

**LEVER-CHAIN MECHANISM DESIGN FOR ALL  
TERRAIN WHEELCHAIR**

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**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**LEVER-CHAIN MECHANISM DESIGN FOR ALL  
TERRAIN WHEELCHAIR**

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in fulfilment of the requirements for the degree of  
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## DECLARATION

“I hereby declare that this report is the result of my own work except for quotes as cited in the reference”.

Signature: .....

Author: .....

Date: .....

## **SUPERVISOR’S DECLARATION**

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Mechanical Engineering

Signature :.....

Name of Supervisor :.....

Date :.....

## DEDICATION



I would like to dedicate my project to my beloved mother, father, and my family members who gave me never ending affection, love, encouragement and pray of day and night throughout this Final Year Project.

## ACKNOWLEDGEMENT



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## **ABSTRAK**

Makalah ini merangkumi reka bentuk dan kajian pergerakan pada reka bentuk mekanisme rantaian tuas untuk kerusi roda semua rupa bumi. Kerusi roda konvensional dilaporkan bertanggungjawab terhadap kesakitan muskuloskeletal di bahagian atas badan. Oleh itu, terdapat pelbagai teknik dan mekanisme yang digunakan dalam peningkatan kerusi roda konvensional. Penyelidik atasan telah mencipta dan fabrikasi kerusi roda yang dimajukan oleh tuil dan menjual kerusi roda mengikut keperluan pasaran. Segelintir Orang Kurang Upaya (OKU) yang tinggal di kawasan luar bandar tidak mampu untuk memiliki kerusi roda untuk mereka melakukan aktiviti dan keperluan asas mereka. Kertas penyelidikan ini bertujuan untuk mengembangkan kerusi roda rantai berkuasa oleh tuil yang mempunyai kos mekanisme yang terendah dari segi penyelenggaraan yang memudahkan kerusi roda diperbaiki di mana-mana di kedai basikal. Selain itu, kajian gerakan melalui Solidworks telah dilakukan untuk memastikan kerusi roda rantai tuil berkesan dalam kelebihan dan kecekapan mekanikal. Oleh itu, dalam reka bentuk ini tuil digunakan untuk menghantar daya untuk menggerakkan kerusi roda dan bukannya menggunakan daya pada menolak rim tayar. Kerusi roda ini di reka bentuk untuk melakukan daya yang terendah untuk pergerakan yang lebih. Ia juga untuk mengurangkan kos daripada kerusi roda yang canggih dan maju seperti kerusi roda elektrik dan kerusi roda bermotor. Bahagian asas dalam basikal digunakan dalam kerusi roda ini untuk memastikan pemancuan mekanisme asas seperti gegancu dan gegancu berkunci yang memancarkan pemacu kuasa melalui rantai yang berputar sepenuhnya dimanfaatkan. Mekanisme merupakan mekanisme yang paling murah, mudah dijaga dan juga diperbaiki.

## **ABSTRACT**

This paper includes design and motion study on lever-chain mechanism design for the all-terrain wheelchair. The conventional wheelchair is reported to be responsible for musculoskeletal pain in the upper limbs. Therefore, there are various technique and mechanism utilized in the improvement of a conventional wheelchair. A researcher has developed a lever propelled wheelchair and fabricated the wheelchair according to the market needs. Some of the Person with Disabilities (PWD) who lived in rural areas cannot afford to own a wheelchair. This work aimed to develop a lever chain wheelchair that has the lowest cost mechanism and easy maintenance which the wheelchair can be repaired anywhere in the bicycle shop. Moreover, motion study through Solidworks has been done to ensure the lever chain wheelchair are purposely efficient in mechanical advantage and mechanical efficiency. So in this design, the lever is used to transmit the force to move the wheelchair instead of applying the force on push rim. This wheelchair is designed in such a way that requires less effort for more movement and it cheaper than the advanced wheelchair such as an electric wheelchair or motorized wheelchair. Basic part in a bicycle is used in this wheelchair to ensure the basic mechanism sprocket and freewheel that transmit the power drive through rotating chain are fully utilized. This mechanism is far most the cheapest mechanism and easy to maintain and repaired.



