UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND FABRICATE MOTOR-ASSIST SYSTEM FOR FIN DRIVE FOOT PEDAL KAYAK

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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MOHAMAD IMAN BIN ISMAIL

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

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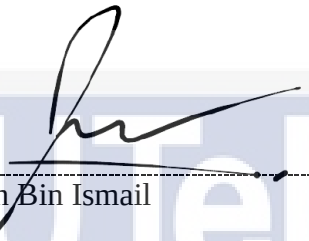
2022

DECLARATION

I declare that this Choose an item. entitled “Design And Fabricate Motor-Assist System For Fin Drive Foot Pedal Kayak” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

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DEDICATION

To my beloved parents and family, who have always encouraged and supported me through my educational journey. Also, to my supervisor Ir. Mazlan Bin Ahmad Mansor, and all my friends who have guided, inspired and helped me to complete my project

ABSTRACT

Kayak fishing is divided into two types: paddle and pedal drive, including fin drive or propeller drive. Because kayaking is a kinetic energy-intensive activity, only the propeller system has a motor-assist drive. This project aims to design and fabricate a design and fabricate motor- assist system for the fin drive foot pedal. The motor-assist drive will reduce the energy needed for a person to pedal the kayak from one point to another. A motor-assist will be produced after design selection. Welding, drilling, finishing, and project components selection will be part of the process. The best design will be picked from the House of Quality method with various options at all levels. The product has been inspected and assembled on the kayak after being made. Overall, the product performs well. Although it is not as fast as a manually operated system, this project has met all the project's objectives.

ABSTRAK

Kayak memancing terbahagi kepada dua jenis: pengayuh dan pacuan pedal, termasuk pacuan sirip atau pacuan kipas. Kerana berkayak adalah aktiviti intensif tenaga kinetik, hanya sistem kipas yang mempunyai pacuan bantuan motor. Projek ini bertujuan untuk mereka bentuk dan membuat kayak bantuan motor untuk sistem pacuan sirip. Pemacu bantuan motor akan mengurangkan tenaga yang diperlukan untuk seseorang mengayuh kayak dari satu titik ke titik yang lain. Bantuan motor untuk pemacu pedal sirip akan dihasilkan selepas pemilihan reka bentuk. Kimpalan, penggerudian, kemasan dan pemilihan komponen projek akan menjadi sebahagian daripada proses. Reka bentuk terbaik akan dipilih daripada kaedah "House of Quality" dengan pelbagai pilihan di semua peringkat. Produk telah diperiksa dan dipasang pada kayak selepas dibuat. Secara keseluruhan, produk berfungsi dengan baik. Walaupun ia tidak sepantas sistem yang dikendalikan secara manual, projek ini telah memenuhi semua objektif projek.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

V	-	Volt
Ah	-	Ampere hour
RPM	-	Revolutions per minute
A	-	Ampere
L	-	Length
W	-	Width
H	-	Height
cm	-	Centimeters
%	-	Percentage
m	-	Meter
s	-	Seconds
m/s	-	Meter per seconds

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Kayaking is a sport that places a high demand on upper-body strength and endurance. (Tesch et al. 1976 Åstand and Rodahl 1977). Nowadays, modern kayaks have grown into various categories classified as river kayaks, sea (or touring) kayaks, racing kayaks, surf kayaks, fishing kayaks, and recreational kayaks depending on users intended use. Today's kayak categories include: "Sit-In," primarily influenced by conventional kayak forms, "Sit-On-Top," which developed from paddleboards with footrests and a backrest. Moreover, "Hybrid" is essentially canoeing with a double blade paddle (also known as a "kayak paddle") and twin hull kayaks with a narrow hull for each of the paddler's legs.

Foot propulsion kayaks, also known as pedal kayaks, are among the most significant innovations in the kayak fishing industry. While pedals are not new in other industries, Hobie Kayaks popularized them among kayak anglers. In 1997, Hobie Kayaks introduced the Mirage Drive, a pedal-powered kayak. Fins that pass sideways and back and forth make up the Mirage Drive.

The pedal kayaks are consisted of two categories depending on the drive type. Propellers propel kayaks, and they are moving by fins. The mechanism that drives the propellers is very similar to that of a vehicle. The gears convert the power produced by pedaling into propeller thrust. In reverse mode, the user can cycle in the opposite direction.

Hobie's Mirage Drive is the second form of the Kayak. This Kayak has fins or blades instead of a propeller. The fins turn sideways as the user cycle the pedals. Their angles

change as they pass sideways, propelling the Kayak forward. When approaching deeper waters, the user should fold the fins under the Kayak since they are vertical. With this form of Kayak, changing the direction these fins face is needed to shift in reverse.

1.2 Problem Statement

Generally, there are two types of kayak fishing: paddle type and pedal drive, which consist of fin drive or propeller drive. In terms of fishing, paddling gives the ability to sneak up on skittish fish is arguably the most mentioned benefit of paddling over pedaling.

It differs from pedaling kayak, giving more advantage in terms of speed. Pedaling gives on-the-water speed and efficiency, whether a rotating pedal with a propeller or pushes/pull pedals with fins. Successful tournament anglers are usually the first to arrive at their chosen location. Anglers who frequently travel vast bodies of water will get the most out of their day if they use a pedal drive to get them where they need to go quickly. However, both paddle and pedal drive share the same problem: the limitation for aged people or people suffering from a common disease such as *cardiovascular disease*.

It is undeniable that kayaking, apart from being a pleasurable and enjoyable sport, has many health and mental benefits. However, as people get old, their physical well-being: *strength, stamina, agility, and flexibility*, drops, making everyday tasks and normal functioning more difficult for the elderly.

1.3 Project Objectives

Because kayaking is an activity that demands extra energy, the main aim of this project is to design and fabricate motor- assist system for the fin drive foot pedal kayak. Due to the motor assist drive being just available for the propeller system, this will reduce the

energy needed for a person to pedal the kayak from one point to another. In specific, the objectives are as follows:

a) To design the motor-assist system for the fin drive foot pedal kayak using computer-aided three-dimensional interactive application (CATIA) software.
b) To fabricate a motor-assist system for the fin drive foot pedal kayak with the help of a motor powered by a battery.
c) To reduce the conservation of human energy.

1.4 Scopes of Project

The scope of this research are as follows:

- To invent and fabricate the motor-assist system for the fin drive foot pedal kayak.
- The type of mechanism and motor that will be used to move the pedal fin drive system.
- Allow additional features by equipped with motor-assist for the kayak.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will focus on the research details and study results on the history of kayaks themselves and the variations between fin drive and propeller drive systems in terms of type, operation, and specifications. It also covers the history of the kayak, including design and analysis from the first kayak to the present. Based on the project scopes, this information will be utilized as the ground rule to select the most appropriate design from the authorized theory and factor for finishing the design.

2.1.1 History of Kayak

Kayaking has recently become one of the most popular water activities, which improves general health and can also transport people to locations that are inaccessible by land. The first people to build and use kayaks were the Inuit, Aleut, and Yup'ik people. Often referred to as "Eskimos," these indigenous people live in modern-day Greenland, Canada, and Alaska ("7 Facts You Didn't Know About the History of Kayaking in Gatlinburg",2020). The word Kayak (ki ak), meaning "man-boat" in Eskimo, was found predominately in the northern parts of the world, North America, Siberia, and Greenland (International Canoe Federation,2017). The Kayak probably originates from Greenland, where the Eskimos used it, while the Canoe has been used worldwide.

Kayaks were initially designed for hunting animals or creatures that dwell in or near water. The Inuit and other indigenous peoples created kayaks by sewing animal skins together, frequently from seals, and extending this material over a frame constructed of wood

or whalebone skeletons. These early kayaking pioneers also utilized whale fat to waterproof their boats. The oldest known Kayak was displayed in the State Museum of Ethnology in Munich, Germany. This Kayak was believed to have arrived in Holland in 1577 (Ocean River Sports, 2021). However, the Kayak, or qajaq, has a considerably longer history than the coasts of Holland in 1577.

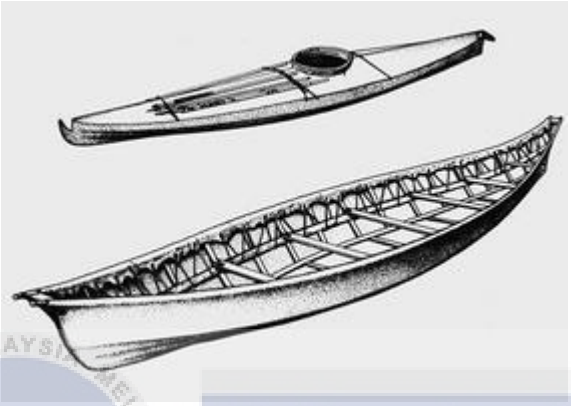


Figure 2.1 "Kayak (qajaq) and Umaiak by Gordon Miller"

(Source: http://www.thecanadianencyclopedia.ca/en/article/kayak)

2.1.2 The Evolution of Kayak

The kayak is not introduced in Europe until the 1800s. However, it is a significant episode in kayaking history. New developments in frames and coverings addressed the necessity for the kayak to be conveniently transported overland. One of these designs was a revolutionary collapsible kayak model called a foldboat invented in Germany in the 1800s (Encyclopedia.com, 2016). The foldboat had an outer layer of rubberized fabric stretched over a foldable tubular frame. The foldboat was designed to be dismantled and transported in just two suitcases. Kayaking as a competitive sport began during the Summer Olympic Games in Germany in 1936 and has since gained international appeal (Encyclopedia.com, 2016).

Percy Blanfold designed and produced hundreds of canvas-covered plywood and wooden kayaks in the 1950s and 1960s, which popularized sea kayaking. It was a soft-sided boat at the time, and it was not long before the French and Germans began utilizing kayaks for recreation. Kayaks were particularly popular among explorers exploring the icy waters of the North and South Poles.

Kayaking as a competitive activity debuted at the 1936 Summer Olympics in Germany and has since earned world acclaim. However, it is also an essential point in kayaking history because this was the year it was adopted as an Olympic sport. It was still seen as a global sport at the time, but the Olympics launched it into an ordinary event. In 1948, the Olympics added its first women's paddling event: the 500-meter singles kayak. The first white water racing event premiered in 1972. Today, the Olympics have more than ten white water competitions ("7 Facts You Didn't Know About the History of Kayaking in Gatlinburg",2020).

In terms of design, production, and usage, most modern kayaks differ significantly from native kayaks. They are frequently designed using computer-aided design (CAD) software, frequently associated with CAD specialized in naval design. Modern kayaks are generally used for various activities, including slow and easy touring on calm water, racing and challenging maneuvering in fast-moving whitewater, and fishing. Modern forms, materials, and building processes enable us to effectively meet these needs while retaining the ideas of the original Arctic inventors.

Commonly, there are two categories of kayak: flat-water and whitewater types. There are five types of flat-water kayaks; sit-on-top, recreational, touring, inflatable, and pedaling kayaks, and four types of kayaks; Playboats, River Runners, Creek boats, Old School, and Inflatable (Duckies). Flat-water kayaks are relatively stable and suited for leisure usage. They are designed to relax in calm, quiet lakes, meandering rivers, little ponds, and quiet

coastal inlets. Whitewater kayaks are also less complicated to roll than other kayak variants. Whitewater kayaks with a hard shell are always sit-in, and the majority are composed of durable remolded plastic.

2.1.3 Fishing Kayak

As kayak fishing gets popular, more kayaks are being created with more additional features. The add-ons features include pole rests, flat hulls for stability, pontoon stabilizers, and pedal-powered water wheels, which allow users to keep their hands on fishing rods while fishing. This kayak is available in two styles; sit-in and sit-on-top. They are built up like a sit-on-top kayak, but users need to pedal instead of paddling. Commonly, a fishing kayak uses a pedal, which is a step up from family-sized pedal boats. This kayak is generally short and sturdy, with enough room for a cooler box and other essentials.

Figure 2.2 Example of fishing pedal kayak

There are two types of pedals used in a fishing kayak: bicycle-style and stair climber style. Pedal kayaks are a good option for kayakers with shoulder and back problems since their legs do most of the work instead of their arms. Kayak users may cover a greater distance

in a pedal kayak than in a sit-on-top recreational kayak because leg muscles are more potent than arm muscles. However, pedal kayaks are heavier. Another advantage is that users may shoot images while traveling over the water with their hands-free. Rudders are also usually available on most pedal kayaks.

2.2 Existing Type of Kayak Propulsion

Kayak technology has improved as kayaking has grown in popularity among water sports lovers. There was a time when there was just one style of kayak (paddle kayaks). Paddle kayaks are still popular and are not going away anytime soon. However, a new type of kayak has taken over. There are two significant types of propulsion to consider: paddling (rowing) and pedal powered.

2.2.1 Paddling (Rowing)

Paddlers remind back of the days when paddling was the only sport available. While the alternatives have altered, paddling still has advantages over pedaling. The most significant advantage of a paddle kayak is that it takes slightly less deck space than a pedal kayak. One of the drawbacks to using a pedal drive system is the extra clearance needed under the boat (YakGear, 2019). In shallow water, some pedaling fishermen flutter their fins. However, anglers must flip up their fins or stop the pedal drive when fish are significantly in shallow water. A mudflat can consume valuable deck space and be annoying after a few switches.

2.2.2 Pedal (Fin Drive)

The first pedal kayak that appeared in 1997 was equipped with Mirage Drive made by Hobie Kayaks. A Mirage drive is a pedal-powered device that uses two identical fins that move forward, backward, and sideways to make the kayak move (Herron, 2021). On-the-

water speed and efficiency are the advantages of pedaling. Successful competition anglers are usually the first to arrive at their selected destination. Anglers who frequently travel vast bodies of water will get the most out of their day if they use a pedal drive to get them where they need to go quickly.

