FEASIBILITY STUDY OF WIND TURBINE AT HIGHWAY FOR POWERING STREETS LIGHTING

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**This report is submitted
in partial fulfillment of the requirement for the degree of
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DECLARATION

I declare that this report entitled “Feasibility Study of Wind Turbine at Highway for Powering Streets Lighting” is the result of my own work except as cited in the reference.

Signature : ....

Name : ....

Date : ....

APPROVAL

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

Signature : ....

Name of Supervisor : ....

Date : ....

DEDICATION

My thesis is dedicated to my beloved family as well as my friends. My grateful parents, Amiruddin Bin Mohammad and Maheran Binti Ismail, deserve special recognition. Their words of encouragements and motivations to persevere are still playing in my head. My siblings and friends have never forgotten for me and are truly remarkable.

ABSTRACT

Wind energy is a new future renewable energy source that has been introduced to the world in order to protect the environment in the long run. Wind turbines can be utilized to increase the turbulence produced by wind energy in roadways. This project will investigate the feasibility of using wind turbines to power street lighting on Malaysian roadways. To undertake this feasibility study, certain parameters will be chosen. This shows the design and fabrication of a vertical axis wind turbine model as well as a model of three different types of vehicles. The SPA and AMJ highways in Melaka, Malaysia, will be the principal area for collecting wind measurement data utilizing an anemometer at a specified height from the ground. It will then be employed as testing parameters for the movement of three different vehicle models as well as a portable table fan wind speed reference. The voltage and current output data will then be gathered and measured with a multimeter. The variations in data output between helical and curve blade types, as well as the state of the wind turbine model with and without barrier mechanism, will be compared. This wind turbine model's graphical output will demonstrate the viability of employing this actual wind turbine model to power street lighting on Malaysia highways. A number of suggestions and enhancements have also been made in order to assist future research on the feasibility of using wind turbines in Malaysia.

ABSTRAK

Tenaga angin ialah sumber tenaga boleh diperbaharui masa hadapan baharu yang telah diperkenalkan kepada dunia untuk melindungi alam sekitar dalam jangka masa panjang. Turbin angin boleh digunakan untuk meningkatkan pergolakan yang dihasilkan oleh tenaga angin di jalan raya. Projek ini akan menyiasat kemungkinan menggunakan turbin angin untuk menyalakan lampu jalan di jalan raya Malaysia. Untuk menjalankan kajian kebolehlaksanaan ini, parameter tertentu akan dipilih. Ini menunjukkan reka bentuk dan fabrikasi model turbin angin paksi menegak serta model tiga jenis kenderaan berbeza. Lebuh raya SPA dan AMJ di Melaka, Malaysia, akan menjadi kawasan utama untuk mengumpul data pengukuran angin menggunakan anemometer pada ketinggian tertentu dari tanah. Ia kemudiannya akan digunakan sebagai parameter ujian untuk pergerakan tiga model kenderaan berbeza serta rujukan kelajuan angin kipas meja mudah alih. Data keluaran voltan dan arus kemudiannya akan dikumpulkan dan diukur dengan multimeter. Variasi dalam output data antara jenis bilah heliks dan lengkung, serta keadaan model turbin angin dengan dan tanpa mekanisme penghalang, akan dibandingkan. Output grafik model turbin angin ini akan menunjukkan daya maju menggunakan model turbin angin sebenar ini untuk menyalakan lampu jalan di lebuh raya Malaysia. Beberapa cadangan dan penambahbaikan juga telah dibuat untuk membantu penyelidikan masa depan tentang kebolehlaksanaan penggunaan turbin angin di Malaysia.

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Also, I'd like to thank Mr. Kamil Anuar bin Akram @ Jummah and Mr. Habirafidi bin Ramly for providing me permission to use the welding workshops and the Integrated Design Project Laboratory (IDP). Both of them not only permit me to utilize the lab, but also assist and coach me in using suitable fabrication equipment techniques. Mr. Kamil was quite helpful in teaching me how to use a CNC Plasma machine cutter. Mr. Habirafidi, on the other hand, has greatly aided in the TIG welding of aluminum components. Even if faults and errors arise throughout the fabrication process, they would like to brainstorm ideas with me in order to provide the best solution for the issues that occurred.

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Last but not least, I'd really like to show my thankfulness to all of my friends who were directly and indirectly participating, as well as my dear father and mother, relatives, and educators, for providing me with self-motivation and excellent care and support in completing my degree. Finally, I intended to extend my thanks to everyone who contributed to the successful completion of this project.

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LIST OF ABBREVIATIONS

VAWT	=	Vertical Axis Wind Turbine
HAWT	=	Horizontal Axis Wind Turbine
SWT	=	Small Wind Turbine
FiT	=	Feed in Tarif System
HVAWT	=	Horizontal Vertical Axis Wind Turbine
DC	=	Direct Current Generator
MPV	=	Multi-Purpose Vehicles
FKM	=	Fakulti Kejuruteraan Mekanikal
UTeM	=	Universiti Teknikal Malaysia Melaka

LIST OF SYMBOLS

C_D	=	Drag Coefficient
C_L	=	Lift Coefficient
P	=	Power
V	=	Voltage
I	=	Current
v	=	Velocity
ρ	=	Density
A	=	Cross-sectional Area/ Swept Area
D_r	=	Diameter of the rotor
H_r	=	Height of rotor

CHAPTER 1

INTRODUCTION

1.0 Project Background

Prof James Blyth of Anderson's College came up with the concept of building the firstwind turbine that could produce electricity in July 1887. Then, Blyth's proceed the idea to buildthe first wind power in his garden to power the lighting at the cottage and making it the first house in the world that have electricity by used wind power source. The purpose of this innovation is to produce a suitable solution (pollution-free) energy generation that can replaceexisting source by using fossil fuels to generate electricity. This source from fossil fuels can causes many types of pollutions that can affects that sustainability of the environment. Wind energy is a non-conventional type of energy that is claimed to be pollution-free. Clean energy, low consumption costs, predictable construction cost reductions, a broad distribution of worldwide wind energy resources, and a significant potential for market expansion, particularly in the replacement of renewable energy, are all advantages of wind energy in terms of the environment (Liew et al., 2020).

Wind energy is the world's strongest clean energy source. One big concern is that the source of wind is always fluctuating as technology progresses. There is an almost constant source of wind generated by high-speed vehicles on the highway. Motivation for thisproject will contribute to the global clean energy trend in a feasible way. Power generation involves two processes. The first process is to use wind turbines to convert the kinetic energy of the wind into mechanical energy. Next, the second process is to pass the mechanical energyin the first process to generator. The basis for converting wind energy into mechanical energy is conservation of mass, energy and power. Small wind turbines can be mounted along the highway to produce electricity by trapping induction wind turbines triggered by moving vehicles. This wind blowing through the wind turbines generate electricity. Electricity will beused as free power to turn on street lights or for other purposes services near the highway.

Wind turbines are divided into two groups based on the relative alignment of their rotation axes with the wind direction which is horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). The main advantage VAWTs on top of HAWTs is the ability to generate electricity under any circumstances wind direction. This advantage makes VAWTs more suitable for Expressway wind power generation taking into account the wind due to the opposite direction of the vehicle and the opposite aerodynamics power can be used to drive VAWTs. VAWTs can be divided into two types, namely drag type and lifting type based on the generation mechanism of blade driving force. The Savonius Turbine and Darrieus Turbine are drag type and lift type of Vertical Axis Wind Turbine (Tian et al., 2020).

Figure 1.1: Example of Vertical Axis Wind Turbine that Installed in highway

1.1 Problem Statement

Most of the energy sources used today caused various pollutants in the air, water or soil. Therefore, new renewable energy needs to be proposed or used by each country in order to keep the sustainability of the environment for future life. The main sources that used in Malaysia to gain the electric energy is from hydropower station, thermal station, gas power station and also from burning of fossil fuels. Most of the existing source that we gain will causepollutant to the environment which affect living things. Wind energy is one of new energy thathave been discovered to be new future renewable energy that are safe to be used. Other than that, wind energy is very suitable to be used on the road to supply electricity for the use of street lights because on the road there is a high speed of wind generated from the movement ofvehicles between the two sides of the road that produces strong disturbance to the air. Therefore, the ideas are to analyses the feasibility of using wind turbine in Malaysia highway for powering the street lightings and at the same time if the power generated have excess energy, it can also use for powering traffic light, road signals and emergency road signage.

Figure 1.2: Example of Wind Turbine that used for Powering Street lighting

1.2 Objectives

The objectives of this project are as follows:

1) To study the existing research that have been done about feasibility of using wind turbine in highway.

2) To design a suitable Vertical Axis Wind Turbine (VAWT) to be placed on highway.

3) To produce small model of Vertical Axis Wind Turbine (VAWT) from its actual replica of prototype.

4) To see differences between two consecutive types of wind turbine blade model to extract as much as wind energy.

5) To conduct a testing for wind turbine model by using two approaches which is by moving three types of modified size of vehicles model and portable table fan.

1.3 Scope of Project

The scopes of this project are:

1) The design of the wind turbine that is suitable to be used on Malaysia highway.

2) The design of the wind turbine is only done by using SolidWorks Software.

3) The data of power output from two types of blades from vertical axis wind turbine model will be compared.

1.4 General Methodology

The actions that need to be carried out to achieve the objectives in this project are listed below.

1) Literature Review

   The information regarding the feasibility of using wind turbine were discovered from existing research that have been done in articles or journals.

2) Selection Type of Wind Turbine

   The suitable design for wind turbine either to use vertical type or horizontal type windturbine were chose due to its functionality and suitability at certain condition.

3) Proposing New Design Concept

   New design for Vertical Axis Wind Turbine (VAWT) were proposed to the supervisorand sketched in SolidWorks Software. Consideration must be taken to the new design such as number of blades for the wind turbine, the height of the wind turbine and lengthof the blade.

4) Produce Model from Actual Prototype

   The sketched design must be fabricated to produce small model wind turbine. The objective of producing small model is to see the movement mechanism of the wind turbine when we applied a certain amount of force to the blade (wind speed).

5) Analysis or proposed suggestion

   The produced model will be tested its suitability based on certain condition such asamount of wind applied and placement of the wind turbine. Also, we will analyze the power generated from the moving wind turbine.

6) Report Writing

   A report on this study will be written at the end of the project.

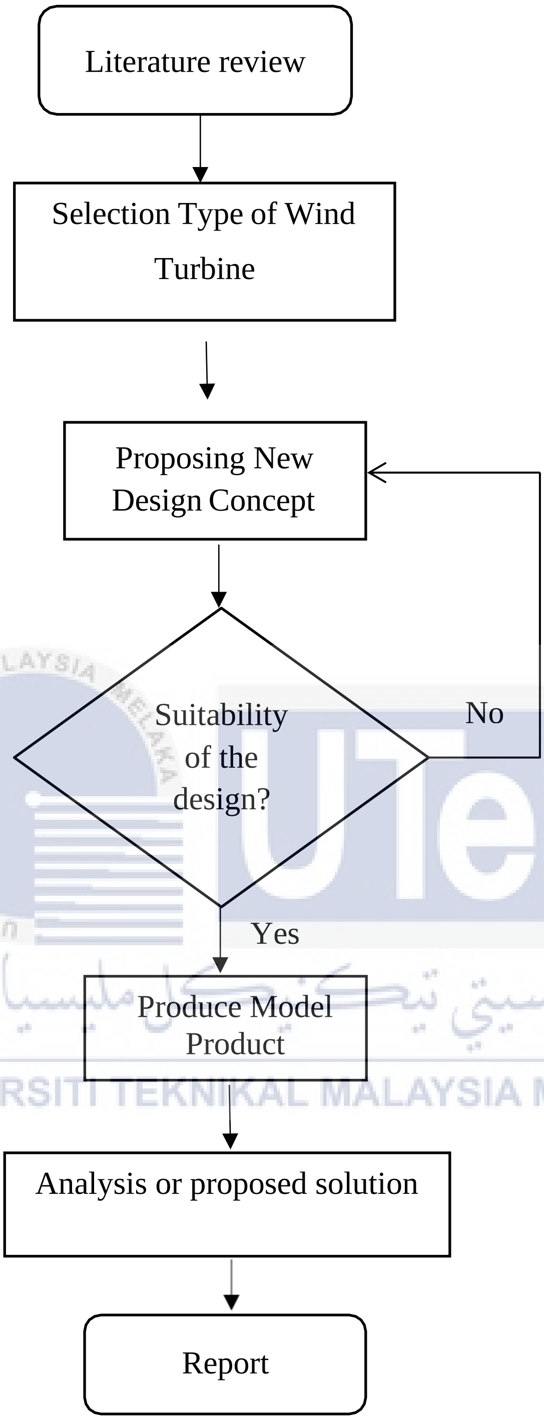

Figure 1.3: Flow Chart of Methodology

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, we will briefly explain a little bit details about the history of wind turbine, two category of wind turbine and suitability of using wind turbine in Malaysia based on research from previous journal. Besides that, the advantage and disadvantage of two wind turbine will be elaborate details in this part. In addition, some part of formula of calculation will be also explain which is related to the power produce by the wind turbine, Drag and lift coefficient and scaling of mode to prototype.

2.1 History of Wind Turbine

Wind energy has been used since earlier period. Historian's date the first usage of wind energy to 1,700 BC, when Hammurabi used windmills to fertilize the plains before Christ Eastern. Although all types of windmills have vertical shafts, the horizontal axis windmill has been used to fulfil numerous jobs in Europe since the eleventh century. To generate power, a wind turbine must go through two phases. First and foremost, the process involves converting the kinetic energy of the wind into mechanical energy for the rotor of the wind turbine. The second step involves transferring mechanical energy from the first phase, which involves using a generator to generate electricity. The conservation of mass, energy, and energy momentum is the foundation for transforming wind energy into mechanical energy.

The world still hasn't reached an agreement unified definition of small and large wind turbines. The definition of small wind turbines (SWT) is based on quantity generate of electricity to cover all kinds of household’s electricity demand. In this article, the emphasis onsmall international wind turbine definition Electrotechnical Commission (IEC) Turbine with rotor. The sweeping area is less than 200 square meters, which is equivalent to the rated powerapproximately 50 kW at voltages below 1,000 Volts of alternating current or 1,500 Volts of direct current. SWT has its own in several countries’ definition. Based on the axis of rotation, SWT can be classified into vertical axis wind turbines (VAWT) and horizontal axis wind turbines (HAWT). SWT can also spin, drag, or raise depending on the sort of force exerted. In recent years, as energy costs have risen and demand for carbon reduction has decreased, the use of SWT has increased (Kumar et al., 2016).

Year after year, the SWT market has risen, with around 870,000 units installed globally in 2013. The total number of SWT units deployed is 8% higher than in 2012, when 806,000 units were installed. The major markets for small wind turbine installation units are China, the United States of America, and the United Kingdom. In several huge markets, such as India and Italy, a small proportion of wind turbines are unregistered. According to the World Wind Energy Association (WWEA), the total number of SWTs to be deployed will exceed one million. The market for SWT applications can be classified into two categories: off-grid and on-grid. SWTs are utilized to charge the battery in the off-grid category, which is where the majority of the existing SWT applications are used. SWT is an online type that connects to the grid.

In research from Xu et al. (2019) in recent years, the implementation of renewable energy moderate to strong support worldwide. The certain types of renewable energy sources such as hydropower are consideredfully developed, others such as solar limited to specific regions. Wind power has been used more than two thousand years; the windmill is catching the wind power use constant speed rotor assembly since 200 BC. Wind energy is a free, abundant, globally available and green energy is the best choice for all renewable energy used for power generation.

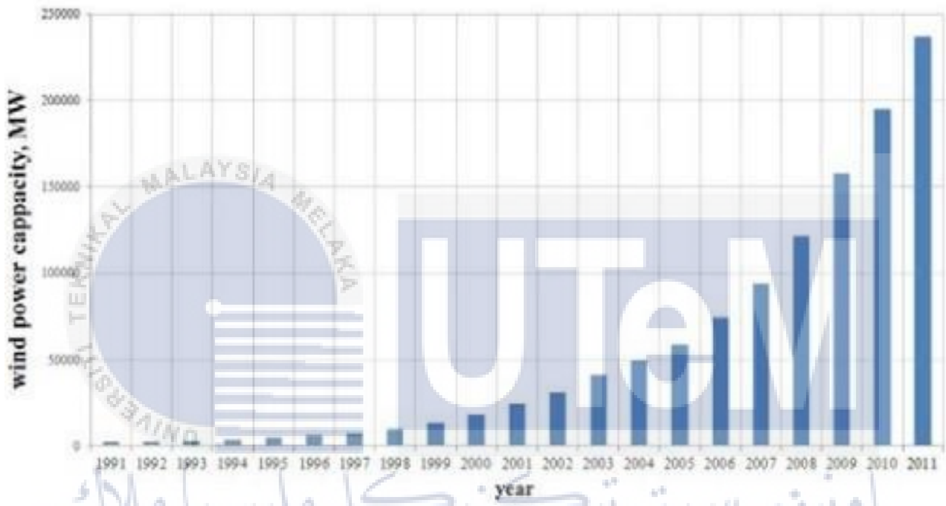

Figure 2.1: World's cumulatively installed wind power capacity during 1991-2011 (Bhosale, 2013)

Figure 2.1 shows the cumulative installed wind power worldwide electricity generation from 1991 to 2011, Figure 2.2 shows the share of the five continents in the total installed wind power capacity Electricity capacity between 1998 and 2011. This Annual growth of total installed wind power capacity the production capacity for the past five years was 26.3% per year, and estimated cumulative installed wind power by 2012, the capacity will exceed 270 GW will provide 12% of global electricity consumption by 2020, wind power will be generated.

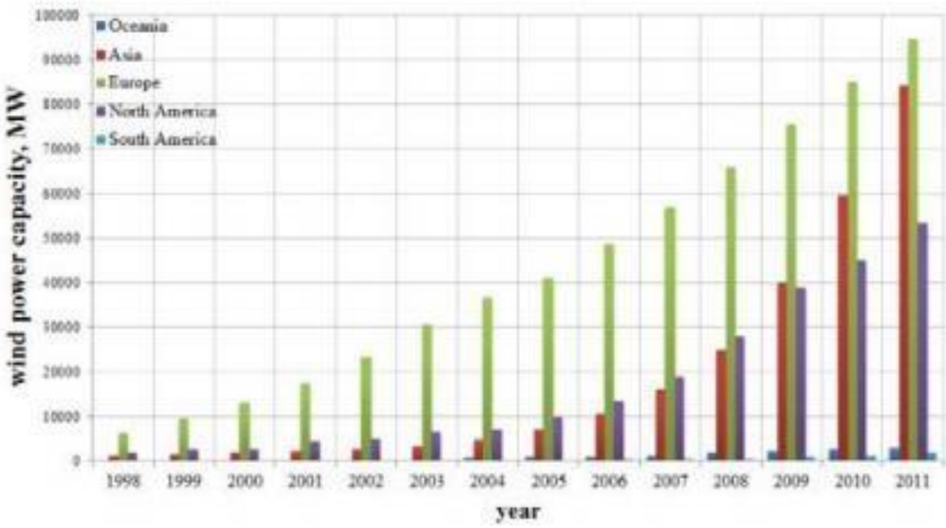

Figure 2.2: Continents' shares of wind electricity capacity during 1998-2011 (N. Goudarzi, 2012)

As shown in Figure 2.2, In research from Goudarzi and Zhu (2013) claims that Europe has the most total installed wind power capacity since 1998 From 4629 MW in 1997 to 94,500 MW in 2011. Although Oceania and South America have the least wind from 1998 to 2011, the power capacity increased, and the total installed capacity Installed capacity in Asia has increased significantly from 1115 MW From 1997 to 2011, it exceeded 84,000 MW.

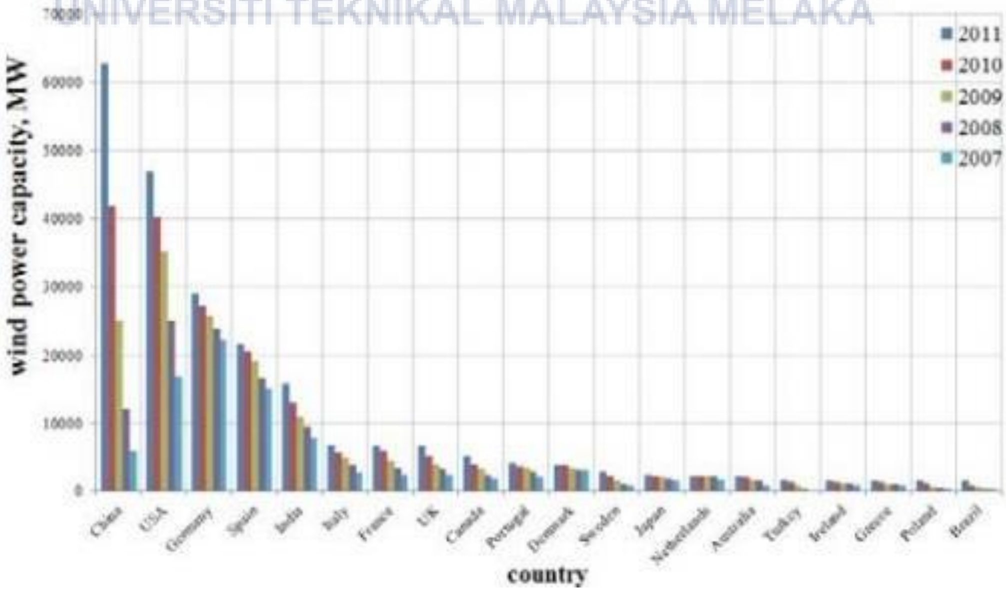

Figure 2.3: Top 20 countries with largest annual wind power capacity 2007-2011 (Goudarzi & Zhu, 2013)

Besides that, Figure 2.3 shows the top 20 countries in the world the largest installed wind power capacity in more than 97 countries as of 2011, these companies are using wind power on a commercial basis. Significant increase in the total installed capacity of wind power Asia's production capacity is mainly due to the rapid increase in wind energy China’s power capacityfrom 5900 Increased from MW in 2007 to nearly 63,000 MW in 2011, of which It is far from the second-ranked country, United States of America (USA). Although Germany still has Europe's largest installed wind power capacity since 2007, the growth rate of installed wind power capacity has been relatively low. Compared with China and the United States, it has become a country third in annual installed wind power capacity.

2.2 Condition and Suitability of Wind Energy in Malaysia

Sustainable power innovation is developing rapidly. In last year's entrepreneurship, wind energy was selected as the basic asset. The vitality of the wind is an inexhaustible source,derived from the air currents flowing through the surface world. Wind turbines can be used toobtain dynamic vitality and convert it into usable electricity, which can provide small (private),medium (network) or large (utility) power for homes, farms, schools or commercial applications. Highways are also used as the main road used by people in the world every day (Ho, 2016).

In Malaysia, sustainable power applications are still new and will be produced. Although Malaysia has its own capabilities, there are hydropower or solar-oriented factories in several places around Malaysia. However, wind power is not yet on the market. Nevertheless,the region of Malaysia is a special technology, located in Southeast Asia, it can get the main wind direction like the northern storm and the southwest heavy rain. Wind turbines and other equipment convert the kinetic energy of wind energy into potential energy, called wind energy,into potential energy. Wind flow or kinetic energy can be used to generate electricity from costreduction and wind turbine energy. Using this model to generate power for lamp posts is the main reason for the production of wind turbines.

In Malaysia, renewable energy is mostly used in the generation of power and transportation. From 2013 to 2040, the new strategy aims to increase the use of renewable energy (Erdiwansyaha, 2019). To aid in the expansion of renewable energy, Introduce a feed-in tariff (FiT) system. More research and development are needed to explore new renewable energy sources in Malaysia's eleventh plan (2016-2020). Have a more diverse portfolio of energy output. new Wind energy, geothermal energy, and ocean energy are all examples of renewable energy. Malaysia's wind map drawing process is expected to be completed in 2016.

Evaluation of the potential Onshore wind energy is currently being developed in Malaysia. The government must decide if wind energy Feed-in Tariffs can be combined with other renewable energy sources. Small's two failed wind energy projects, Perhentian Island and Swallow Reef, demonstrate how tough this is. Without conducting adequate study, go straight to Malaysia to erect wind turbines.

According to new research from Fang et al. (2010), the Indian Ocean and the South China Sea are the primary sources of strong winds in Malaysia. The monthly mean wind speed ranges from 1.5 to 4.5 m/s. Wind speeds of 9 to 11 m/s can be harnessed at higher altitudes. Mersing, Johor, and Kuala Terengganu have been recognized as high wind regions in Peninsular Malaysia, while Kudat and Sabah in East Malaysia have the highest wind potential. In Malaysia, onshore wind power could reach 1.5 megawatts.

Malaysia also possesses offshore wind power potential that has yet to be realized. The monsoon season, which runs from November through February, is when the wind blows fromthe South China Sea. To assure the project's viability, detailed historical wind data must be examined in a given location. Mersing and Kudat are considered possible sites based on findings from prior studies, with average winds of 3 m/s at 60-meter heights. Due to the monsoon season, the southern half of Peninsular Malaysia has more wind potential and greaterwind in the month of January.

Considering wind power is an infrastructure venture, the government must provide good incentives from the start of its implementation in Malaysia. For example, the lack of windgenerating technology in the Feed-in Tariff categories makes it impossible to achieve project profitability at present time. This exacerbates Malaysia's low wind problem. In order to tap into the untapped potential of wind power in Malaysia, suitable technologies for low wind conditions should be developed (Abdullah et al., 2019).

2.3 Pro`s and Con`s for Two Category of Wind Turbine

In research from M. Saad (2014), wind turbines can be divided into two categories. The goal of one type is to generate power from wind at high speeds. The other variety, on the other hand, is designed specifically for low-wind places like Malaysia (Wahabet et al., 2008). The rotor of a wind turbine is made up of a set of blades coupled to a rotor hub; the rotor deflects the airflow, creating a force on the blades, which produces a torque on the shaft, causing the rotor to rotate around a horizontal axis, which is primarily connected to a gearbox and generator. Small turbines are used for a variety of purposes, including charging batteries in boats and powering traffic lights. The larger turbines might be used to make smallcontributions to a power supply while also selling unused power to the source via the electric grid. Many huge turbines, known as wind farms, are becoming a more important renewable energy source, and many governments are implementing them as a strategy to reduce their reliance on fossil fuels.

