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DESIGN OF GRASS CUTTER HOLDER POWERED BY SOLAR USING INTERNET of THINGS (IoT)

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE) WITH HONOURS

2024

Faculty of Mechanical Technology and Engineering

DESIGN OF GRASS CUTTER HOLDER POWERED BY SOLAR USING INTERNET of THINGS (IoT)

Megat Muhammad Zikri Bin Ab Razak

Bachelor of Mechanical Engineering Technology (Automotive) with Honours

2024

DESIGN OF GRASS CUTTER HOLDER POWERED BY SOLAR USING INTERNET of THINGS (IoT)

Megat Muhammad Zikri Bin Ab Razak

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

Faculty of Mechanical Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

DECLARATION

I declare that this Choose an item. entitled “Design Of Grass cutter Holder Powered By Solar Using Internet of Things (IoT)” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

I would like to extend my heartfelt dedication to my family, whose unwavering support and love have been the driving force behind my journey. Your belief in me and words of encouragement have strengthened my determination to strive for my goals and overcome challenges. I am grateful for your patience and understanding as I navigated through the extensive research and writing process. This achievement is a testament to our collective efforts and shared aspirations. I would also like to express my sincere appreciation to all my friends and mentors who have provided invaluable advice, knowledge, and profound insights. Your contributions have shaped my perspectives and enhanced my understanding of the subject matter. Your guidance and support have been instrumental in my growth and development. Lastly, I dedicate this work to all individuals who pursue excellence, seek knowledge, and embrace creativity. May our collective efforts contribute to the advancement of our fields and inspire others to embark on their own journeys of discovery.

ABSTRACT

This project introduces an innovative grass cutter holder that use solar power and IoT technology to revolutionisse grass cutting operations. The system incorporates a solar panel as a renewable energy source, promoting sustainability and reducing environmental impact. By harnessing sunlight, the solar panel generates electricity to the battery that operates the power the grass cutter holder. The integration of IoT technology enhances the functionality and efficiency of the grass cutter holder. Users can remotely monitor and control the grass cutting operations through their smartphones or other internet-connected devices. Real-time data collected from sensors, including grass height and obstacle detection cutting patterns and ensure precise trimming. Safety is a priority in this system, as it incorporates infrared (IR) and ultrasonic sensors for obstacle detection. When an obstacle is detected, the grass cutter holder automatically adjusts its course or halts to prevent collisions and damage. This feature ensures the well-being of the grass cutter holder and its surroundings. The solar-powered IoT grass cutter holder offers various advantages, such as reduced operational costs, improved sustainability, and increased efficiency in grass cutting. Its reliance on solar energy allows for off-grid operation, making it suitable for remote areas or locations with limited access to electricity. Additionally, the IoT capabilities provide users with convenience and flexibility, allowing them to manage grass cutting operations. The Iot also allow to be remotely controlled through the application via a Bluetooth module by using device or smartphone. The grass cutter holder can cover 20.78 m² field area to trim it.

ABSTRAK

Projek ini memperkenalkan pemegang pemotong rumput yang menggunakan tenaga solar dan teknologi IoT untuk mengubah operasi pemotongan rumput. Sistem ini memasukkan panel solar sebagai sumber tenaga yang boleh diperbaharui, menggalakkan kelestarian alam dan mengurangkan impak terhadap alam sekitar. Dengan menggunakan cahaya matahari, panel solar menghasilkan tenaga elektrik untuk menggerakkan pemegang pemotong rumput. Integrasi teknologi IoT meningkatkan keberkesanan dan kecekapan pemegang pemotong rumput. Pengguna dapat memantau dan mengawal operasi pemotongan rumput secara jarak jauh melalui telefon pintar atau peranti yang disambungkan ke internet. Data secara langsung yang dikumpul daripada sensor, termasuk ketinggian rumput dan pengesanan halangan, dianalisis untuk mengoptimumkan corak pemotongan dan memastikan pemotongan yang tepat. Keselamatan merupakan keutamaan dalam sistem ini, yang memasukkan sensor inframerah (IR) dan ultrasonik untuk pengesanan halangan. Apabila halangan dikesan, pemegang pemotong rumput secara automatik menyesuaikan laluan atau berhenti untuk mengelakkan perlanggaran dan kerosakan. Ciri ini memastikan keselamatan pemegang pemotong rumput dan persekitarannya. Pemegang pemotong rumput tenaga solar dengan teknologi IoT menawarkan pelbagai kelebihan, seperti pengurangan kos operasi, peningkatan kelestarian alam, dan peningkatan kecekapan dalam pemotongan rumput. Bergantung kepada tenaga solar membolehkan operasi luar grid, menjadikannya sesuai untuk kawasan terpencil atau tempat yang mempunyai akses terhadap bekalan elektrik. Selain itu, kebolehan IoT memberikan keselesaan dan fleksibiliti kepada pengguna, membolehkan mereka menguruskan operasi pemotongan rumput dari mana-mana sahaja. Iot juga membenarkan untuk dikawal dari jauh melalui aplikasi modul Bluetooth dengan menggunakan peranti atau telefon pintar. Pemegang pemotong rumput boleh meliputi kawasan padang seluas 20.78 m² untuk memotong rumput..

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LIST OF SYMBOLS AND ABBREVIATIONS

D	-	Distance
T	-	Time measure
C	-	Speed of sound
VIN	-	Voltage input
SDK	-	Software development kit

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CHAPTER 1

INTRODUCTION

1.1 Background

Green represents the colour of the beauty of nature that can be seen in forests, trees, and even fields of grass. Their beauty can be enhanced with proper care such as cutting and trimming of their length. Most residential areas in the city that have natural grass choose to decorate their lawns with carpet grass where maintenance is easier, and usually, the area is smaller compared to the natural grass in the village. Most houses in rural areas are built on their own land and have larger yards. The villagers will cut the grass manually using a grass cutter as shown in Figure 1.1. Due to the large area, this grass-cutting process takes a long time and consumes a lot of energy. In addition, most of the residents living in the village area are elderly and their energy is no longer strong to cut the grass consistently. Therefore, this project was created to help them do the grass-cutting process more efficiently.

Figure 1.1 Grass cutter machine

Figure 1.2 Usage of grass cutter

The grass cutter machine is hard to handle as can be seen in Figure 1.2. To achieve the goal of this project, a modification will be made to the existing grass cutter by designing and fabricating a holder to support the grass cutter. In addition, the holder is embedded with IoT powered by solar. Using solar power and IoT system on grass cutter holder will offer several advantages to users.

There are many benefits of using solar power on grass cutter holder. This project uses a 12V battery that needs to be charged continuously when the grass cutter holder is used. Besides that, it also has scalability when using solar power. Due to its high scalability, solar energy enables the installation of IoT systems and devices in a range of configurations and sizes. Other than that, it provides easy installation and maintenance. In addition to solar power, the installation of an IoT system in the grass cutter holder brings automation and increased efficiency to its operation. Therefore, this project is very suitable for the people who has large yard and the villagers who lives in rural areas because it easy to use.

1.2 Problem Statement

Nowadays, many individuals own spacious yards, and in rural areas, villagers may struggle to maintain their fields despite having a grass cutter machine. The challenges posed by heavy and potentially hazardous grass cutter machines are well understood, particularly for senior citizens who may be at risk due to their unsuitability for such tasks. Thankfully, the market offers a wide range of grass cutter machines equipped with advanced features and modern systems that can autonomously trim the grass. While there are numerous innovative grass cutters available for purchase, it would be impractical to acquire a new one when someone already possess a grass cutter at home. Therefore, this project proposing a solution to facilitate the process of cutting grass using the existing grass cutter by building a grass cutter holder integrated with IoT system.

1.3 Research Objective

The project aims to accomplish the following objectives:

1. To design and fabricate a grass cutter holder to support a conventional grass cutter machine.

2. To develop a grass cutter holder using Arduino and mobile application to control the machine.

1.4 Scope of Research

The scope of this research is as follows:

1. Designing a questionnaire that relates to the usage of grass cutter and distribute the questionnaire to at least 50 respondents.

2. From the questionnaire results, gather important information to propose at least three sketching ideas for the grass cutter holder.

3. The conceptual design of the grass cutter holder must support the reaction force to withstand the grass cutter’s oil tank, the grass cutter position and motion.

4. The selections between proposed designs are done using the Pugh method.

5. The best design will undergo further analysis including, structure analysis using CATIA.

6. Determine the type of sensors that are suitable for the holder like motion sensors, IR sensors and ultrasonic sensors.

7. Using Arduino UNO as an IoT platform by combining the sensors to programme the movement.

8. Fabricate the holder base on the selected design and installed all components including the solar panel, motor, and battery.

9. Conduct experimental work to ensure the system can run smoothly in real condition.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

Grass cutters has important functions for many reasons. Firstly, contribute to the upkeep of lawns and outdoor areas by ensuring regular grass cutting. This consistent maintenance results in well-groomed, orderly, and visually pleasing grass, which greatly enhances the overall aesthetic appeal of the environment. Regular grass cutting preserves its neatness, tidiness, and visual allure, ultimately elevating the overall beauty of the surroundings. Furthermore, trimmed grass contributes to the safety and accessibility of outdoor areas, making them suitable for recreational activities such as sports or picnics. In addition to practical considerations, well-maintained grass areas offer significant environmental benefits. Proper grass cutting promotes healthier grass growth by facilitating improved sunlight absorption, water penetration, and air circulation. This, in turn, contributes to the overall vitality of the grass and the surrounding ecosystem. Moreover, regular grass cutting helps prevent the spread of invasive plant species, allowing native plants to thrive and maintain the ecological balance. With the incorporation of lawn mowers into grass cutting, human effort and time was saved (Balaiah, 2017).

The grass cutter IoT based performs the same function but in a technological style through the regular use of our small, everyday cell phone. This device has numerous functions built in, including a robotic arm to clear obstacles from its route, ultrasonic sensors to detect obstacles, solar panels to recharge the battery, and many others. This project makes use of programming skills for IoT and robotics. It can be moved using software inputs. For security reasons, the cutter is not fixed and is also moveable, allowing for simple control of movement in any direction. The entire programming process, including controlling the device's rotation, up-and-down movement, and other movements, is carried out using the Arduino UNO software. Battery is used to store solar energy so that it can be used on cloudy days.

2.2 Type of Grass Cutting Machine

Nowadays, there were several varieties of grass cutting machines available, each designed to serve specific purposes and cater to different scales of grass cutting. Each of them has their advantages and disadvantages based on purpose of use from gas-powered ride-on mowers to electric hybrid robots that use solar power (Dutta PP et al., 2016). Although there were many types of grass cutting machines, there are most focus on machine that mostly people in Malaysia use such as lawn mower and grass cutter. These two grass cutting machines frequently see at side of road, rural areas and some residential areas in the city.

2.2.1 Lawnmower

Figure 2.1 Commercial lawn mower

A lawn mower as in Figure 2.1 that uses gasoline as its power source could be designed and developed to cut and maintain grass and vegetation in various outdoor settings efficiently and effectively. The lawn mower consists of several components, including a cutting unit, a gasoline-powered engine, a steering system, and wheels or casters for maneuverability (Chong & Tiwari, 2020). The cutting unit would be designed to efficiently cut and trim grass and vegetation to a desired length, while the gasoline-powered engine would provide the machine with the necessary power to cut through tough grass and vegetation.

The steering system could vary depending on the model of the lawn mower. Some models may have a traditional steering wheel, while others may have a handlebar that allows the user to control the machine (Siregar, 2018). The wheels or casters provide the lawn mower with the necessary mobility to navigate around obstacles and uneven terrain.

The gasoline-powered engine provides the machine with a high level of power, making it suitable for tackling tough and overgrown areas of grass and vegetation (Siregar, 2018). However, the use of gasoline as a power source could have negative environmental impacts, such as air pollution and increased carbon emissions.