Figure 2.3 Example of pedal fin drive

2.2.3 Pedal (Propeller Drive)

Propel drive function is to propel a propeller-based pedal kayak forward or backward. The Native Watercraft first introduced Propel Drive-based pedal kayak in 2008. The difference between a Propel drive and a Mirage drive is that propel drive consists of rotational pedals that work with a rotating propeller rather than the push pedals of a Mirage drive (Herron, 2021). The operational method is simple in this case. When the pedal is rotating, the propeller rotates as well. Because the propeller is located beneath the kayak, the kayak moves as the propeller turns. The kayak can quickly be propelled forward and backward because the rotation may be done both clockwise and anti-clockwise.

2.3 Four-Bar Linkage

The four-bar linkage, generally known as the most direct closed-loop linkage, consists of four members, with three moving links, a fixed link, and four-pin joints. The joints are usually set up so that the links move in parallel planes, and the arrangement is referred to as a horizontal four-bar linkage.

Figure 2.4 Example of a 4-bar linkage

(Source: https://ocw.metu.edu.tr)

Four-bar linkages can be utilized for various mechanical applications, including converting rotating motion to reciprocating motion, constraining motion, and magnifying force. Four-bar linkages have many categories as crank-and-rocker, draglink, or double-rocker, depending on the type of rotational links used. A crank-and-rocker mechanism is used to transform the steady rotation of the crank into the reciprocal motion of the rocker. The main shaft drives the crank in manufacturing machinery. A functional component that performs a specific production process is attached to the rocker. A drag-link mechanism turns uniform rotation into nonuniform rotation in a single direction, which is employed in machines where the working component must have a velocity that is much higher than the average velocity on some segments while traveling in a single direction.

2.3.1 Grashof Criterion

The four-bar linkage is one of the most utilized linkages. It comprises three moving links and one ground link (also called a frame). Between those connections, there are four pin joints. The components of the four-bar mechanism are as follows. The input link is the link that connects to the driver or power source. The output link is the other connection connecting to the fixed pivot. The coupler is the remaining moving link between the input and output links. The motion of the input link is coupled with the motion of the output link. The lengths of the four-bar mechanism can be configured in various ways, resulting in various movements of the mechanism. Grashof's Criterion aids in categorizing into the following groups:

- Double crank
- Crank – rocker
- Double–rocker
- Changepoint
- Triple rocker

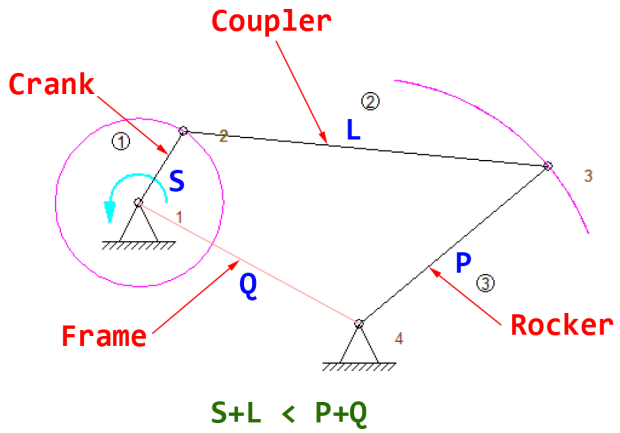


Figure 2.5 Example of Crank – Rocker mechanism

(Source: http://ezymechanic.blogspot.com/)

Grashof's criterion states that a four-bar linkage mechanism must have at least one revolving link if:

$$\boldsymbol{S + L \leq P + Q} \qquad 2.1$$

Which:

S = length of the shortest link

L = length of the longest link

P = length of one of the intermediate length links

Q = length of the other intermediate-length link

2.4 Bicycle Sprockets

A *sprocket* is a mechanically simple wheel that spins and connects to a chain or belt via teeth or tiny holes. Sprockets have been used for many years worldwide in their basic form and used in a wide range of applications, including bicycles, motorcycles, and other machinery. They are generally composed of hardwearing steel, which enhances lifespan. They are sometimes constructed of aluminum as they are lighter, making them suitable for motorcycles or pushbikes but wear faster than steel. To be compatible, they should have the same thicknesses and pitch.

When it comes to bicycle sprockets, the diameter of the sprockets on each side of the chain can be varied to change the total gear ratio of the chain drive. A multi-speed bicycle can have up to 36 different gear ratios. It has two or three different-sized driving sprockets and up to 12 different-sized driven sprockets. Lower gear ratios make pedaling up hills more straightforward, whereas higher gear ratios make pedaling flats and downhills more powerful. Similarly, manually changing the sprockets of a motorcycle can alter the acceleration and top speed characteristics by altering the final drive gear ratio.

Some sprockets with temporary straps feature bridges in the center of the interim belt. Also utilized are bolts and chains when the slip is not permissible for the power transfer from a shaft. Sprocket chains are used rather than straps or ropes and bolts rather than pulleys. They can perform at high speed, and some chain forms are designed that even at high speed, they are quieter.

2.5 Automotive Battery

An automotive battery is a rechargeable battery often used to start a car, motorcycle, and other vehicles. The main objective is to supply the electric starting motor with the electric current, which begins the chemical-powered internal combustion motor, which moves the motor. When the motor is operating, the battery still supplies power for the vehicle's electrical systems. At the same time, the alternator loads the battery when demand increases or decreases. Plate parts consist of a negative and positive plate set. A positive plate set comprises numerous positive electrodes, whereas a negative plate set contains several negative electrodes. A standard starting battery consists of 6 series cells, each with a nominal voltage of 2V. When the battery is charging completely, this results in precisely 12.72V voltage.

2.6 Wiper Motor

Windshield wipers are usually driven by a small electric motor and transmission mechanism (linkage) generally located on the firewall or beneath the cowl panel cover below the windshield. The motor moves the wiper arms back and forth by activating a linkage. The wiper switch delivers a signal to the control module when the wiper is turned on. The control module controls the wiper relay. A 12-volt relay powers the wiper motor. The motor spins a little arm that moves the wiper arms via linkages. The wiper motor uses up to three relays:

one for the wiper motor high-speed circuit, one for the low-speed circuit, and one for the intermittent wipers circuit. The wiper motor is a 12V DC (direct current) motor with gearing and a park switch. When the wipers are positioned at the bottom of the windshield in the "park" position, the park switch allows the engine to stop.

2.7 CATIA V5

CATIA is an acronym for Computer-Aided Three-dimensional Interactive Application. It is a popular 3D modeling program used by companies in various industries, including aerospace, automobiles, and consumer goods.

Dassault is a French engineering behemoth interested in aircraft, 3D designs, 3D digital mock-ups, and PLM software. Dassault Systèmes developed CATIA, a multiplatform 3D software suite including CAD, CAM, and CAE, covering the entire design-to-manufacturing process. CATIA also can generate orthographically, section, auxiliary, isometric, or detailed 2D drawing views to solid models and assemblies. Users may also generate model dimensions and create reference dimensions in the drawing views. CATIA's bi-directional attribute ensures that changes to the model can be reflected in the drawing section and vice versa.

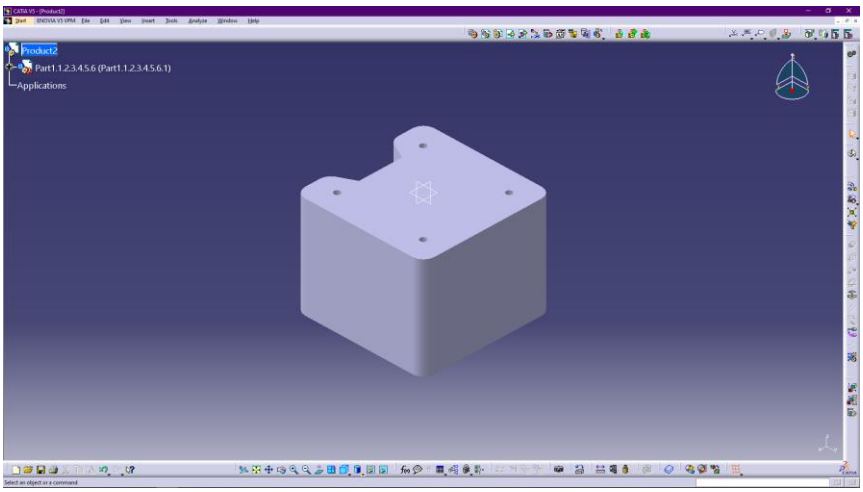


Figure 2.6 Example of 3D CAD design from CATIA V5

CATIA allows consumers to visualize designs in three dimensions. Dassault has altered the product classification from CAD/CAM software to Project Lifecycle Management as CATIA became more widely embraced by industrial organizations. The corporation also broadened the software's scope.

CATIA can also be utilized at various stages of the design process, including ideation, drawing, testing, and iteration. CATIA comes with a variety of workbenches ("modules") that allow it to be used in a variety of industries, including components design, surface design, and assembly, as well as sheet metal design. One of the basic workbenches for solid modeling is the part design. This CATIA module allows users to develop exact 3D mechanical parts with an intuitive and adaptable user interface from drawing in an assembly environment to detailed iterative design.

2.8 House of Quality

The House of Quality (HOQ) can be defined as a product planning matrix that demonstrates how consumer criteria are linked to the methods and processes businesses employ to meet those objectives. HOQ is widely regarded as the essential instrument for facilitating group decision-making throughout the deployment of quality functions. House of Quality diagrams are based on technical and competitive benchmarking data and have a design that resembles the outline of a house. The House of Quality is a conceptual map that allows for cross-functional planning and communication. While referring to patterns of evidence on the house's grid, people with various challenges and responsibilities can hammer out design objectives.

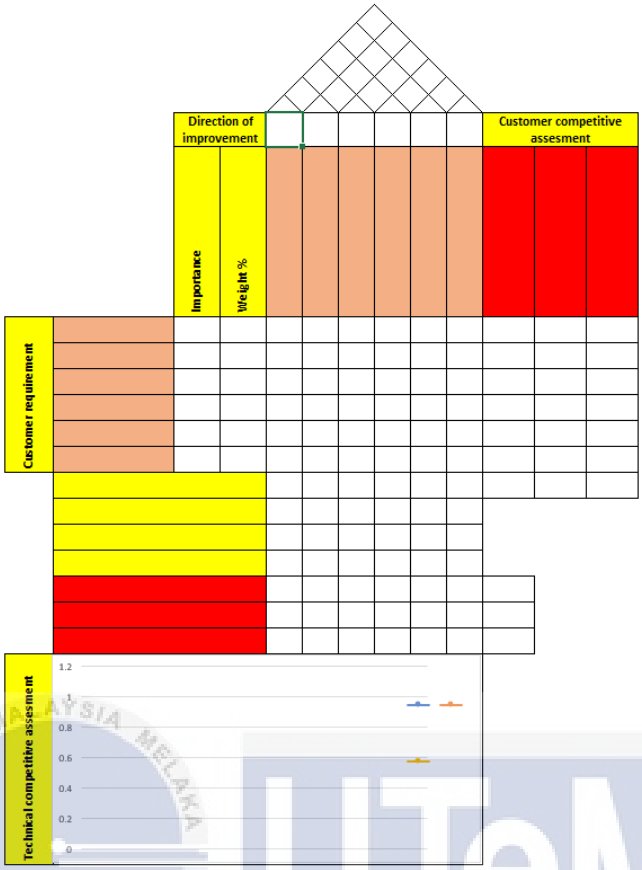


Figure 2.7 Example of House of Quality diagram.

Figure 2.7 shows an example of the House of Quality diagram. The Customer Specifications column on the left lists the high priority features that the customer has prioritized. On a scale from one until five, the numbers to the right show their importance to the customer. The Engineering Specifications section explains how to measure and execute production using engineering approaches. The engineering specifications are given measurements at the base. The symbols in the center grid show how closely each customer criteria relates to each engineering element. The upper component of the house, the "roof," shows potential engineering requirements disputes.

2.9 Summary of Chapter

As fishing kayaks evolve, many companies are looking for innovative methods to enhance the user experience. Motorized kayaks are popular nowadays. Many professional

kayak fishers are focusing on some new motorized versions that provide significant benefits over traditional paddle kayaks.

Anglers with disabilities and anyone who has difficulty pedaling or paddling should consider using a motor. The most common is the ease with which long distances can be covered. When time is limited, a motorized kayak will allow users to set their sights on fishing areas further from the access point or get to local favorites. Some anglers utilize a motor as a backup form of propulsion because it gives them the option to use the motor to go home if they become tired of paddling.

When looking for a pedal kayak, there are various options available on the market. However, motorized kayaks are only available for a propeller system and not for the fin drive system because the propeller system has more kits than the fin drive system.

2.10 Limitation of the Research

There are several limitations for the project development based on the study that has been done. Firstly, the main of the 4-bar linkage's input is a one-way bearing. Because one-way bearings are expensive, a bicycle sprocket can be used as an alternative. They both work on the same principle of transmitting torque between the shaft and housing in one direction while allowing free motion in the other. Next, because of the Covid-19, the field study will be limited, extending the time for this project's research.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, relevant ideas and information must be gathered using the methods specified in the project methodology. Firstly, the investigation and exploration of the kayak model used, which is the primary process. Following the investigation of the method of design selection used and the mechanism used for the pedal drive, the concept study's literature review must be completed to make the project more understandable.

3.2 General Methodology

To meet the project's objectives, the following measures are required:

a) Literature review.