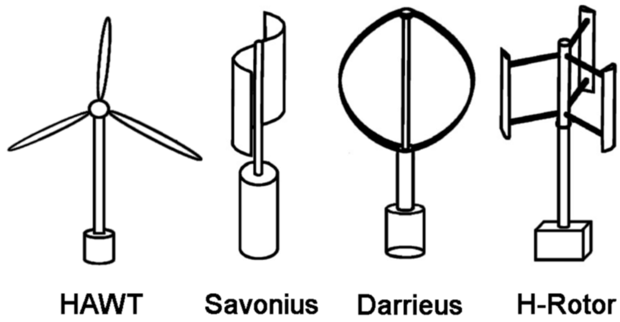

Figure 2.4: Example type of Wind Turbine

2.3.1 Horizontal Axis Wind Turbine (HAWT)

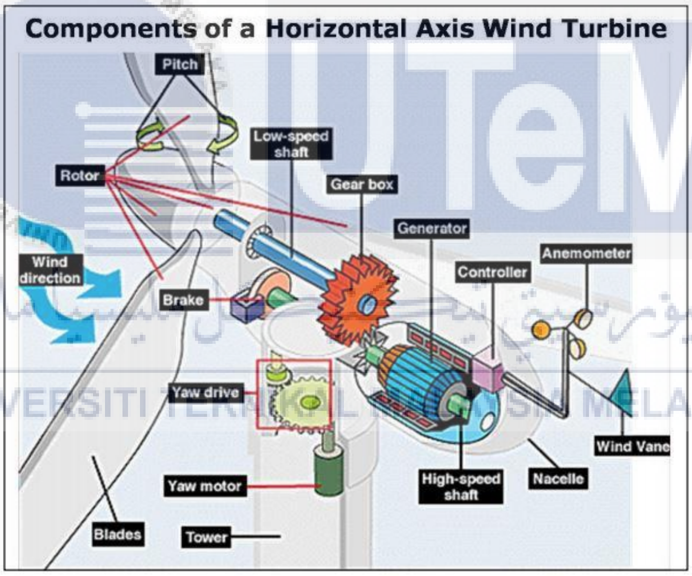

Figure 2.5: Components for Horizontal Axis Wind Turbine (al, 2004)

These Wind Turbines have a Horizontal Axis Turbines must be aimed in the appropriate direction (into or away from the wind, depending on the kind) in order to operate at maximum efficiency. Those that are located away from the wind, known as downwind turbines (“downwind” due to the turbine's placement relative to the tower), are pushed into precise alignment. A simple wind vane is used in traditional and smaller upwind based turbines to obtain proper orientation; big turbines contain a yaw motor and yaw meter. The yaw meter detects the precise direction of the wind, and the yaw motor moves the turbine to keep it aligned with the wind (al, 2004).

Classic windmill designs have been utilized for decades, according to research by (M. Saad, 2014), but a horizontal wind turbine has recently been improved. The HAWT technique was used by people harnessing wind energy to carry boats along the Nile River as early as 5000 B.C. Since then, wind turbines have undergone significant innovation and modification in order to attain optimal performance.

HAWT is made composed of blades that are horizontally oriented and parallel to the ground, and it extracts wind energy. While facing the wind flow perpendicularly, the blades work and revolve due to aerodynamic lift. Because it has a significant advantage over VAWT, HAWT is the most popular wind turbine and has received more research and development funding. HAWT is more efficient than VAWT at extracting energy from the wind force when deployed in a steady wind flow because of its design, which allows it to extract energy over the whole rotation of the blades. It's also unaffected by the backtracking effect. Aside from that, classic designs make installation and maintaining a breeze. Finally, horizontal wind turbines are prominent energy sources, with applications ranging from residential use to hybrid systems (Khudri Johari et al., 2018).

Figure 2.6: Horizontal Axis Wind Turbine (HAWT) – (Source from Wind power Engineering & Development)

2.3.2 Vertical Axis Wind Turbine (VAWT)

Kumara, Hettiarachchi & Jayathilake (2017) found that the Savonius and the Darrieus are the two most common types of VAWTs. The Savonius works in the same way that a water wheel does, by using drag forces. Darrieus, on theother hand, generates lift and turns the turbine using aerodynamic blades. VAWTs operate closer to the ground, which has the advantage of allowing heavy equipment, like as the gearboxand generator, to be placed closer to the ground level rather than in the nacelle. However, because the winds are lower near ground level, less power is created for a given wind and capture area.

A VAWT has an advantage over a HAWT in that it does not require a yaw mechanism because it can harness wind from all directions. This advantage is overshadowed by a slew of other drawbacks, including time-varying power output due to changes in power in a single blade rotation, the need for guy wires to support the main tower, and the Darrieus VAWTS' inability to self-start like HAWTS. When compared to standard horizontal-axis wind turbines,VAWTs offer numerous benefits (HAWTs). Inside the wind farms, they can be packed much closer together, allowing for more in any given space. They are also quiet, omni-directional, and exert lower forces on the supporting structure.

Aside from that, they don't require as much wind to generate power, allowing them to be placed closer to the ground when the wind speed is lower. They are more readily handled and can be used on towering structures because they are closer to the ground. Caltech researchhas found that carefully building wind farms with VAWTs can result in power output that is 10 times larger than a HAWT wind farm of the same size. VAWTs are also quieter than HAWTs, with dB levels at ten meters from the tower measuring approximately 95 dB for a HAWT – which is roughly the sound of a motorway with automobiles passing by – againstnearly 38 dB for a VAWT – which is approximately the sound (M. Saad, 2014).

Figure 2.7: Vertical Axis Wind Turbine (VAWT) – (Source from Wind power Engineering & Development)

In research from Khudri Johari et al. (2018), the downside of VAWT, on the other hand, isincredibly crucial. Because of its low initial torques and problems with dynamic stability, VAWT is inefficient in high-speed wind environments. Because the blades of the VAWT movein the same direction as the wind, they must travel back into the flow before being blown around. Previous research comparing VAWT with HAWT has yielded conflicting results. It's possible that there's no discernible difference or that one is just superior than the other.

Furthermore, VAWT is easy to build, has acceptable initial torque characteristics, and is relatively wind-unaffected. The starting and operational costs are considerably minimal when compared to HAWT. It takes up less area and does not necessitate a large, solid construction. VAWT is used to generate power in both high-level and low-level applications (Campobasso et al., 2016). In high-rise applications, VAWT is used to harvest wind energy and use it to offset the electricity consumption of the building's electrical appliances. In Malaysia's road transport industry, a prospective study on low-level applications was done. VAWT can generate power from moving automobiles when it is positioned on a divider. The energy generated is used to power 300 W street lights. In order to supply electricity to LED lights and emergency signs on highways, a numerical analysis was conducted to estimate the effects of vehicle positioning on wind energy harvesting. As part of a resource estimation assessment research for capturing wind energy, small wind turbines have been erected in tunnel entrances and urban canyons.

The research also shown that the resulting effect can be used in transportation networks (railway, waterway, or airside flows in airports). The drag-based equipment can also be mounted on the upper side of moving vehicles. According to this experimental inquiry, when the rotational direction of the VAWT and the moving wind direction are the same, the usable torque will be large at lower speeds. Several patents have already been filed for employing VAWTs to generate electricity from motorway traffic. From my observation from previous research,Malaysia is suitable to use VAWT type rather than use HAWT because Malaysia has low speedof air than other country (Santhakumar et al., 2018).

2.4 Strategies and Efficiency of Vertical Axis Wind Turbine (VAWT)

To counteract the likely depletion of fossil fuels and rising awareness of carbon emissions and global warming challenges, the design and implementation of electric motor carshas become a current trend. The deployment of such technology could be a viable alternative for extending the life of the current oil stockpile, or possibly completely replacing it. In research from Saqr and Musa (2011) found that this can achieve some of the HVAWT systems objectives in terms of reducing the reliance on fossil fuel. However, there are a number of issues to consider when using electric automobiles.

Hydrogen fuel cells are the current source of electricity in electric vehicles. These cellsgenerate energy from hydrogen and produce water as a contaminant (i.e., Exhaust). Vehicles powered by hydrogen fuel cells demand the presence of hydrogen filling stations. Given the well-known dangers and risks of hydrogen generation, which is required in fueling stations, itmay be difficult to contemplate this alternative, especially given the current political climate and terrorism alerts.

In the United States, several studies have been conducted to determine the number of hydrogen recharging stations required for a smooth transition from oil to electricity-powered automobiles. However, none of these efforts have yielded a technology solution for constructing a national infrastructure for hydrogen filling stations. Furthermore, the hydrogenfuel cell powertrain in automotive applications still has significant flaws (Saqr & Musa, 2011).

The second realistic method for providing reliable lighting for the country's highway network is to connect a powerful lighting system on such a network to the national electrical grid. This will inevitably raise the burden on power plants, which are primarily powered by natural gas and diesel. With increased political instability in major oil-producing countries, a country like Malaysia would undoubtedly examine sustainable energy resources as viable options to support its quickly increasing economy.

2.5 Power Consumption and Wind Energy

The wind speed that impacts the turbine blades varies depending on highway automobile speeds and should be recorded. This generates the estimated wind energy from moving automobiles. The output power of the VAWT is measured individually to determine the wind turbine's efficiency. The amount of wind energy available is determined by:

$$Wind\ Energy = \frac{1}{2}\rho A v^3 \tag{2.1}$$

wherein $\overline{v}$ is the wind speed in meters per second (m/s), ρ is the air density in kilograms per cubic meter (kg/m^3), and A (m^3) is the cross-sectional area of the wind turbine. The cross-sectional area is calculated by multiplying the rotor diameter (D) by the rotor height (H). The standardsea level density (1.225 kg/m^3) is chosen as the reference density. The amount of energy extracted by a wind turbine is determined by the following factors:

$$Amount\ of\ Energy\ Extracted = \frac{1}{2}\rho A v^3 \eta C_p \tag{2.2}$$

The power coefficient (CP) indicates the efficiency of a wind turbine design, while η, indicates the efficiency of the mechanical drive unit. Wind turbines can't convert all of the energy in the wind into work, and unlike other generators, they can only produce electricity inreaction to the wind that's now available. The Betz limit specifies the greatest amount of powerthat may be extracted from a given wind stream. The Betz limit (Cp-max = 0.5926) is the greatest value for the power coefficient, however it's difficult to achieve this efficiency accuratefrom a wind turbine during an experiment. In addition, the swept area restricts the amount of air that passes through the wind turbine. The wind's energy is converted into rotational movement by the rotor. As a result, under the same wind conditions, the larger the swept area,the higher the power output.

2.5.1 Experimental Calculation Formula

$$Power\ Produced = Amount\ of\ Current\ generated\ \times Voltage\ produced$$

$$P = I\ \times V \qquad (2.3)$$

2.6 Airfoil and Aerodynamic Principle

Vehicle aerodynamics can have a significant impact on a car's handling. At permissible road speeds, this has a minor impact, but it becomes more significant at greater speeds. It's worth noting that heavy headwinds and crosswinds encountered while driving on the highway might be very comparable to those encountered when racing (Kumbernuss et al., 2012). Aerodynamics have a significant role in defining the stress characteristics and cornering speed of racing automobiles. Drag, down-force, yaw, and lift are the four aerodynamic factors that affect a car. Drag acts in the rear of the vehicle, slowing it down. On all automotive bodies, drag exists. It rises in proportion to the square of the speed.

Aside from that, a number of terminologies are used to characterize an airfoil, according to new research from (Mouhsine et al., 2018). The mean camber line is the point on the airfoil's upper and lower surfaces that is midway between them. The leading and following edges, respectively, have the most forward and backward points of the mean camber line. The chord line of the airfoil is the straight line connecting the leading and trailing edges, and the chord of the airfoil is the distance between the leading and trailing edges measured along the chord line. The thickness is measured perpendicular to the chord line and is the distance between the upper and lower surfaces. Last but not least, the angle of attack is defined as the angle generated between the relative wind and the chord line.

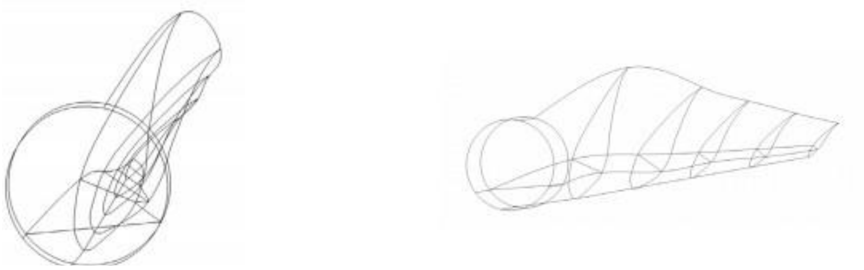

Figure 2.8: Angle of Attack and Chord line of and Airfoil (Left side) and Airfoil cross-sections used in the design of the wind turbine rotor blades (Right Side) (Mouhsine et al., 2018)

2.6.1 Lift and Drag Coefficient

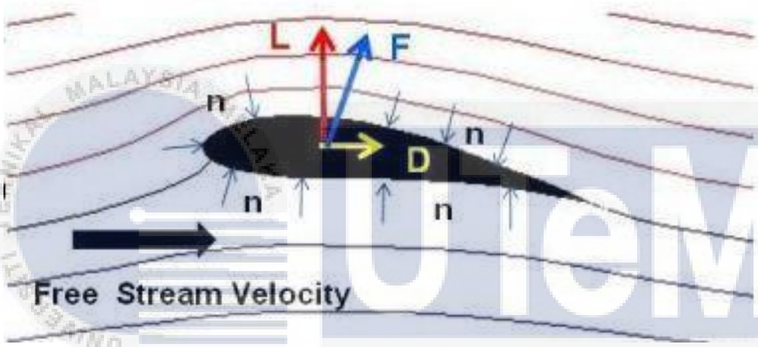

Figure 2.9: Flow Behaviors Direction of Aerodynamics Wind Turbine Blade (Vipul Kshirsagar1, 2018)

Drag occurs when a fluid flows over the surface of a body and attempts to counteract the motion of the body. The combination of pressure and viscous drag is known as aerodynamic drag. The pressure drag is the most powerful of the two. The shear forces operating between the two layers of fluid generate pressure drag (Kshirsagar & V. Chopade, 2018). Many flow issues can be described by non-dimensional parameters, according to theory and research. The Reynolds number is the most essential non-dimensional parameter for characterizing the features of fluid flow conditions. For two- and three-dimensional objects, force and moment coefficients can be defined as a function of Reynolds number. Lift and drag coefficients measured for flow around two- or three-dimensional objects are normally designated with an upper-case subscript. In wind tunnel testing, two-dimensional coefficients are frequently computed over a range of angles of attack and Reynolds numbers. The two-dimensional lift and drag coefficients are written as follow;

2.6.1.1 Drag coefficient equation;

$$C_D = \frac{D}{\frac{1}{2}\rho U^2 A} \tag{2.4}$$

2.6.1.2 Lift Coefficient Equation;

$$C_L = \frac{L}{\frac{1}{2}\rho U^2 A} \tag{2.5}$$

where C_D stands for drag coefficient, D for drag force, ρ stands for air density, U for free stream air velocity, and A stands for cross-sectional area.

For efficient rotor design, aerodynamic performance is crucial. The force responsible for the turbine's power generation is aerodynamic lift, and it is therefore crucial to maximize this force through good selection. Friction generates a resistive drag force that opposes the blade's motion, which must be prevented. It indicates that for rotor blade design, an aero foil section with a high lift-to-drag ratio, often bigger than 30, will be used (Maalawi & Badr, 2003):

2.6.1.3 Lift to Drag Ratio

$$Lift\ to\ Drag\ Ratio = \frac{Coefficient\ of\ Lift}{Coefficient\ of\ Drag} = \frac{C_L}{C_D} = \frac{L}{D} \tag{2.6}$$

The lift/drag ratio is computed by taking the lift coefficient by the drag coefficient, CL/CD, to express the relationship between lift and drag. The L/D ratio indicates the efficiency of an airfoil. Higher L/D ratio aircraft are more efficient than lower L/D ratio aircraft.

With the exception of post stop, high angles of attack, and aerofoil thickness conditions, the co-efficient for the lift and drag of aerofoils is difficult to estimate numerically. However, publicly available software, such as XFOIL model, produces high accuracy. Aerofoils are traditionally tested experimentally with tables that combine lift and drag at various angles of attack and Reynolds numbers. Wind turbine aerofoil designs have traditionally been based on aeroplane technology, with equivalent Reynolds numbers and section thicknesses suitable for blade tip conditions. Due to the changes in operating environment and mechanical stresses, additional considerations should be made for the design of wind turbine particular aerofoil profiles (Schubel & Crossley, 2014).

2.7 Scaling Ratio for Prototype to Model

There are few effective ways for creating a lab-scale model wind turbine that matches the wake flow of its prototype real turbine, according to (B. Li et al.,2019). It severely restricts the development of relative wake flow investigations in wind tunnels. To address this problem, a small-scale wind turbine design technique with high performance and close likeness to the prototype, particularly the blade, should be proposed. According to (Weikang Du et al., 2013) and (Rae Martin, 2011) when constructing a lab-scale wind turbine model to its referenced utility-scale wind turbine, the following similarity conditions should be used: geometric similarity, kinematic similarity, and dynamic similarity.

Geometric similarity is the basic foundation for a similar design where the model and prototype are geometrically similar. For linear scale characteristics, geometric similarity conditions such as diameter, hub height, hub diameter, and so on must be met. The geometric scale ratio L is defined as follows: where D signifies rotor diameter, subscript m denotes model, and subscript p denotes prototype:

Equation 1;

$$\lambda_L = \frac{D_m}{D_p} = \frac{L_m}{L_P} = \lambda \tag{2.7}$$

where D denotes rotor diameter. L as length, m signifies model, and p represents prototype.

When the velocity vectors of the prototype and model flow fields are geometrically equivalent and the corresponding points of the prototype and model flow fields have the same velocity, kinematic similarity is satisfied. Matching the Reynolds number is obviously impossible because to the large difference in lengths between the model and the prototype. The blade tip speed ratio ($TSR = \frac{\omega R}{V_{in}}$) can be used to characterize the kinematic similarity of wind turbine designs in general, where ($TSR = \frac{\omega R}{V_{in}}$) indicates the dimensionless number equal to the ratio of blade tip linear velocity to incoming wind speed Vin. In order to meet the similarity criterion, the TSR of the model blade and the prototype should be consistent, i.e., $TSR_P = TSR_m$. In a regular pattern, the blade rotates. As a result, both the model blade and the prototype must keep the value of the Strouhal number:

Equation 2;

$$Sr_{blade} = \frac{V_P}{\eta_P D_P} = \frac{V_m}{\eta_m D_m} \tag{2.8}$$

where n is the number of rotations per minute (RPM). It has $TSR = \frac{2\pi n}{60V_{in}}$ for the blade, therefore Eq. (2) suggests $Sr = \frac{\pi}{60} \times TSR$. As a result, the similarity of TSR and Sr can be matched. As a result, the design of the reference velocity scaling ratio can be used to achieve the RPM of the model turbine:

Equation 3;

$$\lambda_V = \frac{V_m}{V_p} \tag{2.9}$$

After examining the wake zone of a wind turbine, (Frandsen et al., 2006) and (Göçmen et al., 2016) declare that the thrust coefficient is the most important parameter obtained by various wake models. According to the Jensen wake model, the wake flow grows linearly as the distance from the rotor increases, and the velocity distribution in the wake area is mostly determined by the wind turbine's axial thrust coefficient (Shakoor R. et al., 2016).

2.8 Requirements for Total Effectiveness of Wind Turbine

Figure 2.10: VAWT on middle of highway divider (Al-Aqel et al., 2016)

In the literature, some of the previous research demonstrated the feasibility of implementing this idea and the benefits that will emerge once it is implemented to obtain clean energy for diverse purposes from underutilized wind energy along motorways (Stevens et al., 2006). Installing a vertical axis wind turbine (VAWT) on the highway divider to receive wind from two sides, with the wind speed being higher on one side of the road than the other, is one approach to generate power on roadways. The generated electricity will be stored in batteries and utilized to illuminate the highway at night. The design and selection of the wind turbine blades, in addition to other elements such as wind speed, blade length and form, tower height and design, surface treatment, and the tip speed ration (TSR), have a major impact on the wind turbine's efficiency (Sathyanarayanan et al., 2011). Figure 2.10 describes the proposed vertical axis wind turbine's installation in the midst of the highway divider.

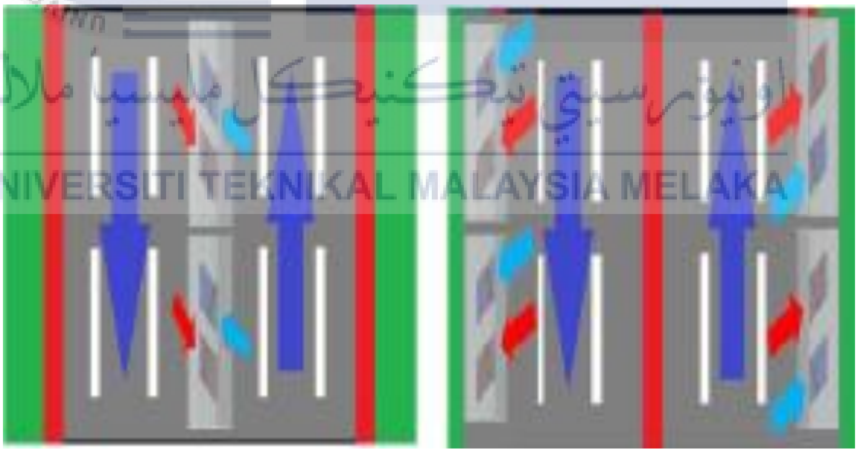

Figure 2.11: Location if Concrete wall places in middle of road (Left Side) and Location of concrete at side of both road (Right Side)

It is possible to view VAWT on highways, which are usually divided into two portions by metal or concrete blocks. The concept of using horizontal axis wind turbines (HAWT) was developed, with HAWT contained in concrete blocks, each holding two small HAWT, and the blocks being placed on the divider area and on both sides of the roadways to create additional electricity. As seen in Figure 2.11, the blocks in the rod's center will receive wind from two directions, whereas the blocks on the edges will only receive wind from one direction (Al-Aqel et al., 2016).

2.8.1 Wind Turbine's Sideways Length from The Road

The purpose of measuring wind speed at different distances from the road is to see how much vehicle-induced turbulent wind is there. At the same time, the three anemometers were placed at different lateral distances from the road shoulder, all at the same level from the ground. The distances from the road were set to be 0.5 m, 1.0 m, and 1.5 m. The height levels from the ground were altered to 0.5 m, 1.0 m, and 1.5 m for various measurements. These distances from the road were kept constant when altering the heights of the anemometers. Figure 2.12 depicts the configuration of the three anemometers, as well as the changing height from the ground at each measurement.

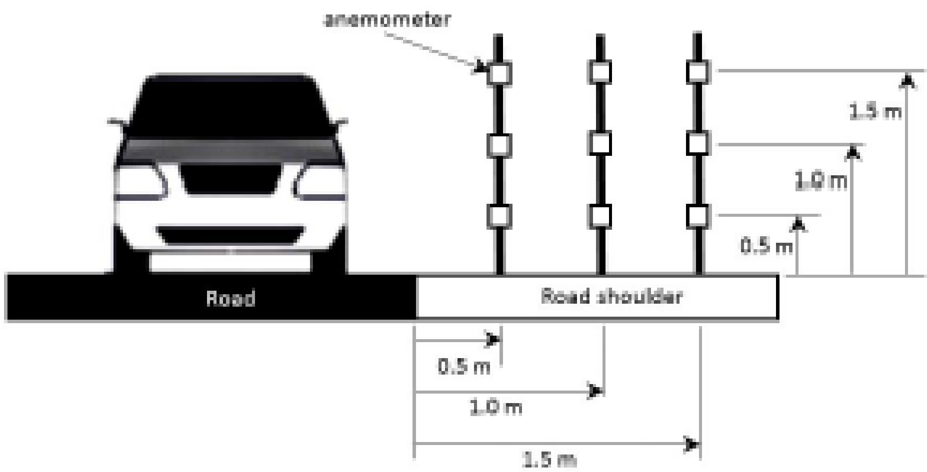

Figure 2.12: An illustration of the location of the anemometers next to the road

The recorded wind velocity of the three anemometers at various lateral distances (0.5 m, 1.0 m, and 1.5 m) from the road at a height of 0.5 m is shown in Fig. 2.13. The data analysis revealed that heavy vehicles passing by the anemometers, such as lorries or buses, were cause for the regularly occurring high readings of wind speed. The strongest wind speed was about 4.5 m/s, according to the anemometer, which was positioned at 1.0 m from the lateral distance of the road shoulder. The high wind speed at this point is linked to the formation of following vortices behind and to the side of the vehicle at a distance of around 1.0 m from the vehicle's body.

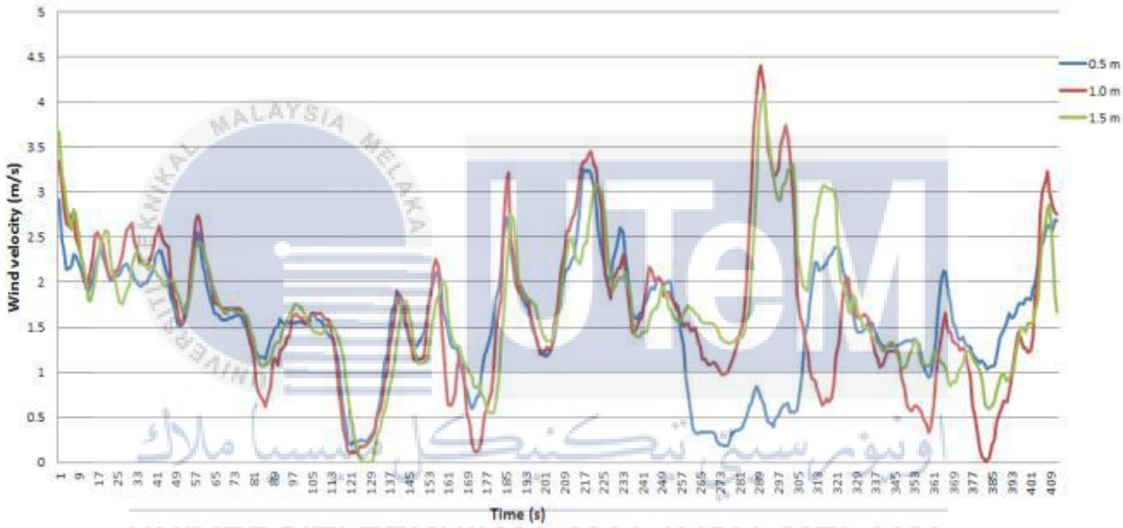

Figure 2.13: Wind velocity was recorded for various lateral lengths (0.5 m, 1.0 m, and 1.5 m) from the road at a height of 0.5 m.

The same approaches were used when the three anemometers' levels were increased to 1.0 m and then 1.5 m. Figure 2.14 shows a sample of the wind velocity recorded by the three anemometers at 0.5, 1.0, and 1.5 m lateral distances from the road at a height of 1.0 m. The largest wind speed recorded was 6 m/s, which was higher than an anemometer reading taken at 1.5 m from the ground. After measuring and analyzing the wind speed induced by moving cars, it was determined that a lateral distance of 1.0 m from the road is the optimal location for installing the wind turbine at all three heights from the ground.