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## LIST OF ABBREVIATION

WHO	World Health Organisation
PWD	Person with Disabilities
VR	Velocity Ratio
QFD	Quality Function Deployment
HOQ	House Of Quality
PDS	Product Design Specification

## LIST OF SYMBOL

$N$  = Number of teeth

$D$  = Pitch diameter

$\rho$  = Chain pitch

$C$  = Centre distance

$L$  = Chain length

$\theta$  = Angle of contact

$\omega$  = Angular speed

$v_c$  = Chain speed



# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND

Disability can represent different meanings to different individuals. Generically, in Malaysian Person with Disabilities Act 2008 defines disability as having long- term physical, mental, intellectual or sensory impairments that may impede their full and effective participation in society in interaction with various barriers.

World Health Organization (WHO) statistics stated that it is estimated that 5–10% (1.3–2.6 million) of the world’s population are Person With Disabilities (PWD). Department of Statistics Malaysia reported that the total population of Malaysia was 26.64 million people in 2006. From the total population, PWD is around 1.3–2.6 million. However, only 220 to 250 PWDs were registered with the Social Welfare Department in December 2007. Due to the increasing number of population, lifespan, and the total number of road and industrial accidents, the number of PWD also predicted to be increasing. The total number of the elderly population in Malaysia is estimated to increase from 1.73 million (6.6%) in 2005 to 3.8 million (11.3%) in 2020. Because of that, the number of people will use a wheelchair reportedly to be increasing. (Rahim, Amirah, and Samad, 2010).

There are types of wheelchair exist in this world which has been done by the researcher day by day. They inventing advancement in every sector that possible bring ease to the patient. Improvement were made to the wheelchair with various design which lead to a conventional wheelchair to an advanced wheelchair for easier use and without burden the disable person more often.



Figure 1.1 : Normal wheelchair



Figure 1.2 : Electric wheelchair



Figure 1.3 : Voice controlled wheelchair



Figure 1.4 : Lever-chain wheelchair

This priority of this paper is to introduce the wheelchair which not required any external assistance to be moved. The patient must be able to operate the wheelchair using his/her comfortably and independently. The patient will require less effort but more efficient to move than conventional wheelchair. This paper included a wheelchair that is affordable and versatile to be used. The wheelchair also can be used in varies terrains and hence accessible to a complex diversity.

## 1.2 PROBLEM STATEMENT

Wheelchair propulsion has been reported to responsible for musculoskeletal pain on the upper terminus. A wheelchair is one of the most efficient tools to help the patient lead normal lives by enabling them to carry out their daily activities. However, musculoskeletal problems are often associated with conventional manual wheelchair propulsion. (Sarraj and Massarelli, 2011). Rough terrain such as rocky, sand, grass and also uphill road are the major problem facing in the countryside such as India and Africa. The conventional wheelchair will burden the patients that require more effort for more movement to that kind of terrain. Hand rim wheelchair propulsion will not adapt these rough terrains normally. This paper will solve all terrains problem to give more efficiency with less effort on the wheelchair to ease the patient to move and perform their daily activities. This project is rarely seen in Malaysia due to unawareness from the villages or rural areas. This might help the poverty in Malaysia to be able to buy a cheap but efficient wheelchair to lighten the burden and make life easier.

### **1.3 OBJECTIVE**

The objectives of this project are as follows:

1. To design a mechanism to use in all terrain wheelchair by using a lever-chain mechanism.
2. To analyse lever-chain mechanism wheelchair.

### **1.4 SCOPE OF PROJECT**

The scopes of this project are:

1. This project will design, develop, and analyse an assistive mechanism to assist a person with a disability to be able move the wheelchair on all terrain.
2. To analyse the mechanical efficiency of mechanism used in lever-chain mechanism wheelchair.
3. To design and study the motion analysis using CAD software which is Solidworks.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 INTRODUCTION TO LEVER CHAIN WHEELCHAIR

Lever-chain wheelchair propulsion has been proposed worldwide since quite a while. These wheelchairs have helped many disabled person in terms of financial and physical mobility to do daily activities especially in India. Typical design consisted of two sprocket-connected levers that rotate freewheel connected to the wheelchair rear wheels, similar to the one used in the steam engine. In addition, lever- propelled wheelchairs are structured with normal operated push levers from the patient himself, which transfer force through the transmission mechanism to the wheels. Hence, the patient requires healthy upper limbs and strong musculoskeletal to operate this lever-propelled wheelchair.