The fin pedal drive's model and functionality will have to be examined through websites and field studies. Other than that, the component and material used will be reviewed through journals, articles, and books. For completing the project, the concept for the innovation will be revised.

b) Survey.

A survey will be created to ask some questions about this project. The findings of respondence and their answers will be saved and analyzed.

c) Design.

Several designs for the motor assist for fin pedal drive will be designed. The best design will be picked from the highest evaluation from the House of Quality method with a variety of options at all levels, from the

most fundamental concepts to the tiniest details of the shape following the technical requirements and customers need.

d) Fabrication.

A motor assist for fin pedal drive will be produced after design selection. Welding, drilling, finishing, and project components selection will all be part of the process.

e) Testing.

The testing goal is to make sure the product's functionality has been made. Some tests are needed before and after finishing. The objective of the tests is to analyze and improve its performance and stability.

f) Data analyses.

Data analysis aims to extract usable information from data and make decisions based on that info. The analyzed data will be the recommendation for future improvement.

g) Report writing.

The report will be written in the context of the completed project.

The summarization of the project methodology can be seen in the flow chart below:

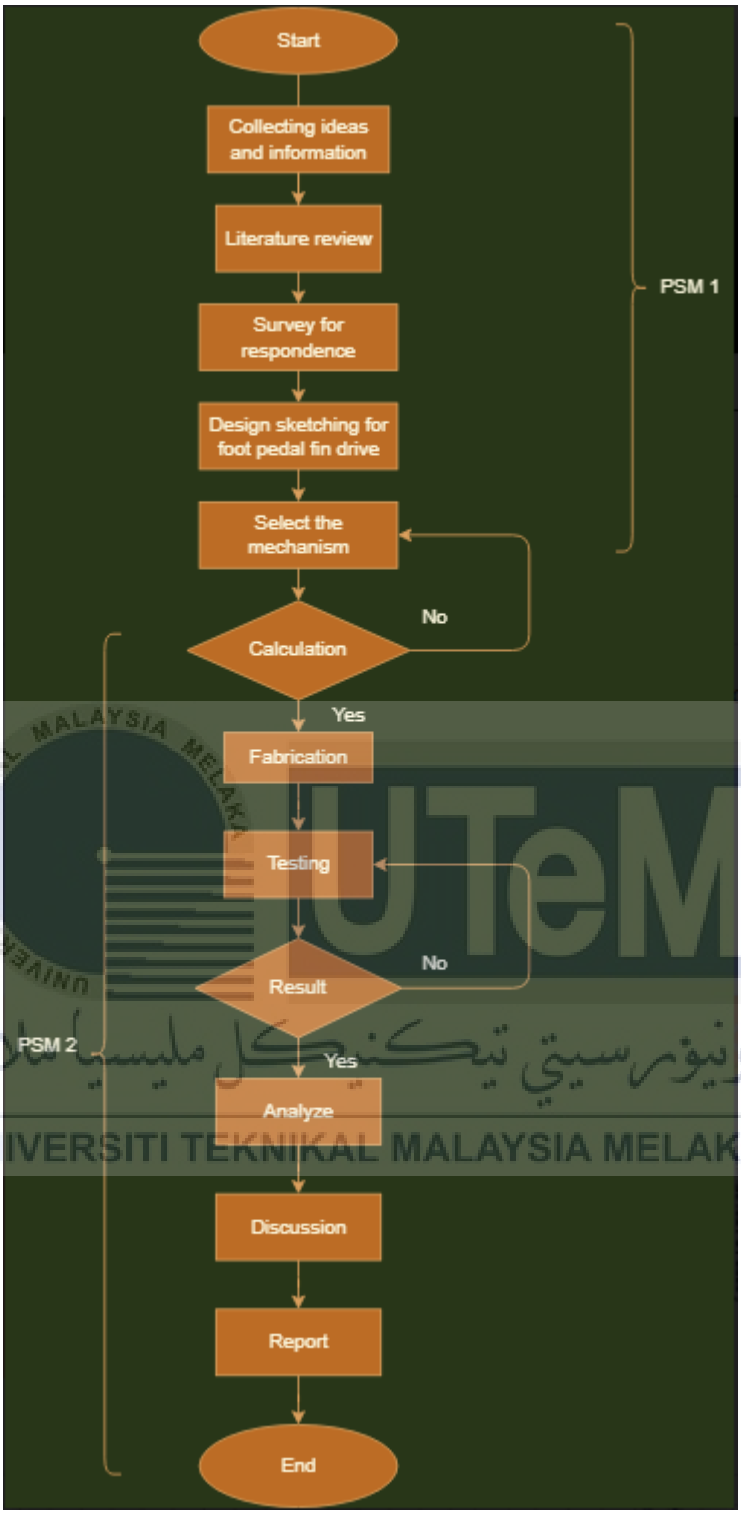


Figure 3.1 Project methodology flowchart.

The flowchart will be used as a reference and guidance throughout the project's development. The benefit gained from this stage was creating an organized working structure

as part of the working environment, hence increasing the project's chances of success. The flowchart in figure 3.1 represents the working schedule of this project.

3.3 Survey Questions

A survey must be distributed to a random group of people through social media. It comprises eight questions that the respondent must answer. APPENDIX C contains the questions and the results of the survey.

3.4 Concept Design of Motor Assist Foot Pedal Fin Drive

3.4.1 Raw Design (Expected Result)

From the findings from books and websites, the ideas for the motor assist will be converted into raw sketching. This rough sketching will be the desired result for this report. There are three types of mechanisms that will be used in this project which are quick-return, 4-bar linkage, and Scotch Yoke mechanism.

3.4.1.1 Design A

Generally, design A uses a single sprocket connected to the wiper motor. This design uses a single long shaft connected between the sprocket and the pedal. When the sprocket rotates at full 360°, the pedal will rotate in a limited range between 0 and less than 90°. A linkage ball joint will be welded to the sprocket to make an offset.

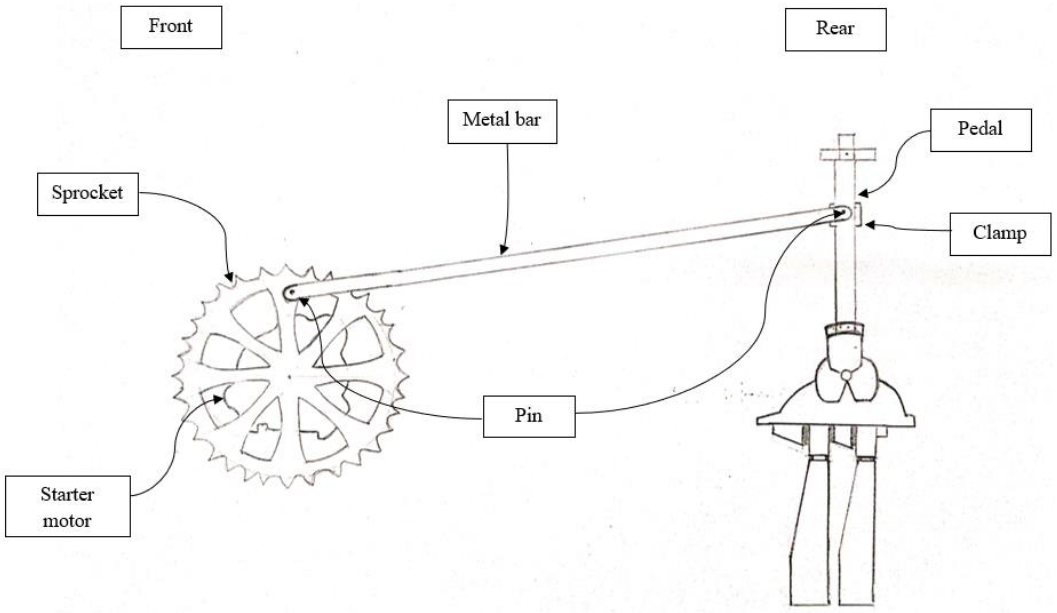


Figure 3.2 Draft design A.

3.4.1.2 Design B

For design B, the primary mechanism used is the quick-return mechanism. It consists of 2 sprockets, a driver sprocket, and a driven sprocket connected by a chain. The driver sprocket will be directly connected to the wiper motor. However, the driven sprocket will be welded with a short bar that consists of a bearing. Then, a slotted bar will be joined with the short bar and a mounting after applying some grease to the bearing.

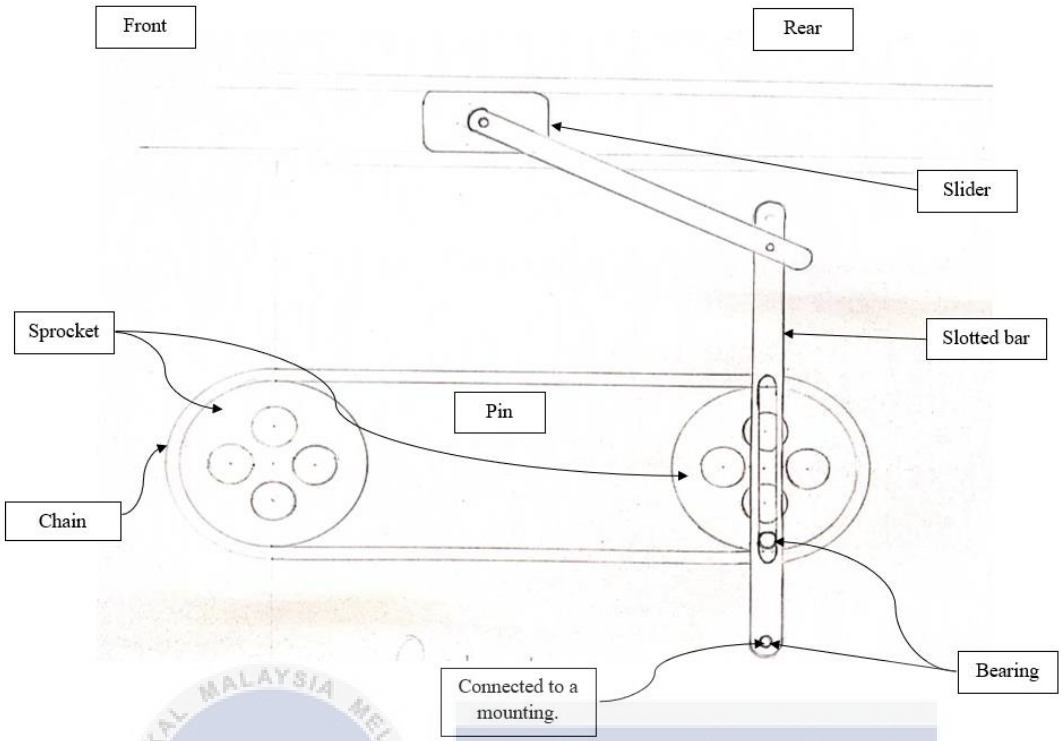


Figure 3.3 Draft design B.

3.4.1.3 Design C

Design C applies a Scotch Yoke mechanism to motor assist. This mechanism only requires one disc as the rotary motion to convert to linear motion, which is a bar that has been welded with slotted metal. The disc will be directly installed to the wiper motor, and a roller will be joined to the disc. The rear metal bar can be attached to the pedal by using a pin or welding method. When the disc spins, the bar attached to the pedal will move linearly with the disc and resulting in the movement of the pedal.

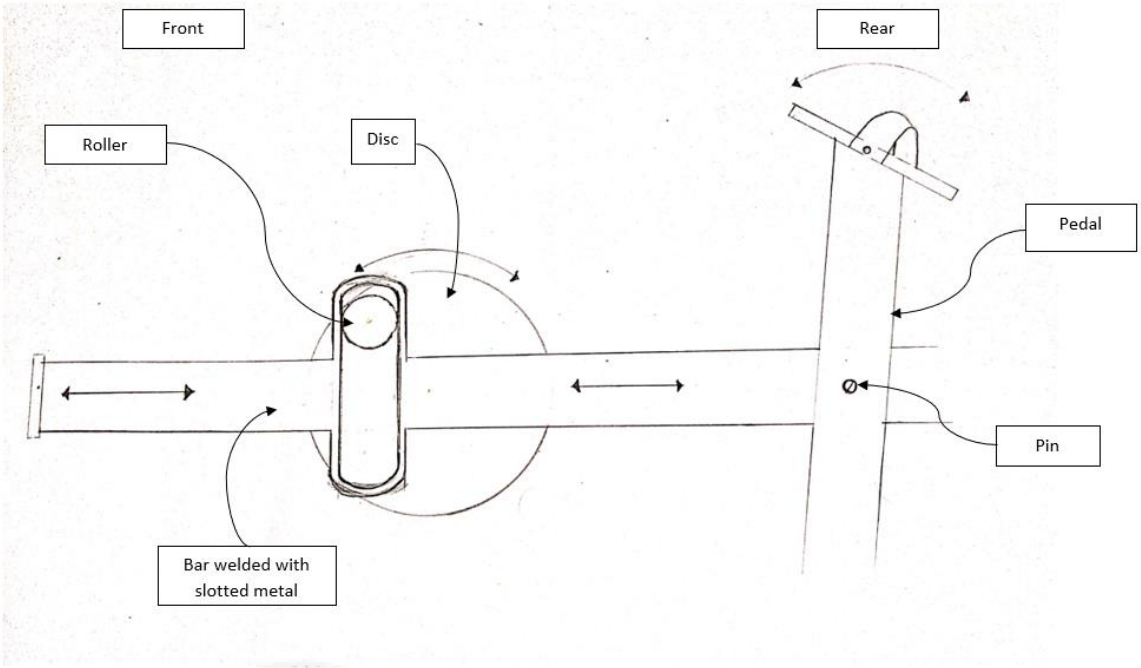


Figure 3.4 Draft design C.