Despite the negative impacts, a lawn mower that uses gasoline as its power source could offer several benefits, including increased efficiency in grass cutting and maintenance, reduced labour costs, and improved time management (McManus & Taylor, 2018). By having a high-performance cutting unit and a gasoline-powered engine, users could accomplish the task of cutting grass more quickly and effectively. Additionally, the steering system and wheels or casters provide users with a high level of control and maneuverability, allowing them to navigate around obstacles and uneven terrain with ease.

2.2.2 Grass cutter

Figure 2.2 Gasoline-powered grass cutter

Figure 2.2 showcases a gasoline-powered grass cutter, which can be designed and developed to efficiently and effectively cut and trim grass and vegetation in diverse outdoor settings. The grass cutter could consist of several components, including a cutting unit, a gasoline-powered engine, and a handlebar. The design offers a higher level of flexible mobility and interchangeability (Khodke et al., 2018). The objectives of this grass cutter machine include, but are not limited to, the following:

a. To decrease the amount of manual labour required for cutting not only weeds or grass but also for trimming flowers and trees.

b. To decrease costs and time associated with cutting tasks while simultaneously enhancing the aesthetic appeal of the environment.

The usage of a gasoline-powered engine would equip the machine with substantial power, making it capable of effectively handling challenging and overgrown grass and vegetation areas. Besides that, it is essential to acknowledge that using gasoline as a power source may result in adverse environmental impacts, including air pollution and heightened carbon emissions (Barton & Pretty, 2010).

While there may give disadvantages to environment, it is important to recognize that a grass cutter powered by gasoline can also offer numerous benefits. A trimmer with more power and torque may be required by those who work in areas that have a IoT of foliage or dense soil. The grass trimmer that packs a powerful punch or offers the versatility of interchangeable power accessories is being sought. These include increased efficiency in grass cutting and maintenance, reduced labour costs, and improved time management. With a high-performance cutting unit and a gasoline-powered engine, users can accomplish grass cutting tasks more quickly and effectively (Battery vs. Petrol Grass Trimmers: Which is the Best Choice for You?, 2023). Furthermore, the handlebar design allows for precise control, enabling users to navigate around obstacles and uneven terrain with ease.

2.3 Solar Power Management

Solar management managed and used solar energy as a source of power. The sun, a fusion reactor that has been blazing for billions of years, is the source of solar energy. It offers a plentiful and sustainable source of energy. Solar energy has become more popular as a fossil fuel substitute in the context of renewable energy. Common lawn maintenance tools like grass cutters have historically relied on gasoline or electricity, both of which may be expensive. These machines can run on an electric motor to power the cutting blades by capturing solar energy through solar panels. Solar energy is harnessed through photovoltaic cells in a solar panel to generate electricity power. This power is then stored in a battery. A voltage regulator ensures a consistent voltage level, which is using to supply power to an Arduino. The Arduino, in turn, provides a high supply output to a transistor for switching purposes. This transistor drives the motor driver IC and motors, enabling their operation (Ibrahim, et al., 2020).

Solar cells, usually referred to as photovoltaic cells, are at the core of solar management because directly transform sunlight into electrical energy through the photovoltaic effect. When sunlight's photons hit a solar cell, excite the electrons inside the semiconductor material, creating an electric current and voltage.

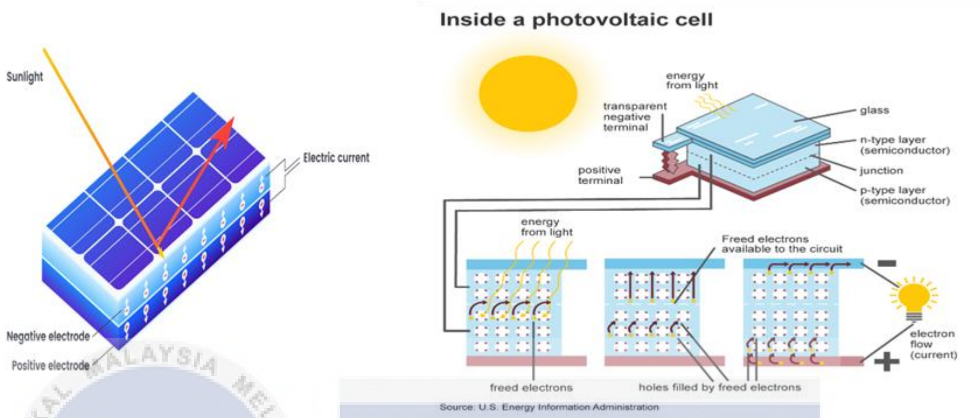


Figure 2.3 Photovoltaic cell

In Figure 2.3, the photovoltaic cell is absorbing energy from sun and convert to electric power. The key elements of solar management are solar panels, which are made up of connected solar cells. Solar energy was gathered and transform into useful electricity. Peak power, peak voltage, peak current, and maximum system voltage are some of the characteristics that must be considered while evaluating the performance of solar panels (Ismail, et al, 2019). The effectiveness and capacity of the solar panel system to produce electrical power are determined by these elements. Solar base energy source, which is easier to use, more advantageous (Shaikh Aman, et al., 2021). This guarantees that solar installations run as efficiently as possible, preventing performance degradation, and increasing energy output over their lifetime.

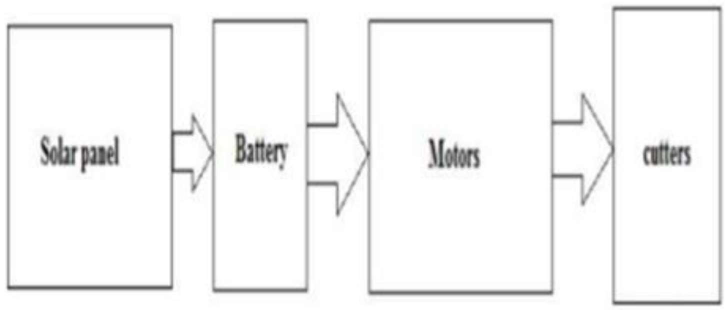


Figure 2.4 Block diagram of solar system

In Figure 2.4 shows the block diagram of solar system (Shaikh Aman, et al., 2021). A unique tool for cutting grass that is powered by solar energy does so by drawing electricity from the sun (Pita & Sob, 2019). Its tiny solar panels capture sunlight and convert it into electricity. The grass cutter holder is powered by this electricity, so it doesn't require gasoline or electricity from a power outlet to operate. In some aspects, having a solar-powered grass cutter holder is advantageous. In the first place, it does not emit damaging carbon emissions like conventional fuel-powered grass cutters do. This benefits the environment by lowering air pollution. Second, since sunlight is unrestricted and free, using solar energy is economical. Neither fuel purchases nor power payments are necessary. Finally, because have fewer parts that could malfunction or require maintenance, solar-powered grass cutter holds are simpler to maintain (Athina, et al., 2021).

Basically, a solar-powered grass cutter cuts grass using the power of the sun. It is equipped with solar panels that absorb sunlight and convert it to electricity. Without using gasoline or electricity from a power socket, this electricity powers the grass cutter. Compared to conventional grass cutters, it is easy to maintain, and benefits the environment.

2.4 Application of IoT

The IoT is a networked system of interconnected computing devices, mechanical and digital machines, objects, animals, or people who can exchange data over a network without the need for human-to-human or human-to-computer interaction. The term "thing" refers to any natural or artificial object that can be given an Internet Protocol (IP) address and has the ability to transfer data over a network, including people with implanted heart monitors, farm animals with biochip transponders, cars with built-in tyre pressure monitors, and other examples (What is IoT?, 2023).

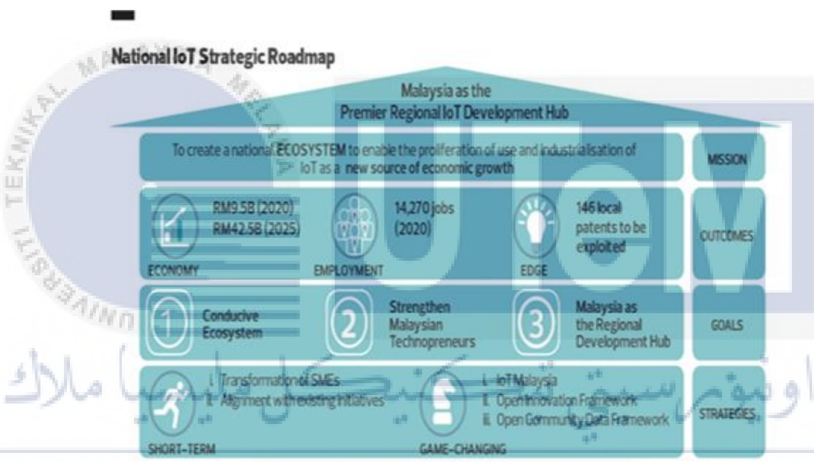


Figure 2.5 Ecosystem of Iot in Malaysia

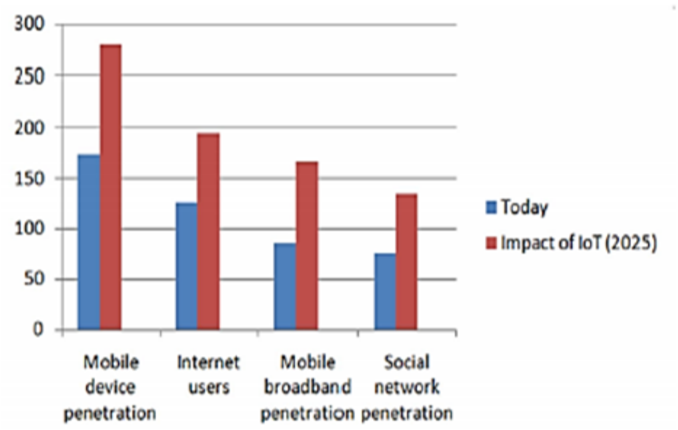


Figure 2.6 Graph of Impact Iot in Malaysia

Figure 2.5 shows that how Iot system implant in Malaysia. Malaysia is in a great position to take advantage of the IoT's economic prospects. Strong foundations of Small and Medium-sized Enterprises (SME), established Electric and Electronics (E&E) and Telecommunication sectors, and implementation of various Governmental Innovation Initiatives will become the basis in facilitating the implementation of IoT initiatives as shown in Figure 2.6. Broadband Internet and cellular penetration rates are 67.8 percent and 145 percent, respectively (Tiwari, 2022). Corporations across a range of industries are increasingly utilising the Internet of Things (IoT) to run more effectively. Therefore, Iot system will give positive impact when installs to grass cutter holder.

The IoT ecosystem is made up of web-enabled smart devices that use embedded systems, like CPUs, sensors, and communication gear, to gather, send, and act on the data get from their surroundings. By connecting to a IoT gateway or other edge device, which allows data to be transferred to the cloud for analysis or locally analysed, IoT devices can share the sensor data acquire (Posey, 2022). The Arduino UNO -based solar-powered grass cutter holder is specifically designed to efficiently cut the grass in various locations. This grass cutter holder incorporates IoT technology, allowing it to be remotely controlled through the application via a Bluetooth module. The hardware components of the proposed model include an Arduino UNO board, a solar panel, a DC motor, a motor driver, rechargeable batteries, and a Bluetooth module. The model is programmed using the Arduino UNO to control the grass cutter holder's operations (Balakrishna K, 2022). The control mechanism enables the grass cutter to move forward, backward, right, and left, as well as turn on, turn off, and stop functions. To ensure obstacle avoidance during movement, an ultrasonic sensor is connected to the head of the grass cutter prototype. This sensor helps prevent collisions with obstacles while the grass cutter is in operation.

Users can access and control these devices through applications and user interfaces such as mobile apps or web-based dashboards. IoT has applications in various fields like healthcare, agriculture, transportation, and smart homes (Shalimov, 2023). It brings benefits like improved efficiency, automation, and real-time data for better decision-making. However, security and privacy are important considerations to protect against potential risks.