The wheelchair designed used in this study is three-wheeled lever chain wheelchair which designed for all terrain purpose. The main purpose of this study is lever mechanism is to carry maximum load in minimum efforts. Furthermore, the patient will require less effort for more movement of the wheelchair. By using lever, it increases the velocity of the wheelchair with less force needed.

## **2.2 COMPARISON BETWEEN CONVENTIONAL AND LEVER CHAIN WHEELCHAIR**

### **2.2.1 Conventional Wheelchair**

Over the past several years, there has been increasing interest in wheelchair among the inventors and designers. This is due to significant high demand from the customer as the increasing of disable person in this worldwide. People are aware about conventional wheelchair with hand rim propulsion but in advanced technology, people began to demand a futuristic design with new technology for ease people lifestyle. Conventional wheelchair are widely used in hospital because of sturdy, durable and comfortable, accommodate long period of sitting. Moreover, manual wheelchair light in weight for easier to move and carry. In propulsion aspect, conventional wheelchair has good indoor portability and it is easy to steer in forward and backward direction but for turning it requires high initial force to move. (Bhende *et al.*, 2017).

In general, normal wheelchair propulsion can be divided into two phases which completed one full cycle: recovery phase and drive phase. These propulsion techniques become most important issue to the user because they wanted to reduce the incident occur in upper extremities. The disadvantages for manual wheelchair that it cannot use for outdoor due to inefficiency for rough terrain like grass, sand surface, rocky places and ramps. (Bhende *et al.*, 2017). Due to that, hand rim wheelchair is an ineffective form of human movement. The hand rim wheelchair will result in generally high strain on cardiorespiratory and musculoskeletal systems, just as high as energy consumption, high heart rate and low mechanical performance. (van der Woude *et al.*, 1997). Figure 2.1 shows the effect on upper body from hand rim wheelchair locomotion.

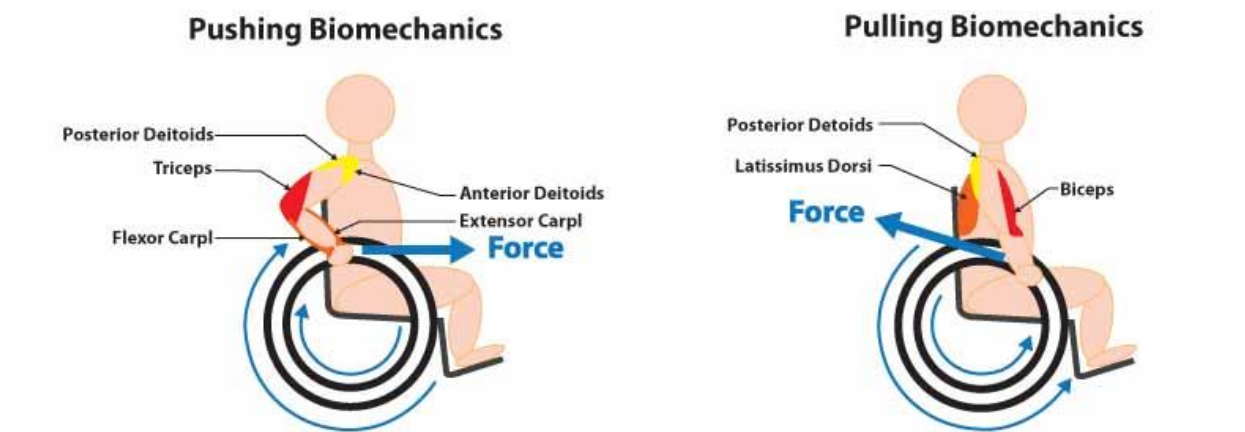


Figure 2.1 : Effect on upper body from hand rim wheelchair locomotion  
(Jameslacchianaresearch, 2012)

From figure 2.1, forward propulsion seems to propel in wrong movement in upper body. Soon, the upper body will permanent damage that lead to worsen shoulder. Upper body areas are not designed for heavy activity especially for long time period. Musculoskeletal problem issue are commonly related to biceps and triceps muscle which often damage the muscle due to extreme force given to the wheelchair.

It is actually pulling the wheel backward motion give less damage to your body with certain angle of hand position because the muscle can tolerate greater tension and have the ability to develop to cope with strong activity.

Shoulder damage does not simply end only in the wheelchair but the damage continues when the patient wants to perform their daily life such as reaching or grabbing things. Shoulder injuries can be harmful to user and their independence.