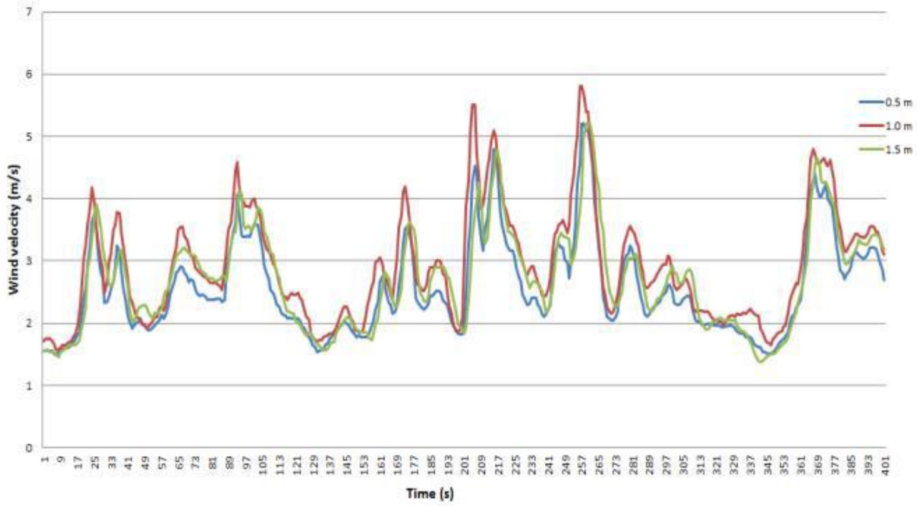

Figure 2.14: Wind velocity at various lateral lengths (0.5 m, 1.0 m, and 1.5 m) from the road at a level of 1.0 m.

2.8.2 Altitudes of Wind Turbine from The Ground

Based on the results of the lateral distance from the road assessment, which showed that 1.0 m distance from the ground is the best location for placing the wind turbine, the three anemometers were fixed at this lateral distance from the road to find out the optimum height from the ground at which the wind turbines will be set up. The anemometers were placed at 0.5, 1.0, and 1.5 meters above ground level to measure wind velocity simultaneously. A sampling of the results is shown in Figure 2.15.

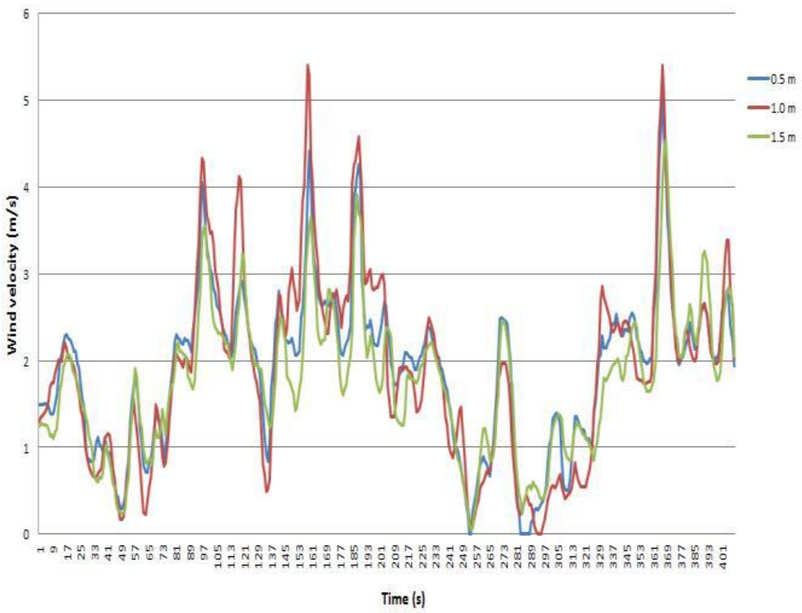

Figure 2.15: Wind speed at a height of 1.0 m from the road

The maximum power velocity was measured by the anemometer at 1.0 m from the ground, and it was around 5.5 m/s, as shown in Fig. 2.15. Increased turbulence intensity could be to fault for this. Kinetic energy happens at a distance of roughly 1.0 m from the side zone of the driving vehicle. At a lateral location of 1.0 m and a height of 1.0 m, the wind flow has the fastest speed at which the wind turbines can extract the most energy from the wind flow due to driving vehicles.

2.8.3 Orientations Respect to The Road

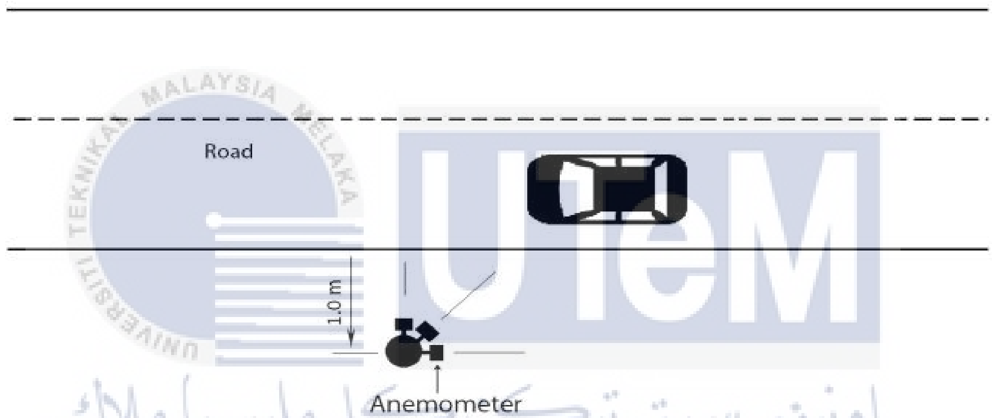

Figure 2.16: The three anemometers were setup at three different angles (Al-Aqel et al., 2016).

The HAWT only catch wind from one direction, which must be evaluated in order to direct the HAWT in the best possible orientation. The three anemometers beside the road in Figure 2.16 were installed in three distinct directions: parallel to the road, perpendicular to the road, and 45 degrees from the road. One anemometer was positioned in each orientation to acquire the best effect. At a height of 1.0 m above the ground, the three anemometers were installed. The wind speed in each direction was significantly different from what was seen in the other directions.

To catch the most energy from the wind created by moving vehicles on the roadways, HAWT should be installed at a distance of 1.0 m from the road, at a height of 1.0 m from the ground, and at a 45-degree angle from the road. According to the research, the HAWT can obtain the maximum amount of energy by putting those three needs in place. Thus, we can try to proof that VAWT places on middle between two directions also can get the best optimum energy by following same procedures as from previous research of HAWT.

CHAPTER 3

RESEARCH METHODS

3.0 Introduction

In this chapter 3, we will explain the details about the flow of procedure that we used to make sure that the project was successfully done smoothly by following the flow of procedure that have been implemented. These methodologies start rightly after we do some reading from previous articles and researches that have been done to gain as much as information regarding to the wind turbine. After that, we gain enough information about type of wind turbine, we start to propose a few conceptual designs for our prototype product. Afterwards, the nicest concept of design that meets the existing requirements were selected as our official scheme design of prototype. The example of conceptual design will be discussed and shared in this chapter.

3.1 Conceptual Design

Conceptual design is a step in the design process in which the broad outlines of a product's purpose and shape are defined. Interactions, experiences, procedures, and strategies are all part of the process. It includes feedback what people want and how to address their requirements with products, services, and operations. Concept sketches and drawings are common elements of conceptual design. For our design, we get the idea to sketched from previous designs that have been designed.

3.1.1 Conceptual Design 1

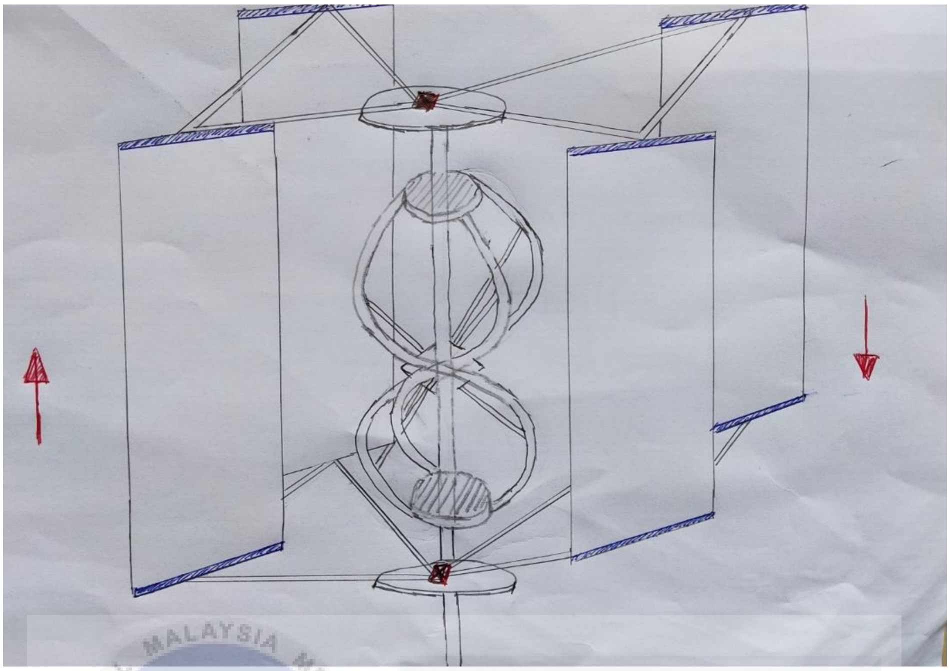

Figure 3.1: The conceptual Design 1 with meets several requirements

For this first design as shown in Figure 3.1, the helical type blade was sketched for blade type as helical type of vertical axis wind turbine as it is very suitable for low-speed wind in Malaysia highways. This design was sketched based on existing design that already have in previous research but al little bit improvement in designs. The barrier support is inserted to focus the flow of wind in 45° orientation towards the blade. However, this design was rejected because the barrier was not suitable to attaching it together with the wind turbine. Because it will make the wind turbine itself heavy with addition of barrier. The recommendation is to make the barrier together with the support stand-alone itself. If the barrier mechanism is combined together with the wind turbine mechanism it will give additional load to the turbine at it will become heavy.

3.1.2 Conceptual Design 2

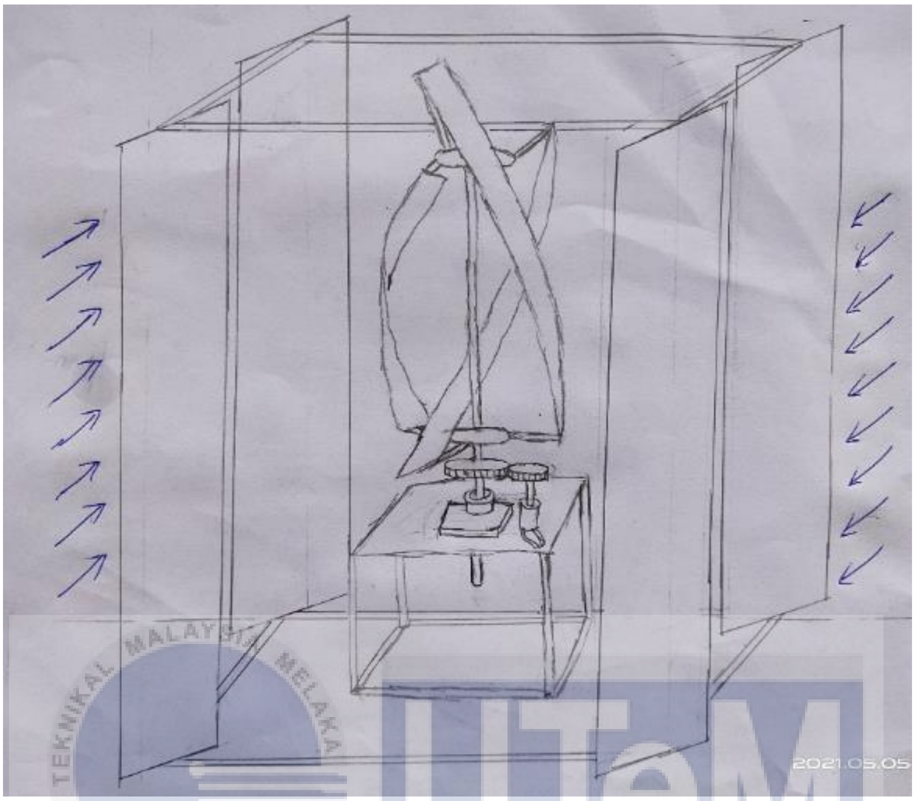

Figure 3.2: The Conceptual Design 2 with meets several requirements

This conceptual design 2 shown in Figure 3.2 is almost same as previous design. However, these designs have different concept style of wind turbine mechanism and barrier mechanism. For wind turbine, it designed with proper shape of helical blade. This helical blade assists by blade support at top and bottom of the blade. Next, the base was design using rectangular shape to make sure the turbine will stable when it operates. For part of transmission system from mechanical to electrical energy, we are using spur gear system and DC generator as transmitter. For part of barrier mechanism, we separate it with wind turbine. The barrier mechanism equipped with four-sided piece rectangular shape of barrier that design to direct the wind energy 45° to the blade of wind turbine. Indirectly, it will help to gain maximum efficiency of wind energy from moving vehicles.

3.2 SolidWorks Drawing for Model Design

The selected style for conceptual 2 was selected as our final design. Several requirements have been made to select it as our best design. For part of scaling for three requirement that we are follow which is for lateral distance from wind turbine to road we are using scale ratio of 1:3, Height of wind turbine from ground scale ratio of 1:1 and the orientation angle is same which is 45° of orientation direct to the blade of wind turbine.

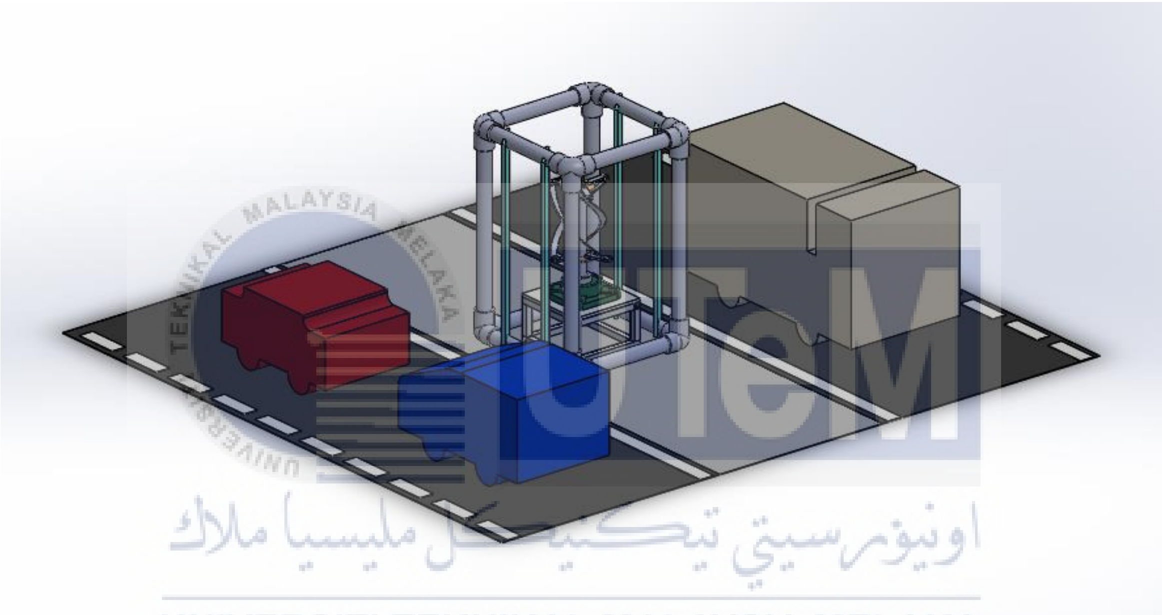

Figure 3.3: Overall Model Design for our Project

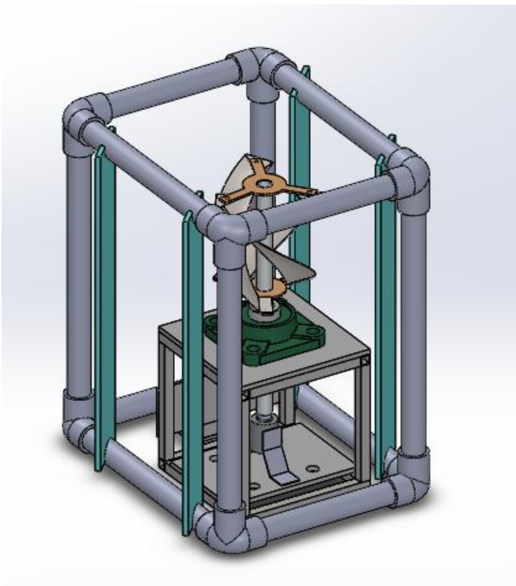

Figure 3.4: Wind Turbine Model along with Barrier Mechanism

3.2.1 Model Drawing for Wind Turbine

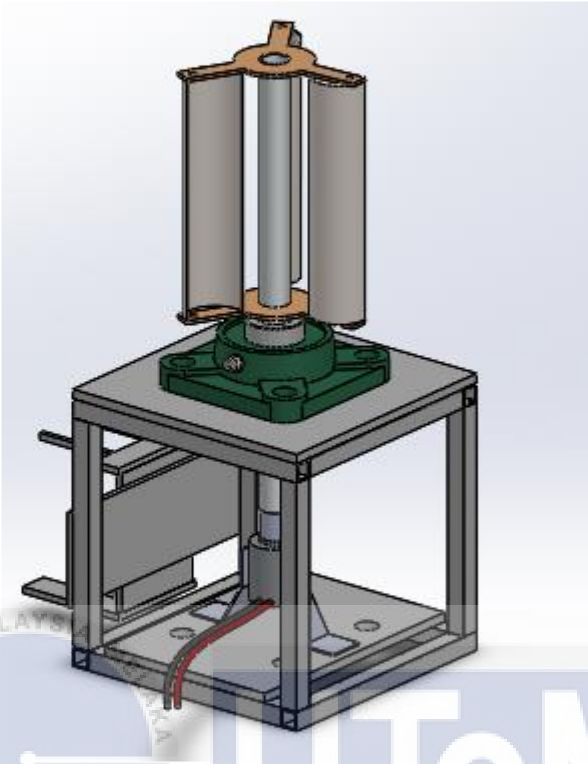

Figure 3.5: Model for Wind Turbine

We have drawn the scheme design by using SolidWorks software as shown in Figure 3.5. For base of wind turbine part, we are using material of hollow rectangular stainless steel with dimension of 1cm × 1cm for body of the base, while for base to support direct the surface of the wind turbine, we are using aluminum sheet with thickness of 5mm. To hold the shaft that equipped with diameter of 15mm, we insert the bearing housing UCF 202 that suitable with shaft of diameter of 15mm. Meanwhile, there is two component of hub that placed at top of shaft and middle of shaft. The hub of a wind turbine is the element that connects the blades to the main shaft and, potentially, the remainder of the motor train. The hub is responsible for transmitting and sustaining all of the loads generated by the blades. Whilst, material that we are using for our blade is aluminum sheet with thickness of 2mm that suitable to make helical shape.

3.2.2 Helical and Curve Type of Blade

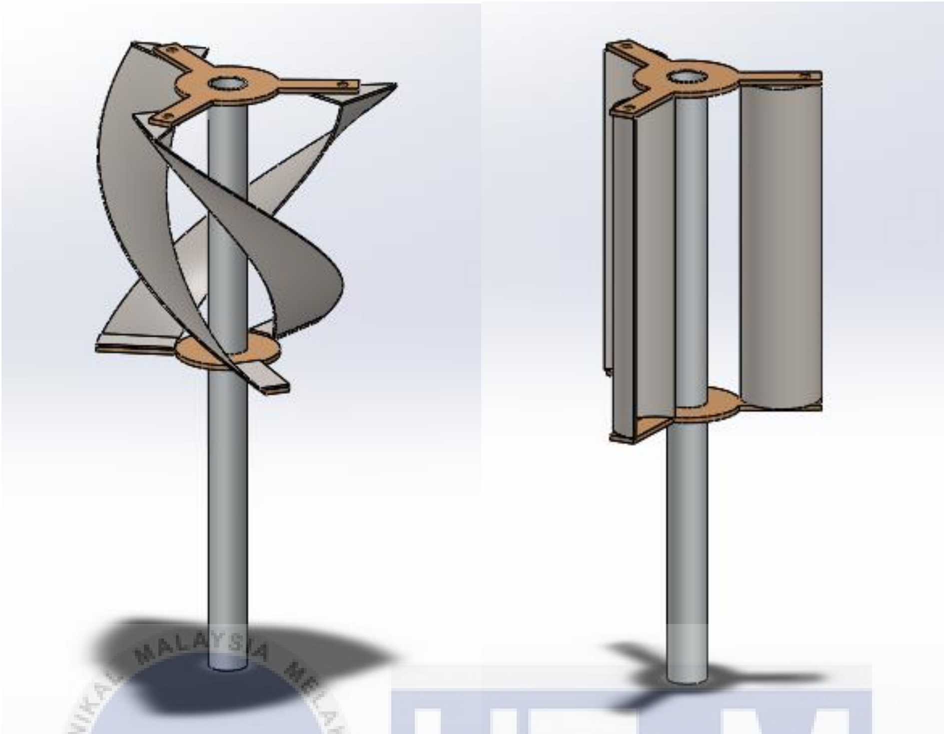

Figure 3.6: Helical and Curve Type of Blade

Blade is important mechanism in order to extract as much as wind power/energy that produce from natural wind and moving vehicles. Majority of experiment have done that shows helical type of blade is much efficient than other type such as curve blade to extract wind energy and produce high power output. Thus, two comparison experiment will be made between these two shapes of blade to see which one will produce more power and more efficient in terms of model wind turbine analysis.

3.2.3 Model Drawing for Barrier Mechanism

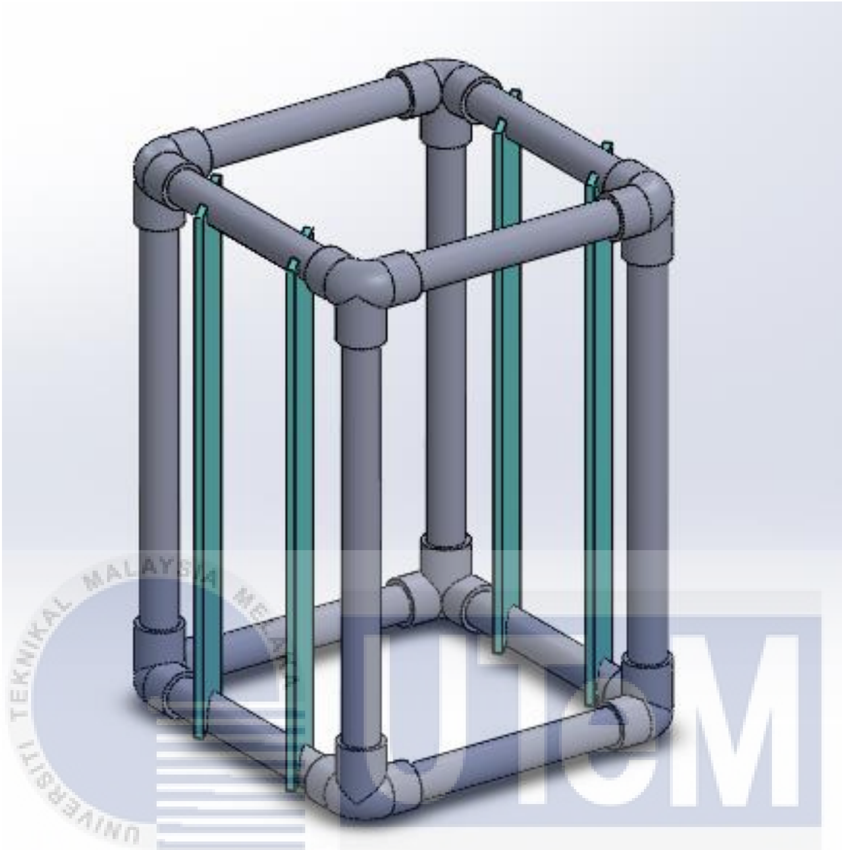

Figure 3.7: Model for Barrier Mechanism

As we mentioned before, the barrier mechanism is acted as component that directing the wind energy directly to the turbine blade with supporting angle of 45°. The body of the barrier we are using PVC pipe with 3-way connector as the joiner. While, for four barriers, we are using plastic coagulated sheet almost like manila card but a little bit thicker. We make some cut at top and bottom of the barrier frame to make sure that the barrier sheet can be slightly fix at that position of 45°. Barrier mechanism will contribute high wind energy than the one that without barrier mechanism from previous analytical research that have been made (A. A. Al-Aqel, 2013). Therefore, two comparison data experiment will also will be running to see which state extract more wind power and triggered the blade to rotate faster.

3.2.4 Model Vehicles

The three types of model vehicles that have been drawn is sedan, MPV car and lorry. All dimension for this vehicle we made from scaling of RC car as our reference that we have been survey from shopping website which is RC car with cross section of (22.5cm x 15.5cm x 11 cm).

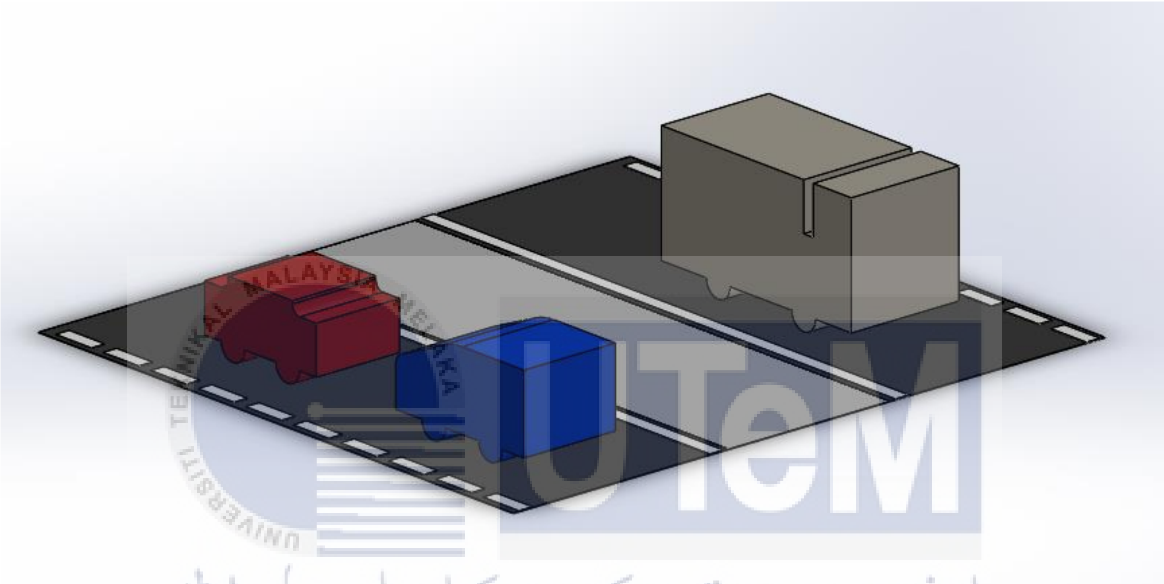

Figure 3.8: Model for Three type of Vehicles on road

3.2.4.1 Vehicle Type 1 (Sedan)

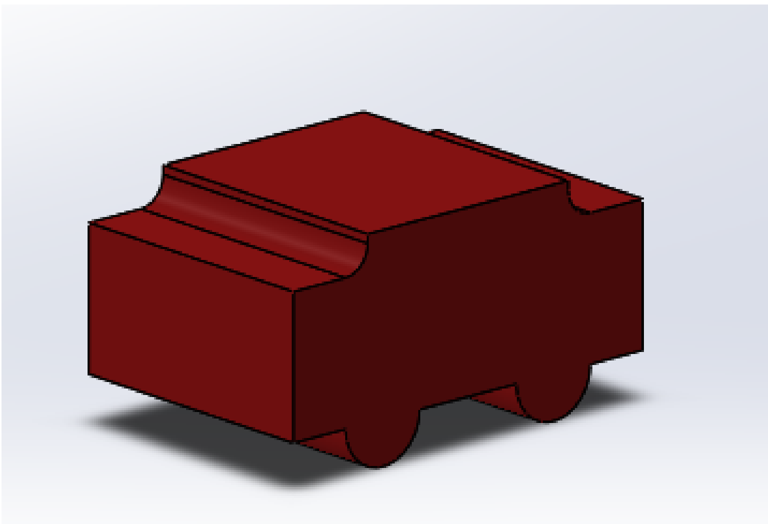

Figure 3.9: Model Vehicle Type 1 (Sedan)

For this sedan model as shown in Figure 3.9, it has a cross section dimension of (23.5cm × 15.5cm × 12.5cm). We take the Toyota brand as our reference as the replica for sedan prototype with dimension as shown in Figure 3.10. Also, the average scaling ratio for our model to prototype car is around 1:15.