Figure 2.7 Arduino UNO Board

The IoT and robotics-integrated grass cutter holder has unique features that improve its functionality. Arduino UNO as shows in Figure 2.7, as IoT platform is an open-source platform that facilitates communication and interaction between servers and hardware, enabling the automation of various tasks. It features 8 digital pins (GPIO) that can be utilized for controlling motors and other systems incorporated in the grass cutter. To power the platform, a 5V input is provided to the Vin pin. The grass cutter holder is connected to the internet, allowing remote control from any location in the world. This means that users, who have readily accessible devices like cell phones, may operate the grass cutter holder. The use of Arduino UNO software, which enables programming and control of the grass cutter's movements, including the exact rotation of its wheels, brings robotics into action.

2.5 Application of Sensor

The advent of IoT technology has enabled the integration of everyday objects into the internet. In the present time, a wide range of entities, including residences, office buildings, factories, and even entire cities, are interconnected to gather data and use it for diverse objectives. In the realm of IoT, sensors hold a crucial position in developing innovative solutions. Serve as devices that detect external information and convert it into discernible signals for both humans and machines. This process allows for efficient data acquisition and analysis, facilitating the realization of IoT-based applications. (Gharib N, et al., 2019).

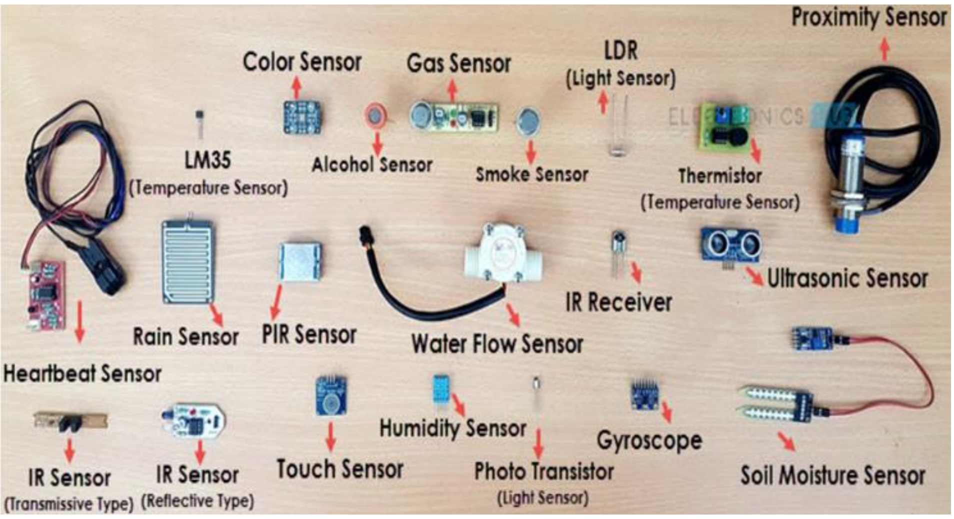


Figure 2.8 Examples of IoT sensors

Figure 2.8 shows various IoT sensors that has been used in daily life (Ravi Teja, 2021). A World of Sensors encompasses a wide range of sensor types that can be found in homes, offices, cars, and other locations. These sensors serve the purpose of simplifying our lives by performing various automated tasks. For example, motion sensors activate lights when detect presence, ensuring convenient illumination. Temperature sensors help adjust room temperature for optimal comfort. Smoke or fire sensors provide early detection and warning systems in case of emergencies. In smart homes, sensors can even automate tasks like brewing coffee or opening garage doors when a car is nearby. Sensors play a crucial role in enabling automation and enhancing the efficiency and convenience of our daily lives (Teja, 2021). Sensors are used in grass cutter holder powered by solar using IoT project to enhance the functionality and safety of the grass cutter holder. There are several sensors will be used to sync with Arduino UNO in this project.

2.5.1 Infrared Sensor

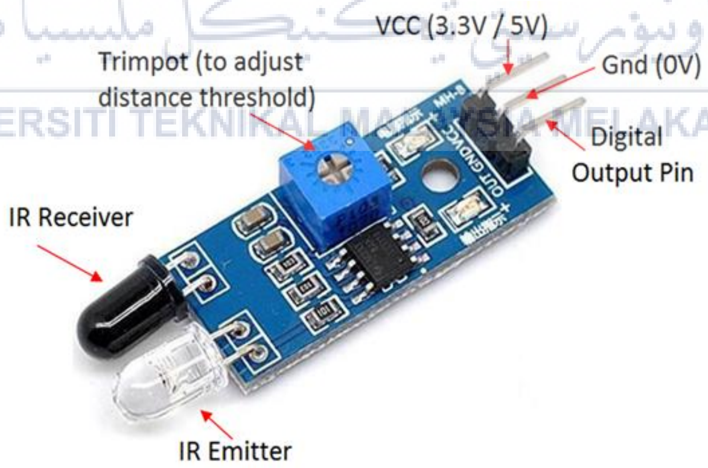


Figure 2.9 Infrared (IR) sensor module

Figure 2.9 shows the detail component of infrared (IR) sensor module (Solarduino, 2020). The IR sensor is an electronic device designed to detect and measure infrared radiation present in its surrounding environment. The discovery of infrared radiation can be attributed to the accidental observation made by astronomer William Herschel in 1800. While conducting temperature measurements of different colors of light using a prism, he noticed that the highest temperature was just beyond the red light. Infrared radiation, although part of the electromagnetic spectrum like visible light, is not visible to the human eye due to its longer wavelength. It is important to note that any object that emits heat, which includes anything with a temperature above approximately five degrees Kelvin, emits infrared radiation.

Infrared sensors can be classified into two types: active and passive. Active infrared sensors function by both emitting and detecting infrared radiation. Consist of two components which are light emitting diode (LED) and a receiver. When an object approaches the sensor, the emitted infrared light from the LED reflects off the object and is subsequently detected by the receiver. These active IR sensors serve as proximity sensors and find wide applications in obstacle detection systems, particularly in robotic devices (Jost, 2019). Figure 2.10 shows the principle of active IR sensor.

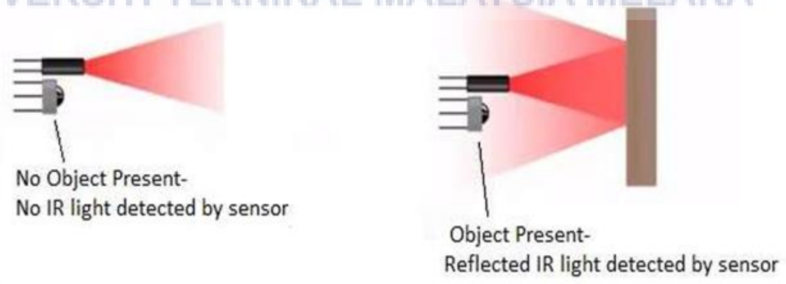


Figure 2.10 Principle of active IR sensor

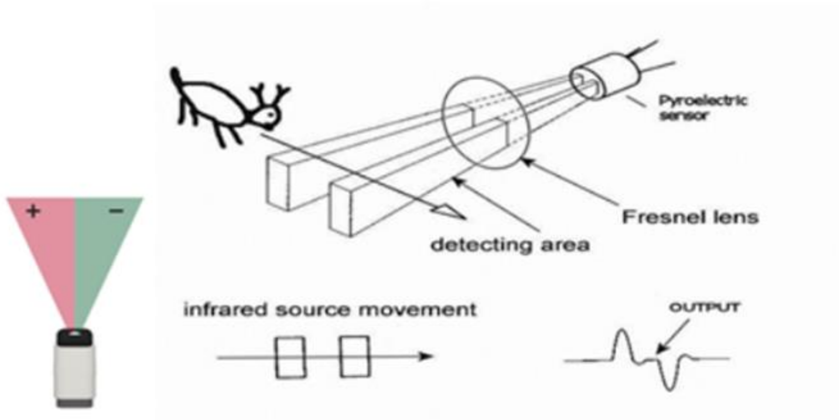


Figure 2.11 Principle of passive IR sensor

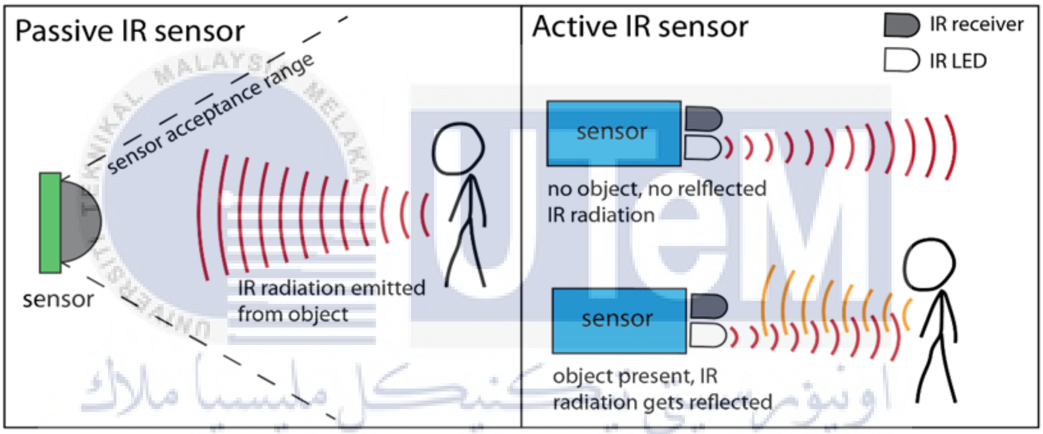


Figure 2.12 Difference between active IR sensors and passive IR sensors

Figure 2.11 shows the principle of passive IR (PIR) sensor, it has little difference from active IR sensor that shows in Figure 2.12 (Jon Bumstead,2018). Passive infrared (PIR) sensors solely detect infrared radiation without emitting it through an LED (Sharmar,2014). These sensors find widespread use in motion-based detection applications, particularly in home security systems. When an object in motion, which emits infrared radiation, enters the detection range of the PIR sensor, the variation in IR levels between the two pyroelectric elements is measured. Subsequently, the sensor sends an electronic signal to an embedded computer, which then activates an alarm (Bumstead, 2018). The infrared sensor is very useful to install in grass cutter holder project. This is because IR sensor are used for obstacle detecting which will not allow the grass cutter to hit it and according to the coding it will change the direction and again continue the cutting (Mamtaj Alam, 2019).

2.5.2 Ultrasonic sensor

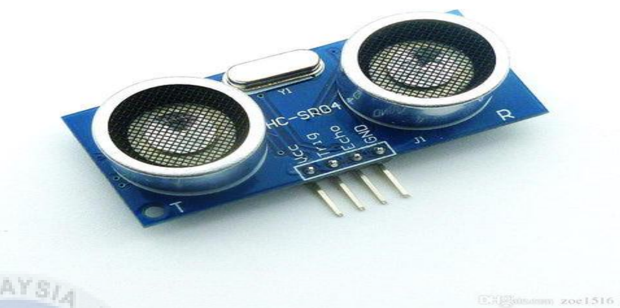


Figure 2.13 Ultrasonic sensor

An ultrasonic sensor that shows in Figure 2.13, is an electronic device utilized for measuring the distance of a target object by emitting ultrasonic sound waves and converting the reflected sound into an electrical signal. Unlike audible sound, ultrasonic waves propagate at a higher speed. The sensor consists of two primary components: the transmitter, which emits sound waves through piezoelectric crystals, and the receiver, which captures the sound waves after having traveled to and from the target.

To determine the distance between the sensor and the object, the sensor measures the time it takes for the emitted sound to reach the receiver. This calculation is performed using the formula $D = ½ T \times C$, where D represents the distance, T corresponds to the time measured, and C denotes the speed of sound, approximately 343 meters/second (Jost, 2019).

