists and shoulders and can cause wounds from the bolster for patients. Most of bolster users endure from a condition called crutch palsy which happens when the external edge of the bolster saddle harms nerves within the axilla.

This also can effect of harmed nerves and can lead to add up to loss halfway of motion in a few of the of the arm and hand (Subramony, 1989).

With a hand free crutch, for long-term crutch users or short-term crutch users will be helped them in their daily life. It will more better and comfortable crutches for them compared to conventional axillary crutches user. There also help to less discomfort use conventional crutches and harsh forces on the hands and axilla.

Based on previous study, conventional crutches required twice as much energy to walk with crutches than to walk without assistance (Fisher & Patterson 1981). People with disabilities or leg injuries often do not want to use so much energy on a daily life just for walking. With a new designed in hand free crutches and more ergonomically effective crutch, the use of energy can be less. Most of patients will wish to use crutches instead of wheeled mobility because maybe the effort to ambulation will not be as high compared to conventional crutches. (Adriana Segura, McNair Scholar, Penn State, 2012).

The purpose of this study is to develop a design and fabricate for hand free crutch that has a modified or improvement from conventional crutches. The benefit of hand free crutches is to allow the leg to bend at the knee during walking and also allowing the patients to exercise the muscles associated with this movement. However, some of force is applied to the lower leg and particularly to the patellar tendon when their walking.

## **1.2 Problem Statement**

Nowdays people with disabilities need more challenges in their daily lives. So, crutches are one of the ways that helped people with disabilities for standing and walking which in return will improve the growth of bones, circulation of blood, reduce bladder infections and reduce pressure lesions (Shortell, Kucer, Neeley, & LeBlanc, 2001). Other than that, crutches have a physiological and psychological benefits especially when it compared to the wheelchair and most previous study also proved that used of crutches have more of advantages. By using crutches, it force a patients to walking compared use of wheelchair and also helps the patients for recovery. In any case, conventional crutches may abdicate a huge number of issues to the patients which may eclipse its benefits. For occurrence, conventional axillary crutches tend to exchange vibrating powers to the shoulders and wrists of the patients which might case wounds and bothering. Too, a common condition related with crutches utilization is Palsy, which is basically when the external edge of the crutch saddle and harms nerves the axilla. This might result in add up to or fractional loss of motion in a few of the upper limit muscles (Subramony, 1989). In any case, a fast recuperation can be accomplished by suspending the utilize of the crutches. So, hand free crutches are one of solution to help patients from got other any injuries. In other words, hand free crutches also helped a patients to reduce their injuries and encouraging a patients for fast recovery.

## **1.3 Objective Of Project**

The direction of this project is based on the following objectives:

- To analysis and optimization design concept of hand free crutches
- To fabricate hand free crutches for replace conventional crutches
- To make portable crutches, low cost and able support weight maximum 150 kilogram

## **1.4 Scope Of Project**

The limitation of this project is based on the following scopes:

- Fabricate of hand free crutches only for patients that has lower leg injuries or ankle injuries
- Hand free crutches only can be used for patients has injuries on one of their leg which is left or right and not for both leg injuries
- Hand free crutches only can be used for patients with maximum body weight below 150 kilogram
- Hand free crutches only can be used for patients with average age between 12 years old and above.
- Hand free crutches are designed for lower knee injuries and not for patients that no have lower leg or lower knee.

## **1.5 Rationale of study**

The purpose of this research, as already mentioned at the objective, is to improvements the conventional crutches by design a new concepts of crutches which hand free crutches or hand free leg brace. This project will be achieved primarily by design three of concept hand free leg brace the continued with analyzing the crutch using Solid Work software. This analysis to establish the result from the three concept which a few data will be measure, such as maximum weight the crutches can achieve, area of deformation and safety of factor.

Another benefit that can be gained from this research is that it will can use for patients that have lower leg injuries which it will be test for 10 of patients for product testing. From the testing, it can be identifying the patient's requirements and limitations such as their thigh flexibility and universal size . By identifying the size and comfortable of the product by user experience, hand frre leg brace can determine a benefit from this product compared to another types of crutches and it can determine safety of product for user. Overall, this research will lead to an improved of conventional crutches for user experience and their comfortable for daily live.