3.5 Design Selection

Before beginning the fabrication process, choosing a design from the raw designs is essential. The design is selected to ensure this project's success using the House of Quality (HOQ) technique. House of Quality diagrams are based on technical and competitive benchmarking data and have a design that resembles the outline of a house. HOQ is often known as the essential instrument for facilitating decision-making throughout the deployment of quality functions.

3.5.1 Customer Importance Ratings

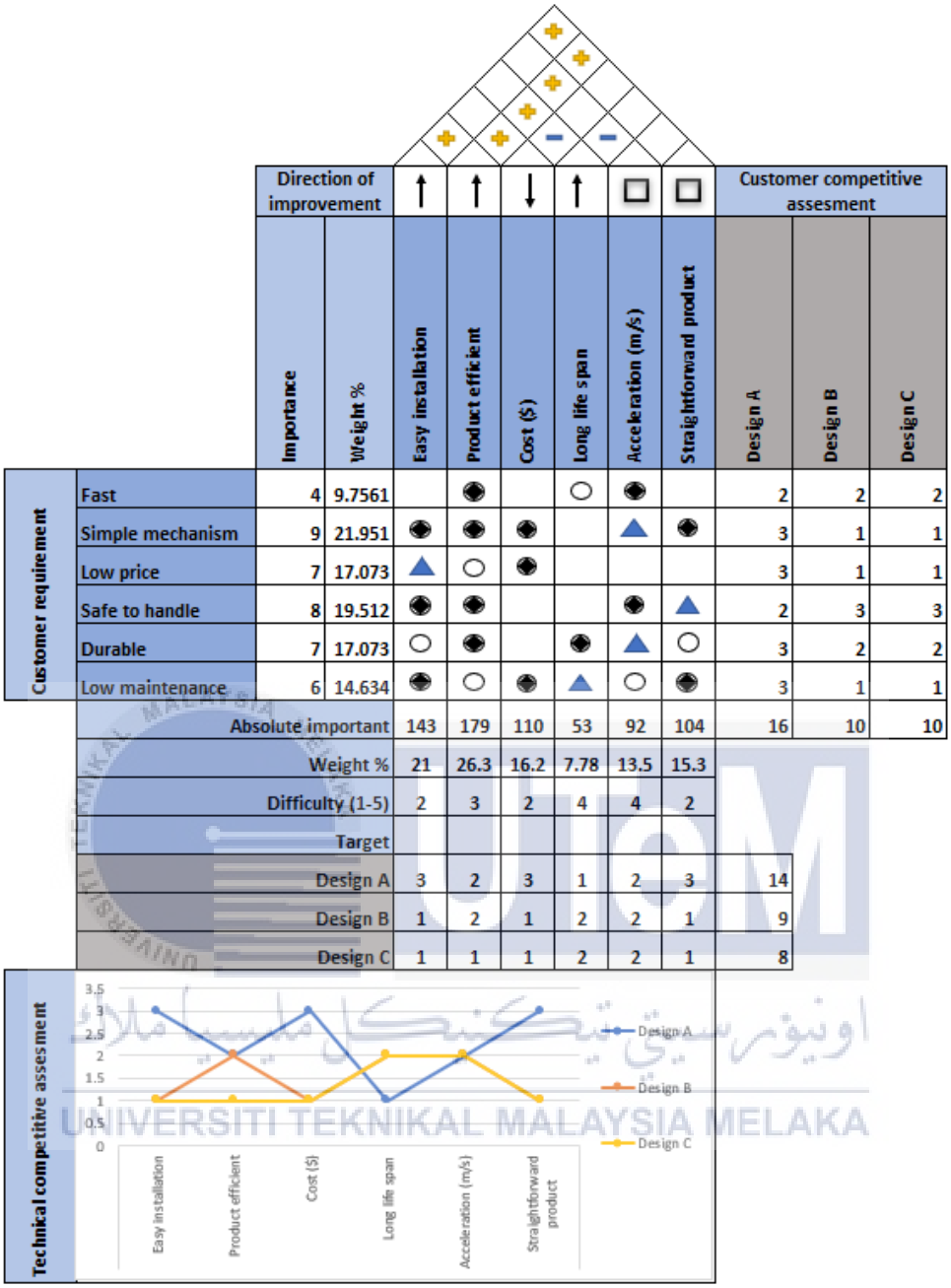
From the surveys that have been distributed to randoms of people, the results translated into House of Quality (HOQ). After the customer rated the best of 3 of the crucial criteria needed for the motor assist kayak, the results taken converted into the importance ratio.

3.5.2 Engineering Characteristics

Engineering characteristics, also known as technical characteristics, are characteristics of a product or service that may be measured and compared to competitors in designs A, B, and C. The engineering characteristics that are likely to affect one or more consumer qualities along the top of the quality house have been listed. If a standard engineering characteristic has no impact on customer needs, it may be irrelevant to the house's engineering characteristic list.

3.5.3 Analysis of The House of Quality

Calculate and place the relative weight for each customer attribute into the relative weight column in percent. The customer requirement with the highest score is ranked first and will be placed first, while the customer requirement with the lowest score will be placed last. Next, calculate the importance of the company in question and all its competitors. Then, for each company, the relative weights were determined.



		Direction of improvement		↑	↑	↓	↑	□	□	Customer competitive assesment		
		Importance	Weight %	Easy installation	Product efficient	Cost ($)	Long life span	Acceleration (m/s)	Straightforward product	Design A	Design B	Design C
Customer requirement	Fast	4	9.7561		◆		○	◆		2	2	2
	Simple mechanism	9	21.951	◆	◆	◆		▲	◆	3	1	1
	Low price	7	17.073	▲	○	◆				3	1	1
	Safe to handle	8	19.512	◆	◆			◆	▲	2	3	3
	Durable	7	17.073	○	◆		◆	▲	○	3	2	2
	Low maintenance	6	14.634	◆	○	◆	▲	○	◆	3	1	1
	Absolute important			143	179	110	53	92	104	16	10	10
	Weight %			21	26.3	16.2	7.78	13.5	15.3			
	Difficulty (1-5)			2	3	2	4	4	2			
	Target											
	Design A			3	2	3	1	2	3	14		
	Design B			1	2	1	2	2	1	9		
	Design C			1	1	1	2	2	1	8		

Figure 3.5 Benchmarking by using House of Quality (HOQ)

Due to the customer's needs and requirements being defined, service offerings and products have been built and prioritized accordingly. Based on figure 3.5, the simple mechanism is the most essential (24.333%) for the customer requirement and needs, and the product does not have to be fast because it has the minor importance than others (6.6667%).

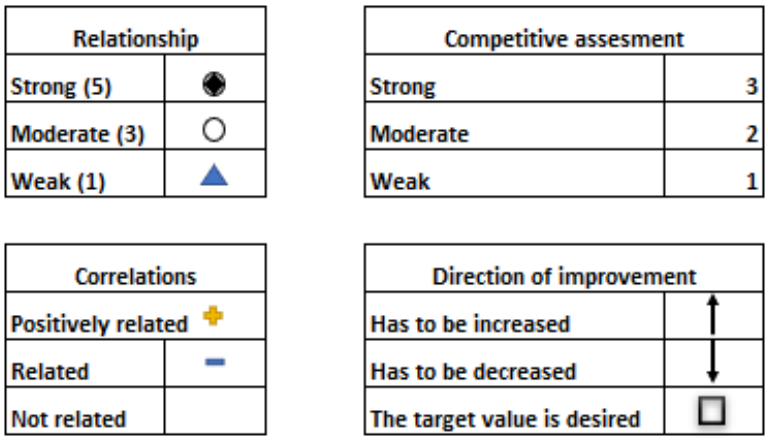


Figure 3.6 Legends for the House of Quality

The primary goal of this HOQ method is to fulfill the customer requirements, which a simple mechanism, a proper safety structure, and a long-lasting construction for a motor assist kayak that is more flexible and stronger. Based on figure 3.5, design A is in the leading position while design B and C are in a lagging position. Thus, the fabrication process will be based on design A. The product should be a simple mechanism product, safe to handle, low price, efficient use, low cost, and straightforward. The motor wiper will support the kayak in going ahead by rotating the sprocket and converting it to linear motion via a shaft attached to the sprocket and the pedal. Following then, each response would give information about the structure's style and functionality.

3.6 Performing Dimensional Measurements

One of the most critical aspects of this project is to take measurements. Measuring is essential because it involves processing, assembly, and inspection, which allows for creating products that are consistent with the design and ensure product quality. If the measurements are collected wrong, the product quality may be damaged, resulting in a defective product and a bad outcome.

Some measurements were obtained beforehand to fabricate the motor-assist system, including the length of the pedal, the distance from the pedal to the base of the mounting that would be built, the area of the mounting's base, and the distance between screw holes. The measurement is also necessary for doing the calculation to demonstrate the theory of the mechanism utilized in this project.

3.7 Calculation

In general, Grashof's Criterion will be the basic concept of the mechanism in this project. Grashof's Criterion aids in determining whether or not a single part can rotate continuously. Use the Criterion to four-bar kinematic chains connected by Pin-Joints. At least one portion of a Grashof mechanism rotates continually. The motor-assist system will employ the most well-known Grashof mechanism, which is the basic Crank-Rocker.

3.8 CATIA V5

The main application for drawing and designing in this project will be CATIA software. It comprises the project's overall view of the product. After the design has been through the House of Quality (HOQ), the best design will be developed CATIA before being used for the fabrication process. This application was chosen for various reasons, including it can save time and money, low cost, being more precise, and having the capacity to manage multi-part geometries more efficiently than traditional composite design solutions. The drafting and dimension of the parts in CATIA V5 can be referred in APPENDIX E.

3.9 Fabrication Process of Motor Assist Kayak for Pedal Fin Drive

The motor assist kayak for pedal fin drive will be invented by referring to design A because design A has the most score in technical benchmarking, as shown in figure 3.5. Moreover, in customer competitive assessment, design A has more scores than designs B

and C. Although the life span assumed for design A is lower than other designs due to easy installation and straightforward product, design B is more reliable than others. Moreover, design A has the most straightforward mechanism compared to other designs that use more storage in the kayak cabin. The main components that will be used in fabrication are a sprocket and metal plate, a square hollow aluminum bar, and a wiper motor.

3.9.1 Automotive Battery Specification

The wiper motor in this project requires electric energy to operate, so a battery is required to provide sufficient power to the wiper motor. The motorcycle battery is the type of battery used in this project.

Table 3.1 Specification of the battery used

Brand	**Specifications**		
	Type	Voltage (V)	Capacity
TokioHama YTZ5S - BS	Gel	12	5.0 Ah

3.9.2 Wiper Motor Specification

The wiper motor is the main component in this project which moves the 4-bar linkage mechanism. A wiper motor was chosen for this project because it is suitable for all kinds of weather and outside operation. In addition, wiper motors have high torque and low speed, making them theoretically suited for overcoming load in the water.

Table 3.2 Specification of the wiper motor

Brand	**Specifications**					
Wiper motor Proton Wira	Motor Voltage	Speed (RPM)	Power (Watts)	Rated Voltage (V)	Current no load (A)	Speed on load (RPM)
	12	45	14	13.5	1.5	38

3.9.3 Cutting Material

The raw materials bought at the hardware shop were a 1.5cm x 1.5cm (L x H) of mild steel square hollow and 0.5cm thick metal plate bars. The raw materials were then brought to the workshop for the cutting process based on the finalized drawing. The mild steel square hollow was cut to 40 cm long for the long shaft, while the metal plate bars were cut into a 13cm x 12cm (L x W) and a 14.5cm x 12cm (L x W) for the motor mounting. The raw materials were cut by using a metal cutting machine.

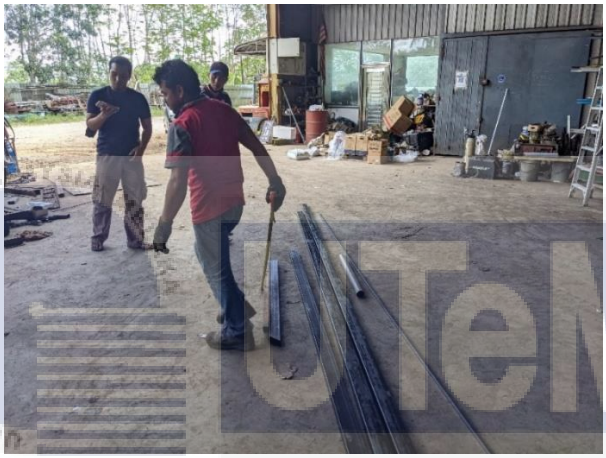


Figure 3.7 Buying raw materials at the hardware shop.

Figure 3.8 Cutting the plate bar by using a metal cutting machine.

3.9.4 Drilling Process

After the cutting process, the parts were drilled using a drilling machine. Based on figure 3.9, the base of the mounting was drilled into four holes, and each hole is drilled by using a 3mm radius of drill bit.

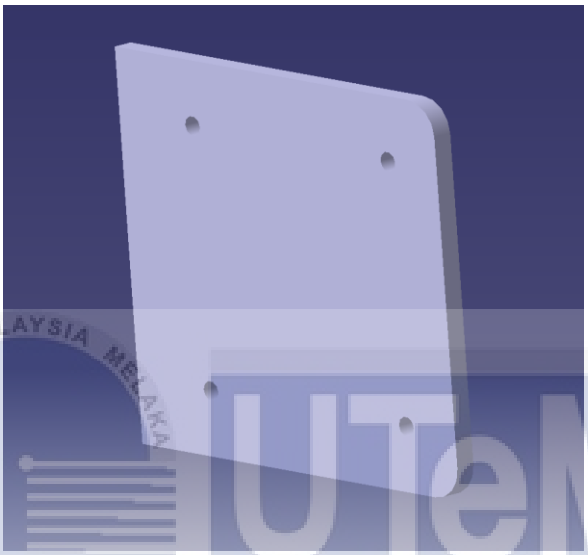


Figure 3.9 The design of the mounting base in CATIA V5

The vertical parts of the mounting were drilled into four holes. Based on Figure 3.10, a hole at the center of the mounting is drilled by using a 10mm radius of drill point, while three holes with each drilled by using a 3mm drill point.