Figure 3.10: Prototype of Sedan Car (Toyota)

3.2.4.2 Vehicle Type 2 (MPV)

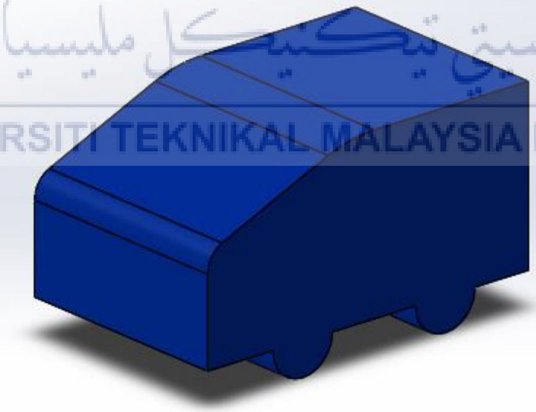

Figure 3.11: Model Vehicle Type 2 (MPV)

For this MPV model as shown in Figure 3.11, it has a cross section dimension of (27cm × 17cm × 15.5cm). We take the Toyota brand as our reference as the replica for MPV prototype with dimension as shown in Figure 3.12. Also, the average scaling ratio for our model to prototype car is around 1:15.

Figure 3.12: Prototype of MPV Car (Toyota)

3.2.4.3 Vehicle Type 3 (Lorry)

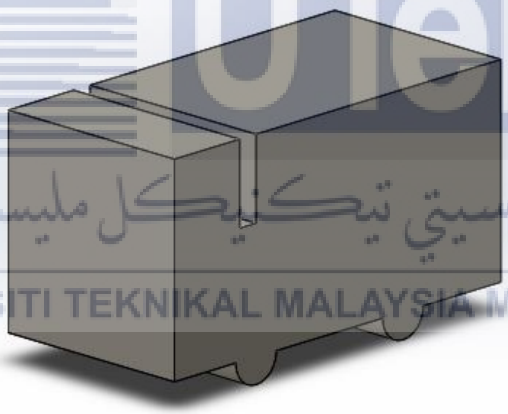

Figure 3.13: Model Vehicle Type 3 (Lorry)

For this lorry model as shown in Figure 3.13, it has a cross section dimension of (40cm × 20cm × 22.5cm). We take the Tipper Truck type as our reference as the replica for Lorry prototype with dimension as shown in Figure 3.14. Also, the average scaling ratio for our model to prototype car is around 1:17.

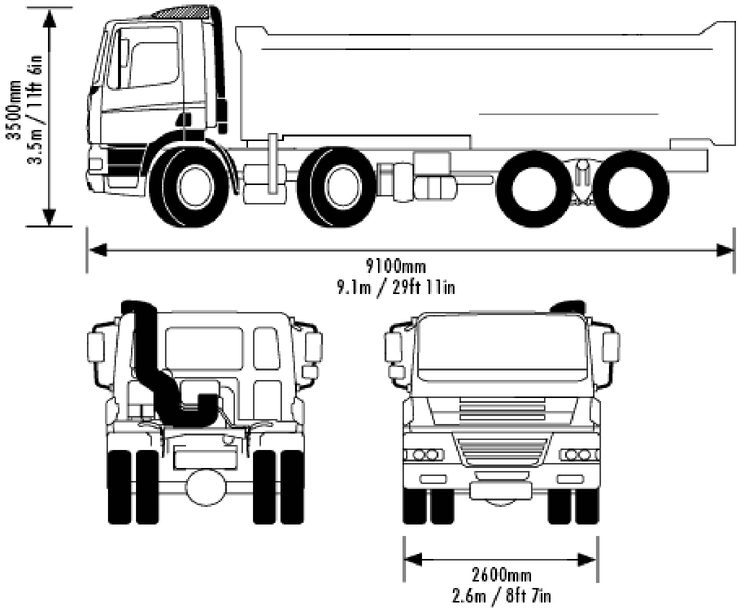

Figure 3.14: Prototype of Lorry (Tipper Truck Type)

3.3 Detail Design

In this chapter, the preliminary process that were used to proceed the feasibility study of wind turbine will be implemented. The process of producing the model of wind turbine starting with the selection of material for each part also will be explained briefly. It's also indicating the detail design that were used to choose correct dimension and parameter for the wind turbine model barrier component and model of three types of vehicles as in Figure 3.15.

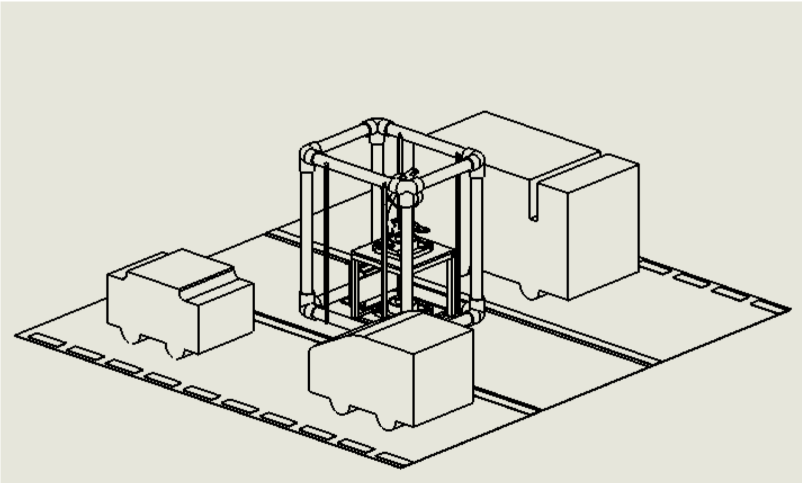

Figure 3.15: SolidWorks Drawing Model of Vertical Wind Turbine with Three Type of Vehicle Model

The final draft for the model of wind turbine has been drawn in the SolidWorks Drawing software. The drawing includes necessary view such as isometric, top, front and right view. Each of the drawing view play important roles in order to get accurate dimension for certain parts. The detail drawing for the final assembly and subassembly parts will be shown in appendix.

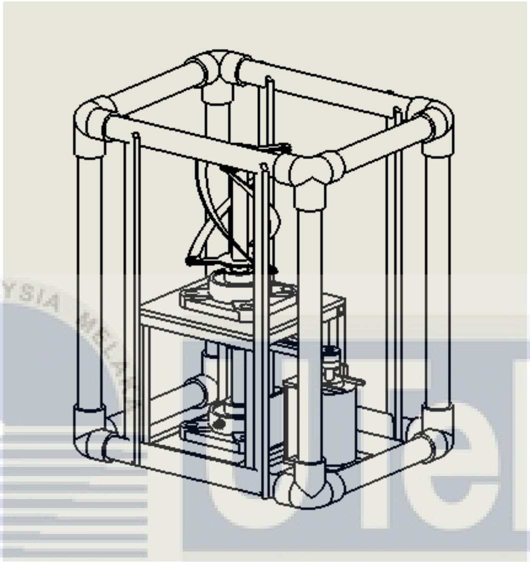

Figure 3.16: SolidWorks Drawing of Vertical Model of Wind Turbine with Barrier Assembly

3.4 Selection of Material

Material selection is an important stage in the design of any physical thing. The basic purpose of material selection in the context of product design is to minimize cost while satisfying product performance requirements. The qualities and costs of candidate materials are the starting point for systematic selection of the best material for a given application. The use of a material index or performance index that is relevant to the desired material qualities can often improve with material selection. The material that has been assigned for this vertical axis wind turbine model were using different type of material and thickness. This is to ensure the efficiency of this wind turbine model that will function well when there is turbulence wind energy from the wind.

Table 3.1: Material Selection

No.	Part/ Component	Type of Material
1	Hub Support	Aluminium (3mm thickness)
2	Blade	Aluminium (1mm thickness), Tin (Two Bottle Recycle Drink Tin)
3	Shaft	Aluminium Hollow Rod (Ø15mm)
4	Base	2 x Stainless Steel Plate (5mm thickness)
5	Base Support	Hollow Rectangular Steel (1cm x 1cm)
6	DC Micro Motor	7000 rpm with 6V-12V

3.5 Fabrication Process

The process of producing this wind turbine model were conduct step by step starting from fabrication of the base part until fabrication of shaft with hub support. The estimated time for this fabrication process is about 6 weeks. This is because there is many errors and failures occur during conduct this manufacturing process that makes rework method take places. In order to use the equipment that have in workshop of Faculty (FKM), permission from the laboratory`s person in charge (technician) and laboratory manager need to perform. Some of the laboratory that need to be used collided with student scheduled class. Booking and early notification are required before accessing any labs in order to use the workshop/laboratory.

3.5.1 Cutting Process

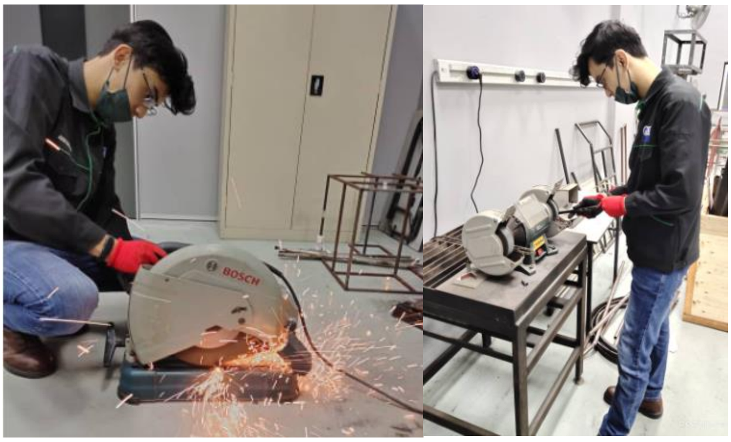

Figure 3.17: Process of Cutting Material

The initial step in the production process of this product is to perform a cutting operation for each of the materials as shown in Figure 3.17. Cut-Off Saw Machine is used to cut materials such as hollow rectangle steel and hollow aluminum cylinders. The cut is based on the detail design that has been sketched as a reference. Stainless steel plate has been used to support the base structure during assembly. Figure 3.18 demonstrates the CNC Plasma Machine was used to cut the plate steel. The machine software receives the instructions from the CAD drawing via the file dxf* format drawing. Hub mechanism, blade and base mechanism was cut using these CNC Plate Machine. The machine itself have the maximum requirement to use that machine which is material that need to be cut must not exceeded thickness of 5mm and hole size not less than 10mm diameter. Bench Grinder Machine was used as a polisher/tidy up the cut surface in order to eliminate superfluous fragments.

Figure 3.18: Process of Cutting Material using CNC Plasma Machine

3.5.2 Joining Process

3.5.2.1 TIG Welding

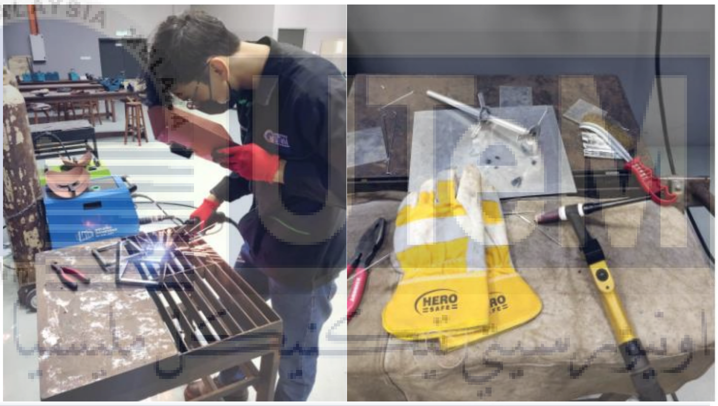

Figure 3.19: Welding Process (MIG and TIG welding)

Welding takes place once each material has been cut according to the detail design. When it came to welding steel, MIG welding was the chosen method. For each point of intersection, a base assembly was welded to provide a complete basis for the wind turbine. The plate foundation was then correctly welded in accordance with the welding plan. Initially, TIG welding was utilized to join the hub aluminum to the aluminum shaft for the hub support. For short info, Tungsten inert gas welding TIG), also known as gas tungsten arc welding, is an arc welding technology that produces welds with a non-consumable tungsten electrode. An inert shielding gas protects the weld region and electrode from oxidation and other ambient contaminants.

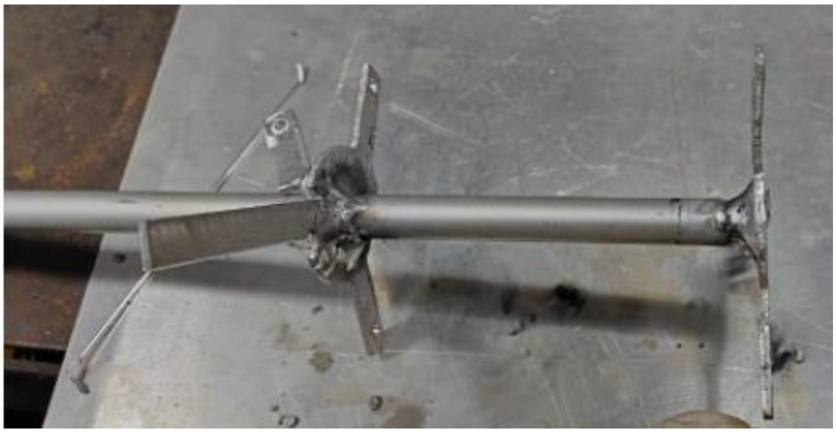

Figure 3.20: Defects that Happened During Using TIG Welding as Joiner

TIG welding is one of the most common methods for welding aluminum parts. After many attempts to utilize TIG welding, a fault in the material caused the hub and shaft to develop a sizeable hole in some areas, and one part of the blade connector was abruptly cut off. Following that, various attempts were made to keep the component from being reworked.

3.5.2.2 Xtraseal Steel Joiner

Figure 3.21: Xtraseal Steel Joiner

However, a rework process is required to remove component faults that will impair the blade's rotation as shown in Figure 3.20. Another approach for dealing with this issue has been to utilize the Xtraseal 4-minute steel gum. This Steel Gum has adequate strength to act as a steel bonding mechanism to replace the TIG Welding which cause defect at the welded parts. Therefore, the failure happened caused extended time to produce the wind turbine as soon as possible to conduct test for the wind turbine model as scheduled.

3.6 Completed Fabrication Product of Model Wind Turbine

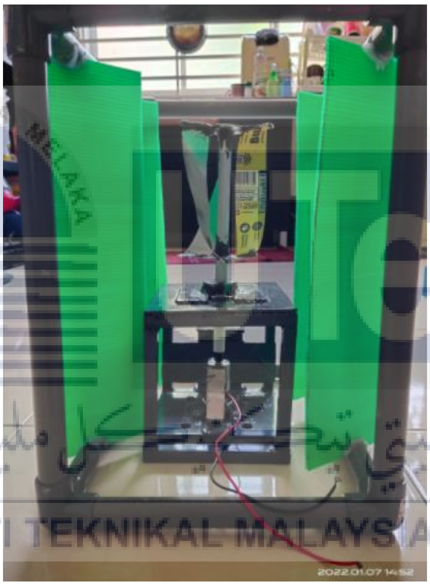

Figure 3.22: Finished Model of Vertical Wind Turbine

Fortunately, after several defects and unplanned errors occur during fabrication and testing procedure, model of wind turbine model with barrier mechanism and three types of vehicles model would be able to be produced. Several errors such as TIG Welding defects, unsuitable weight of material for blade mechanism and unsuitable mechanical parts gives a little bit tough time to produce the model of this vertical wind turbine. Recycle type of thin tin have been used to replace the earlier plan to use aluminum (1mm) as our blade material selection.

3.7 Testing and Experimental Method

Experimental that will be conduct involved several conditions of the wind turbine model. For the basic foundation of this experiment, there is four data conditions of experiment will be carried out from two approaches which is by using model of three vehicles and table fan. The four conditions are helical blade type wind turbine with and without barrier mechanism and curve blade type wind turbine with and without barrier mechanism.

3.7.1 Equipment Use for Testing

Figure 3.23: Multimeter and Anemometer Measurement Equipment

Two basic equipment will be used to measure the output current and voltage from the rotating shaft of model wind turbine and wind speed measurement as shown in Figure 3.23. Multimeter will be connected directly with the motor wire to read the voltage and current output. While, anemometer will be also to measure the wind speed at highways and during initial set-up the experiment.

3.7.2 Collect Wind Measrement At Specified Location

Figure 3.24: Measure the Wind Speed at Highways

Anemometer have been main equipment to measure the wind speed at middle of road highways. Five main locations have been selected to measure the wind energy at four conditions of elevation which is 0.5-meter, 1.0-meter, 1.5-meter and 2.0-meter. The highest value of wind speed will be selected as reference for each elevation.

3.7.3 Conduct Testing for Model of Wind Turbine with Three Modifies Size of Vehicles

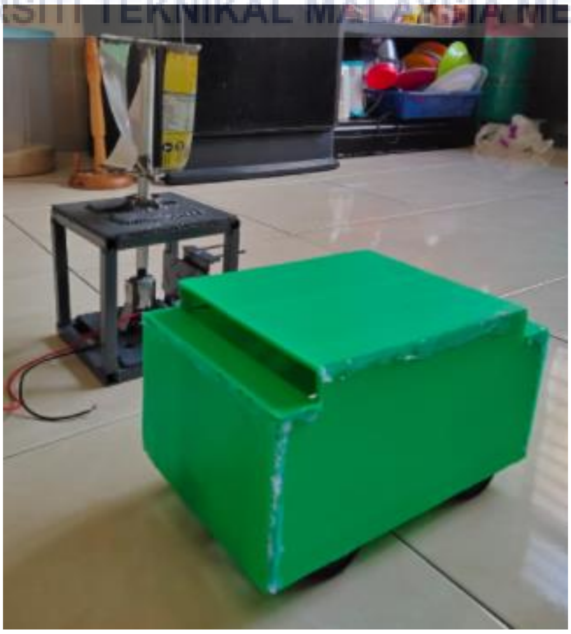

Figure 3.25: Test Running the Three Modified Model of Vehicles

Initial plan for the project is to run three modified vehicles model from RC Car. The modifid parameter vehicles followed the scalling ratio will be move at its maximum speed parallel with the wind turbine model and will make the blade triggered to be rotated. After several attenpt have been done by using all other size of vehicles model which is sedan, MPV and lorry, there is very minimal movement of the wind turbine blade. The reading of anemometer also shows no wind speed value occur when the vehicle passes the anemometer. Therefore, experimental data will only foussed on the second approaches which is conduct measurement of power output by using source wind energy from portable table fan.

3.7.4 Conduct Testing for Model of Wind Turbine with Portable Table Fan

Figure 3.26: Set-up Experiment for Wind Turbine Model with Portable Table Fan

The wind speed should be control according to the reference wind speed that have been selected according to the elevation. The elevation and the wind speed value will be 0.5-meter (3.1 m/s), 1.0-meter (4.4 m/s), 1.5-meter (4.6 m/s), and 2.0-meter (4.2 m/s). After the wind speed value has produce stable value, then 30 seconds interval will start to collect the data voltage and current output. Each reading for each condition will be repeated three-times to get the best value for data. The result of the experiment will be presented in chapter 4.

CHAPTER 4

RESULT AND DISCUSSION

4.0 Introduction

A brief exposition for testing and experiment part will be conducted in this chapter. Several locations and variables will be selected in order to carry out the experimental approach.

4.1 Collect Wind Data Measurement at Specific Selected Location

Table 4.1: Wind Speed Measurement for Four Different of Elevation Height

Selected Location	Elevation from Ground (m)	Wind Speed Measurement (m/s)
1) Bertam Setia, (Lebuh SPA)	0.5	2.6
	1.0	2.2
	1.5	2.8
	2.0	3.5
2) Bertam Putra (Lebuh SPA)	0.5	3.1
	1.0	3.5
	1.5	4.6
	2.0	4.2
3) Bertam Ulu (Lebuh SPA)	0.5	3.1
	1.0	2.6
	1.5	3.3
	2.0	3.0
4) Taman Paya Rumput (Lebuh AMJ)	0.5	2.9
	1.0	3.9
	1.5	3.5
	2.0	3.8
5) Taman Permai, Rembia (Lebuh AMJ)	0.5	2.5
	1.0	4.4
	1.5	3.0
	2.0	2.8

4.2 Calculating the Theoretical Wind Power and Output Power Extracted

The wind energy that produces from the natural movement of air and movement of highway vehicles will contribute for the rotating of the wind turbine. The turbulence of wind speed especially from large vehicle will spike up the speed of the wind energy that will gives more energy when contacted with the wind turbine blade. At the same time, the value of the wind power can be compared with the value of power extracted (output power) from the wind turbine using the equation 2.1 and 2.2 as below;

$$Wind\ Energy = \frac{1}{2}\rho A v^3 \tag{2.1}$$

Amount of power that absorb by wind turbine can be calculated using the equation below:

$$Amount\ of\ Energy\ Extracted = \frac{1}{2}\rho A v^3 \eta C_p \tag{2.2}$$

A) $\rho = Density\ of\ Air = 1.225\,\frac{kg}{m^3}$

B) $v = Velocity\ of\ Wind\ @\ Wind\ Speed\ (\frac{m}{s})$

C) $A = Blade\ Swept\ Area = Diameter\ of\ Rotor\ \times Height\ of\ Rotor$

$= H_r \times D_r = 0.0916\ m \times 0.125\ m$

$= 0.01145\ m^2$

D) *Based on our average value of wind speed measurement, we got it about below 5 m/s of average majority value.* (Ehab Hussein Bani-Hani, 2018) *declare that as a result, the VAWT total efficiency is 34.6 percent for low wind speeds below 5 m/s, which is highly promising. Thus, the overall efficiency for vertical axis wind turbine model is;*

$$\eta C_p = 34.6\% = 0.346$$

Sample of Calculation (v = 3.1 m/s)

1) $Wind\ Power = \frac{1}{2}\rho A v^3$

$= \frac{1}{2}(1.225\frac{kg}{m^3})(0.01145\ m^2)\ (3.1 m/s)^3$

$= 0.209$ W

2) $Power\ Extracted = \frac{1}{2}\rho A v^3 \eta C_p$

$= (0.209\ Watt)(0.346)\ = 0.0723\ W$

Table 4.2: Data of Theoretical Wind Power and Output Power Extracted

No.	Elevation (m)	Wind Speed	Wind Power (W)	Power Extracted (W)
1	*0.5*	*3.1 m/s*	0.209	0.0723
2	*1.0*	*4.4 m/s*	0.652	0.2256
3	*1.5*	*4.6 m/s*	0.745	0.2578
4	*2.0*	*4.2 m/s*	0.567	0.1962

From Table 4.2 shows the calculated theoretical value for wind energy produce from moving vehicles and natural wind at highways. The highest value for the wind power is at elevation of placement anemometer at 1.5 m from ground and wind speed of 4.6 m/s which is 0.745 W. While the lowest wind power produce is 0.209 W at elevation of 0.5 m from ground with wind speed of 3.1 m/s. Besides that, the highest and lowest power extracted from the wind turbine is 0.2578 W and 0.0723 W. The graphical pattern difference between theoretical wind power and power extracted by vertical axis wind turbine can be seen in Figure 4.1.