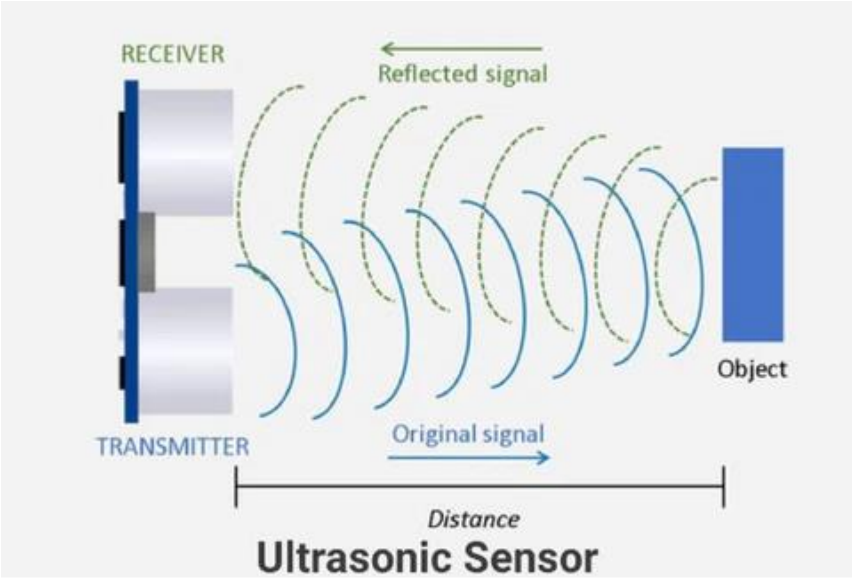


Figure 2.14 Principle of ultrasonic sensor

The operational principle of this module is straightforward as can be seen in Figure 2.14 (Robocraze,2020). It transmits an ultrasonic pulse at a frequency of 40kHz, which propagates through the air. When encountered an obstacle or object, the pulse reflects to the sensor. By determining the travel time of the pulse and utilizing the speed of sound, the distance can be accurately calculated. In terms of presence detection, ultrasonic sensors are capable of detecting objects irrespective of their colour, surface characteristics, or material composition (except for extremely soft materials like wool, which tend to absorb sound). By incorporating an ultrasonic sensor, the grass cutter holder gains the ability to accurately detect the length of grass in a lawn. This functionality allows for precise trimming of the grass. With the ultrasonic sensor in place, the grass cutter holder can be programmed to pause the trimming process until the length of the grass reaches the desired measurement. This ensures that the grass is trimmed accurately and efficiently, as it prevents over-trimming or cutting the grass too short. The ultrasonic sensor plays a crucial role in maintaining the desired length of the grass and achieving a neat and well-maintained lawn.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology refers to the specific procedures or sequence of steps used to identify, select, process, and analysis detailed project information in order to ensure its successful implementation. It provides a framework for evaluating the validity and reliability of a study as a whole. In this chapter, the flow chart, presented in Figure 3.1, has been developed and implemented to ensure the successful achievement of this project. The initial step in running this project involved defining the problem statement, which led to the determination of the project title. The project's objective was to address the identified problem, and potential solutions were established during this phase. To strengthen the project, a thorough literature study was conducted. Various designs of grass cutter holders were collected and evaluated to identify the best design option. The selected design was supported by relevant evidence, and its potential to solve the problem was assessed. If the selected design proves capable of addressing the problem, it is then imported into the Arduino software for further data analysis. This step allows for a deeper understanding and evaluation of the design's effectiveness. By following this methodology, the project aims to ensure the successful implementation of the chosen design solution and ultimately achieve the desired project outcomes.

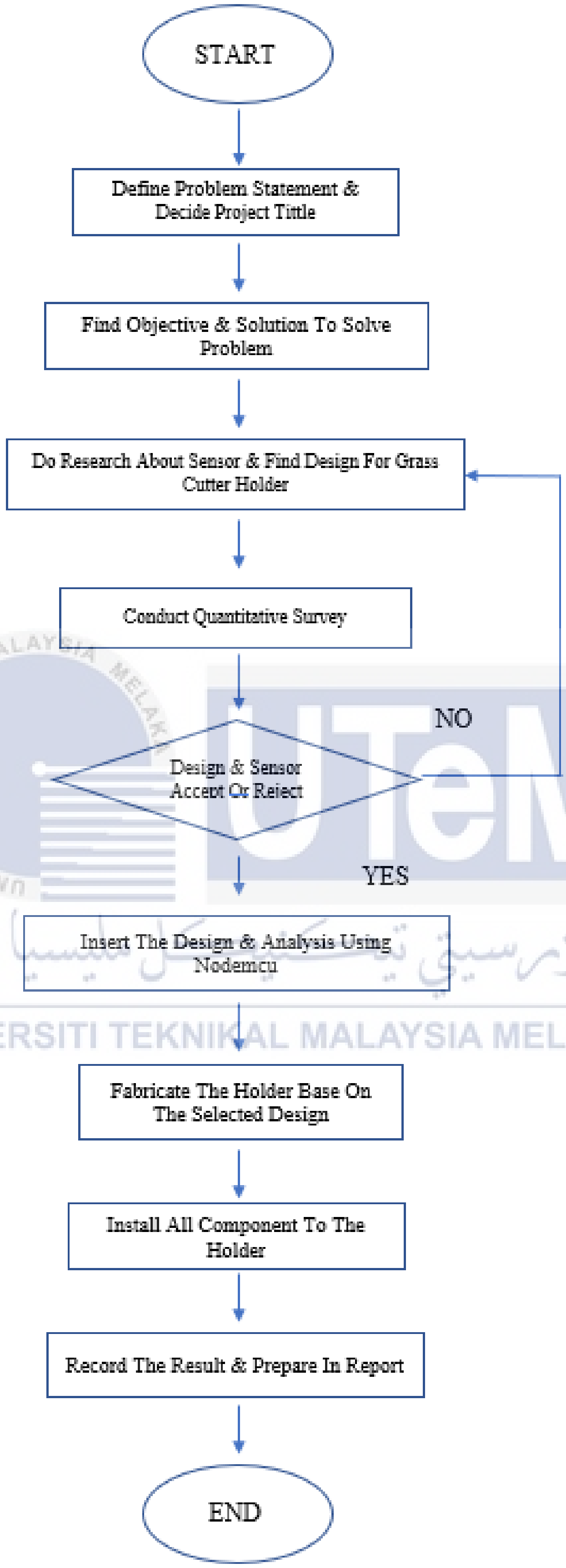


Figure 3.1 The flowchart of the project

3.2 Result of Questionnaire

Questionnaires as in Appendix B have been disseminated among individuals associated with this project, which proves highly valuable in determining the suitability of the project for grass cutter users. Moreover, the feedback obtained through these questionnaires serves as a valuable resource for enhancing the project and addressing the specific needs and requirements of the target audience. The questionnaire was created using the Microsoft Forms platform and distributed through social media. A total of 54 responses were received from the survey. Figure 3.2 shows result that grass cutter holder project is acceptable to all people.

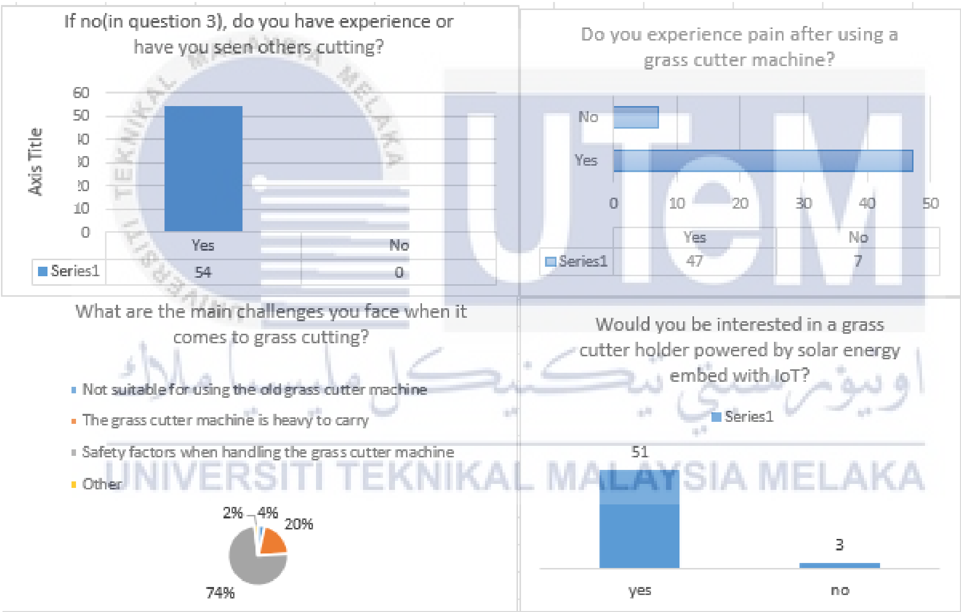


Figure 3.2 Result from the questionnaire

3.3 Conceptual Design

To ensure the optimal design for this project, several design concepts were proposed and evaluated. The design process entails exploring multiple design options before selecting the final design. Therefore, this subtopic will provide an explanation of the proposed designs.

3.3.1 Conceptual Design 1

Figure 3.3 Front view of conceptual design 1

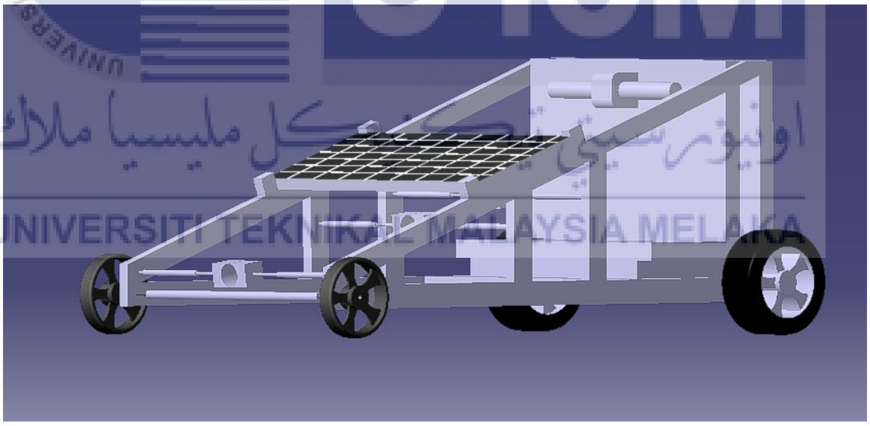


Figure 3.4 Conceptual design 1

Figure 3.3 and Figure 3.4 depict the grass cutter holder designed with four wheels, which significantly improves its stability during operation. However, due to the weight distribution and design of the holder, it may become challenging to move it forward easily. The increased weight of the holder can impact its maneuverability and may require additional effort to overcome resistance and propel it forward. The weight for this design is estimated around 17 kg. The grass cutter can be placed at rear side of grass cutter holder .