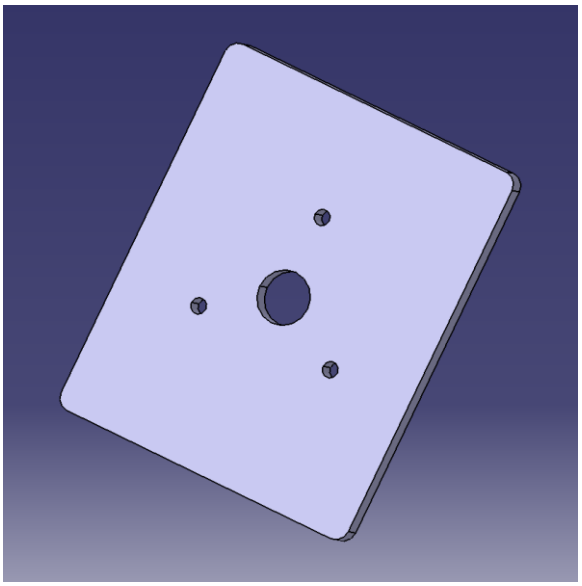


Figure 3.10 The design of vertical parts of the mounting in CATIA V5.

Figure 3.11 Drilling the mounting process by using a drilling machine

3.9.5 Welding Process

After the drilling process, the mounting parts are welded based on figure 3.12 by using Metal Inert Gas (MIG) welding type. The mounting parts were placed at a 90° of angle before the welding process.

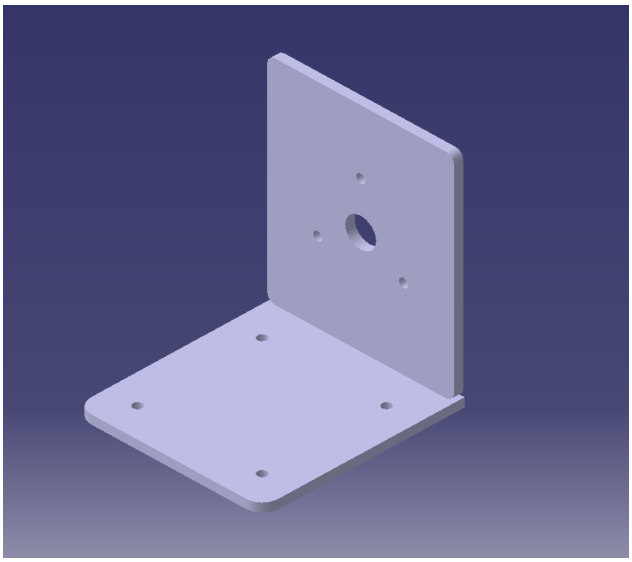


Figure 3.12 Isometric view of the mounting motor in CATIA V5.

Figure 3.13 Welding process of the mounting parts by using MIG welding.

Next, the end of the mild steel square hollow that has been cut is welded to the right-hand link of the wiper based on the figure below. Before weld, the links of the wiper were cut into two parts which are 7.7cm and 8cm.

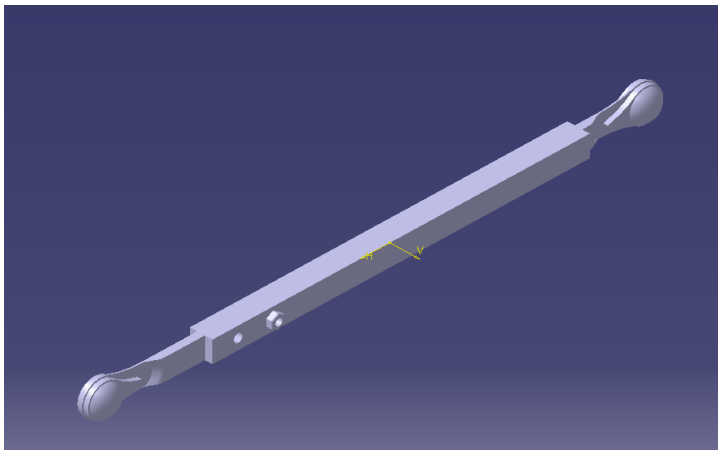


Figure 3.14 The long shaft that connects between pedal and wiper motor

The welded product is the connecter between the pedal and the wiper motor. The wiper link was used because it contains a ball and socket joint that can move freely when the wiper motor is turned on. For the bicycle sprocket, the surface needs to be welded with the wiper bracket based on figure 3.15.

Figure 3.15 The post-welding process of the bracket wiper and sprocket in CATIA V5.

3.9.6 First Product Testing

After all the raw materials have been fabricated, the first testing has been made. If any flaws happen, such as the welding cracked or the holes made do not fit, they need to be fixed immediately. All the parts have been assembled, and the wiper motor is connected directly to the power source.

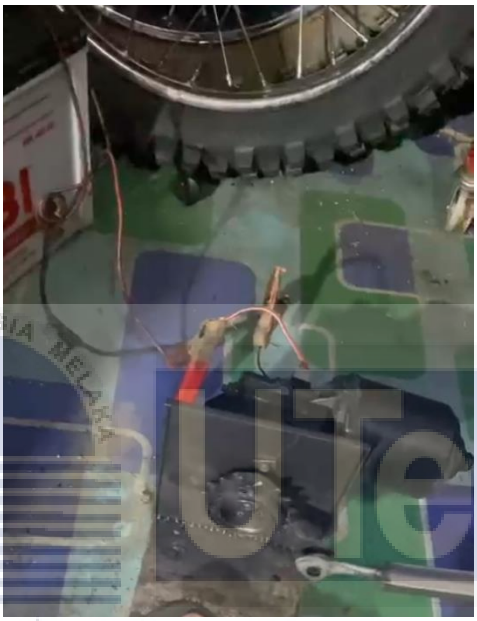


Figure 3.16 First testing with the power source.

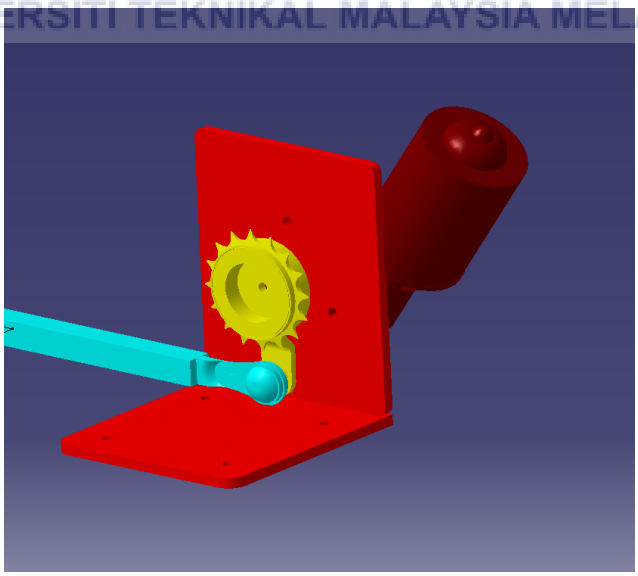


Figure 3.17 The assembled design of the mounting, sprocket, and wiper motor in CATIA V5.

3.9.7 Finishing Process

The goal of the finishing process is to improve the surface of the fabricated product to achieve a specific quality. Improved appearance, adhesion, corrosion, tarnish, wear resistance, hardness, defect elimination, and surface friction reduction are desirable properties. These approaches can be used to restore original dimensions or salvage or repair a part in some instances.

After the fabricating process was completed, the excessive weld spots were ground using the grinder machine because it would affect the product's parameters and dimensions. The edges of the product were ground by using a flap disc type of grinder disc.

Wire wheels type was used to polish the materials to remove the rust from the product. For safety reasons, use safety goggles as the wires every so often snap off from the grinder that possibly flies into the eye.

After polishing the product, use sandpaper to smoothen by rubbing it to the product's surface and preparing the area before the painting process. The sandpapers used in this process are P850, P1000, and P200. Sandpaper grit is commonly expressed as a number inversely proportional to particle size. A large number, such as 1500, results in fine grit, while a bit number, such as 20 or 40, implies a coarse grit.

Lastly, apply aerosol spray paint on the product. This process used different types of aerosol spray can: matte black, metallic black, and clear (lacquer). This process is very crucial to ensure that the product does not quickly get rusty and to sustain in any weather condition.

Figure 3.18 First layer of spray paint.

Figure 3.19 The second layer of spray paint applied to the product.

Figure 3.20 Spray lacquer applied as the last layer.

3.10 Summary of The Chapter

From this chapter, there are many methods used to ensure the success of the project development in this project. The flowchart is used to create the project. A total of 100 people responded to the survey. The criteria required for the customer have been reduced to a tiny scale and translated on the House of Quality table to make the process easier on selecting the best design. Furthermore, the Gantt chart assists with product development plans. During the fabrication process, several difficult conditions: the welding section cracking, the drilled holes not fitting the mounting base, and the materials rusting quickly, all of which extend the fabrication process and make it take a long time to complete. Overall, the issues were resolved by doing a preliminary inspection, which double-checked the measurements, computations, and instruments used in the fabrication process.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and analysis of the data on developing the motor-assist system for the fin drive foot pedal kayak. Moreover, this chapter will also cover the result of the assembly part design in CATIA V5, and the result of the fabrication product.

4.2 Results

4.2.1 Theory of 4-Bar Linkage

Based on the measurement that has been recorded, the calculation was made before the design concept in CATIA V5 and the fabrication process.

Table 4.1 Result recorded from the measurement on a kayak

Parameter	Value (cm)
Length of shortest link (Input)	5.5
Length of the longest link (Coupler)	38
length of one of the intermediate length links (Output)	25
length of the other intermediate-length link (Ground)	40

By using the equation 2.1, substitute the value from the table,

$$\mathbf{5.5 + 38 \leq 25 + 40} \qquad 4.1$$

So,

$$\therefore 43.5 \leq 65$$

Based on Grashof's Criterion formula, if the sum of the shortest and the longest link of planar quadrilateral linkage is less than or equal to the sum of the remaining two links, the shortest link can rotate fully with respect to a neighboring link. From the result, theoretically, it is possible to achieve the design of the crank–rocker mechanism for the motor assist kayak because the sum of S and L is less than the sum of P and Q.

4.2.2 Final Result of Motor Assist Kayak in CATIA V5

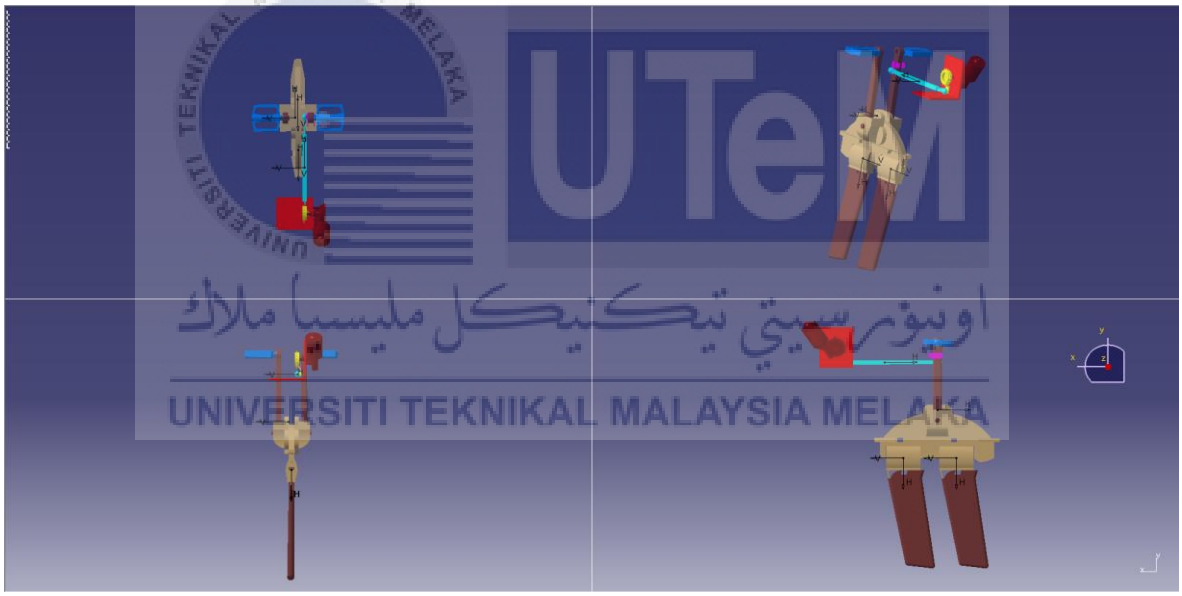


Figure 4.1 Orthographic view of assembled with pedal fin drive.

The parts were designed in CATIA V5 after collecting data from surveys and selecting the design using the HOQ method, field measurement, and calculations. Afterward, the parts were assembled to create a concept design for a motor assist kayak with foot pedal fin drive. The pedal fin drive is also created in the CATIA software to show the end outcome of the design and to prove the previous measurements and calculations.