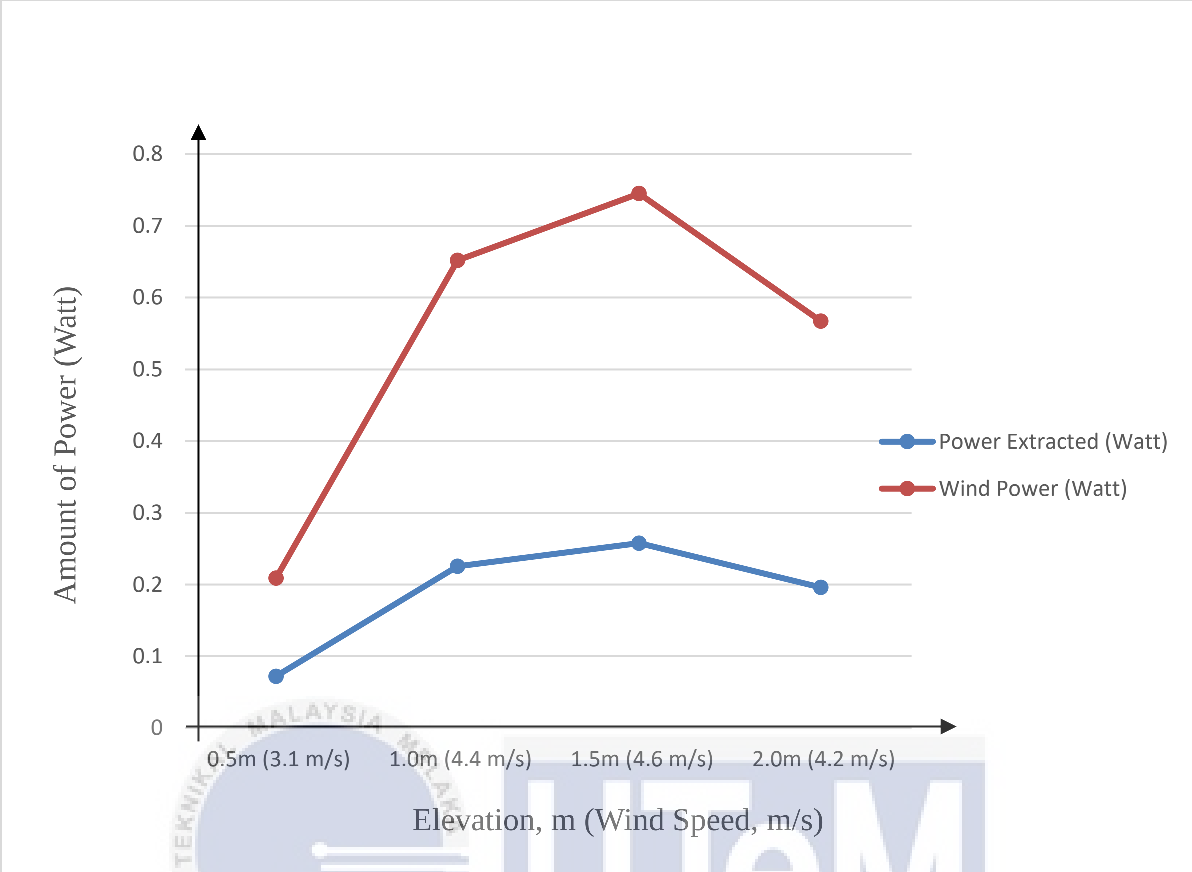

Figure 4.1: Graph Analysis Comparison for Theoretical Wind Power Generated and Power Extracted from the Wind Turbine

4.3 Experimental Data of Power Output Wind Turbine with Portable Table Fan

The calculations for power output/power produced from the wind turbine can be used the normal equation of power as below;

<u>Sample Calculation (For Helical Blade Type Without Barrier Mechanism)</u>

V = 3.1 m/s, Voltage = 0.65 V, Current = 21 mA

1) $Power\ Produced = Amount\ of\ Current\ generated\ \times Voltage\ produced$

$$P = I \times V$$

$$P = (21\ mA) \times (0.65\ V)$$

$$= 0.0137\ W$$

2) Percentage Wind retrieved from Wind Power

$$Percentage\ Retrieved = \frac{Output\ Power}{Wind\ Power} \times 100\%$$

$$= \frac{0.0137\ Watt}{0.209\ Watt} \times 100\%$$

$$= 6.56\ \%$$

3) Percentage Difference of Power Output Between Theoretical and Experimental Value

$$Percentage\ Difference = \frac{Output\ Power}{Power\ Extracted} \times 100\%$$

$$= \frac{0.0137\ Watt}{0.0723\ Watt} \times 100\%$$

$$= 18.95\ \%$$

4.3.1 Condition 1: Helical Type of Blade Without Barrier Mechanism

Table 4.3: Experimental Data for Helical Blade Type Without Barrier Mechanism

Wind Data Measurement for Helical Type of Blade							
No	*Wind Speed*	*Voltage Output (V)*	*Current Output (mA)*	*Highest Value*	*Output Power (W)*	*Percentage Retrieved (%)*	*Percentage Difference (%)*
1	**3.1 m/s (0.5m)**	0.60	20	0.65 V / 21 mA	0.0137	6.56	18.95
		0.65	21				
		0.60	20				
2	**4.4 m/s (1.0m)**	0.85	34	0.85 V / 34 mA	0.0289	4.43	12.81
		0.80	32				
		0.80	33				
3	**4.6 m/s (1.5 m)**	0.95	37	1.00 V / 39 mA	0.0390	5.23	15.12
		1.00	39				
		1.00	38				
4	**4.2 m/s (2.0 m)**	0.75	30	0.75 V / 30 mA	0.0225	3.97	11.47
		0.75	30				
		0.70	28				

Result from Table 4.3 shows the first condition helical blade of vertical wind turbine model without barrier mechanism experimental value of voltage and current output collected at four different various of wind speed. The highest voltage and current output are at wind speed of 4.6 m/s which is 1.0 V and 39 mA. While the lowest value that collected is 0.65 V and 21 mA at 3.1 m/s wind speed. Also, the highest and lower output power that have been collected is 0.039 W and 0.0137 W. From percentage retrieved of wind from the theoretical wind energy of moving vehicles, wind speed of 3.1 m/s gained the highest retrieved percentage which is 6.56 % followed by 5.23% by wind speed at 4.6 m/s. The value of percentage difference between experimental power output and theoretical power extracted from wind turbine can also been seen in Table 4 which shows wind speed of 4.2 m/s received smallest percentage difference among other wind speed which is 11.47% percentage difference from the calculated theoretical power extracted from wind turbine.

4.3.2 Condition 2: <u>Curve Type of Blade Without Barrier Mechanism</u>

Table 4.4: Experimental Data for Curve Blade Type Without Barrier Mechanism

Wind Data Measurement for Curve Type of Blade							
No	*Wind Speed*	*Voltage Output (V)*	*Current Output (mA)*	*Highest Value*	*Output Power (W)*	*Percentage Retrieved (%)*	*Percentage Difference (%)*
1	**3.1 m/s (0.5m)**	0.7	31	0.78 V / 33 mA	0.0257	12.30	35.55
		0.75	32				
		0.78	33				
2	**4.4 m/s (1.0m)**	1.00	40	1.00 V / 40 mA	0.0400	6.13	17.73
		0.90	38				
		0.95	40				
3	**4.6 m/s (1.5 m)**	1.00	40	1.08 V / 46 mA	0.0497	6.67	19.28
		1.05	45				
		1.08	46				
4	**4.2 m/s (2.0 m)**	0.90	38	0.90 V / 38 mA	0.0342	6.03	17.43
		0.85	37				
		0.85	38				

Result from Table 4.4 shows the second condition curve blade of vertical wind turbine model without barrier mechanism experimental value of voltage and current output collected at four different various of wind speed. The highest voltage and current output are at wind speed of 4.6 m/s which is 1.08 V and 46 mA. While the lowest value that collected is 0.78 V and 33 mA at 3.1 m/s wind speed. Also, the highest and lower output power that have been collected is 0.0497 W and 0.0257 W. From percentage retrieved of wind from the theoretical wind energy of moving vehicles, wind speed of 3.1 m/s gained the highest retrieved percentage which is 12.3% followed by 6.67% by wind speed at 4.6 m/s. The value of percentage difference between experimental power output and theoretical power extracted from wind turbine can also been seen in Table 5 which shows wind speed of 4.2 m/s received smallest percentage difference among other wind speed which is 17.43% percentage difference from the calculated theoretical power extracted from wind turbine.

4.3.3 Condition 3: <u>Helical Type of Blade with Barrier Mechanism</u>

Table 4.5: Experimental Data for Helical Blade Type with Barrier Mechanism

Wind Data Measurement for Helical Type of Blade							
No	*Wind Speed*	*Voltage Output (V)*	*Current Output (mA)*	*Highest Value*	*Output Power (W)*	*Percentage Retrieved (%)*	*Percentage Difference (%)*
1	**3.1 m/s (0.5m)**	0.60	19	0.65 V / 21 mA	0.0137	6.56	18.95
		0.65	21				
		0.65	21				
2	**4.2 m/s (2.0m)**	0.70	24	0.78 V / 29 mA	0.0226	3.99	11.52
		0.78	29				
		0.70	25				

Table 4.5 reveals the results for third condition which is helical blade type of vertical wind turbine model with barrier mechanism. For experiment of wind turbine with barrier mechanism, only two consecutive values of speed can be controlled due to unstable wind supply by portable table fan which is at 3.1 m/s and 4.2 m/s. The results indicates that at wind speed of 4.2 m/s achieved its highest voltage and current output at 0.78 V and 29 mA with output power of 0.0226 W. While, results for wind speed 3.1 m/s demonstrates achieved its highest voltage and current output at 0.65 V and 21 mA with output power of 0.0137 W. Besides that, Table 6 also shows the percentage retrieved of wind energy from highways which is at wind speed 3.1 m/s retrieved about 6.56% wind power, while wind speed at 4.2 m/s extracted only 3.99% of energy from wind power. In addition, there is percentage difference between experimental output power and theoretical power extracted by wind turbine. It`s can be seen that wind speed at 4.2 m/s gained low percentage difference which is 11.52% than win speed at 3.1 m/s which have value of 18.95% percentage difference.

4.3.4 Condition 4: <u>Curve Type of Blade with Barrier Mechanism</u>

Table 4.6: Experimental Data for Curve Blade Type with Barrier Mechanism

Wind Data Measurement for Curve Type of Blade							
No	*Wind Speed*	*Voltage Output (V)*	*Current Output (mA)*	*Highest Value*	*Output Power (W)*	*Percentage Retrieved (%)*	*Percentage Difference (%)*
1	**3.1 m/s (0.5m)**	0.66	23	0.66 V / 23 mA	0.0152	7.27	21.02
		0.62	20				
		0.65	22				
2	**4.2 m/s (2.0m)**	0.75	30	0.75 V / 30 mA	0.0225	3.97	11.47
		0.70	27				
		0.70	27				

Apart from that, Table 4.6 demonstrates the results for third condition which is curve blade type of vertical wind turbine model with barrier mechanism. The results indicates that at wind speed of 4.2 m/s achieved its highest voltage and current output at 0.75 V and 30 mA with output power of 0.0225 W. While, calculated data for wind speed 3.1 m/s demonstrates achieved its highest voltage and current output at 0.66 V and 23 mA with output power of 0.0152 W. Furthermore, Table 7 also shows the percentage retrieved of wind energy from highways which is at wind speed 3.1 m/s retrieved about 7.27% wind power, while wind speed at 4.2 m/s extracted only 3.97% of energy from wind power. In addition, there is percentage difference between experimental output power and theoretical power extracted by wind turbine. It's can be seen that wind speed at 4.2 m/s gained low percentage difference which is 11.47% than win speed at 3.1 m/s which have value of 21.02% percentage difference.

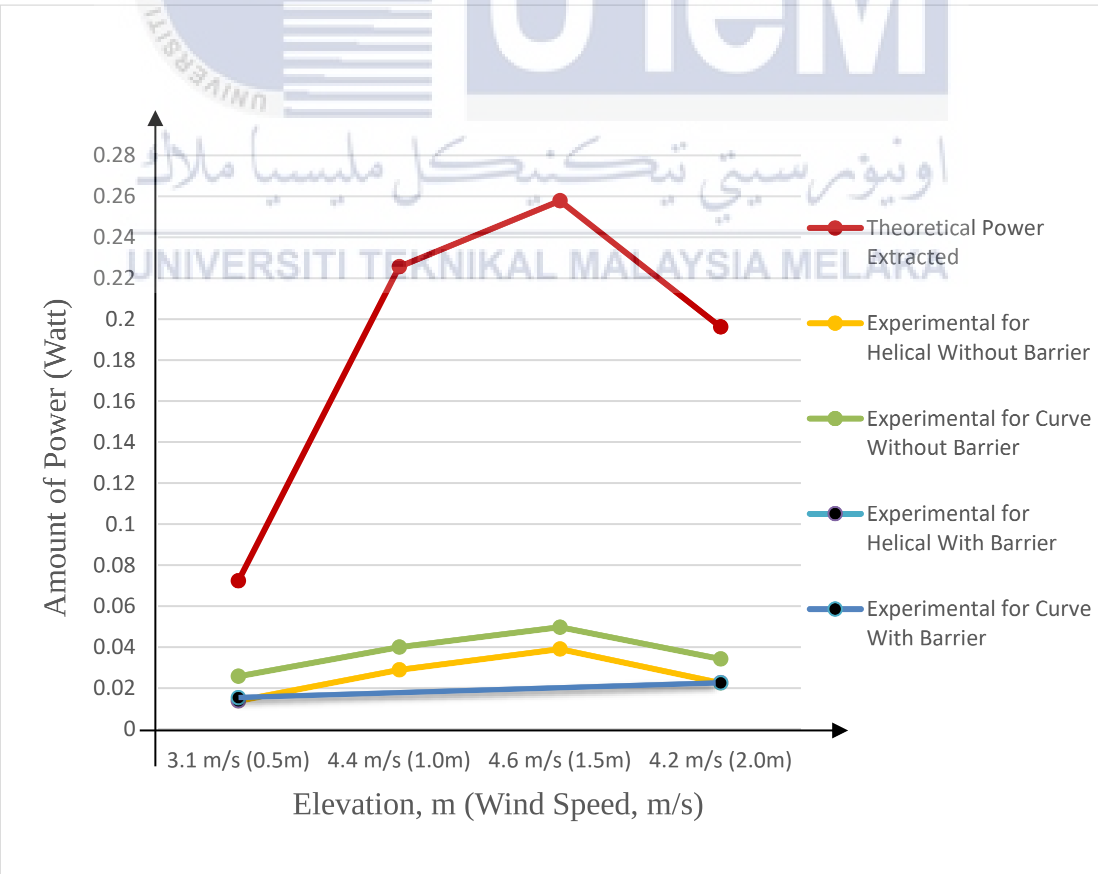

Figure 4.2: Graph Analysis Comparison for Theoretical and Experimental Power Output of Wind Turbine Model

The results and statistics of power output from the rotation of the wind turbine have been revealed as a result of the experiment. In this experiment, the output power produced when some of the wind energy hits the turbine blade causes it to rotate clockwise. The shaft's mechanical energy is subsequently transformed to electrical energy. After that, plug the multimeter to the motor to see the values for voltage and current output. It can plainly be seen that when the vertical axis wind turbine model's blade rotates faster, it produces higher voltage and current output. The data findings for four conditions of wind turbine blades with different approaches employing a barrier mechanism are shown in the experiment. The pattern between theoretical and experimental output power produced can be noticed in the graphical analysis Figure 4.2. The theoretical power extracted pattern line will serve as the comparison's reference/baseline. The pattern for helical and curve blades of vertical axis wind turbines without barrier mechanisms is almost identical, however the output power value differs slightly. The output power for each helical and curve type blade should be compared as the data value. According to most prior studies, helical blade wind turbines are more efficient at extracting more power from turbulent wind energy (Manikanda Gokul A1, 2019).

The findings show that the results are the polar opposite of what the majority of past research has claimed. This is because there may be a tiny design flaw in this helical blade type that causes it to produce less power than a curve blade type at the same constant wind speed. Without a barrier mechanism, the highest output power for a helical blade type wind turbine model is 0.0390 W at 4.6 m/s. The highest curve blade type wind turbine model can also be concluded at 4.6 m/s wind speed without barrier mechanism, which is 0.0497 W. At a wind speed of 3.1 m/s, the curve blade wind turbine model without a barrier mechanism extracted the largest percentage of wind energy (12.30%) from other states/conditions.

Furthermore, employing helical blade kinds of wind turbine models, the greatest amount of output power measured in this experiment is around 0.0497 W. The output power may be low because the motor used has a low current permeability, which influences the amount of voltage produced. Even if the output voltage is high, but the current output is low, the extracted output power will be immediately resisted from gaining a high value. Furthermore, a barrier mechanism should be in place to maximize the turbulent wind energy directed to the wind turbine model's blade. However, because to the inconsistency of wind speed, there may be a small loss of wind energy when it strikes the barrier mechanism.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Wind energy is one of the future renewable energies that can be implemented to be use in order to save the environment for future generations. The turbulence of wind power at highways has many benefits especially in terms of power source that can be used it for lighting system alongside the highways. Experimental approaches have been done to see whether it is suitable to place the vertical axis wind turbine in Malaysia highways. Measurement of wind speed by using anemometer reveals that the maximum wind energy that can be captured in the middle of roadways is about 4.6 m/s which quite promising when it is at elevation of 1.5 m from ground. It also can be seen that the large vehicles such as lorry and MPV gives quite giving impact to produce large wind energy plus with the natural wind itself. Earlier objectives for the experimental method were to run the three types of model vehicles parallel with the wind turbine model. The three-body size of vehicles that have been prepared is Sedan, MPV and Lorry which have been scaling down from the reference existing actual vehicles.

However, when conduct the testing of the vehicles model with the wind turbine model, it can be clearly seen that there is no readings of wind speed anemometer and the blade of the wind turbine model itself were not moving. Therefore, for these approaches, it can be concluding that it is not suitable as the source of wind speed itself doesn`t enough to strikes well the blade to make its moving to produce reading of output power. Plus, the condition of the wind also needs to be triggered by large speed of vehicles with maximum speed in order to produce big amount of turbulence wind energy in surroundings.

Meanwhile, experimental data have focused on second approached which is by conduct testing of wind turbine model with portable table fan. The highest readings of wind that collected at highways with four different elevations have been used as wind speed reference speed. Results shows that curve blade type wind turbine model produce significant high output power of 0.0497 W than other elevation and other type of blade. Apart from that, the highest value of output power for helical blade type of wind turbine not too far which is 0.039 W. Both highest value of output power is in condition of without using the barrier mechanism that acted as wind directed mechanism.

In line with that, the objective of the project has been achieved. The model of vertical axis wind turbine model with two different shapes of blade have been well design and build within the timeline. Also, the model of three types of vehicles model were not to forget to be modified using the reference guided in drafting. Plus, experimental testing also was conduct successfully follow the two approaches that have been planned early.

5.2 Recommendation

There is no regret by doing the experiment at all. There is some good new knowledge in renewable energy would be understand. However, for future research, several improvements have to be mad in order to have an accurate and precise data result. As the study of this project is focusing on model of wind turbine model, the suggestions of material selection for blade should be using 3D Printing material which is lighter and more efficient on movement of model wind turbine. 3D Printing would produce less resistance and produce accurate readings of power output in terms of model analysis.

Next, the mechanical parts also need to be improved. The suitable motor needs to have a high voltage and current produce in order to produce good readings of power output. Besides that, mechanical driven unit should be implemented in order to increase the power produce. The mechanical components such as gears and belts can be used to increase the output power with the help of the driver and driven unit. Step-up transformer would be beneficial also in terms of increasing output power in order to light up the streets lighting.

The suitability of using this vertical axis wind turbine for powering Malaysia highways is significantly good in terms of using new renewable source. More research and analysis need to be made in order to use this technology as average wind speed recorded in Malaysia highways is only about 5 m/s. Three - helical blade type of wind turbine should be more efficient to extract more wind energy that other existing type of blade. As an end, the areas remaining on Malaysia's middle highways were not large enough to accommodate a larger vertical axis wind turbine. Because the spaces in the middle of the roadways are not very wide, other designs, such as a hanging type of wind turbine, should be developed for future research.

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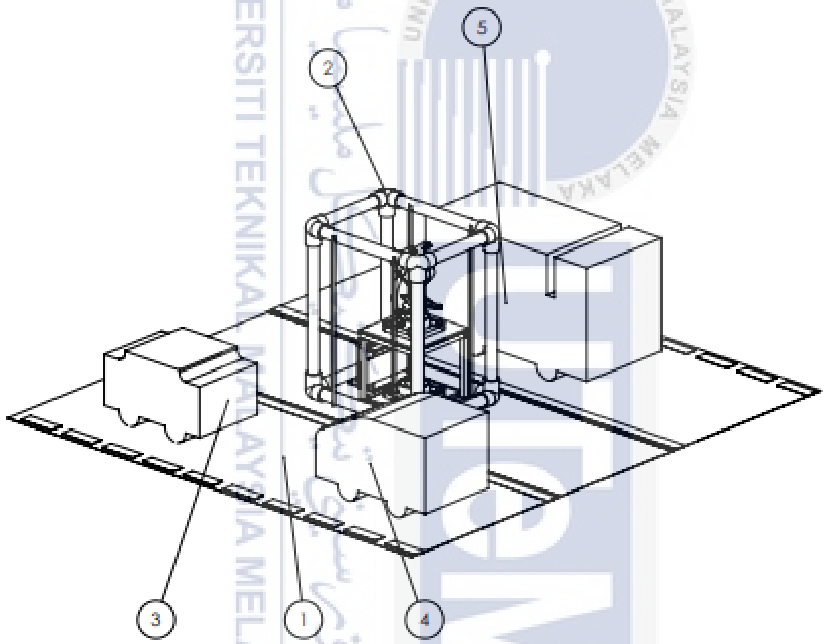
APPENDICES

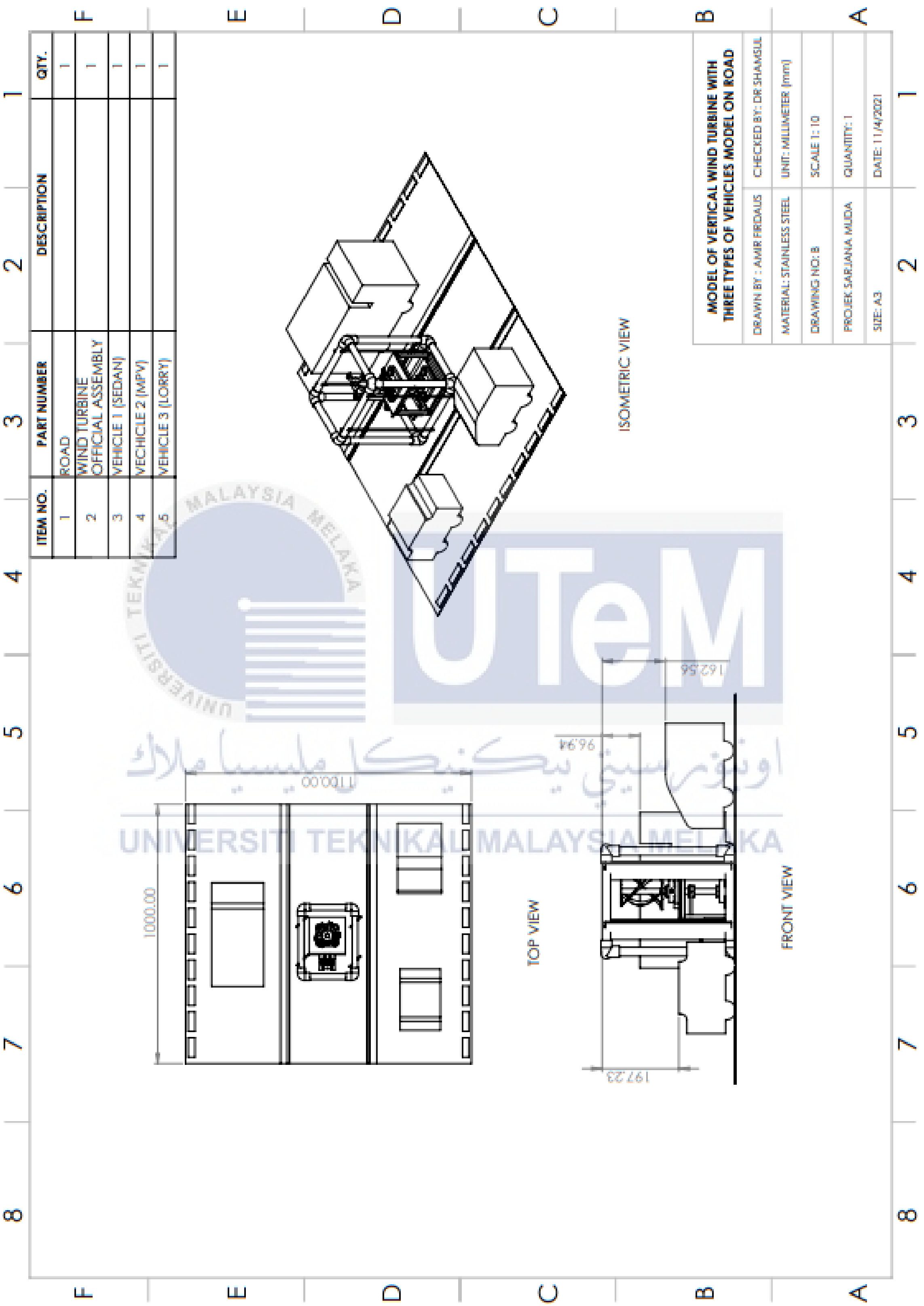
APPENDIX A-1
DETAIL DESIGN
(25 Drawing)

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	ROAD		1
2	WIND TURBINE OFFICIAL ASSEMBLY		1
3	VEHICLE 1 (SEDAN)		1
4	VECHICLE 2 (MPV)		1
5	VEHICLE 3 (LORRY)		1



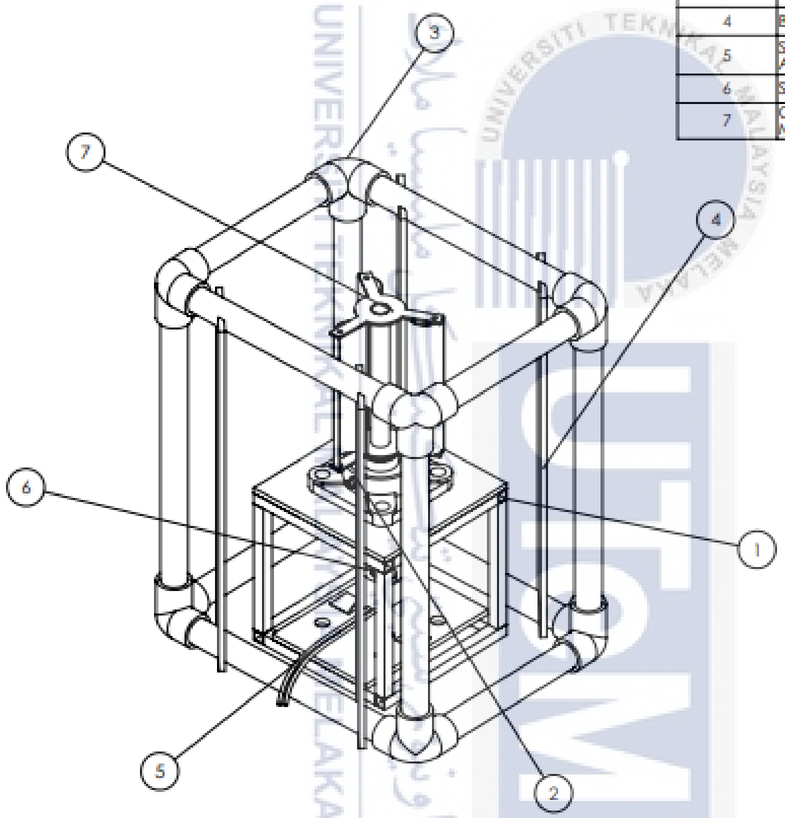
ISOMETRIC VIEW

MODEL OF VERTICAL WIND TURBINE WITH THREE TYPES OF VERTICAL MODEL ON ROAD	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL	UNIT: MILLIMETER (mm)
DRAWING NO: A	SCALE 1: 7
PROJEK SARJANA MUDA	QUANTITY: 1
SIZE: A3	DATE: 11/4/2021