3.3.2 Conceptual Design 2

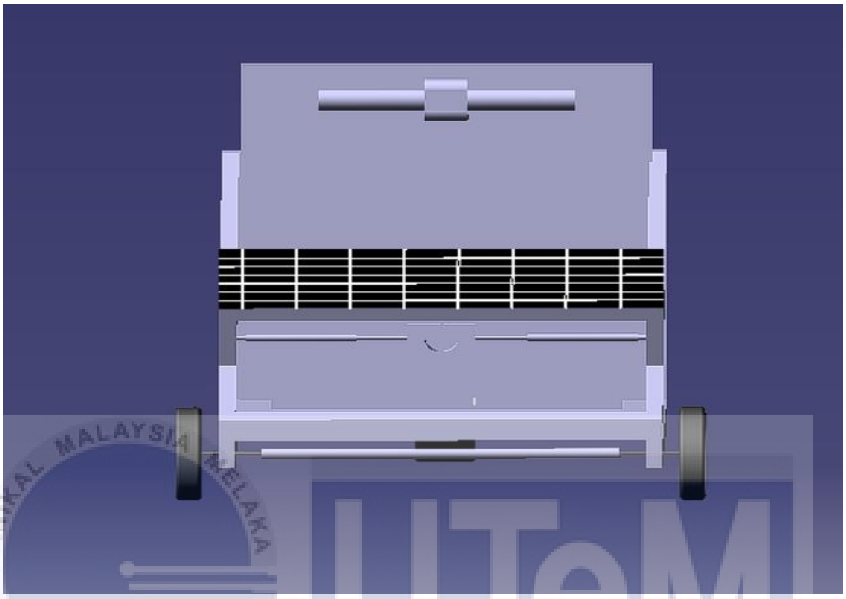


Figure 3.5 Front view of conceptual design 2

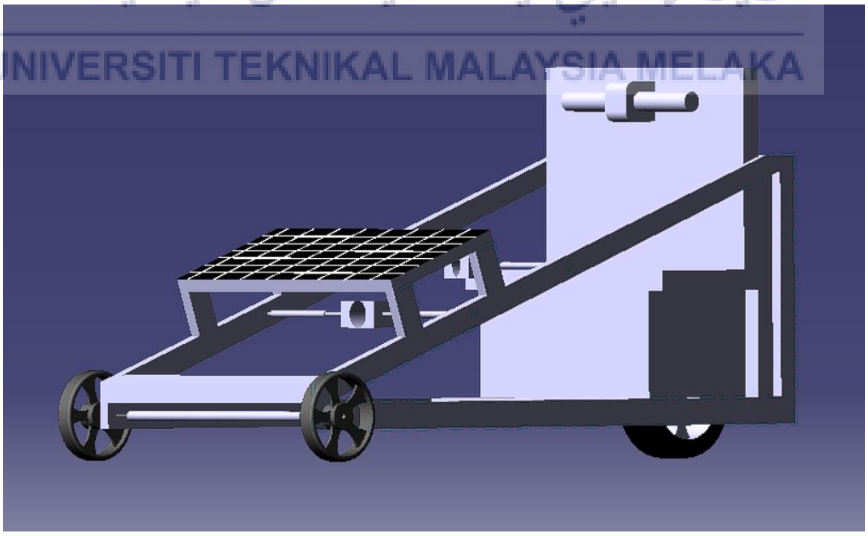


Figure 3.6 Conceptual design 2

Figure 3.5 and Figure 3.6 show the grass cutter holder with a configuration that includes three wheels, with two wheels positioned in the front and one wheel at the rear. This wheel arrangement may lead to reduced stability for the holder. Additionally, the placement of the solar panel on the holder is not optimal for efficient sunlight absorption. As a result, the grass cutter holder may experience limitations in its ability to generate sufficient power from the solar panel. The weight for this design is estimated around 30 kg. The grass cutter can be placed at rear side of grass cutter holder which same place as conceptual design 1 .

3.3.3 Conceptual Design 3

Figure 3.7 Front view of conceptual design 3

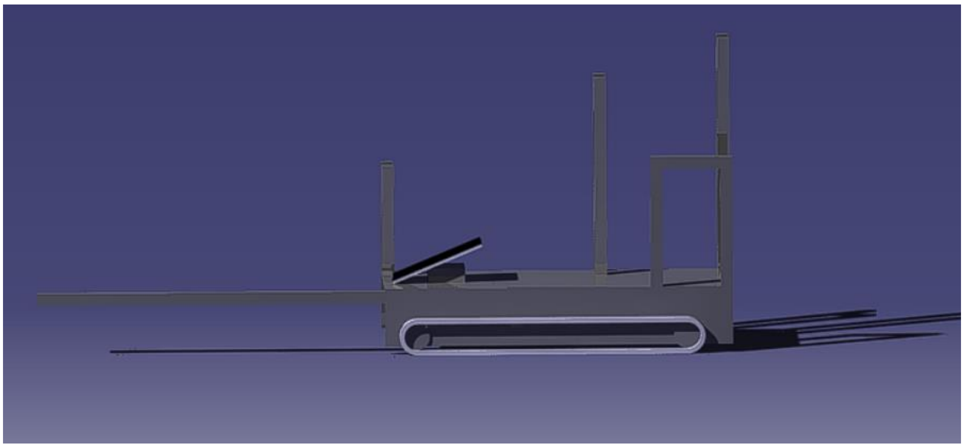


Figure 3.8 Conceptual design 3

Figure 3.7 and Figure 3.8 show the grass cutter holder that incorporates four wheels, enhancing its stability during operation. Additionally, the height of the holder is designed to be optimal, ensuring increased stability. The positioning of the solar panel on the holder is strategically optimised to maximise sunlight collection and energy generation. By carefully considering the placement of the solar panel, the grass cutter holder can effectively harness sunlight and generate the necessary power for its functionalities. The weight for this design is estimated around 20 kg. The grass cutter can be installed at rear side which palce been provided.

3.4 Selection of Design(Pugh Method)

To determine the final design for this project, the Pugh table was employed as a decision-making tool. The Pugh table is a quantitative technique widely used in engineering to rank various options within a set. This method enables a systematic evaluation of the advantages and disadvantages of each design based on specific criteria. By using the Pugh table, the rationale behind selecting the final design is reinforced. The Pugh Method utilizes a weight scale of 1, 2, or 3 to evaluate the importance of criteria. A weight of 1 signifies lower importance, while a weight of 3 indicates higher significance (Ted Hessing, 2021). This method involves several evaluation steps. Firstly, identify the crucial criteria relevant to the project or problem. Then, select a baseline alternative as a reference for comparison. This baseline establishes a benchmark for evaluation. Evaluate each design alternative against the identified criteria and assign a score of -1, 0, or +1 to indicate its performance relative to the baseline for each criterion. To consider the relative importance of the criteria, multiply the scores of each alternative by the corresponding criterion weight. Calculate the total scores by summing up the weighted scores for each alternative.

Table 3.1 Pugh table for this project

CRITERIA	WEIGHT	Conceptual Design 1	Conceptual Design 2	Conceptual Design 3
FLEXIBLITY	3	-1	0	1
DURABLE	1	1	-1	1
LOW COST	2	0	0	0
SIZE	1	-1	-1	1
STABILITY	2	0	1	0
RATE				
1		1	2	5
0		2	1	2
-1		-4	-2	0
SUMMATION		-1	1	7

Table 3.1 presents the Pugh table specifically used in this project, where weights were assigned on a scale of 1 to 3. Based on the result conceptual design 3 has the highest score of 7. This indicates that conceptual design 3 outperforms the other designs in terms of its evaluated criteria and is deemed the most favorable option among the three.

3.5 Internet of Things(IoT) System

This IoT eliminates the need for direct human-to-human or human-to-computer interaction. Through applications and user interfaces like mobile apps or web-based dashboards, users gain access to and control over these connected devices. In the case of the grass cutter holder, allowing it to be connected to the internet. This connectivity enables remote control and operation of the grass cutter holder. By using readily accessible devices such as smartphones or other connected devices, users have the convenience of managing the grass cutter holder's functions and settings remotely.

3.5.1 Sensor Selection

In this project, the selection has been made to incorporate two sensors, namely the infrared sensor and the ultrasonic sensor. The infrared sensor serves the purpose of obstacle detection, ensuring that the grass cutter avoids collisions by altering its direction through programmed instructions. On the other hand, the ultrasonic sensor is utilizing to determine the length between the grass and grass cutter holder. When the grass reaches the desired length, the ultrasonic sensor triggers a signal to automatically halt the cutting process. To operate these two sensors seamlessly, the project utilizes the Arduino software.

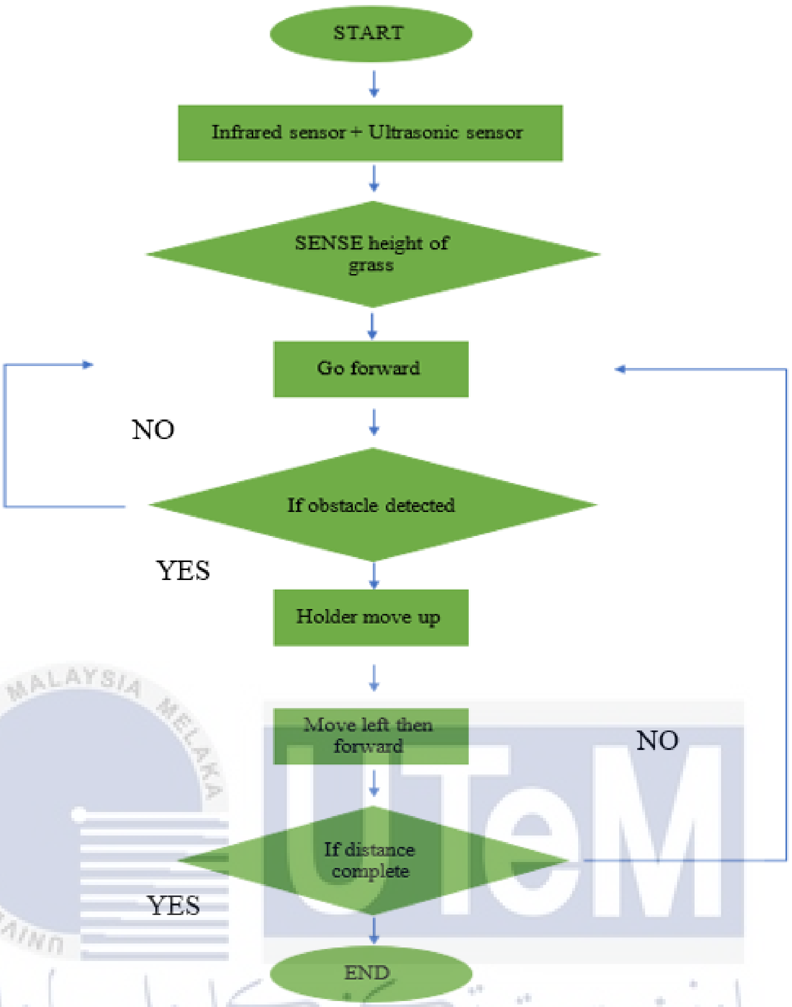


Figure 3.9 The flow chart of sensor process

Figure 3.9 shows the flow chart of sensor process. An infrared sensor as can be seen in Figure 3.10, is an electronic device that plays a crucial role in detecting and measuring infrared radiation present in the surrounding environment. Unlike visible light, which is also part of the electromagnetic spectrum, infrared radiation cannot be seen by the human eye due to its longer wavelength. In the context of a grass cutter holder, incorporating an infrared sensor is highly beneficial. It serves the important function of detecting obstacles, thereby preventing the grass cutter from colliding with objects. The sensor's signals are then used to adjust the grass cutter holder's direction based on the programmed instructions, ensuring safe and efficient operation.

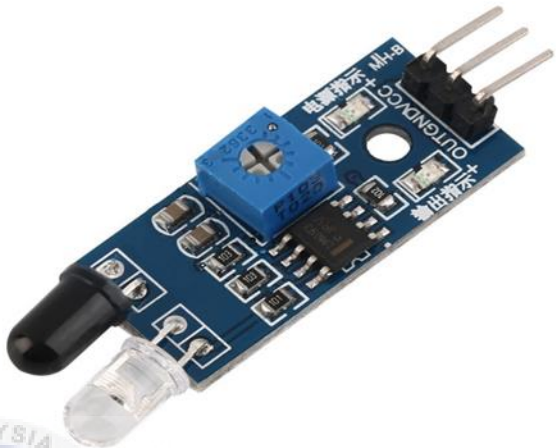


Figure 3.10 Infrared sensors

An ultrasonic sensor as can be seen in Figure 3.11 is an electronic device that plays a key role in measuring the distance of a target object by emitting ultrasonic sound waves and converting the reflected sound into an electrical signal. Unlike audible sound, ultrasonic waves propagate at a frequency higher than what the human ear can detect. In the context of a grass cutter holder, incorporating an ultrasonic sensor proves highly useful. It enables the sensor to detect the length of grass in a lawn, allowing precise trimming. By using the ultrasonic sensor, the grass cutter holder can be controlled to pause the trimming process until the length of the grass reaches the desired measurement. This ensures that the grass is trimmed accurately and efficiently.