4.2.3 Final Result Fabrication of Motor Assist Kayak

Figure 4.2 Motor assist kayak assembly

After finishing the last fabrication process, which is the finishing process, the product was assembled to the kayak provided.

4.2.4 Field Testing

The field testing has been made at Tasik Ayer Keroh, Melaka. Field testing aims to guarantee that the product is functional and works efficiently. The distance for each test was 50 meters, and the time it took the kayak to reach the finisher was recorded using a stopwatch. A product testing was also made to achieve all the research objectives in this project.

Table 4.2 The data of time recorded for kayak equipped with motor-assist travelled 50 meters of distance.

Distance (m)	Time taken (s)	Speed (m/s)
50	32	1.56
50	35	1.43
50	33	1.55

Table 4.3 The data of time recorded for kayak with manually pedalled travelled 50 meters of distance.

Distance (m)	Time taken (s)	Speed (m/s)
50	23	2.17
50	21	2.38
50	23	2.17

Based on both table 4.2 and table 4.3, it can be concluded that the kayak equipped with motor-assist system has a much lower value in terms of speed than manually pedaled in 50 meters. A Motor-assist system needs more time to travel at a certain distance than manually pedaled.

4.3 Summary

In this chapter, the parts are assembled once developed in CATIA V5 software, as shown in figure 4.1. The product has been inspected and assembled on the kayak after being fabricated. The issues arising during the inspection have been resolved before the second inspection. After the motor-assist is fully functional, it goes through the finishing process.

After the finishing procedure, the product was tested and held in Tasik Ayer Keroh, Melaka. The speed difference between manually operated by using foot pedal and motor-assist are noticeable. The speed is slower when using the motor-assisted system than when manually pedaling the kayak. The time it took the kayak to travel 50 meters with the motor assist was recorded, and the kayak's speed was determined. Overall, the product performs well, although it is not as fast as a manually operated system because speed and acceleration have the lowest ratings on the House of Quality table, as shown in figure 3.5.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Overall, this project has been completed satisfactorily and met all the project's objectives. The first goal is to use computer-aided three-dimensional interactive application (CATIA) software to build the motor-assist system for the fin drive foot pedal. Before finalizing the conceptual design, it went through several steps. The brainstorming idea is the beginning step in the design process. It is standard procedure when designing something to conduct some research before beginning the rough design sketches. The challenge for this project was defined, including the project requirements, design issues, and the necessity of resolving the design. After that, a literature study was used to conduct some background research.

After various considerations were made by randomly distributing questionnaires to some people and using the house of quality technique to support this assertion, a design has been chosen for this project. The next step is to convert the design chosen into a conceptual design in CATIA V5. Before that, various measures were obtained, including the pedal's length and the distance between the pedal and the mounting's base. The design is also based on a calculation made using Grashof's Criterion method, according to which the shortest link in a planar quadrilateral linkage can rotate fully with respect to a neighboring link if the sum of the shortest and longest links is less than or equal to the sum of the remaining two links.

The next objective is to produce a battery-powered motor-assist system for the fin drive foot pedal kayak. Following the design concept created in CATIA V5 software, the fabrication process referred to the design concept. The initial step in the fabrication process

is to purchase raw materials from a hardware store, such as mild steel square hollow and metal plate bars. After that, the raw materials are cut according to the specifications established in the concept design. Then, the metal bars that have been cut are welded together to form a mounting for the motor connected to a sprocket, which is also welded to the wiper link since the wiper link has a ball-and-socket joint that can move freely in one plane. The mounting must then be drilled according to the specifications. Various usual problems occur during the fabrication process: welding sections cracking during the first test, drilled holes not fitting with the kayak's base mounting, and the coupler being cut shorter than required. Overall, the problems were overcome by employing the proper procedure and tools and double-checking the measurements.

After the fabrication phase, the product goes through the finishing step. The finished product was ground using a grinder machine equipped with flap disc grinder discs. The product needs to grind because some excessive weld spots must be removed to smooth the surface and, in some cases, to repair a part. The object was smoothed out before being sprayed using an aerosol spray can. The product was sprayed with three distinct types of paint: matte black, metallic black, and lacquer. The finishing technique ensures that the product does not rust quickly and can withstand all types of weather.

The finalized product is finally assembled into a fishing kayak for testing. The test was held in Tasik Ayer Keroh, Melaka. A simple circuit connects the motor to the battery, containing a pair of wires and a switch to control the electric current. The sprocket rotates when the switch is turned on, causing the coupler to move the pedal. The kayak travelled 50 meters, and the time has been recorded to calculate the kayak's speed at a constant speed, and this proves that the third objective has been achieved. Although it is not as fast as pedaling by foot, it demonstrates that the project has been completed effectively, along with the previous calculations and methodology. There are several reasons why the kayak moves

slower than if pedaled manually, including the lowest speed of the wipers, the power required for the motor to overcome the force of the water, and the weight of the kayak well the driver. Based on the result findings, it can be determined that this project was completed successfully, all the objectives were achieved, and methods used in the literature review were proven.

5.2 Recommendations

For future improvements, the results of the motor-assist system could be enhanced as follows:

i) According to the results, the time taken for the kayak to travel 50 meters is not so fast. On the other hand, use a more powerful motor that can overcome the force of underwater, which improves the speed for a more extended period. According to the results, the time taken for the kayak to travel 50 meters is not so fast.

ii) A mounting cover must be invented to improve the safety features because the mounting is exposed and has no safety precautions. Even though the sprocket does not revolve at a high rate, it has many teeth that can cause injury to users.

iii) Maximize the transmission angle for the 4-bar linkage using calculations and measurements concerning Grashof's Criterion. The analysis of the 4-bar linkage is required to enhance the fin drive's maximum capability by using other software, such as MATLAB MathWorks. The mechanism can be

improved using MATLAB MathWorks by tracing the time ratio, the acceleration of the strokes, and the animation of the mechanism.

iv) The joint of the 4-bar linkage mechanism can be improved by using a one-way type of bearing which is safer to handle and more efficient.

5.3 Product Potential

This product can potentially be more practicable from the recommendations that can be improved. This product can also compete with the existing product, which is motor-assisted for propeller drive system because it has the same concept to reduce human energy while kayaking. Lastly, this product can be marketed in all markets and is suitable for pedaled fishing kayaks.

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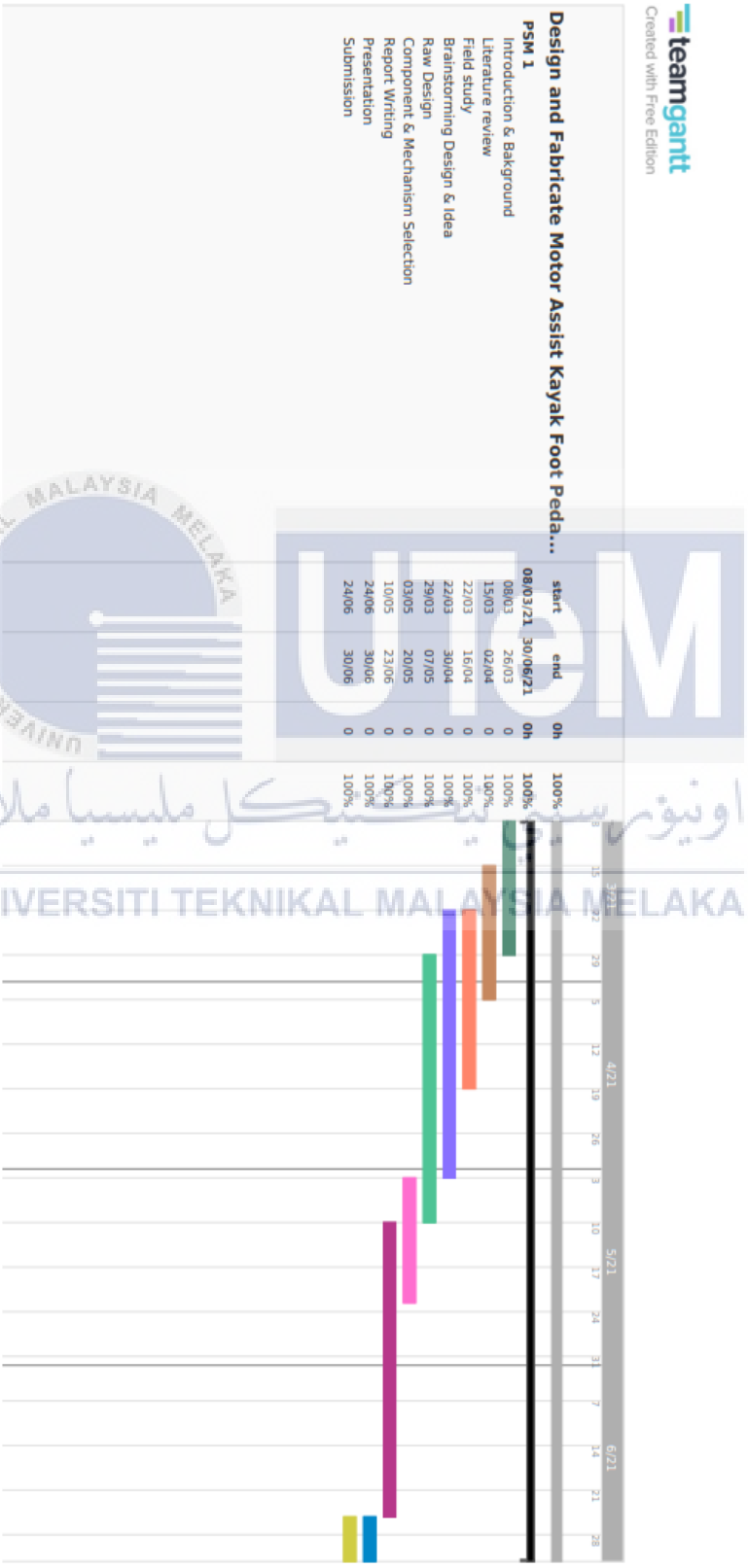
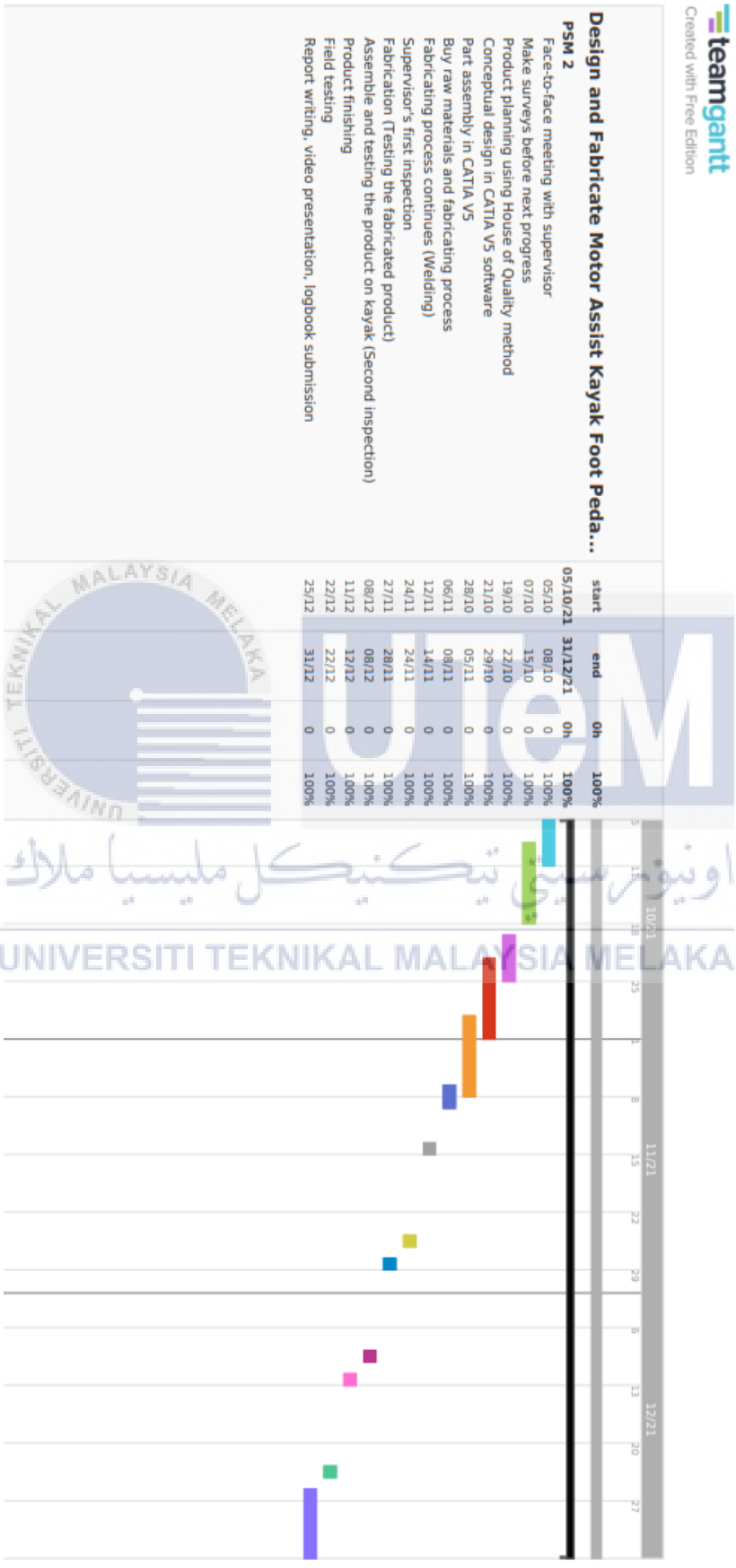
APPENDICES

APPENDIX A Gantt Chart of PSM 1



APPENDIX B Gantt Chart for PSM 2



APPENDIX C Survey questions in using Google Form platform

Kayak Foot Pedal Fin Drive System.