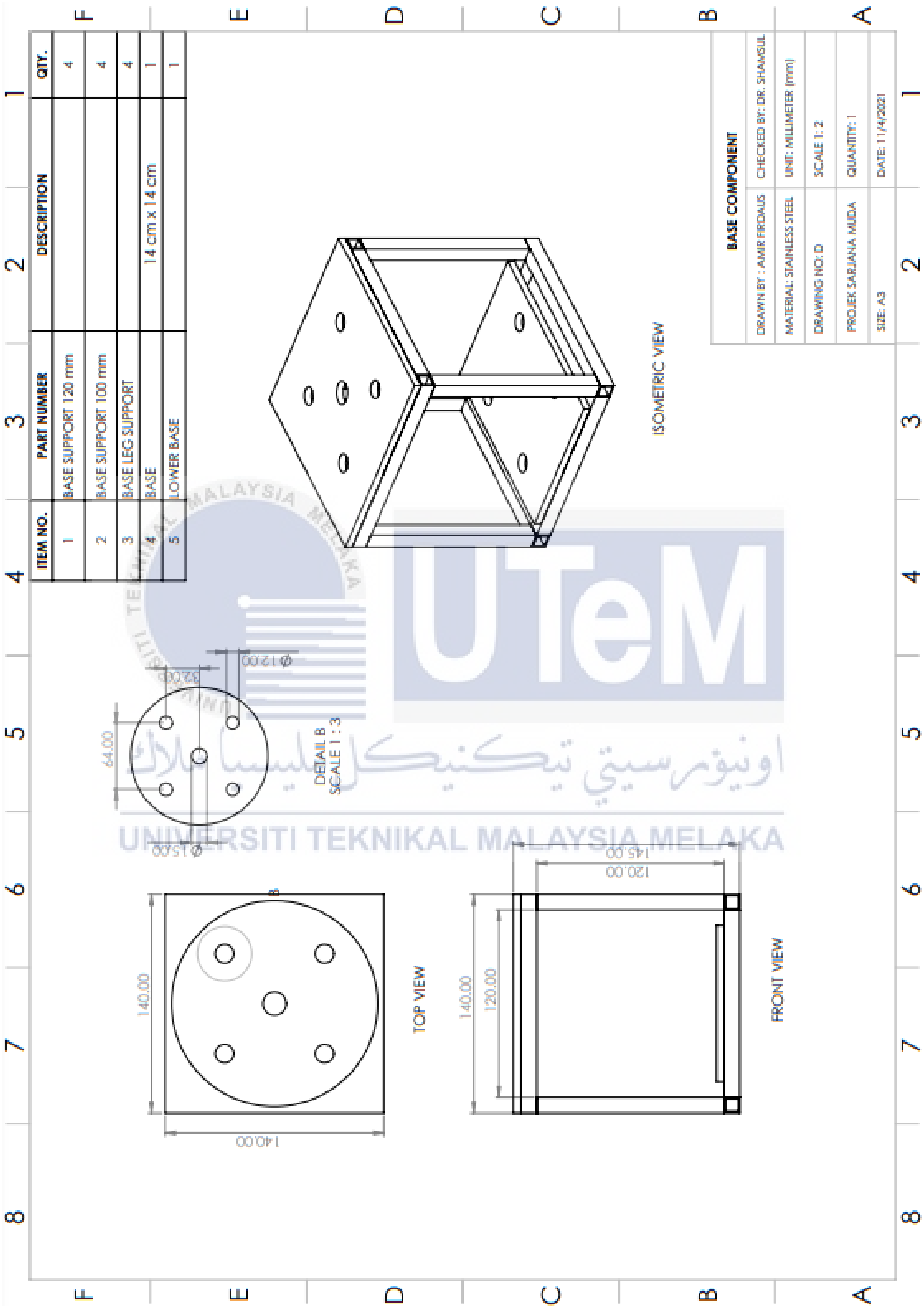
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	ROAD		1
2	WIND TURBINE OFFICIAL ASSEMBLY		1
3	VEHICLE 1 (SEDAN)		1
4	VECHICLE 2 (MPV)		1
5	VEHICLE 3 (LORRY)		1

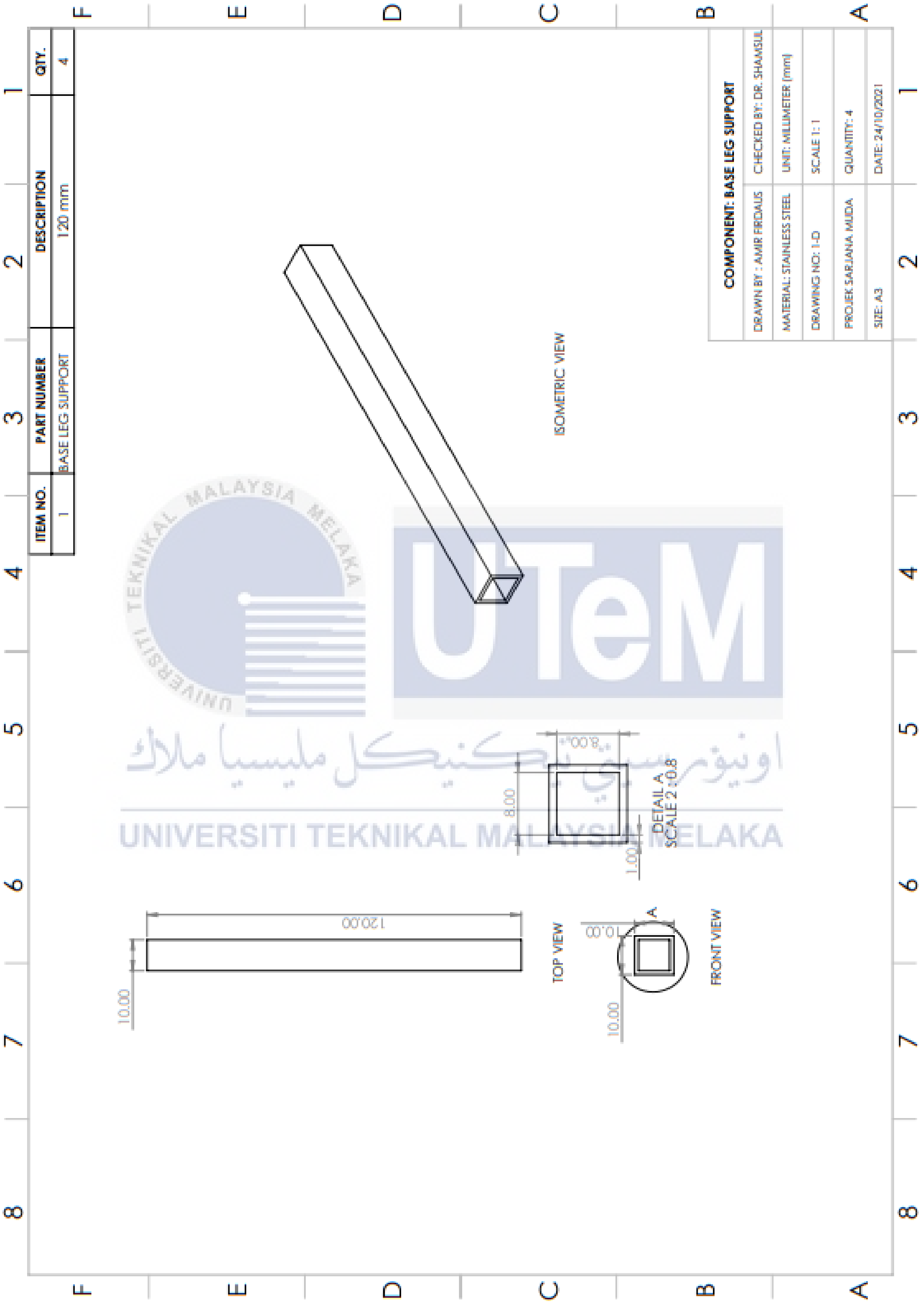
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BASE ASSEMBLY		1
2	UCF202		1
3	BARRIER ASSEMBLY		1
4	BARRIER		4
5	SMALL MOTOR ASSEMBLY		1
6	SMALL MOTOR SHAFT		1
7	CURVE BLADE MECHANISM		1

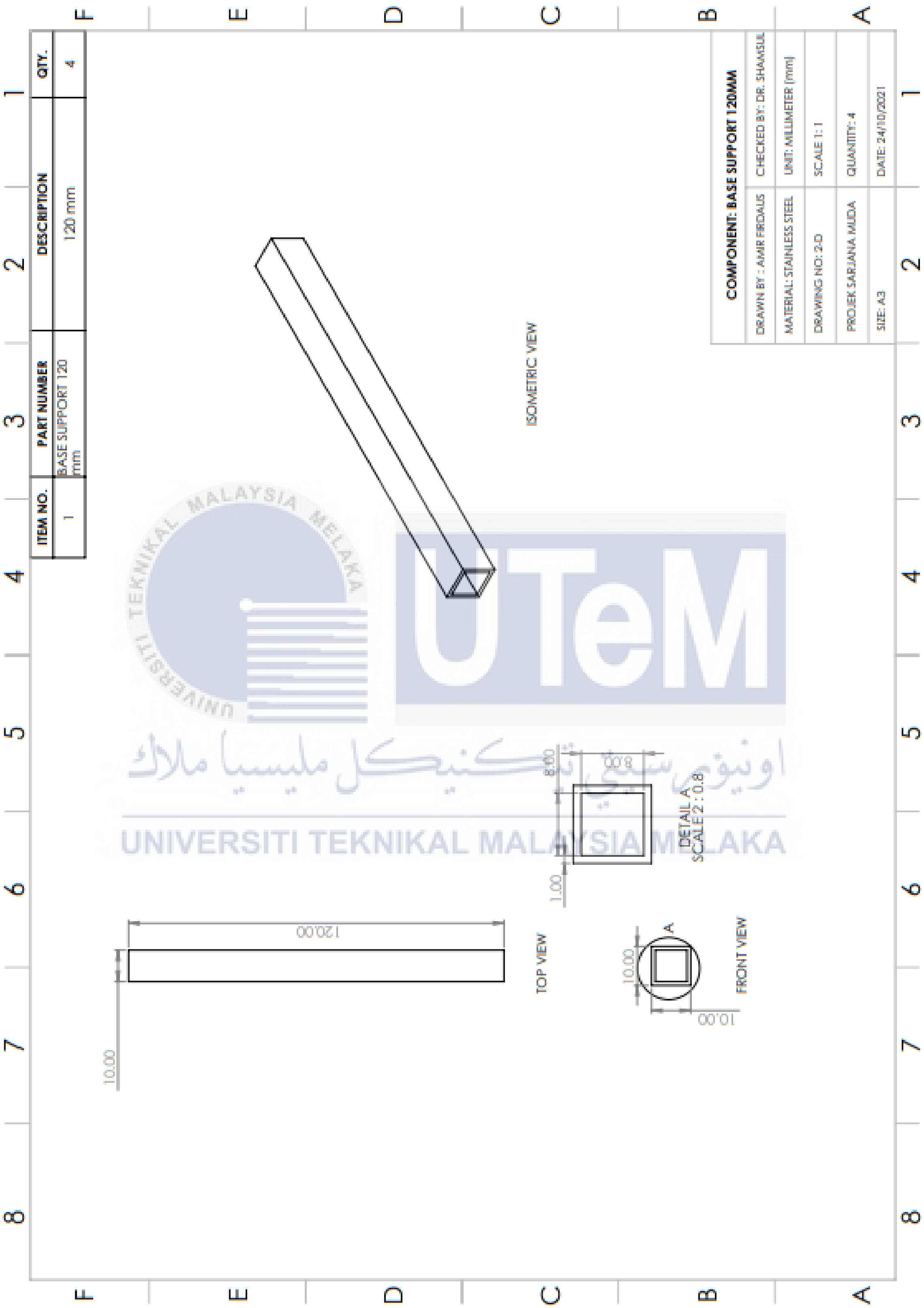


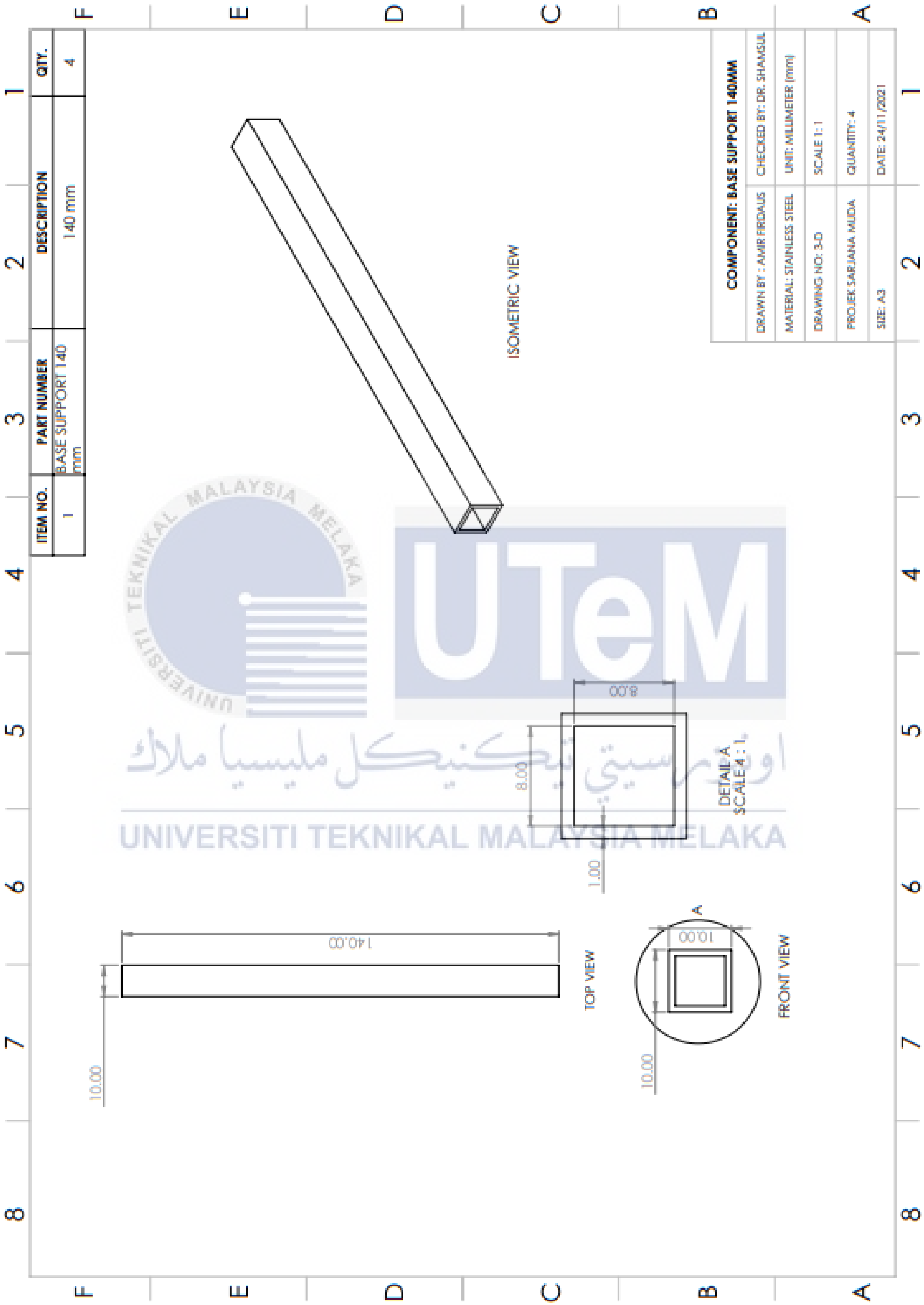
ISOMETRIC VIEW

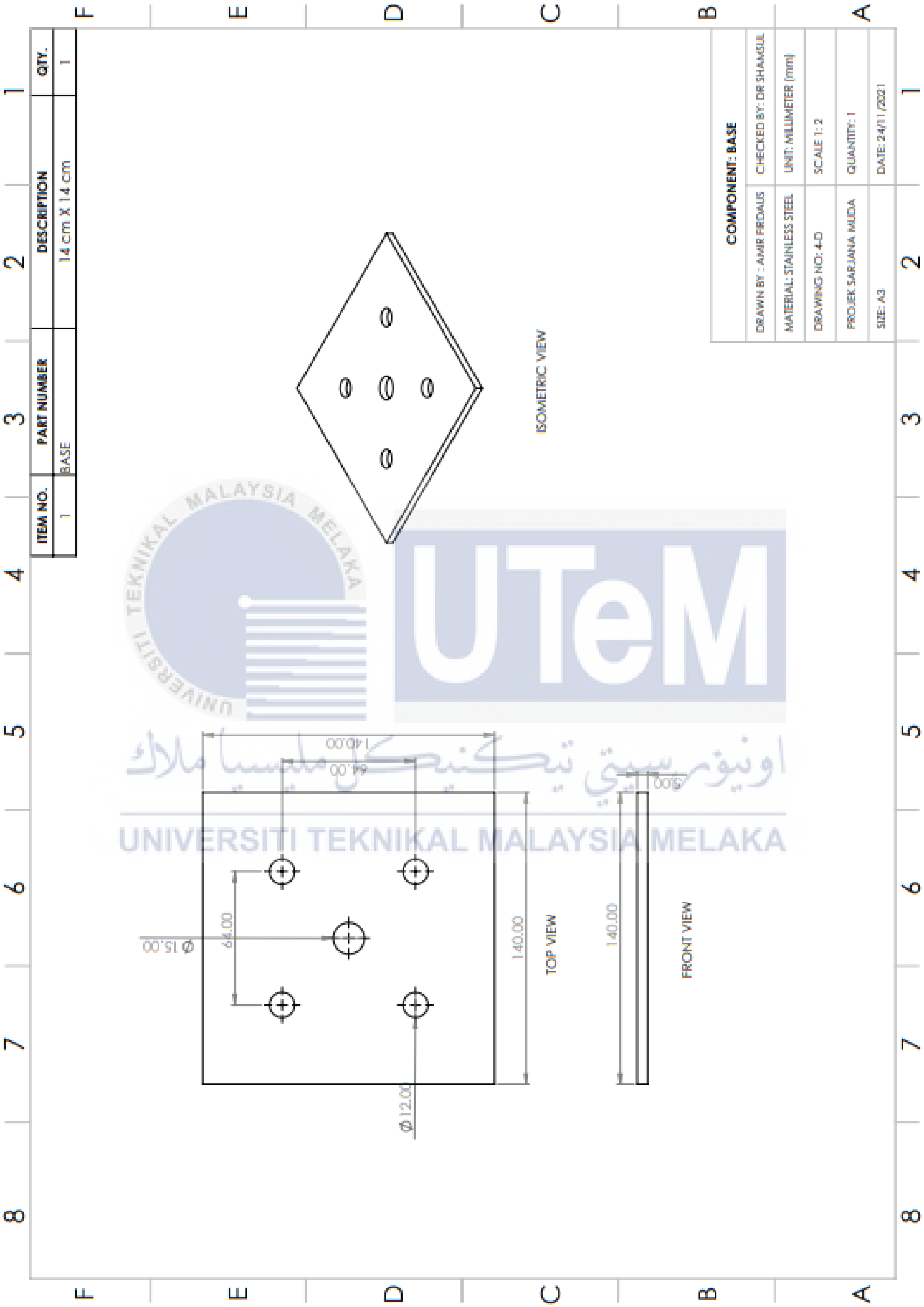
MODEL OF VERTICAL WIND TURBINE WITH BARRIER MECHANISM	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL	UNIT: MILLIMETER (mm)
DRAWING NO: C	SCALE 1: 3
PROJEK SARJANA MUDA	QUANTITY: 1
SIZE: A3	DATE: 08/1/2022


ITEM NO. | PART NUMBER | DESCRIPTION | QTY.
1 | BASE SUPPORT 120 mm | | 4
2 | BASE SUPPORT 100 mm | | 4
3 | BASE LEG SUPPORT | | 4
4 | BASE | 14 cm x 14 cm | 1
5 | LOWER BASE | | 1
ISOMETRIC VIEW
BASE COMPONENT
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: D
SCALE 1: 2
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 11/4/2021
Ø12.00
32.00
64.00
Ø15.00
DETAIL B
SCALE 1 : 3
145.00
120.00
140.00
120.00
140.00
140.00
TOP VIEW
FRONT VIEW

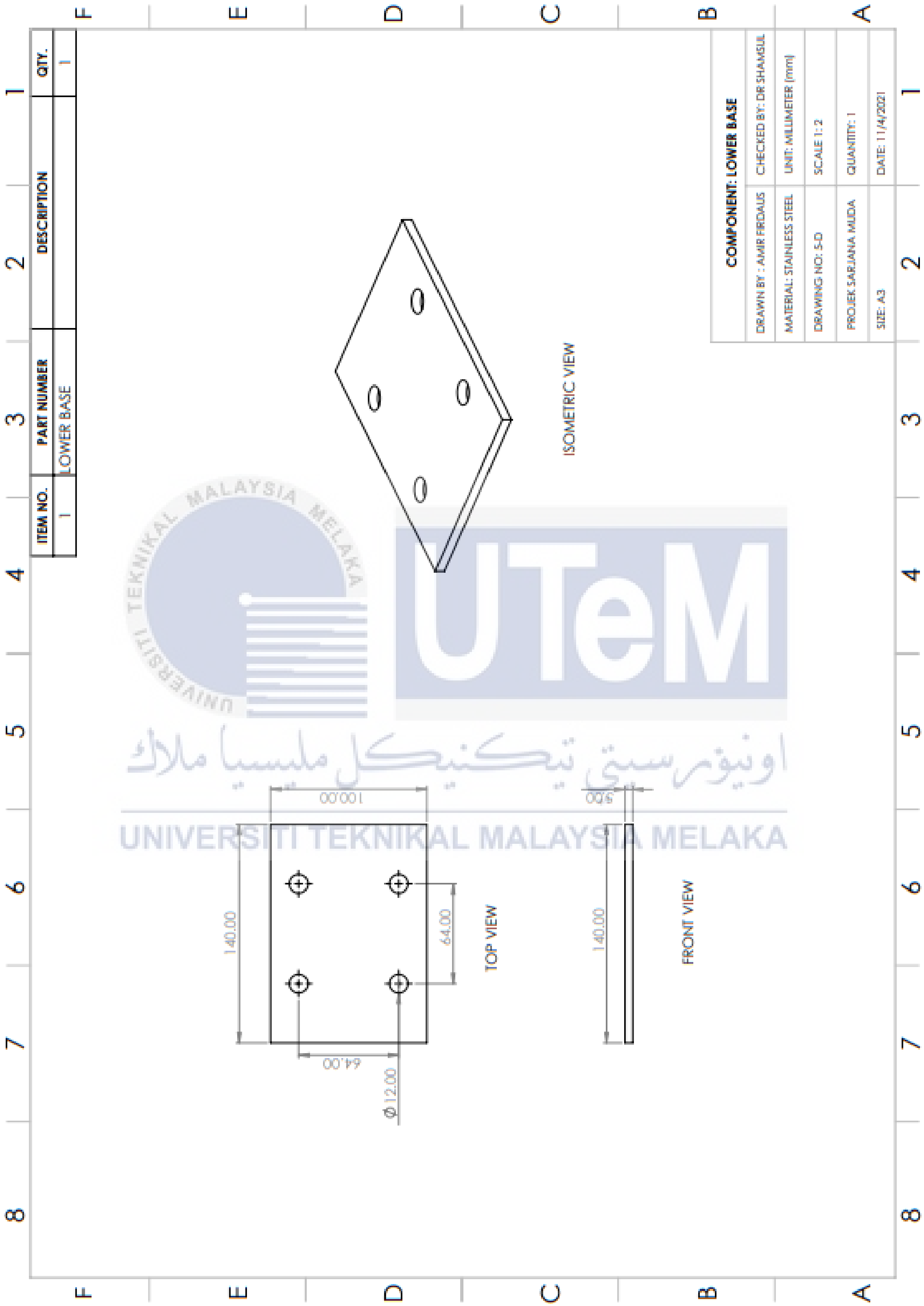

ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BASE LEG SUPPORT
120 mm
4
ISOMETRIC VIEW
TOP VIEW
FRONT VIEW
DETAIL A
SCALE 2 : 0.8
120.00
10.00
8.00
1.00
A
COMPONENT: BASE LEG SUPPORT
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: 1-D
SCALE 1: 1
PROJEK SARJANA MUDA
QUANTITY: 4
SIZE: A3
DATE: 24/10/2021


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BASE SUPPORT 120 mm
120 mm
4
ISOMETRIC VIEW
TOP VIEW
FRONT VIEW
DETAIL A
SCALE 2 : 0.8
120.00
10.00
8.00
1.00
A
COMPONENT: BASE SUPPORT 120MM
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: 2-D
SCALE 1: 1
PROJEK SARJANA MUDA
QUANTITY: 4
SIZE: A3
DATE: 24/10/2021


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BASE SUPPORT 140 mm
140 mm
4
ISOMETRIC VIEW
COMPONENT: BASE SUPPORT 140MM
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: 3-D
SCALE 1:1
PROJEK SARJANA MUDA
QUANTITY: 4
SIZE: A3
DATE: 24/11/2021
8.00
8.00
1.00
DETAIL A
SCALE 4 : 1
140.00
10.00
TOP VIEW
10.00
10.00
A
FRONT VIEW

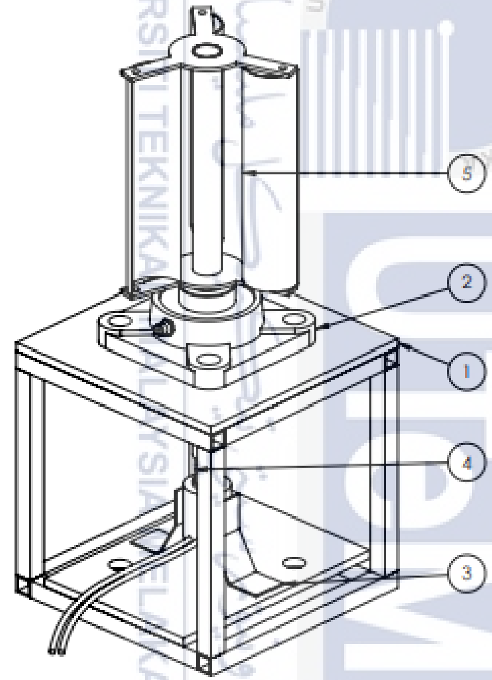


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BASE
14 cm X 14 cm
1
ISOMETRIC VIEW
TOP VIEW
FRONT VIEW
140.00
64.00
Ø 15.00
Ø 12.00
5.00
COMPONENT: BASE
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: 4-D
SCALE 1 : 2
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 24/11/2021



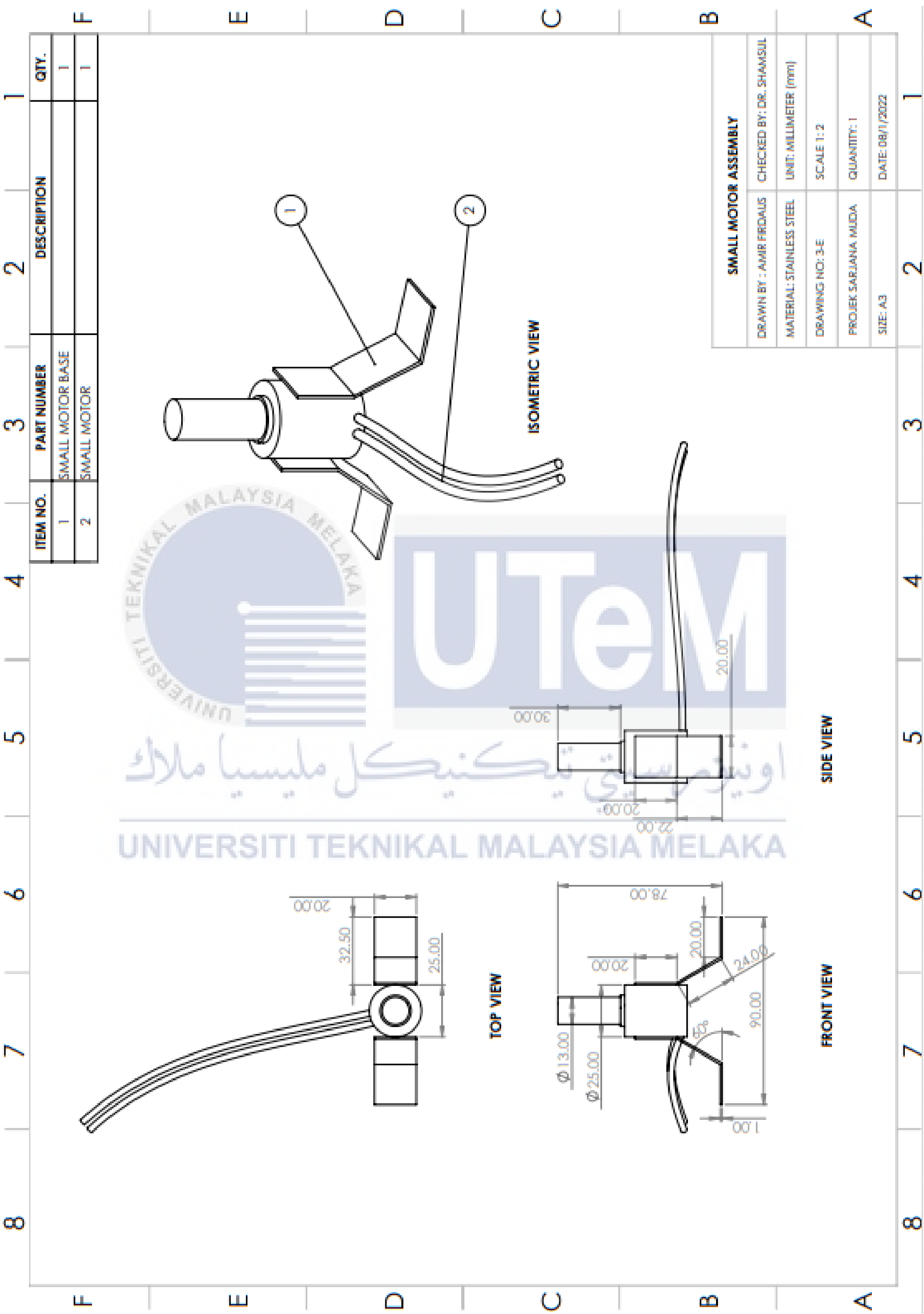
ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
LOWER BASE
1
ISOMETRIC VIEW
TOP VIEW
FRONT VIEW
100.00
140.00
64.00
64.00
Ø12.00
9.00
140.00
COMPONENT: LOWER BASE
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: 5-D
SCALE 1: 2
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 11/4/2021