Figure 3.11 Ultrasonic sensor

3.5.2 Board Selection

Figure 3.12 Arduino UNO board(Techmakers Innovation, 2019)

The Arduino UNO R3 board stands out as a versatile microcontroller board, as illustrated in Figure 3.12, offering a multitude of features for diverse projects. This board proves particularly advantageous for the car parking distance sensor project due to its cost-effectiveness without compromising on capabilities. Despite its economical price, the Arduino UNO R3 board provides a robust feature set crucial for various applications. It excels in value when compared to other microcontroller boards in the market, offering essential functionalities such as digital and analogue I/O pins, PWM support, and communication interfaces necessary for seamless integration of sensors and actuators. Moreover, the Arduino UNO R3 board boasts a thriving community of developers, ensuring ample documentation, tutorials, and support for beginners. The abundance of open-source libraries and examples tailored for the Arduino platform enhances usability and expedites development. Its affordability facilitates cost-effective prototyping and scalability, allowing for straightforward expansion using Arduino-compatible shields or modules if additional functionality or connectivity is needed as project advances. In Figure 3.13 shows the the Arduino UNO pinout to connect with electronic component.

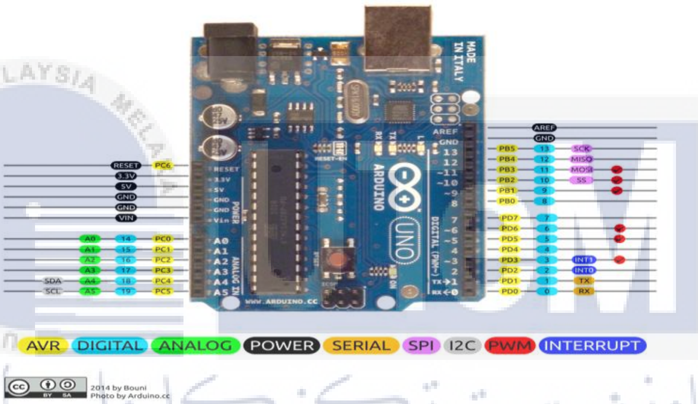


Figure 3.13 Arduino UNO pinout

3.5.3 Circuit Diagram

Figure 3.14 shows the circuit diagram IoT system of grass cutter holder. The Arduino UNO board has been successfully connected to the ultrasonic sensor, which are integral components of the grass cutter holder. These sensors are strategically installed within the grass cutter holder to enable its advanced functionalities. In Figure 3.15, the coding for the ultrasonic sensor in Arduino IDE Software are shown.

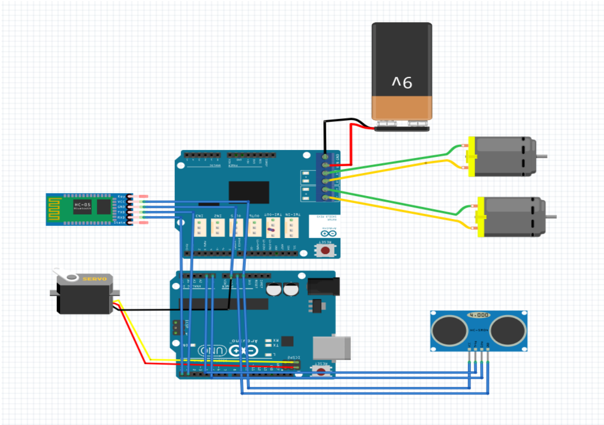


Figure 3.14 circuit diagram IoT system of grass cutter holder

```
void Obstacle() {
  distance = ultrasonic();
  if (distance <= 12) {
    Stop();
    backward();
    delay(100);
    Stop();
    L = leftsee();
    servo.write(spoint);
    delay(800);
    R = rightsee();
    servo.write(spoint);
    if (L < R) {
      right();
      delay(500);
      Stop();
      delay(200);
    } else if (L > R) {
      left();
      delay(500);
      Stop();
      delay(200);
    }
  } else {
    forward();
  }
}
```


Figure 3.15 The coding for the ultrasonic sensor in Arduino IDE Software

3.5.4 IoT connectivity module

Figure 3.16 Bluetooth module HC-05 (RAMElectronics, 2019)

The HC-05 Bluetooth module, as depicted in Figure 3.16, is a widely utilised wireless communication component in electronic projects. Operating on Bluetooth 2.0 (Class 2), it supports the Serial Port Profile (SPP) and typically functions at an operating voltage of 3.3V, with the capability to handle 5V signals. With a communication range of approximately 10 meters (Class 2 range) and an adjustable baud rate, commonly set to 9600 bps by default, the HC-05 employs UART (Universal Asynchronous Receiver-Transmitter) for interface. The Bluetooth device is named HC-05 by default, and its pairing code (PIN) is typically set to 1234 but can be customized. Operating on the 2.4 GHz ISM band, it features low power consumption, making it suitable for battery-powered projects. The HC-05 supports both master and slave modes, though it is commonly configured as a slave device. Its compact dimensions facilitate easy integration into various projects, and it may incorporate indicator LEDs to display Bluetooth connection status. Configuration adjustments, such as baud rate, device name, and pairing code, can be made using AT commands. Compatible with microcontrollers like Arduino and Raspberry Pi, the HC-05 offers a cost-effective solution for wireless communication.

3.5.5 Solar Panel

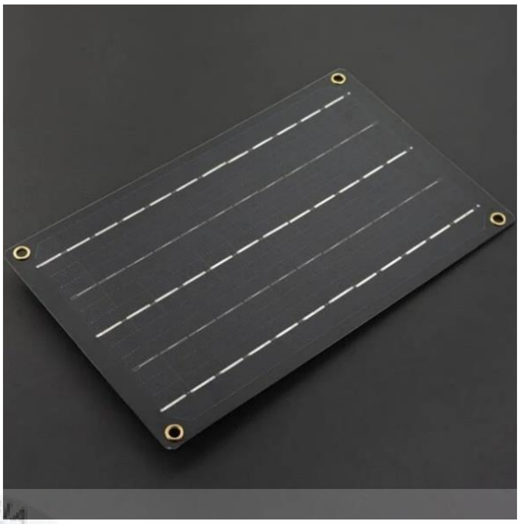


Figure 3.17 Solar panel

Solar panel as shown in Figure 3.17, is indispensable in the grass cutter holder project as it serves as a vital source of power generation. Referred to as a photovoltaic (PV) panel, the solar panel plays a pivotal role in capturing sunlight and converting it into usable electricity. A suitable type of solar panel that can be used for a project with a 12V battery is a 12V monocrystalline solar panel. Monocrystalline panels are made from a single crystal structure, typically silicon, resulting in a high level of efficiency. It have a uniform black colour and are known for their sleek appearance. Monocrystalline panels perform well in low-light conditions and have a higher power output per square foot compared to polycrystalline panels. Monocrystalline solar panels typically have high efficiency, ranging from 15% to 20% or even higher. This means it can convert a significant portion of sunlight into electrical energy. The energy storage capacity of the battery is typically measured in kilowatt-hours (kWh) and depends on the battery's capacity. In this project, the grass cutter holder use 12V battery , so solar panel has storage capacity of 1.2kWh with a capacity of 100Ah.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This project focuses on modernising a traditional grass cutter holder into a solar-powered IoT device. The primary aim is to improve the efficiency and convenience of grass cutter by implementing a holder controlled through Arduino coding. The enhanced design harnesses solar energy for power to move the grass cutter holder. The project involves thorough simulation and analysis to ensure optimal functionality, accompanied by a comprehensive discussion of the final code. Static analysis is also conducted to validate the design's structural integrity, ensuring safety and durability for the smart grass cutter holder. The incorporation of IoT technology facilitates remote monitoring and control, offering users a seamless and user-friendly experience. In essence, this innovative solution signifies a stride towards sustainable and efficient grass cutter, aligning with contemporary technological advancements and environmental considerations.

4.2 Static Analysis

This project focuses on leveraging Finite Element Analysis (FEA) within the realm of Computer-Aided Design (CAD) to optimise the structural design of a grass cutter holder. FEA serves as a sophisticated analytical method, reducing the reliance on physical prototypes and facilitating the enhancement of product quality during the design phase. Specifically, static analysis is conducted using Ansys software, a powerful tool for simulating structures, electronics, or machine components. Ansys allows for the analysis of strength, toughness, elasticity, temperature distribution, electromagnetism, and fluid flow.

In this project, the application of FEA through Ansys aims to perform stress analysis on the grass cutter holder, identifying force concentrations at specific points. The insights gained from this analysis inform decisions regarding material selection and design shapes to meet predetermined requirements, ultimately optimizing the grass cutter holder's structural integrity. The project's goal is to ensure the holder can withstand anticipated loads and environmental conditions, thereby enhancing its overall performance.

Table 4.1 Material for the holder

Material	Steel
Weight	34.097 kg
Connection type	Fixed
Maximum von Misses stress	2.2178 MPa
Minimum von Misses stress	1.6623e-004 MPa
Maximum shear stress	1.1842 MPa
Minimum shear stress	8.56e-005 MPa

Table 4.1 shows that the material for the holder is steel with density of 7.85e-006 kg mm^-3 and for this project, the shear stress and von Misses stress can be referred in Table 4.1

and the visual can be referred in Figure 4.2 and 4.3. Von Misses stress is not a real stress, but it is a measure of energy density. As a unit of energy density is same as unit of stress, von Misses is called stress. However, this von Misses stress is useful in ascertaining failure in ductile material. In Figure 4.1, the maximum shear stress for this holder is 1.1842 MPa while for the minimum shear stress is 8.56e-005 MPa. In Figure 4.3, it shows the maximum total deformation of the design is 1.0189e-002 mm.

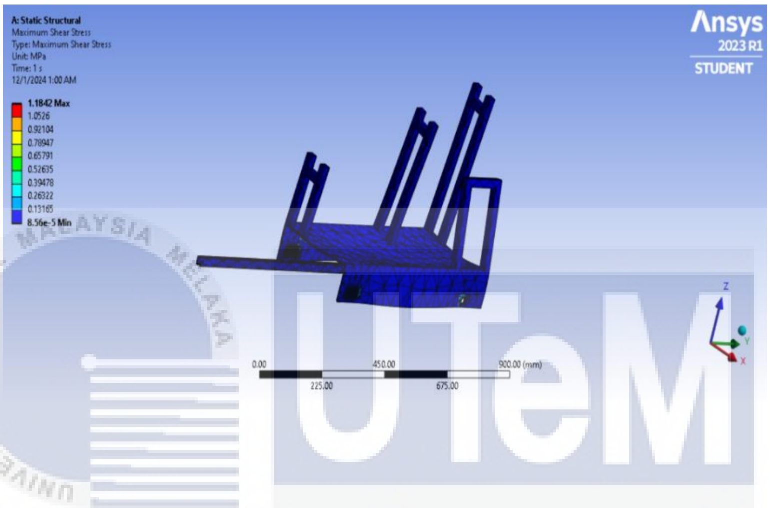


Figure 4.1 The maximum shear stress in Ansys software

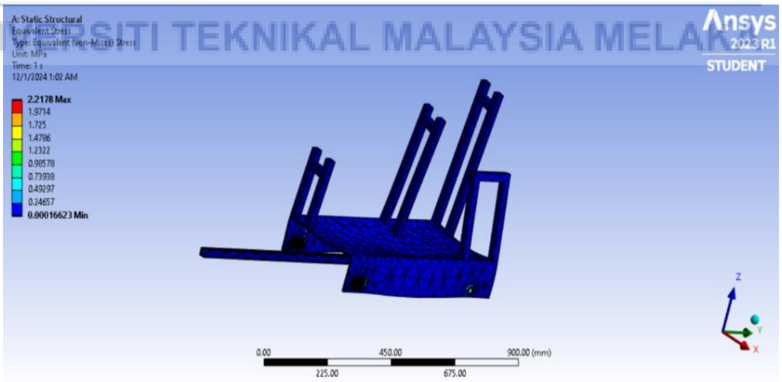


Figure 4.2 The equivalent (von-Misses) Stress in Ansys software

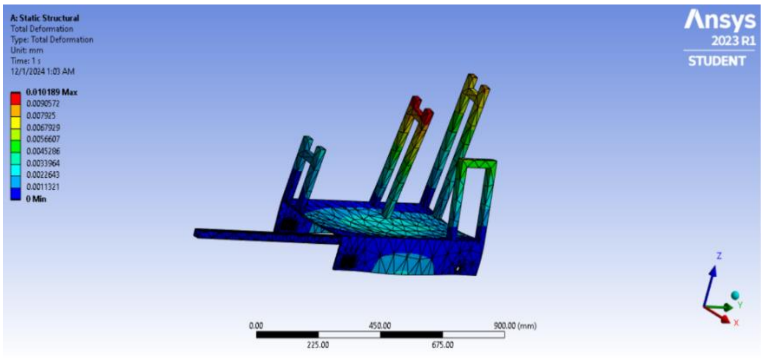


Figure 4.3 The total deformation of the design

4.2.1 Motor Performance

The time taken for this grass cutter holder were recorded based on real experiment. This time taken used to calculate the speed of grass cutter holder. In Table 4.2, the time taken for movement of holder in 3m distance is recorded.