Assalamualaikum, and greetings to all respondents,

I am final year student of Bachelor of Mechanical and Manufacturing Engineering Technology (Automotive) from Universiti Teknikal Malaysia Melaka.

Currently, I am on my final year project, to design and fabricate motor assist kayak foot pedal fin drive system. Currently, there are 2 types of foot pedal drive in the market which are propeller, and fin drive. However, all the motor assist drive only available for propeller system. This survey is important to collect data from the respondent, and come out with the best decision for the fin drive system.

Your responds is much appreciated. Thank you for your cooperation.

* Required

Age *

- ◯ 18 -25
- ◯ 26 - 35
- ◯ 26 - 45
- ◯ 46 - 55

How many types of kayak do you know? *

- 1
- 2
- 3
- More than 4

What type of kayak pedal drive do you familiar with?

- Propeller drive
- Fin drive

How often do you usually do kayak activities? *

- A day per week
- 3 days per week
- Everyday
- Never

Average distance that you usually travel by kayak? *

- 500m - 1km
- 1.1km - 1.5km
- 1.6km - 2km
- More than 2.1km

Do you think that this idea to develop motor assist kayak for foot pedal fin drive is helpful? *

- ◯ Yes
- ◯ No

If no, why?

Your answer

In your opinion, what is the most crucial criteria for a motor assist kayak? *

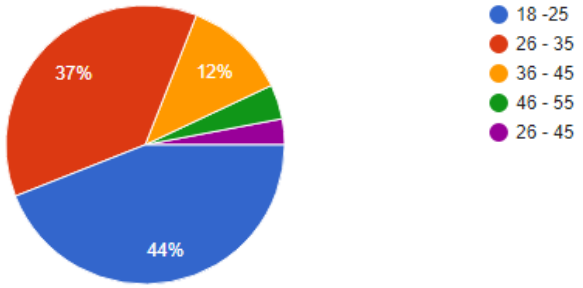
Choose 3 options

- ☐ Fast
- ☐ Simple mechanism
- ☐ Low price
- ☐ Safe to handle
- ☐ Durable
- ☐ Low maintenance

APPENDIX D Google form data respondence

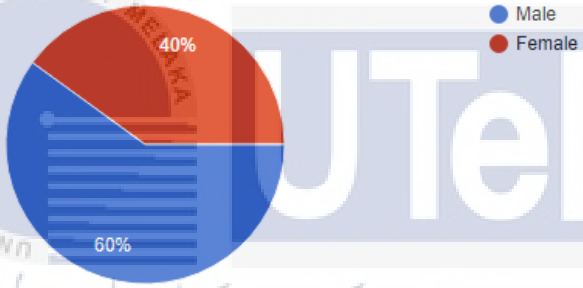
Age

100 responses



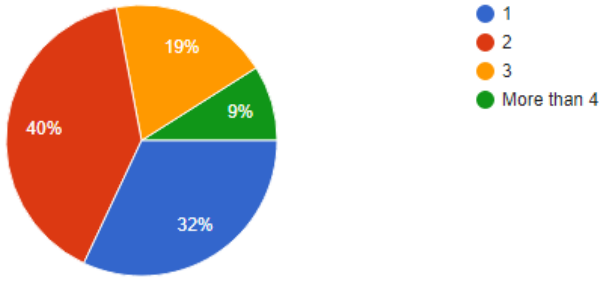
Gender

100 responses



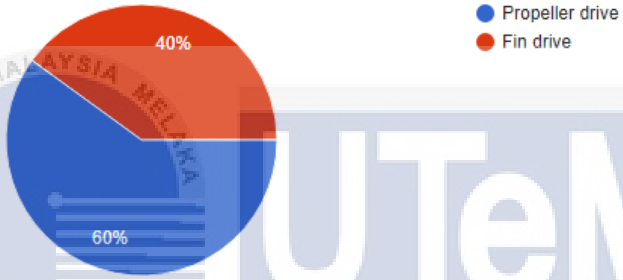
How many types of kayak do you know?

100 responses



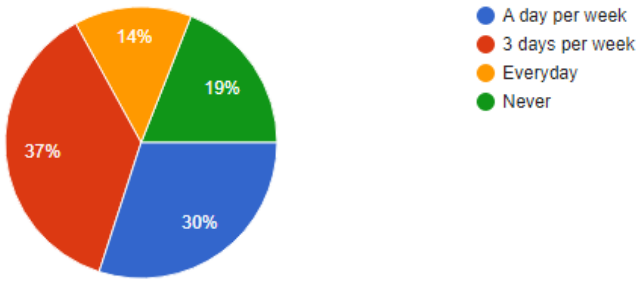
What type of kayak pedal drive do you familiar with?

100 responses



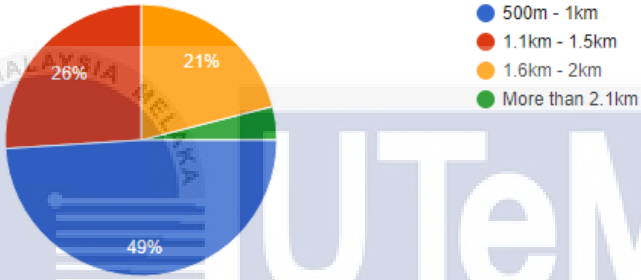
How often do you usually do kayak activities?

100 responses



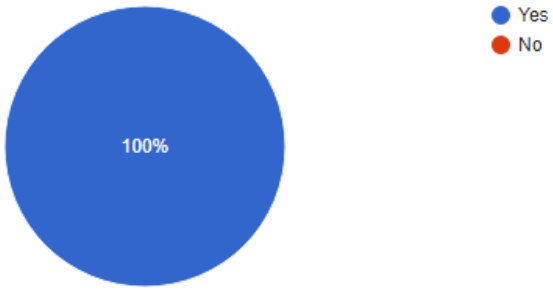
Average distance that you usually travel by kayak?

100 responses



Do you think that this idea to develop motor assist kayak for foot pedal fin drive is helpful?

100 responses



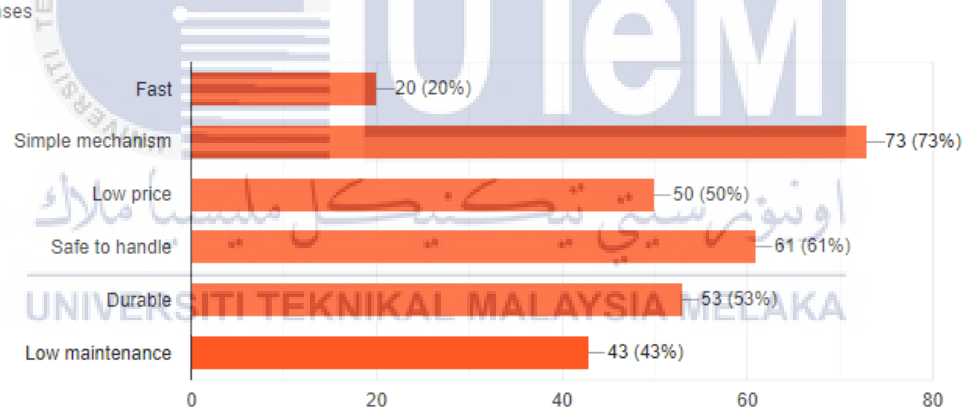
If no, why?

0 responses

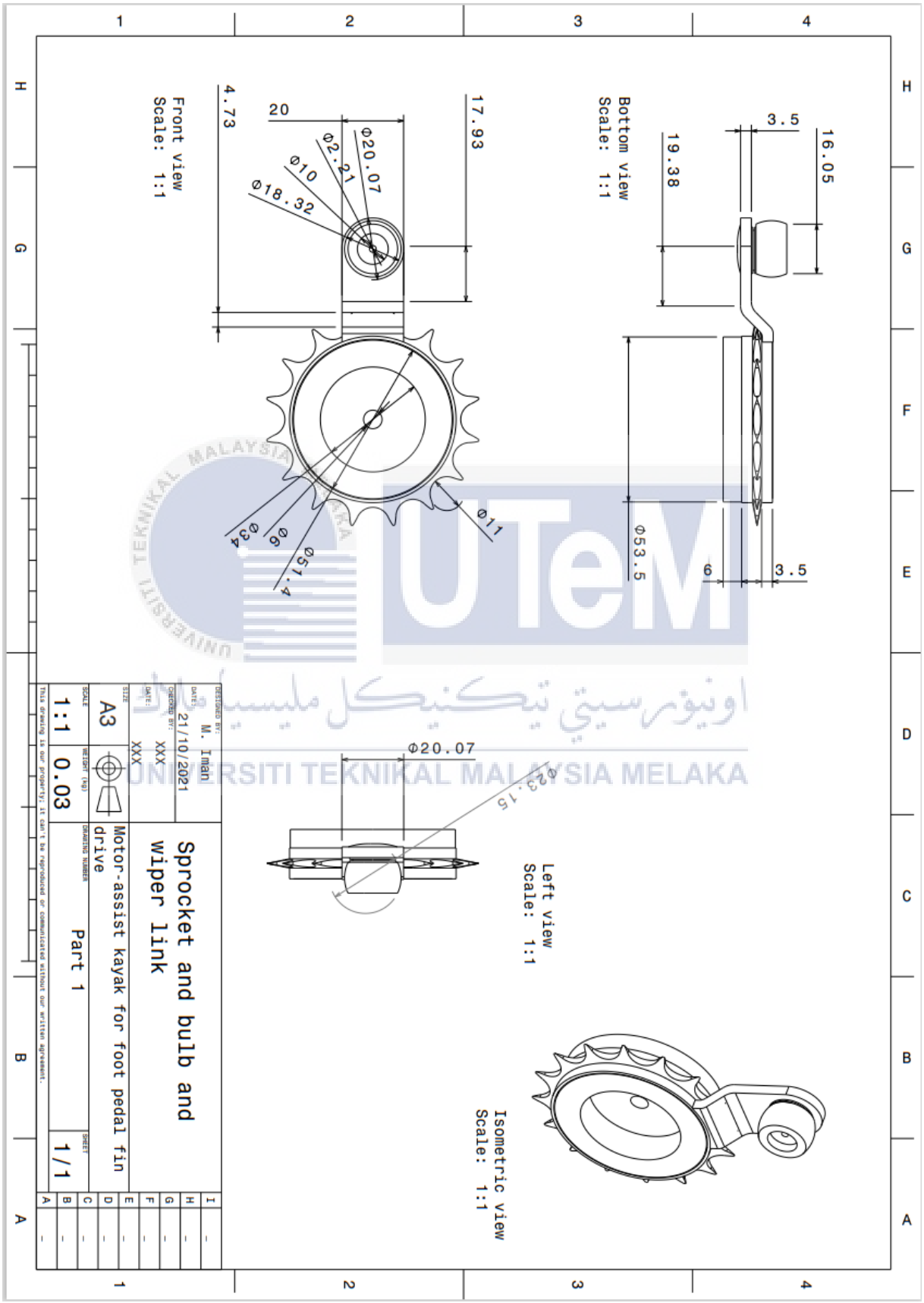
No responses yet for this question.

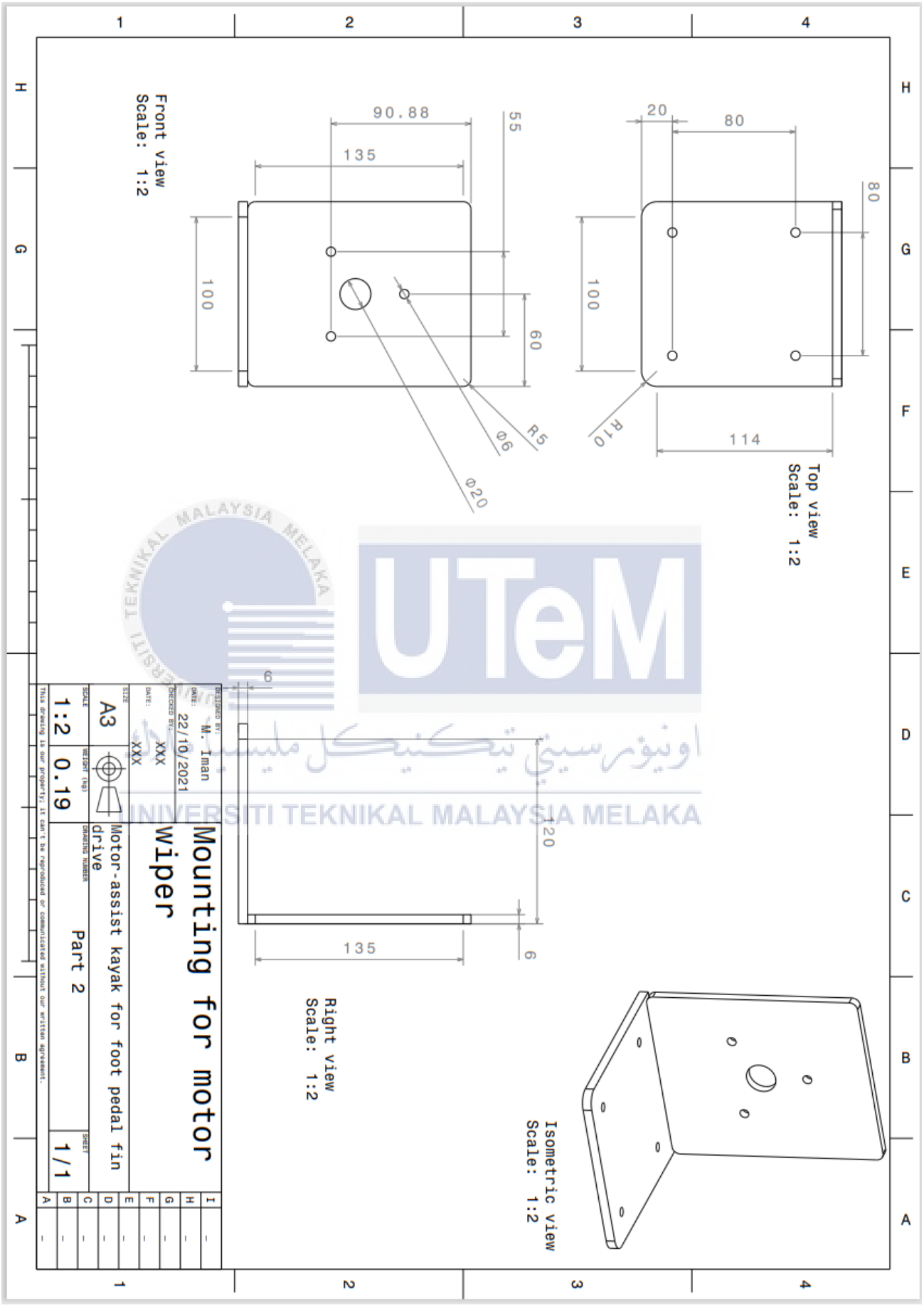
In your opinion, what is the most crucial criteria for a motor assist kayak?