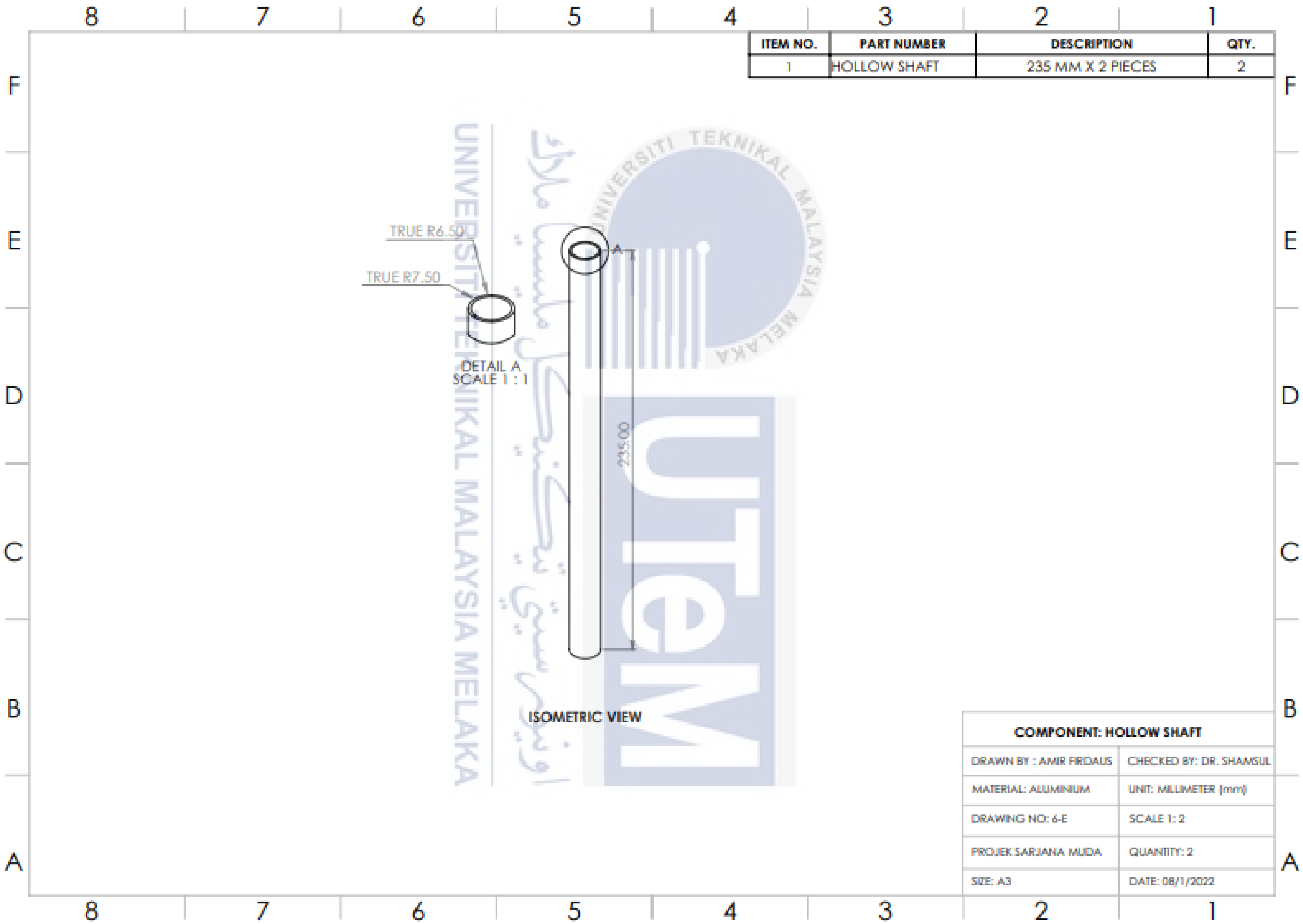
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BASE ASSEMBLY		1
2	UCF202		1
3	SMALL MOTOR ASSEMBLY		1
4	SMALL MOTOR SHAFT		1
5	CURVE BLADE MECHANISM		1

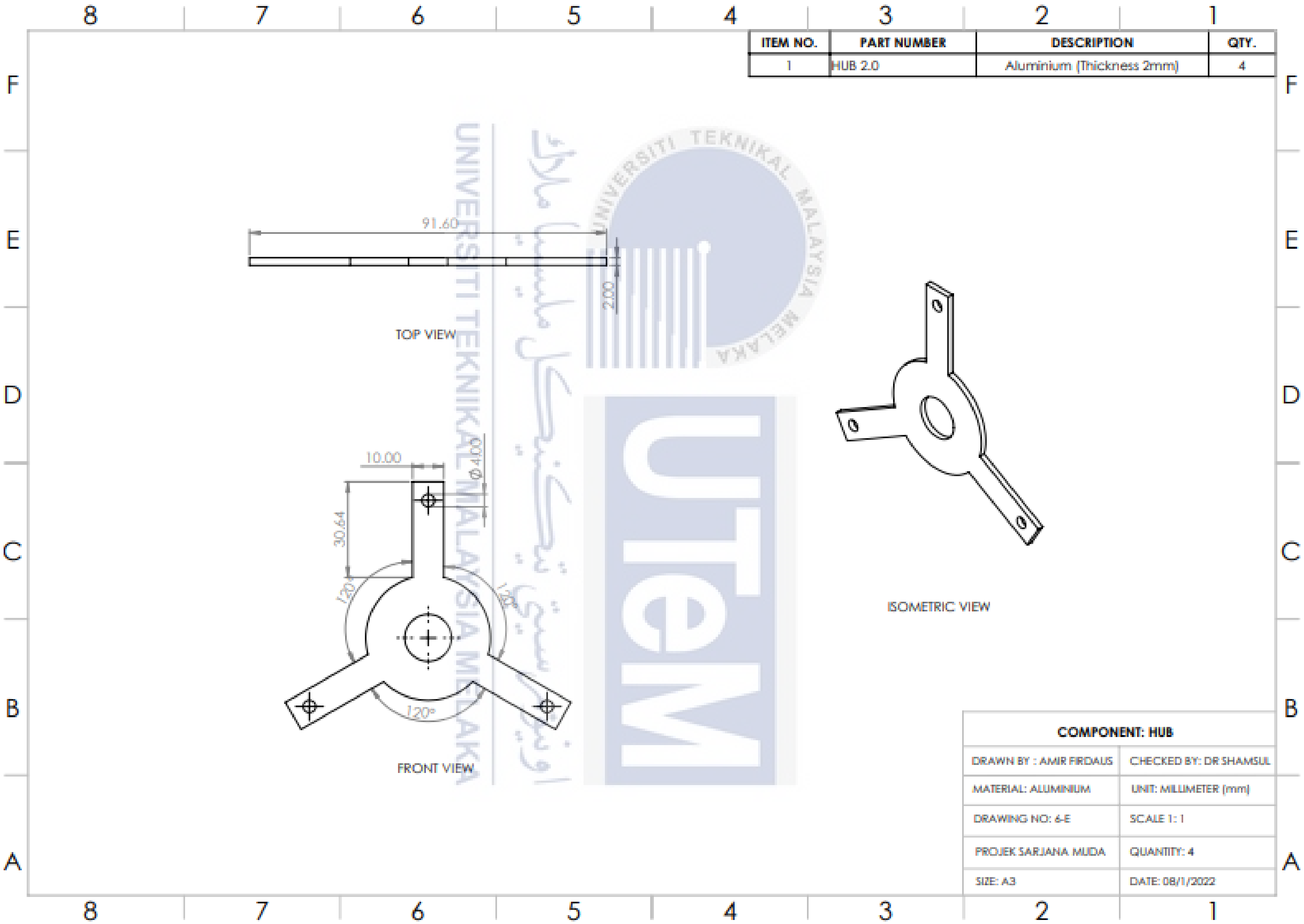


ISOMETRIC VIEW

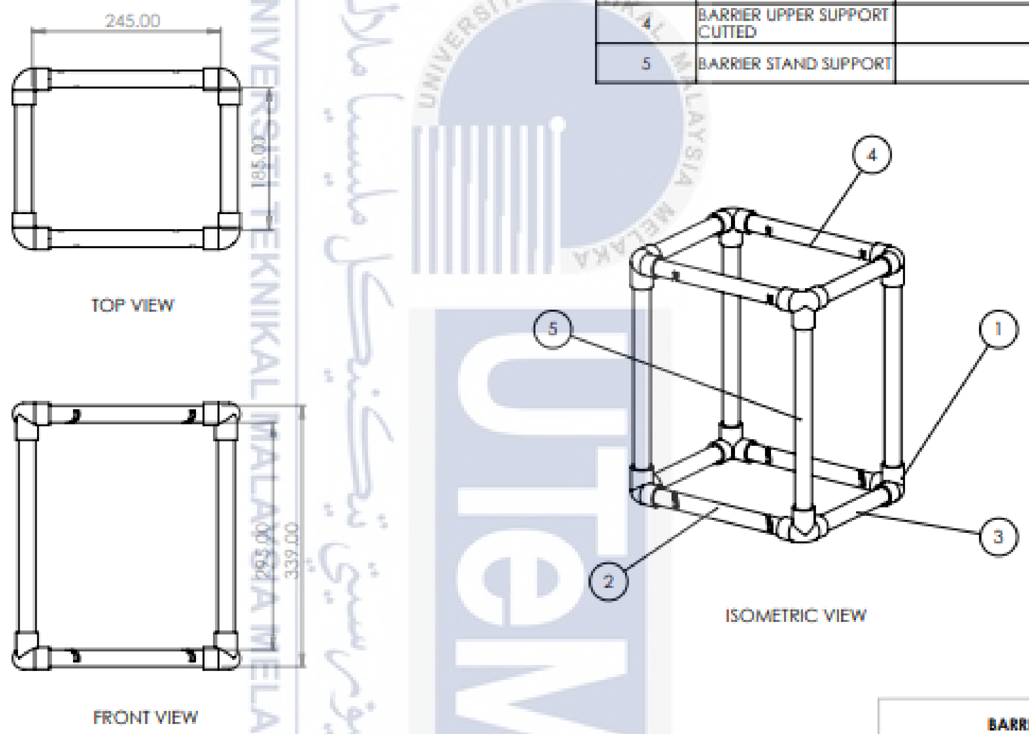
WIND TURBINE MODEL ASSEMBLY	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL	UNIT: MILLIMETER (mm)
DRAWING NO: E	SCALE 1: 4
PROJEK SARJANA MUDA	QUANTITY: 1
SIZE: A3	DATE: 08/1/2022


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
SMALL MOTOR BASE
1
2
SMALL MOTOR
1
ISOMETRIC VIEW
SIDE VIEW
TOP VIEW
FRONT VIEW
SMALL MOTOR ASSEMBLY
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: STAINLESS STEEL
UNIT: MILLIMETER (mm)
DRAWING NO: 3-E
SCALE 1:2
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 08/1/2022

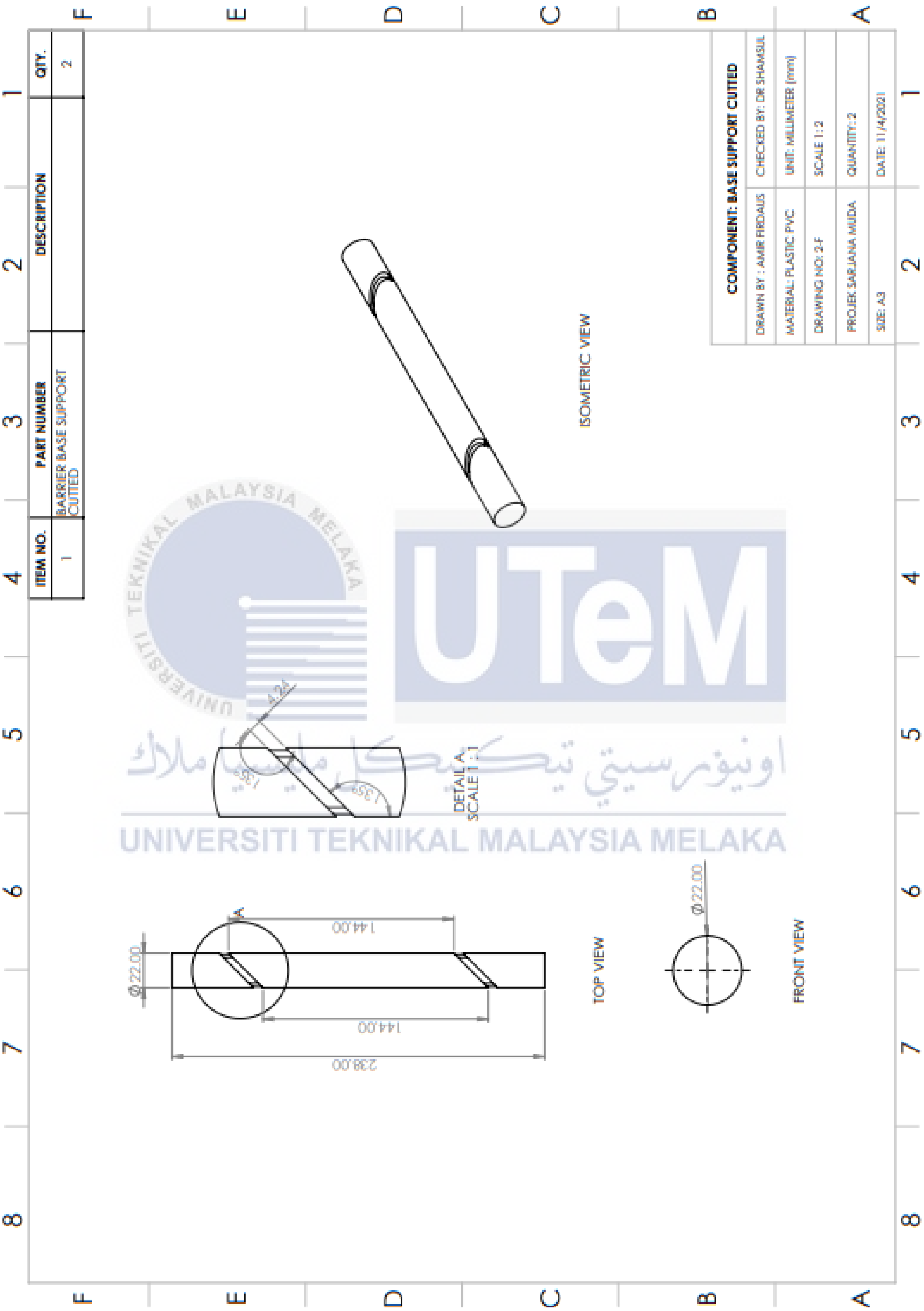

ITEM NO. | PART NUMBER | DESCRIPTION | QTY.
1 | HOLLOW SHAFT | 235 MM X 2 PIECES | 2
TRUE R6.50
TRUE R7.50
DETAIL A
SCALE 1 : 1
A
235.00
ISOMETRIC VIEW
COMPONENT: HOLLOW SHAFT
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: ALUMINIUM
UNIT: MILLIMETER (mm)
DRAWING NO: 6-E
SCALE 1: 2
PROJEK SARJANA MUDA
QUANTITY: 2
SIZE: A3
DATE: 08/1/2022

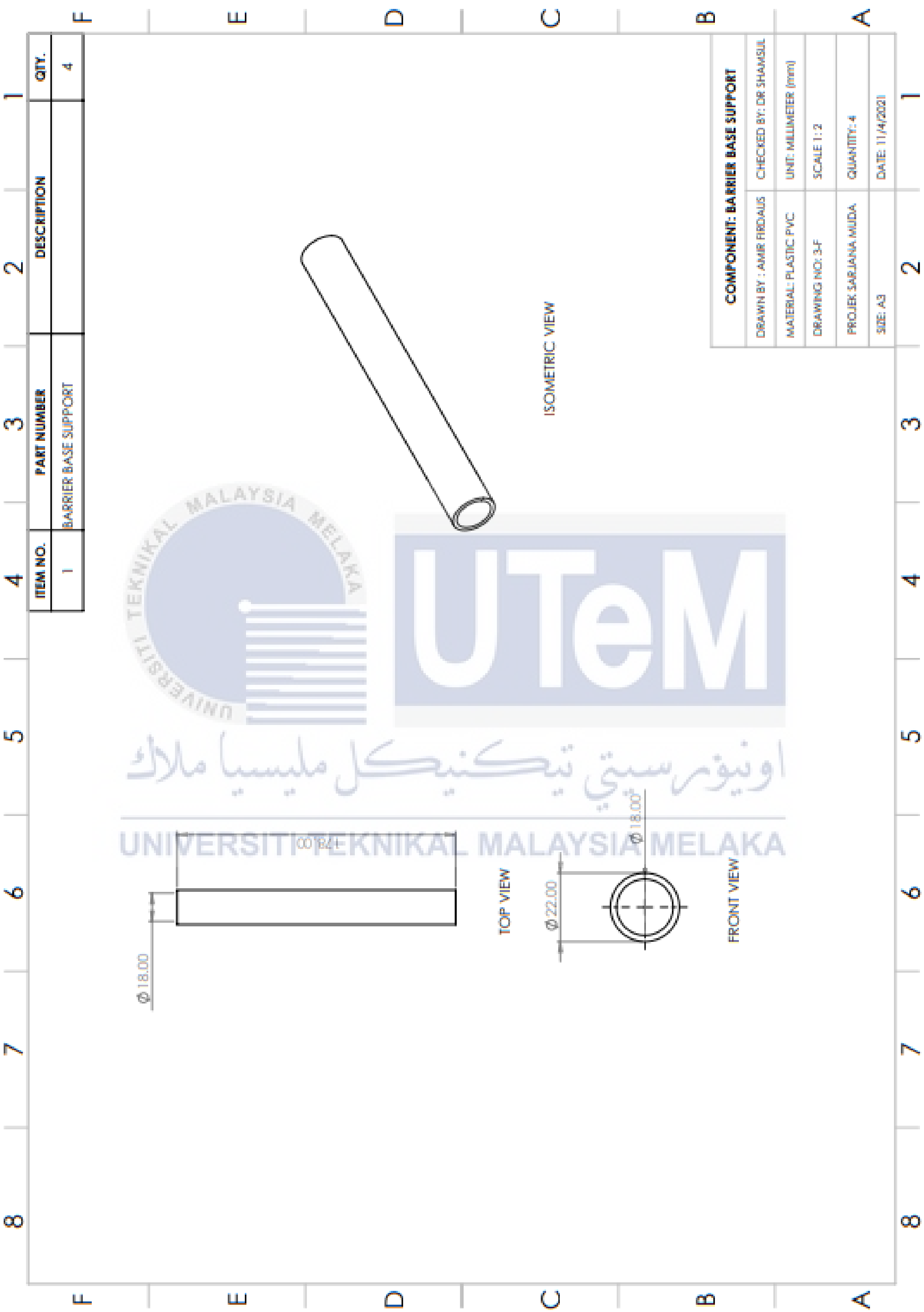

ITEM NO. | PART NUMBER | DESCRIPTION | QTY.
1 | HUB 2.0 | Aluminium (Thickness 2mm) | 4
91.60
2.00
TOP VIEW
10.00
Ø4.00
30.64
120°
120°
120°
FRONT VIEW
ISOMETRIC VIEW
COMPONENT: HUB
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: ALUMINIUM
UNIT: MILLIMETER (mm)
DRAWING NO: 6-E
SCALE 1: 1
PROJEK SARJANA MUDA
QUANTITY: 4
SIZE: A3
DATE: 08/1/2022

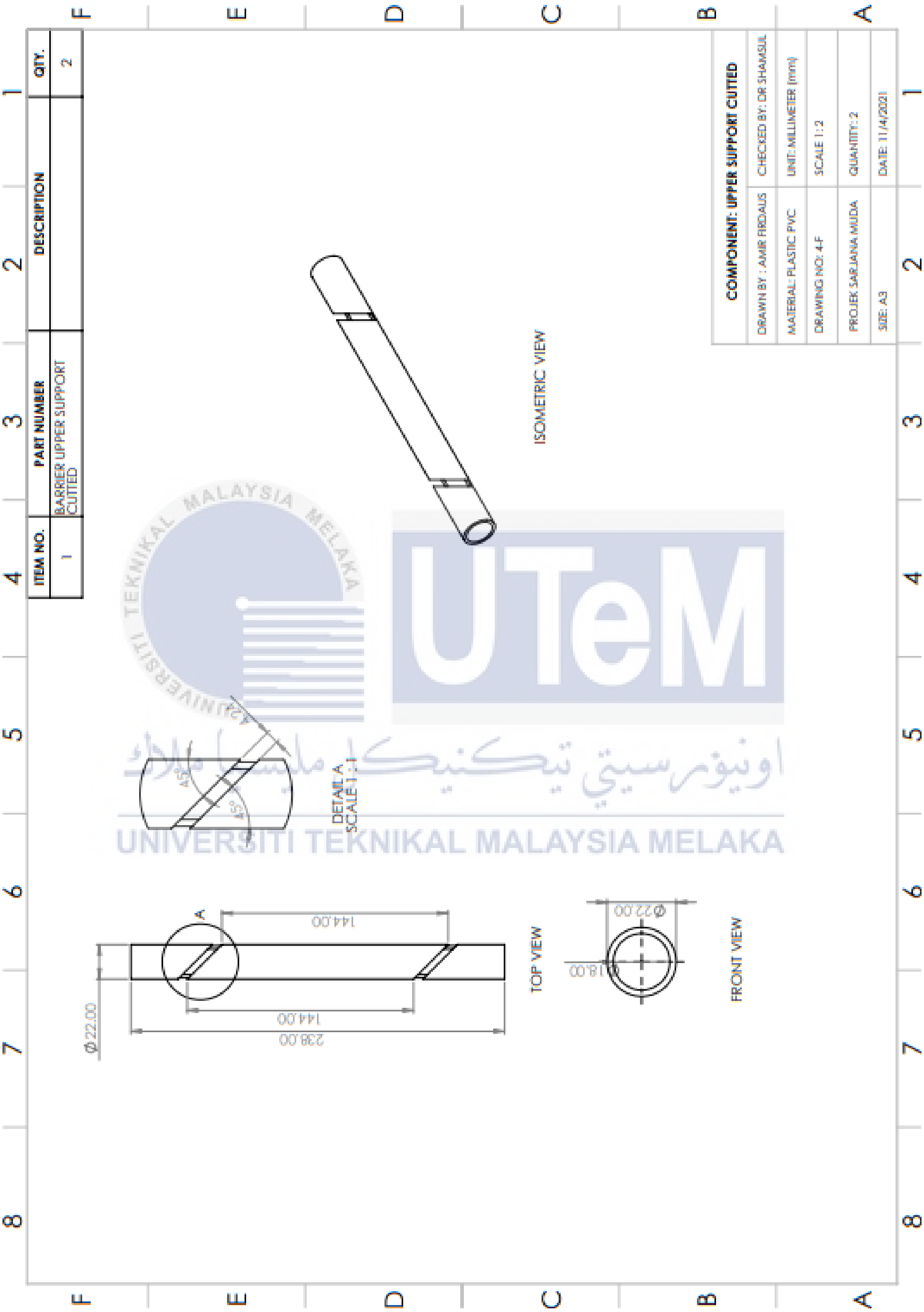
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	3 WAY CORNER ELBOW		8
2	BARRIER BASE SUPPORT CUTTED		2
3	BARRIER BASE SUPPORT		4
4	BARRIER UPPER SUPPORT CUTTED		2
5	BARRIER STAND SUPPORT		4