# **CHAPTER 2**

## **LITERATURE REVIEW**

### **2.1 Introduction**

In this literature review chapter will consist of information and summarizing about several type of leg brace crutches that was built and their characteristic. In this section provided process of obtaining and summarizing the related information through the reviews on the journals, books, internet resources, articles and etc. It provides the background knowledge of the studies and worked as a guide to the later part of a project. Similarly, in this project, the information of a conventional leg brace crutches such as the history and the components are studied in the earlier part of this stage. Besides that, in this chapter will provided the information about step to analysis of the hand free leg brace crutches obtained by pass study of journal and other source.

Crutches aids help patient walk or move from one place to another if they are disabled or have an injury. There are many types such as include crutches, canes, walkers, wheelchairs and motorized scooters. Someone injury may need a walker or cane if they are at risk of falling. For those need to keep their body weight off their foot, ankle or knee, they may need crutches.

In this chapter also shows the market of assistive devices is flushed with products that look mostly the same with crutches, but it is have own characteristic which resembles to a crutch. A crutch itself has not evolved much during many years even its function and it appearance (Rimgaile samsonaite, 2008). Producers try to produce them as cheap as possible and to make one that fits all, however for users are not satisfied but they cannot choose.

## 2.2 History Of Crutches

Crutches or walking stick have aided of human to hold themselves up when they became sick or injured. Since it created as support devices, there were used in ancient Egypt for the first time. The crutch was first created and design for lower limb injury by Emile Schlick by 1917. Crutch mills start build up their production in the hills of New England, where they were produced (Rimgaile samsonaite, 2008). Besides that, some of these mills are still operation and receives orders for customers, and it still using the same manufacturing methods with some improvement that were used during the Civil War at 1861 - 1865. There are also have two different types of crutches which have design differently followed by their specification of design. Later, A.R. Lofstrand, Jr. was created the first crutches with it can be adjustable on the height and making the crutches better and customizable. However, the designs of crutches not changed too much especially the classic pattern and conventional pattern and still is commonly used.

The early design of the crutches was formed in a T-formed strolling stick then it design were replace formed into the V-molded support that regardless like crutches nowadays. Normally, 'T' shaped crutch which was the foundation on which more common 'V' shaped crutches of past designed concept (Michelle Tonutti, 2015). Once upon a time, some of crutches were produced using a combination of hardwood which it was sliced as needs be until part closer to the best into this V shape and a wooden underarm area. It also have been connected to the best and center for both underarm and handle use.

These underarm crutches were prominent as they took into consider the use of the hands while supporting the harmed individual's weight underarm which implied that the patients could lift overwhelming burdens and perform regular undertakings even with constrained portability. Afterward, an ergonomic and luxury model was created for those with the good financial to get to them, which made a progressively open to sling top of crutches from a calfskin pocket and loaded up with the strong strands of steed tail. The heap on the two contact focuses among brace and body has been being developed for a long time is as yet being improved in present day times.

### 2.3 Function Of Crutches

The crutch is the only and reliable way to stability the mobility of individuals with lower limb injuries by supporting their body weight during movement in lifestyle for example ascending or descending stairs and walking. It provides a steady environment for recovery by allowing the injured body part in a stack free condition. It is known that the crutches have been used for 5,000 years' time ago (S. Epstein, 1937). Individuals used fall from tree branches as supporting sticks to assist balancing or ambulating injured body. From its primitive shapes, the current arrangements of underarm and lower arm crutches have been advanced through different experimental designs.

However, crutch strolling has a few unresolved issues, including the suitable length of the crutch, crutch palsy, palmar pain during crutch weight support, and deviation of the crutches cushion from the axillary during the crutch position phase. In specific, the cushion of crutches not support properly from the axillary during the crutch position stage, and this is one of the factor issues why it not be a safe crutch walking.

One of the disadvantages is that the crutches cushion is not held solidly against the chest wall, also the crutch tends easily to displace from the axillary and have possibly leading to falls. So, the problem of the crutch cushion not align from the axillary should be consider to ensure for patients safety. From the previous study, it already showed that external rotation of the crutch all through the part stance phase, was guaranteed that the crutch cushion was held tightly against the chest wall during single-crutch walking (International Journal of Innovative Technology & Creative Engineering, 2011).