Table 4.2 Time taken recorded

No	Distance movement	Time Taken(s)
1	1 meter	18
2	2 meters	36
3	3 meters	54

4.2.2 Battery Consumption and Endurance

Battery consumption patterns refer to the amount of energy the grass cutter holder's system utilises during various tasks. This includes movements in different directions, obstacle avoidance, and any additional functionalities. The analysis helps identify peak energy consumption periods and allows for the optimization of power management algorithms to enhance overall efficiency.

For this project, the battery consumption has been calculated to know the battery lifespan to support the grass cutter holder without charge it. Figure 4.4 has shown the calculation of battery life. The assumption of device consumption is 1300 mAh, after covering all component such as two DC motors, servo motor, ultrasonic sensor, and Bluetooth module. From calculation, it shows that the holder can run in maximum time of 2 hours.

$$\text{Battery Life} = \frac{Battery\ Capacity (mAh)}{Load\ Current\ (mA)}$$

$$\text{Battery Life} = \frac{2600\ mAh}{1300\ mA}$$

$$\text{Battery Life} = 2\ \text{hours}$$

Figure 4.4 The calculation of battery life for holder

By knowing the battery consumption, it can help calculating the area that can run by grass cutter holder. In Figure 4.5 show the formula calculate the area of grass cutting. By using the value of speed and value of battery consumption, it will get the data for distance of grass cutter holder can run. In Figure 4.5, the calculation shows the maximum area of grass cutter holder is 20.78 m^2.

$$\text{Maximum Distance} = \text{speed x maximum time}$$

$$\text{Maximum Distance} = 0.06\ \text{m/s x } 7200\text{s}$$

$$\text{Maximum Distance} = 432\ \text{m}$$

$$\text{Area} = \sqrt{432m}$$

$$\text{Area} = 20.78\ \text{m}^2$$

Figure 4.5 The calculation of maximum area

4.2.3 Solar Charging Efficiency

The charging rate, measured in watts or amps, is assessed to determine how quickly the solar panels recharge the battery. Additionally, the duration of charging cycles is considered to understand the time required to restore the battery to its full capacity. These parameters help in estimating the grass cutter holder's downtime between charging sessions. The maximum output solar panel current is 0.25 A. This value of solar panel current was used in calculating charging rate of solar with the battery that used in this project. Figure ?? shows the calculation of the charging rate by solar power. In Figure 4.6 shows the calculation of charging rates by using solar.

$$\text{Solar panel current} = \frac{Wattage}{Voltage}$$

$$\text{Solar panel current} = \frac{3\ W}{12\ v}$$

$$\text{Solar panel current} = 0.25\ \text{A}$$

$$\text{Charge Time} = \frac{Battery\ capacity(Ah)}{Solar\ current}$$

$$\text{Charge Time} = \frac{2.6\ Ah}{0.25\ A}$$

$$\text{Charge Time} = 10.4\ \text{hours}$$

$$\text{Charging rate} = \frac{0.25\ A}{10.4\ hours}$$

$$\text{Charging rate} = 0.02\ \text{Ah/hours}$$

Figure 4.6 The calculation of charging rate

4.2.4 Speed of Grass Cutter Holder Motion

In this project, speed is needed to ensure that the holder movement is relevant. Therefore, a few steps calculation was provided here in this report. In Figure 4.7, it shows the volume of the design is 1.282 m² that used to calculate the maximum load for this design. The maximum load for the design is 320.5 MN as calculated in Figure 4.8. For the calculation maximum load, the compressive strength from analysis on Ansys software was used.

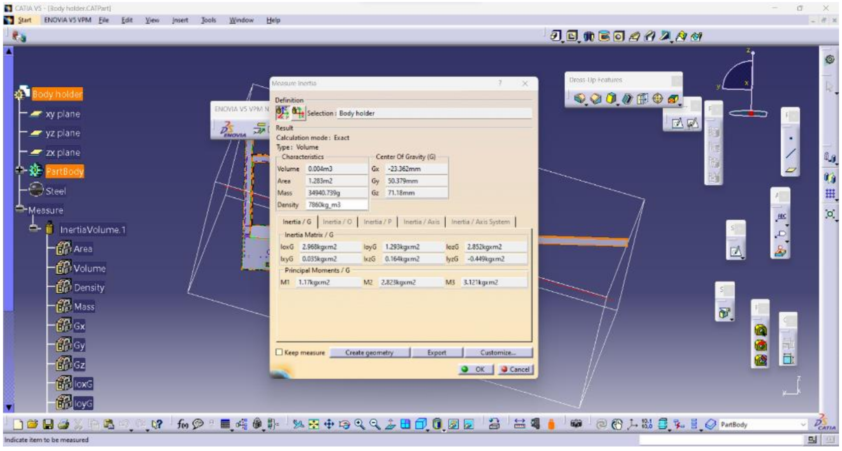


Figure 4.7 The measure inertia on Catia V5

$$Compressive\ Strength\ (MPa) = \frac{Max\ Load}{Area}$$

$$Max\ load = (Compressive\ Strength)\ (Area)$$

$$Fmax = 250MPa \times 1.282\ m^2$$

$$Fmax = 320.5\ MN$$

Figure 4.8 The calculation of maximum load on holder

The ultimate tensile strength value is 460 MPa. This value of strength was used in calculating the safety factor of the design. Figure 4.9 shows the calculation of the safety factor and the value. Since the value of safety factor is 1.84, it shows that the stress value is within the allowable limit.

$$Factor\ of\ safety = \frac{Ultimate\ Tensile\ Strength\ (MPa)}{Compressive\ Strength\ (MPa)}$$

$$Factor\ of\ safety = \frac{460\ MPa}{250\ MPa}$$

$$Factor\ of\ safety = 1.84$$

Figure 4.9 The calculation of factor of safety

4.2.5 Final Design

During the analysis for this project, the design was improvised by adding a few mechanisms. This mechanism is needed due to the movement of the holder and must be analyzed in the Ansys software. However, this mechanism is only used for analysis purposes. It was added to the design since the ultrasonic sensor needs a servo to scan the obstacle. It is located parallel with grass cutter blade. Refer to Figure 4.10 that shows the final design. The dimensions of the design can be referred in Appendix D.

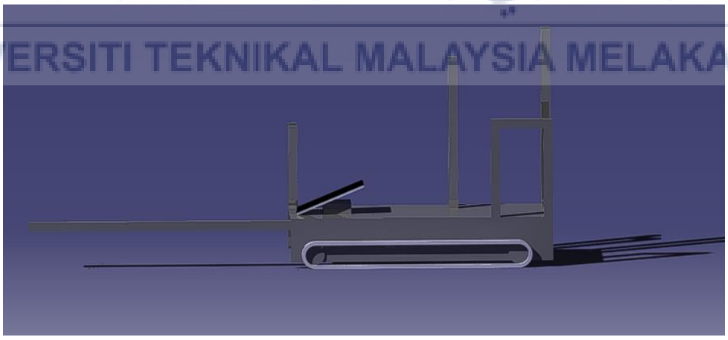


Figure 4.10 Final design

4.3 Arduino Coding & Equipment

In this topic, the coding for the Arduino software includes circuit diagram are explained in detail. The equipment or tools that are used for the circuit also is changed due to the modification of the circuit diagram and the coding.

4.3.1 Arduino Coding

The Arduino coding needs to be transformed because the presence of the motor that run the holder operation. A servo, ultrasonic sensor, and two dc motors need to be declared in the coding. Figure 4.11 shows some Arduino coding for this project in declaration of a servo and two dc motors.

```
#include <Servo.h>
#include <AFMotor.h>
#define Echo A0
#define Trig A1
#define motor 10
#define Speed 170
#define spoint 103
char value;
int distance;
int Left;
int Right;
```


Figure 4.11 The declaration of all components in this project

In this coding, the 'else if' is used due to the conditions that set up for this project. Since the grass cutter holder moves until it scan the obstacle by the ultrasonic sensor and servo motor to move the sensor. If there have any obstacle that have been scan by sensor, it will take the action to avoid the obstacle to continue the movement. Figure 4.12 shows the example of coding ‘else if’ void obstacle for this project. The full coding for this project can be referred to Appendix E.

```
void Obstacle() {
  distance = ultrasonic();
  if (distance <= 12) {
    Stop();
    backward();
    delay(100);
    Stop();
    L = leftsee();
    servo.write(spoint);
    delay(800);
    R = rightsee();
    servo.write(spoint);
    if (L < R) {
      right();
      delay(500);
      Stop();
      delay(200);
    } else if (L > R) {
      left();
      delay(500);
      Stop();
      delay(200);
    }
  } else {
    forward();
  }
}
```

Figure 4.12 The example of the “else if” coding for obstacle

In this project, the Bluetooth system is instrumental in enabling remote control capabilities for the grass cutter holder. The implementation involves the use of a Bluetooth module, such as the HC-05, establishing wireless communication between the grass cutter holder and an external device, typically a smartphone or a Bluetooth-enabled remote control. In Figure 4.13 shows the example coding ‘else if’ void Bluetooth for this project.

```
void Bluetoothcontrol() {
  if (Serial.available() > 0) {
    value = Serial.read();
    Serial.println(value);
  }
  if (value == 'F') {
    forward();
  } else if (value == 'B') {
    backward();
  } else if (value == 'L') {
    left();
  } else if (value == 'R') {
    right();
  } else if (value == 'S') {
    Stop();
  }
}
```

Figure 4.13 The example of the “else if” coding for Bluetooth

The void loop was also used in this Arduino coding due to change the function in this project system. There are two options of this grass cutter holder to move by using obstacle sensor or control using Bluetooth connection. The example of Arduino coding in applying the void loop as in Figure 4.14.


```
void loop() {
  //Obstacle();
  //Bluetoothcontrol();
```

Figure 4.14 The void loop in the Arduino coding

4.3.2 Arduino Circuit & Equipment

The Arduino circuit for this project had to be changed due to the addition in mechanism. At first, the circuit is considered simple. However, after the modification of the coding and the circuit becomes complex. The circuit for this project is shown in Figure 4.15 and Table 4.3 shows the equipment for the circuit and the quantity.