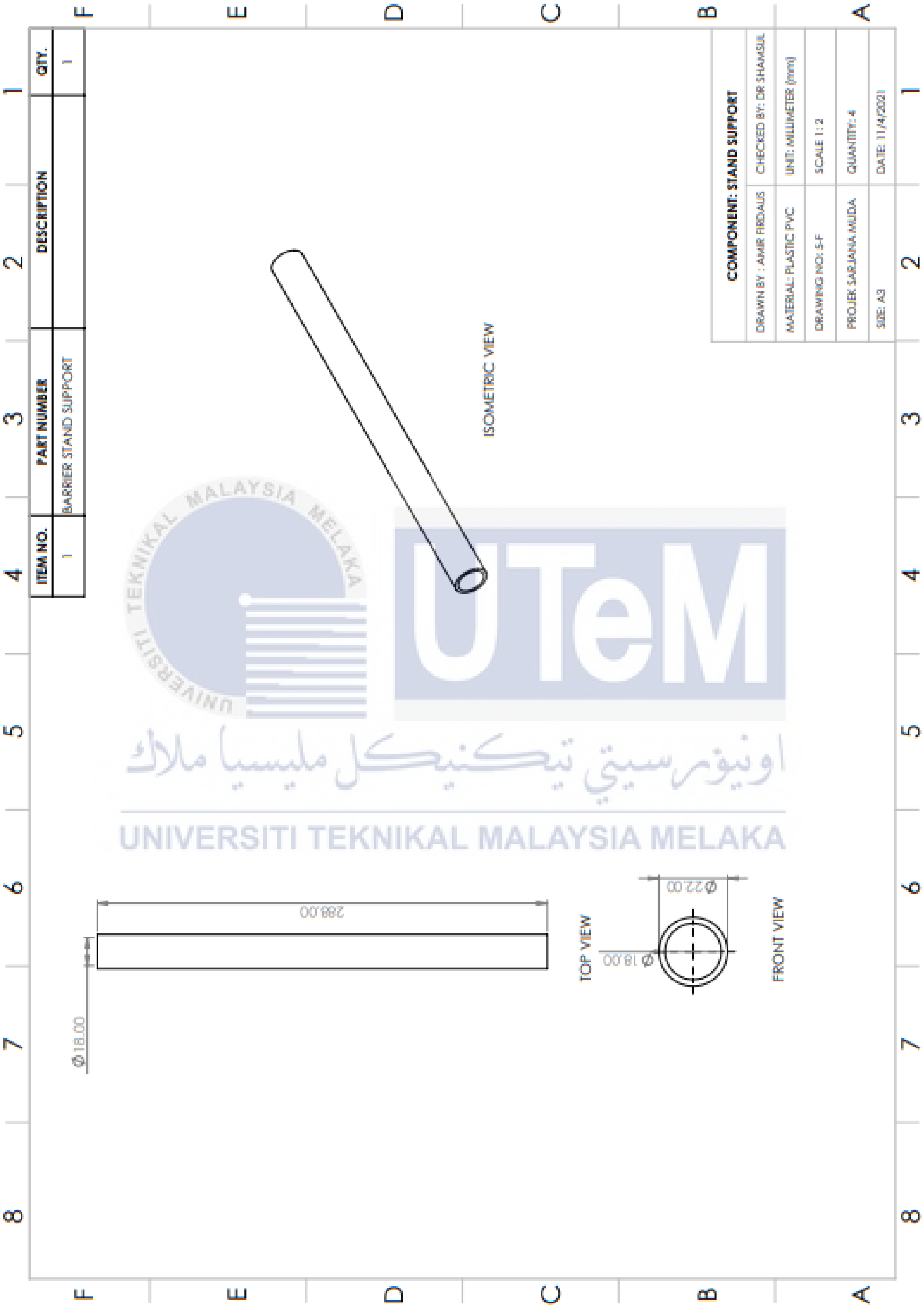


BARRIER MECHANISM	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR SHAMSUL
MATERIAL: PLASTIC PVC	UNIT: MILLIMETER (mm)
DRAWING NO: F	SCALE 1 : 5
PROJEK SARJANA MUDA	QUANTITY: 1
SIZE: A3	DATE: 11/4/2021

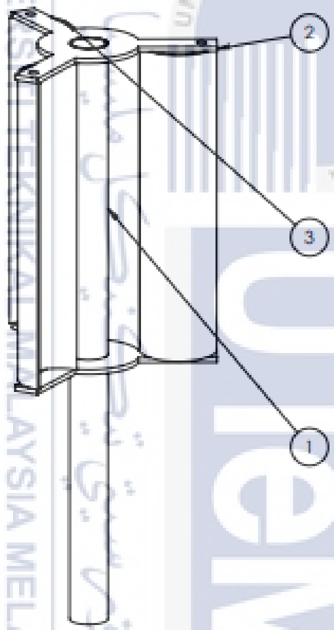

ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BARRIER BASE SUPPORT CUTTED
2
ISOMETRIC VIEW
DETAIL A
SCALE 1 : 1
4.24
135°
135°
144.00
144.00
238.00
Ø22.00
A
TOP VIEW
Ø22.00
FRONT VIEW
COMPONENT: BASE SUPPORT CUTTED
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: PLASTIC PVC
UNIT: MILLIMETER (mm)
DRAWING NO: 2-F
SCALE 1:2
PROJEK SARJANA MUDA
QUANTITY: 2
SIZE: A3
DATE: 11/4/2021


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BARRIER BASE SUPPORT
4
ISOMETRIC VIEW
128.00
Ø18.00
TOP VIEW
Ø22.00
Ø18.00
FRONT VIEW
COMPONENT: BARRIER BASE SUPPORT
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: PLASTIC PVC
UNIT: MILLIMETER (mm)
DRAWING NO: 3-F
SCALE 1:2
PROJEK SARJANA MUDA
QUANTITY: 4
SIZE: A3
DATE: 11/4/2021


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BARRIER UPPER SUPPORT CUTTED
2
ISOMETRIC VIEW
DETAIL A
SCALE 1 : 1
45°
A
144.00
144.00
238.00
Ø22.00
TOP VIEW
Ø22.00
Ø18.00
FRONT VIEW
COMPONENT: UPPER SUPPORT CUTTED
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: PLASTIC PVC
UNIT: MILLIMETER (mm)
DRAWING NO: 4-F
SCALE 1 : 2
PROJEK SARJANA MUDA
QUANTITY: 2
SIZE: A3
DATE: 11/4/2021

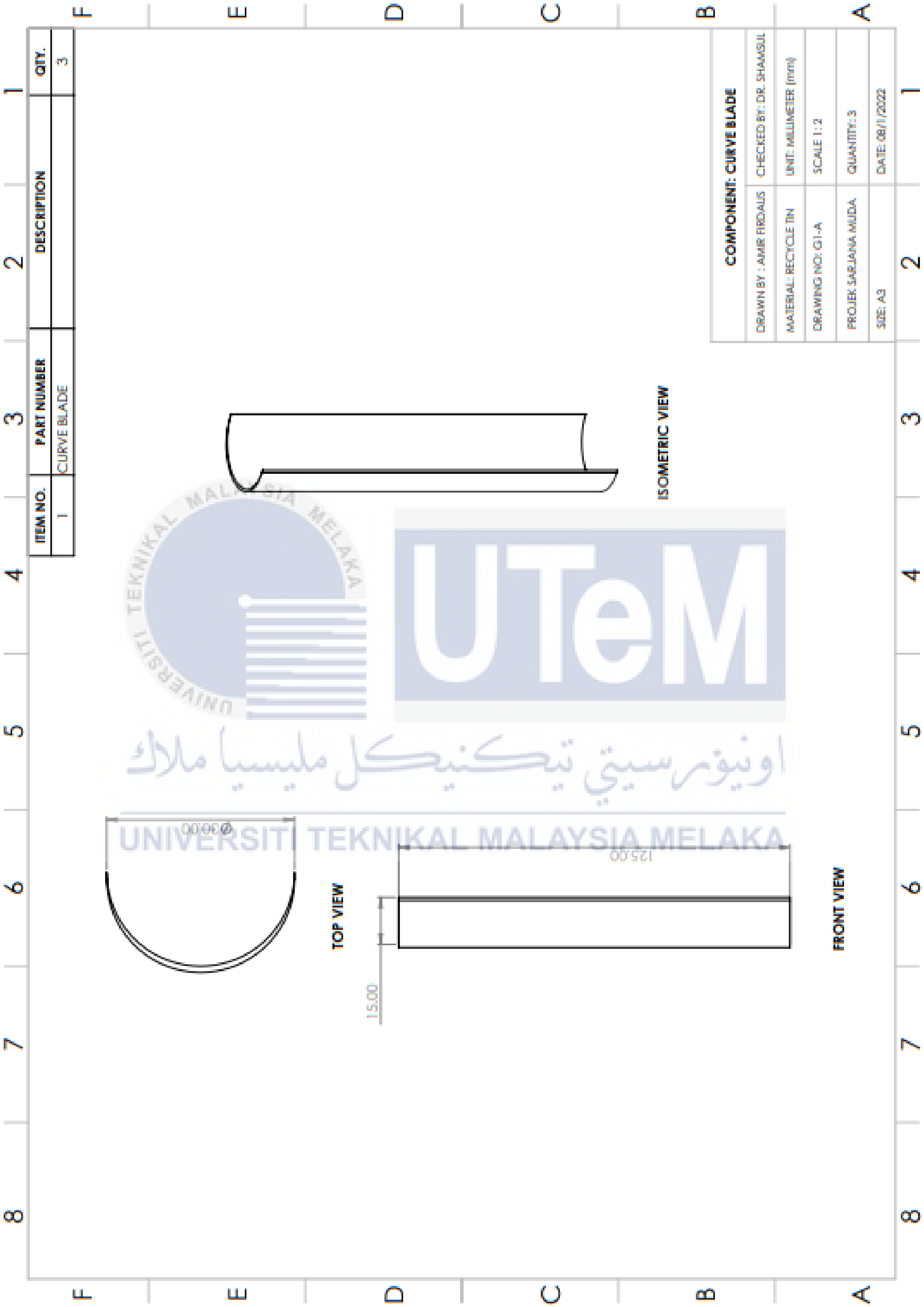

ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
BARRIER STAND SUPPORT
1
ISOMETRIC VIEW
288.00
Ø18.00
TOP VIEW
Ø22.00
Ø18.00
FRONT VIEW
COMPONENT: STAND SUPPORT
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: PLASTIC PVC
UNIT: MILLIMETER (mm)
DRAWING NO: 5-F
SCALE 1:2
PROJEK SARJANA MUDA
QUANTITY: 4
SIZE: A3
DATE: 11/4/2021

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	HOLLOW Shaft	235 MM X 2 PIECES	1
2	HUB 2.0	ALUMINIUM (THICKNESS 2mm)	2
3	CURVE BLADE		3

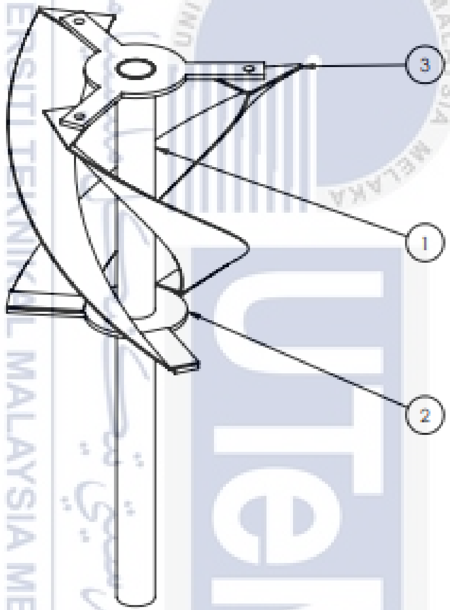


ISOMETRIC VIEW

CURVE BLADE MECHANISM	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR. SHAMSUL
MATERIAL: ALUMINIUM	UNIT: MILLIMETER (mm)
DRAWING NO: G1	SCALE 1 : 2
PROJEK SARJANA MUDA	QUANTITY: 1
SIZE: A3	DATE: 08/1/2022


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
CURVE BLADE
3
ISOMETRIC VIEW
TOP VIEW
FRONT VIEW
Ø30.00
125.00
15.00
COMPONENT: CURVE BLADE
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR. SHAMSUL
MATERIAL: RECYCLE TIN
UNIT: MILLIMETER (mm)
DRAWING NO: G1-A
SCALE 1 : 2
PROJEK SARJANA MUDA
QUANTITY: 3
SIZE: A3
DATE: 08/1/2022

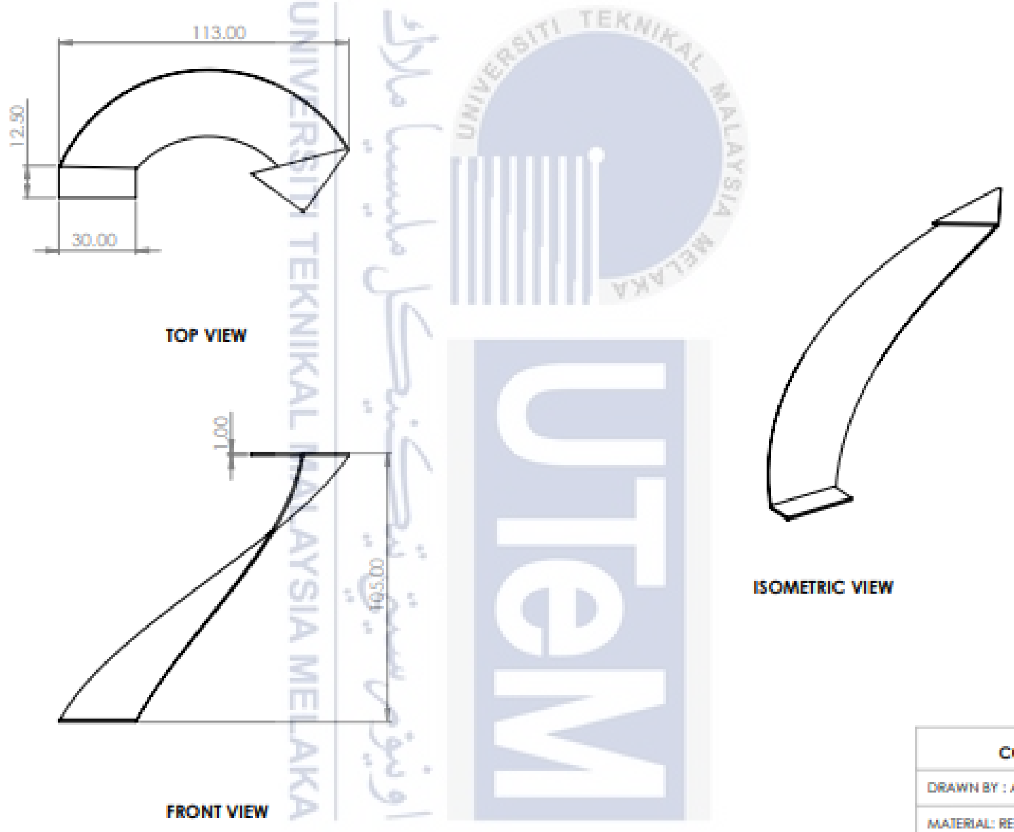
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	HOLLOW SHAFT	235 MM X 2 PIECES	1
2	HUB 2.0	ALUMINIUM (THICKNESS 2mm)	2
3	HELICAL BLADE	ALUMINIUM (THICKNESS 1mm)	3



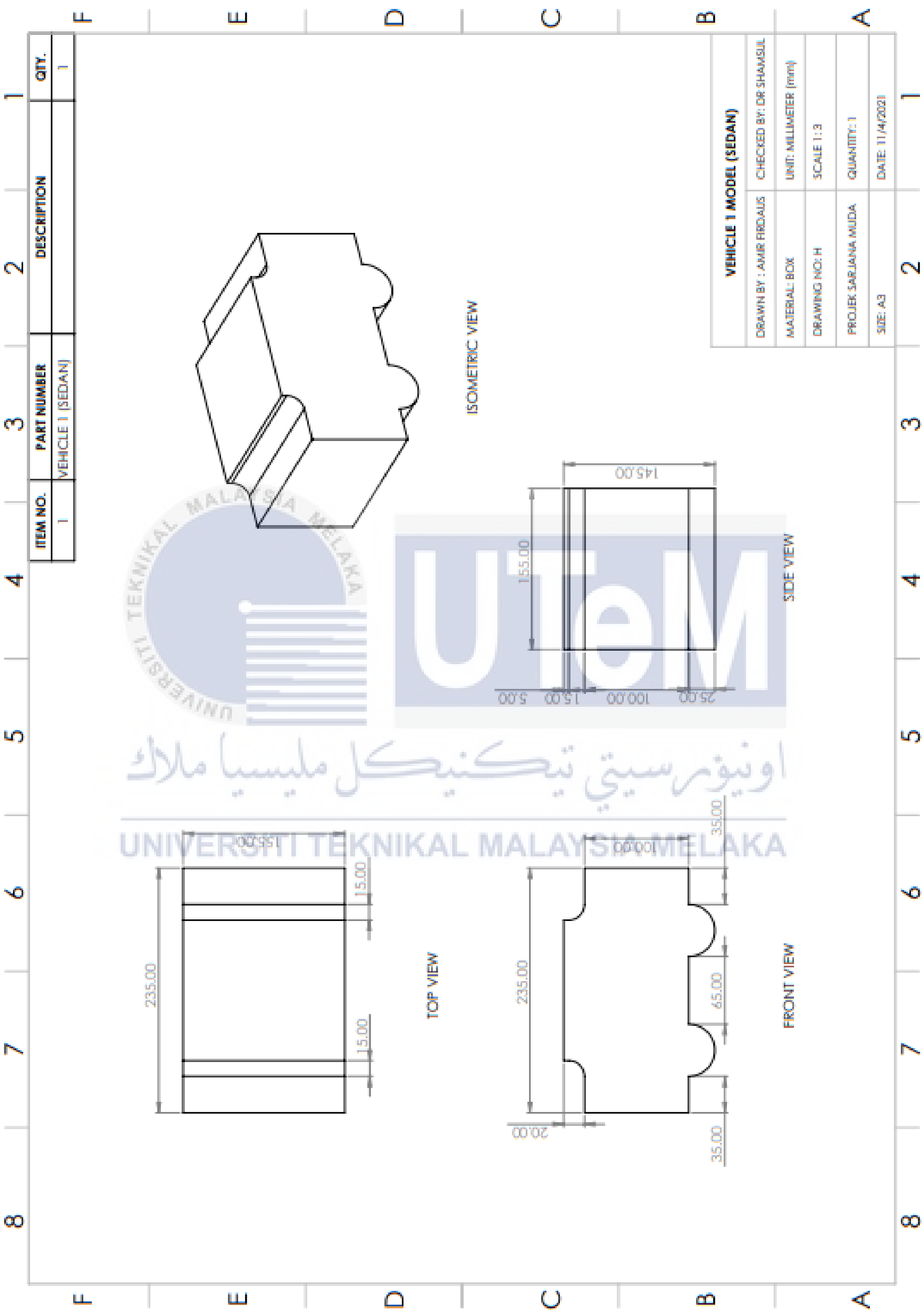
ISOMETRIC VIEW

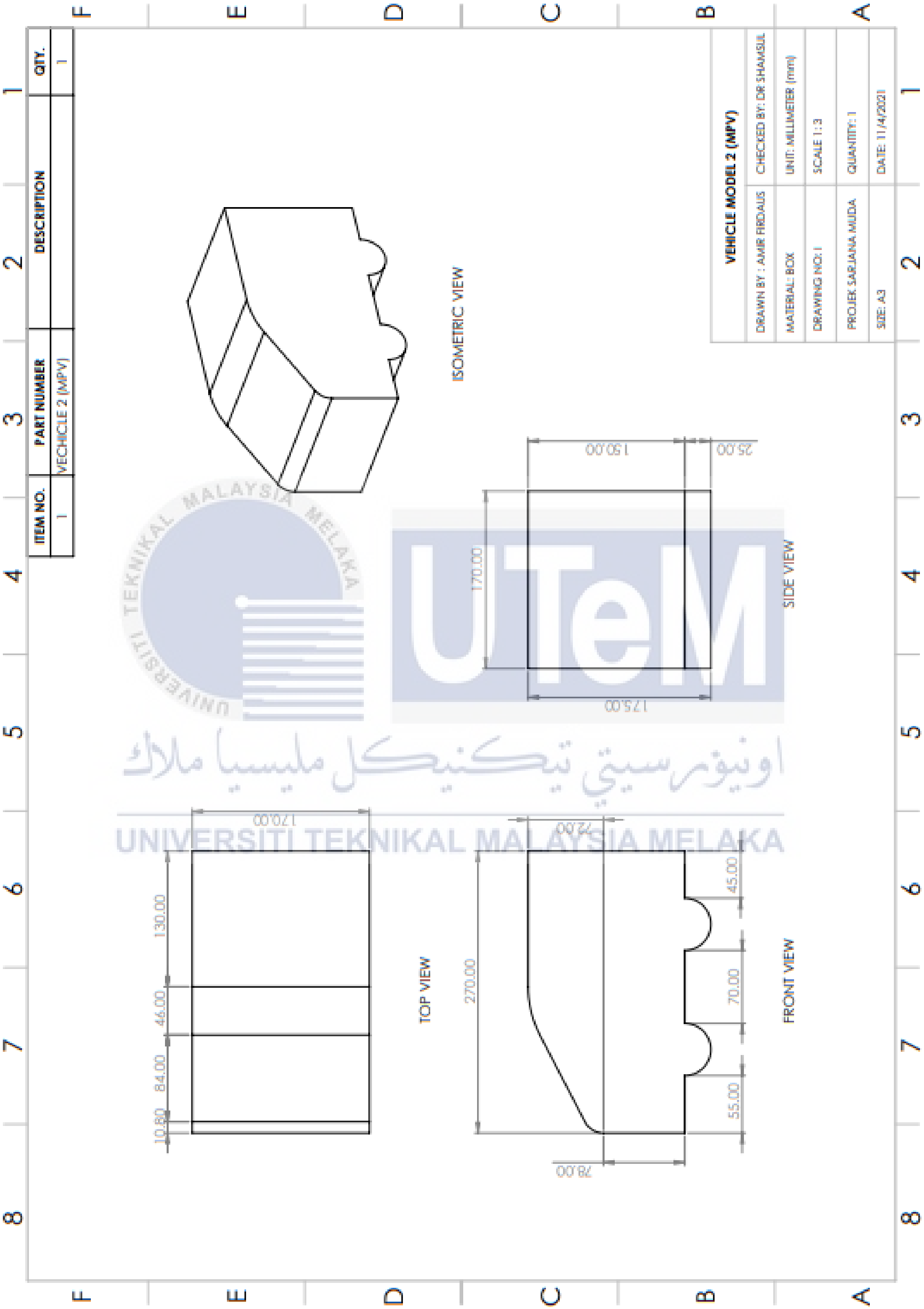
HELICAL BLADE MECHANISM	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR. SHAMSUL
MATERIAL: ALUMINIUM	UNIT: MILLIMETER (mm)
DRAWING NO: G2	SCALE 1 : 2
PROJEK SARJANA MUDA	QUANTITY: 1
SIZE: A3	DATE: 08/1/2022

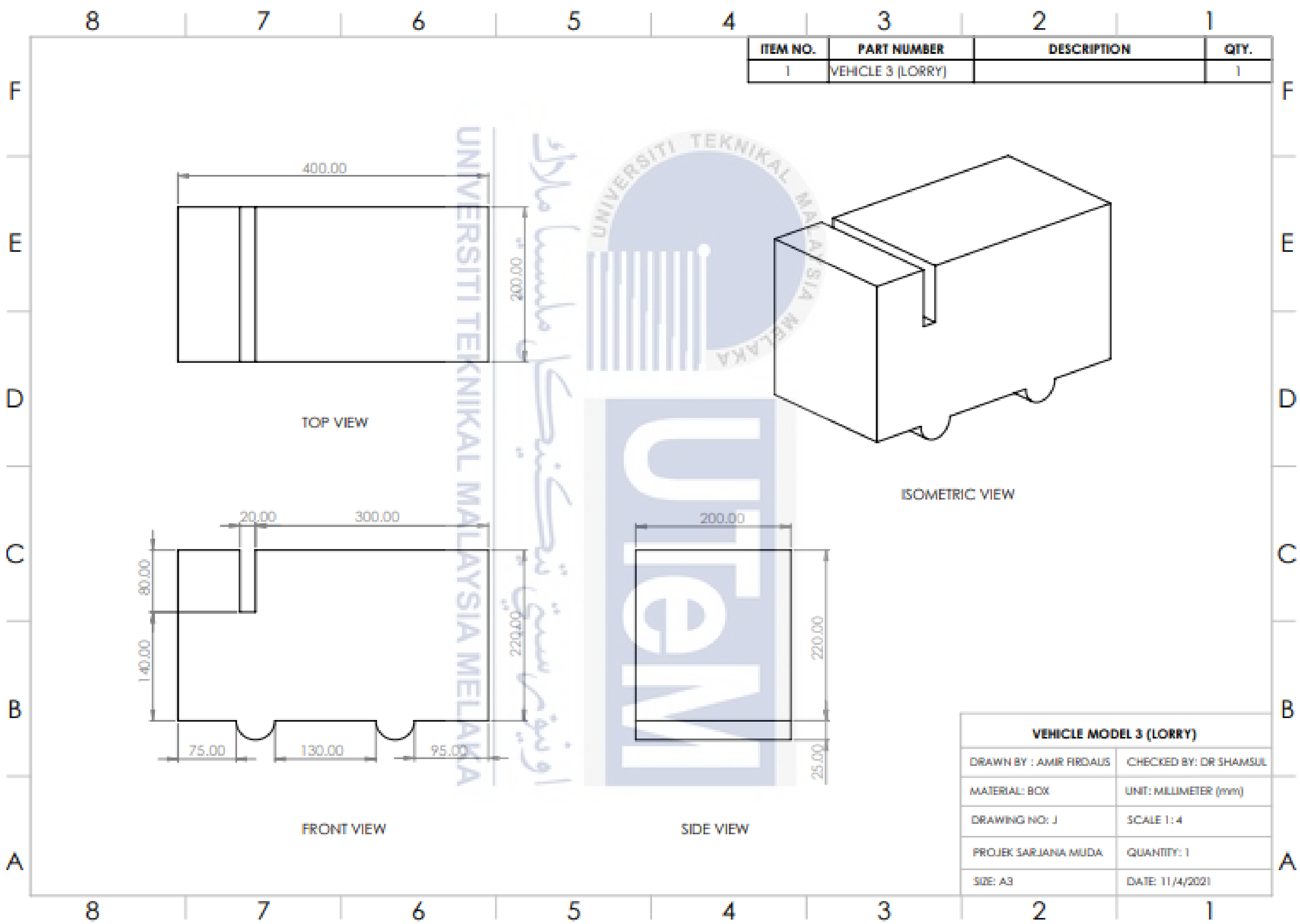
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	HELICAL BLADE	TIN (THICKNESS 1mm)	3



COMPONENT: HELICAL BLADE	
DRAWN BY : AMIR FIRDAUS	CHECKED BY: DR. SHAMSUL
MATERIAL: RECYCLE TIN	UNIT: MILLIMETER (mm)
DRAWING NO: G2-A	SCALE 1 : 2
PROEK SARJANA MUDA	QUANTITY: 3
SIZE: A3	DATE: 08/1/2022


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
VEHICLE 1 (SEDAN)
1
ISOMETRIC VIEW
SIDE VIEW
TOP VIEW
FRONT VIEW
145.00
155.00
5.00
15.00
100.00
25.00
155.00
235.00
15.00
15.00
235.00
100.00
35.00
65.00
35.00
20.00
VEHICLE 1 MODEL (SEDAN)
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: BOX
UNIT: MILLIMETER (mm)
DRAWING NO: H
SCALE 1:3
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 11/4/2021


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
VECHICLE 2 (MPV)
1
ISOMETRIC VIEW
SIDE VIEW
TOP VIEW
FRONT VIEW
150.00
25.00
170.00
175.00
170.00
72.00
130.00
46.00
84.00
10.80
270.00
45.00
70.00
55.00
78.00
VEHICLE MODEL 2 (MPV)
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: BOX
UNIT: MILLIMETER (mm)
DRAWING NO: I
SCALE 1:3
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 11/4/2021


ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
VEHICLE 3 (LORRY)
1
400.00
200.00
TOP VIEW
ISOMETRIC VIEW
20.00
300.00
80.00
140.00
220.00
75.00
130.00
95.00
FRONT VIEW
200.00
220.00
25.00
SIDE VIEW
VEHICLE MODEL 3 (LORRY)
DRAWN BY : AMIR FIRDAUS
CHECKED BY: DR SHAMSUL
MATERIAL: BOX
UNIT: MILLIMETER (mm)
DRAWING NO: J
SCALE 1 : 4
PROJEK SARJANA MUDA
QUANTITY: 1
SIZE: A3
DATE: 11/4/2021

APPENDIX A-2
PROJECT DETAILS PICTURE

(8 Images)