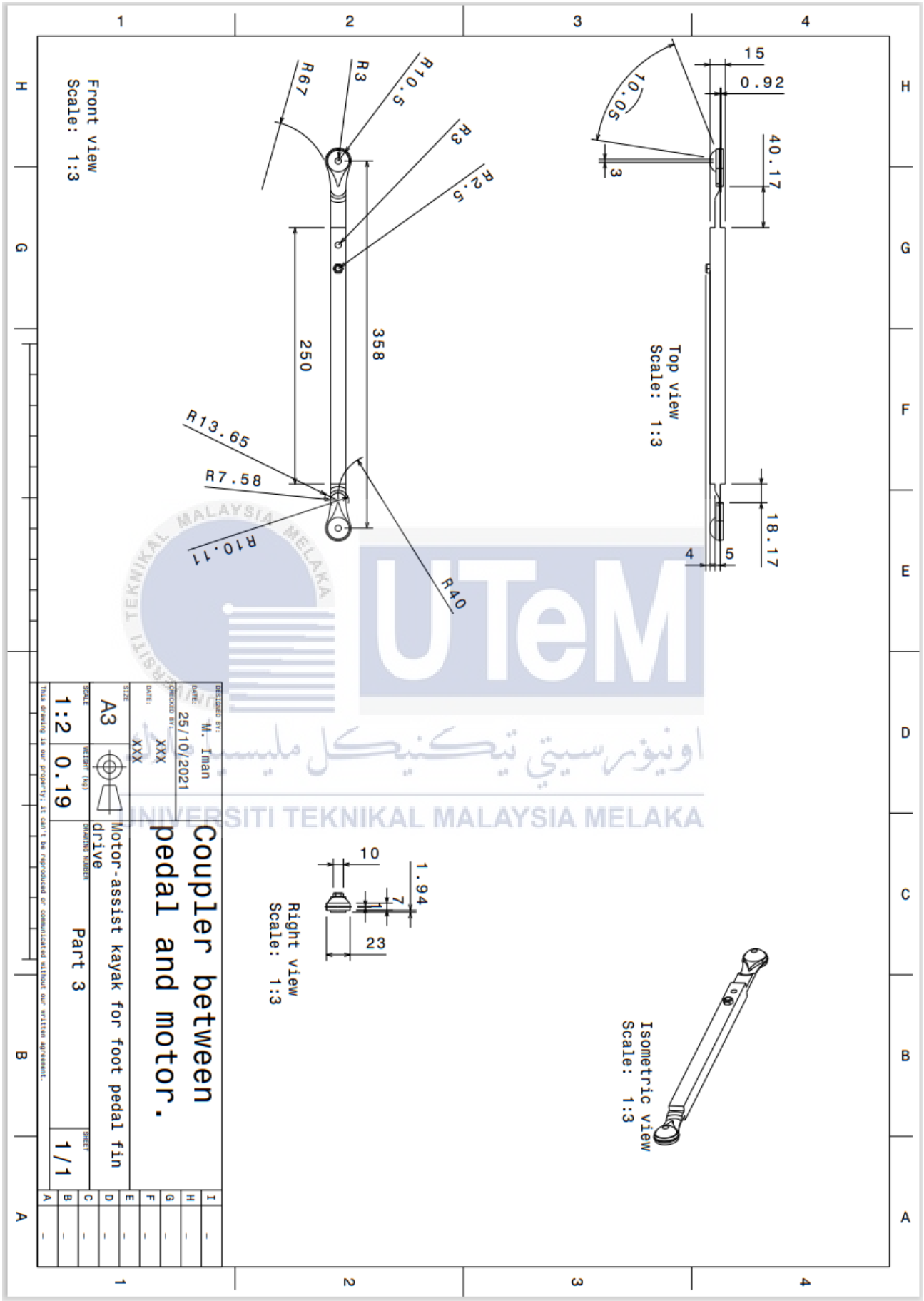
100 responses

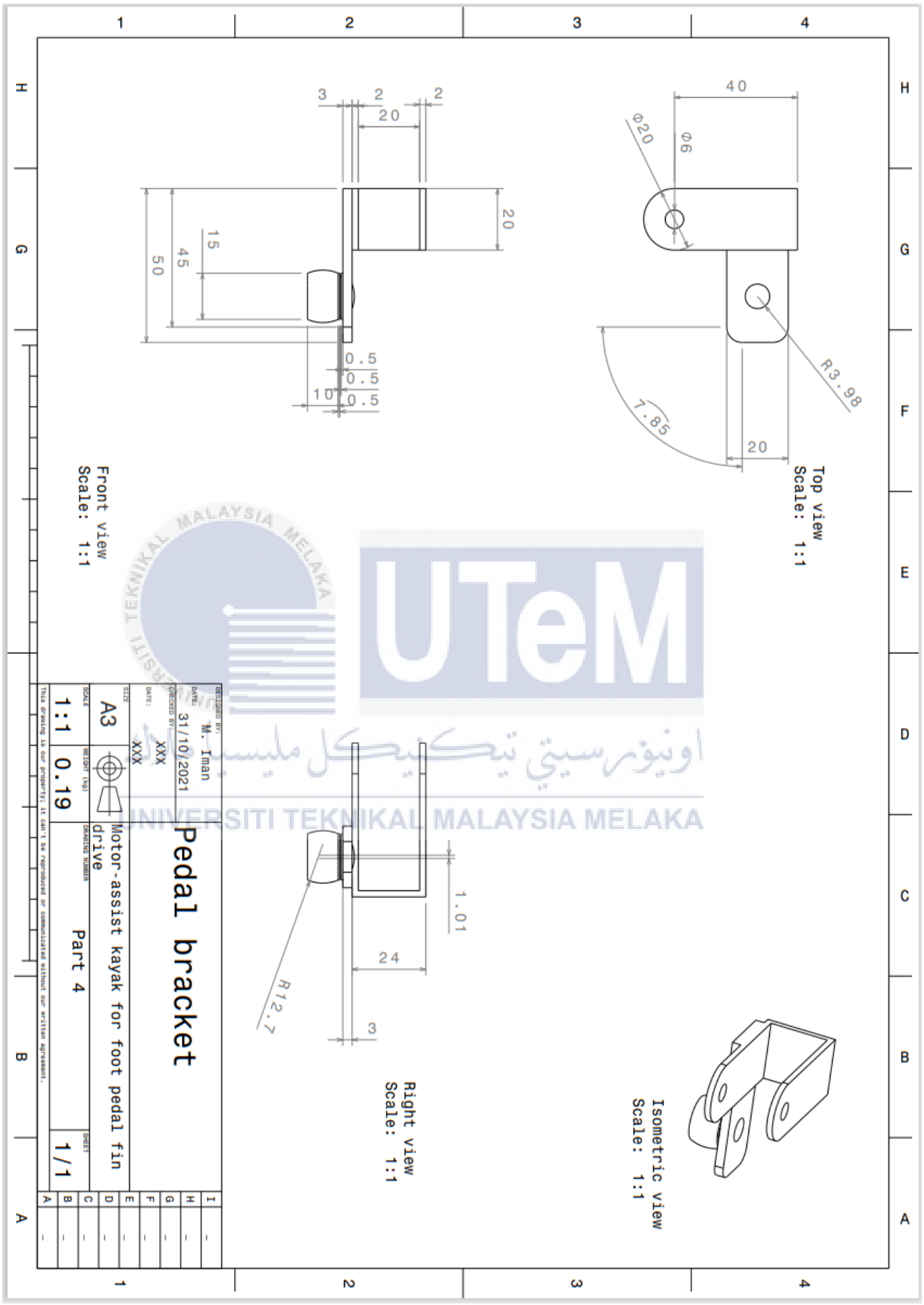


APPENDIX E ISO drawing for selected design

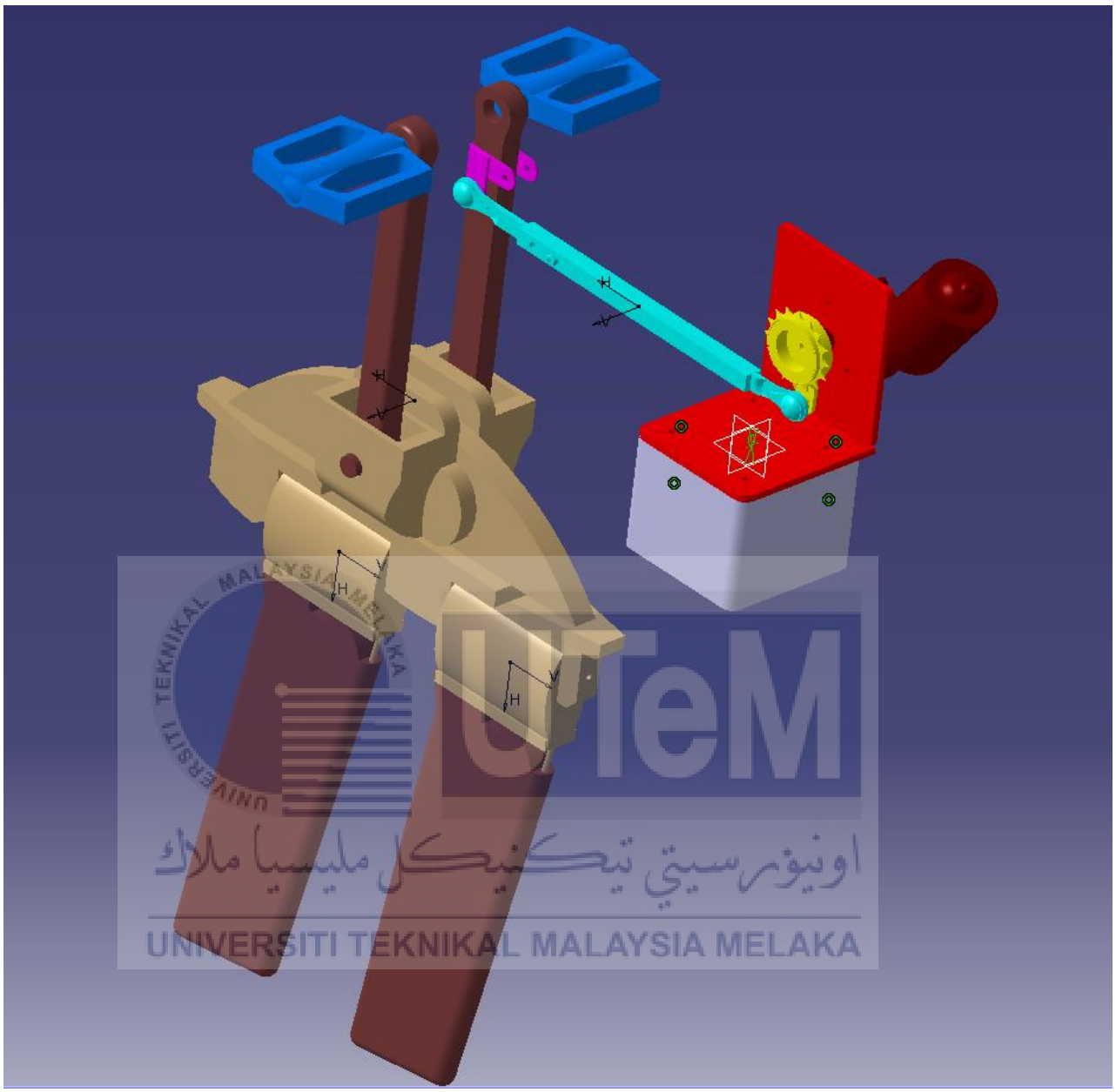








APPENDIX F Assembled part in CATIA V5



APPENDIX G Assembled product on the kayak after finishing process

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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TAJUK: **DESIGN AND FABRICATE MOTOR-ASSIST SYSTEM FOR FIN DRIVE FOOT PEDAL KAYAK**

SESI PENGAJIAN: **2021/22 Semester 1**

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Design And Fabricate Motor-Assist System For The Fin Drive Foot Pedal Kayak

by Ir. Mazlan Ahmad Mansor

ENDORSED BY:

Ir MAZLAN BIN AHMAD MANSOR
Pensyarah
Fakulti Teknologi Kejuruteraan Mekanikal Dan Pembuatan
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