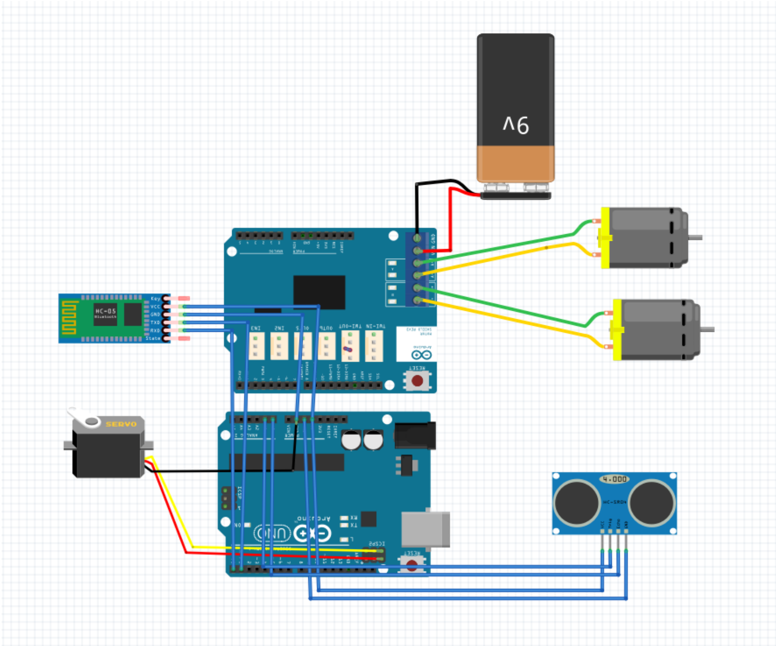


Figure 4.15 The circuit diagram for this project

Table 4.3 The equipment for the project

No	EQUIPMENTS	QUANTITY
1	Micro servo tower	1
2	Battery lipo 3s 12v	1
3	Arduino Uno R3	1
4	Connecting wire (male to male)	5

5	Connecting wire (male to female)	6
6	Ultrasonic sensor	1
7	Arduino HC-05 Bluetooth module	1
8	Arduino L293D DC motor driver	1
9	Wire tape	3
10	Switch	2

4.3.3 Sensitivity of Sensor Testing

This testing needs to be done for a sensor that is currently used in this project. This testing is important to know the susceptivity of the sensor. It affected the working system in this project. From this testing, the distance of obstacle can be determined.

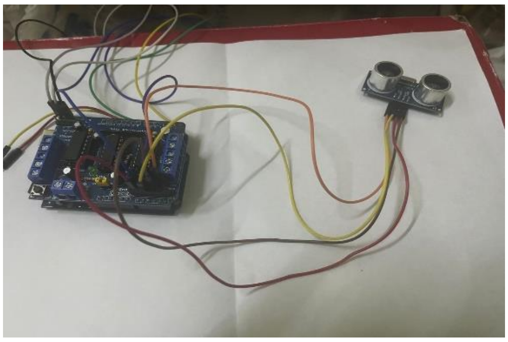
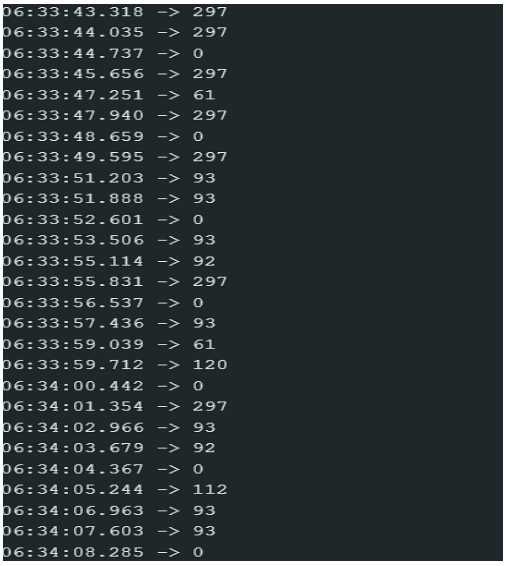


Figure 4.16 The installation of ultrasonic sensor for testing

Figure 4.16 shows the installation of the ultrasonic sensor during the testing. The equipment needed for the installation is Arduino Uno and connecting wire of female to female and male to female. The Arduino Uno also connected with the USB port directly to the Arduino software.

Figure 4.17 The clear are infront sensor

This ultrasonic sensor testing is conducted in Figure 4.17. Ultrasonic sensor is put directly in clear area without any obstacle front of the sensor. This condition showed the output as in Figure 4.18. The output appeared because of there is no obstacle scan by the sensor. This sensor cannot detect the object in front of it.



```
06:33:43.318 -> 297
06:33:44.035 -> 297
06:33:44.737 -> 0
06:33:45.656 -> 297
06:33:47.251 -> 61
06:33:47.940 -> 297
06:33:48.659 -> 0
06:33:49.595 -> 297
06:33:51.203 -> 93
06:33:51.888 -> 93
06:33:52.601 -> 0
06:33:53.506 -> 93
06:33:55.114 -> 92
06:33:55.831 -> 297
06:33:56.537 -> 0
06:33:57.436 -> 93
06:33:59.039 -> 61
06:33:59.712 -> 120
06:34:00.442 -> 0
06:34:01.354 -> 297
06:34:02.966 -> 93
06:34:03.679 -> 92
06:34:04.367 -> 0
06:34:05.244 -> 112
06:34:06.963 -> 93
06:34:07.603 -> 93
06:34:08.285 -> 0
```

Figure 4.18 The output print of no obstacle

However, if the object in front onto the sensor as in Figure 4.19, the different output produced. This is because of the object make it same situation as if it had obstacle. The output printed out and this sensor have a quick reaction as can be seen in Figure 4.20, the result output can easily change once the object remove from the sensor.

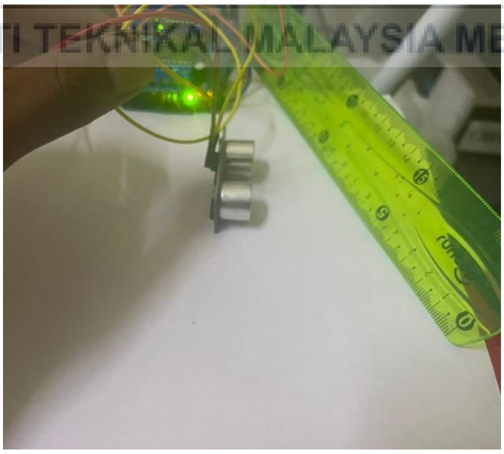


Figure 4.19 The obstacle put in front of the sensor

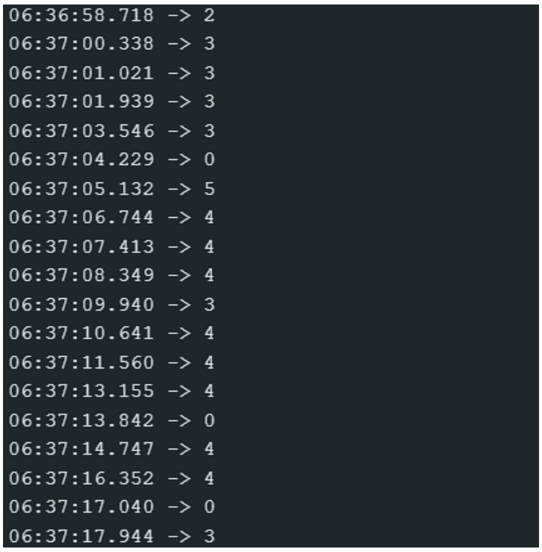


Figure 4.20 The output result of obstacle

4.4 Discussion

This project is to design the grass cutter holder powered by solar using ultrasonic sensor and Bluetooth module and Arduino software was used as a platform to make the system. In designing the holder, Catia V5 is the main software that been used. However, the analysis process was done by Ansys 16.0 software. The static analysis was done in the software and can be referred in Appendix C for full report of the analysis. To design the circuit for this automatic door, Thinkercad and Fritzing is a good choice to create the circuit in short time. For the prototype, sheet metal was used as a body holder following the shape and dimensions of the holder design and the servo is attached perpendicular with grass cutter blade. The hollow steel was used as holder for the main pipe of grass cutter machine. Figure 4.21, Figure 4.22, and Figure 4.23, show the prototype assemble process including the circuit.

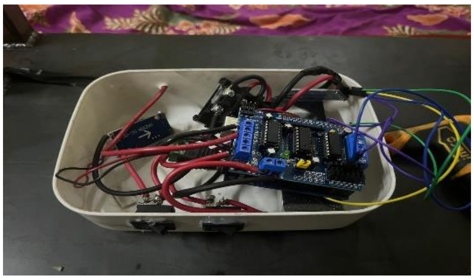


Figure 4.21 The circuit before making prototype

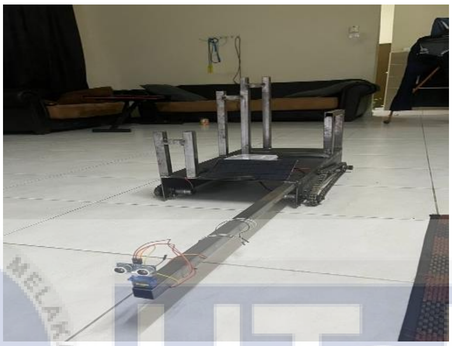


Figure 4.22 The making of prototype

Figure 4.23 Testing the prototype with grass cutter machine

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Summary of Report

The grass cutter holder with automatic control system is an innovative project designed for efficient grass cutting with integrated smart features. The project utilises a combination of DC motors, a rechargeable battery, and a solar charging system for sustainable and autonomous operation. The system incorporates Bluetooth remote control and obstacle avoidance functionalities, providing flexibility in its operation.

The analysis of the holder design by Ansys software shows that the maximum loading for the design is 301 MN and for the minimum loading is 1.388x10-6 MN. Moreover, the safety factor for this design is 1.84 which means that the strength is higher than the stress and it consider a safe design. Furthermore, this holder design is the safest design compared to the other proposed design.

The examination of the grass cutter holder's structural design through Ansys software reveals that the design can withstand a maximum loading of 320.5 MN. This robust structural capacity deems it suitable for deployment in outdoor environments, where the grass cutter holder will be positioned. Additionally, the safety factor for this design is calculated to be 1.84, indicating that the strength surpasses the applied stress levels, thereby confirming its safety and reliability. Moreover, this holder design outperforms other proposed designs in terms of safety, attributed to its ability to withstand external conditions when in the open position.

5.2 Future Work

Below is the suggestion for the future work on this project:

a) Design the body structure for the body holder that can accommodate with grass cutter machine.

b) Streamline the design and suggest an increased safety factor for the design.

c) Conduct additional research on the standard dimensions of grass cutter holders and analyze the materials used in their construction.

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APPENDICES

APPENDIX A: Gantt Chart for PSM 1 & PSM 2

No	Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	PSM title registration	■													
2	PSM1 briefing	■													
3	Briefing on project title with supervisor	■													
4	Report writing of Literature Review		■	■	■										
5	Correction of Literature Review				■	■	■	■							
6	Report writing of Introduction							■	■						
7	Correction of Introduction								■	■	■				
8	Report writing of Methodology										■	■			
9	Correction of Methodology											■	■		
10	Submission of First Draft Report												■		
11	Correction of First Draft Report												■	■	
12	Submission of Final Draft Report														■

Tasks	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Equipment Preparation														
Create and install the project														
Project Testing														
Result and Discussion														
Conclusion and Recommendation														
Pre-Submission Report														
Correction														
Final Report Submission														
Presentation														

APPENDIX B : Survey questions

1. Gender *

- Man
- Woman

2. Age (years old) *

- 21-29
- 30-39
- 40-49
- 50-59
- 60 and above

3. Do you have any grassy areas or lawn in your home? *

- Yes
- No

4. If no(in question 3), do you have experience or have you seen others cutting? *

- Yes
- No

5. How do you currently maintain the grass? *

- Manual cutting
- Hired service

6. How often do you cut the grass? *

- Once every two weeks
- Once every month
- Once during the growing season

7. What are the main challenges you face when it comes to grass cutting? *

- The grass cutter machine is heavy to carry
- Safety factors when handling the grass cutter machine
- Not suitable for using the old grass cutter machine
- Other

8. Do you experience pain after using a grass cutter machine? *

- Yes
- No

9. Would you be interested in a grass cutter holder powered by solar energy embed with IoT? *

- Yes
- No

10. What are your expectations from such a solution? *

- Cost savings
- Convenience
- Reduced manual labour
- Other

11. According to your preferences, what are the features that need to be in the grass cutter holder that you want? *

	Agree	unnecessary	Disagree
Light	○	○	○
Durable	○	○	○
Rustproof	○	○	○
Waterproof	○	○	○
Easy to use	○	○	○
Attractive design	○	○	○

12. Would you prefer a user-friendly interface for controlling and monitoring the grasscutter holder? *

- Yes
- No

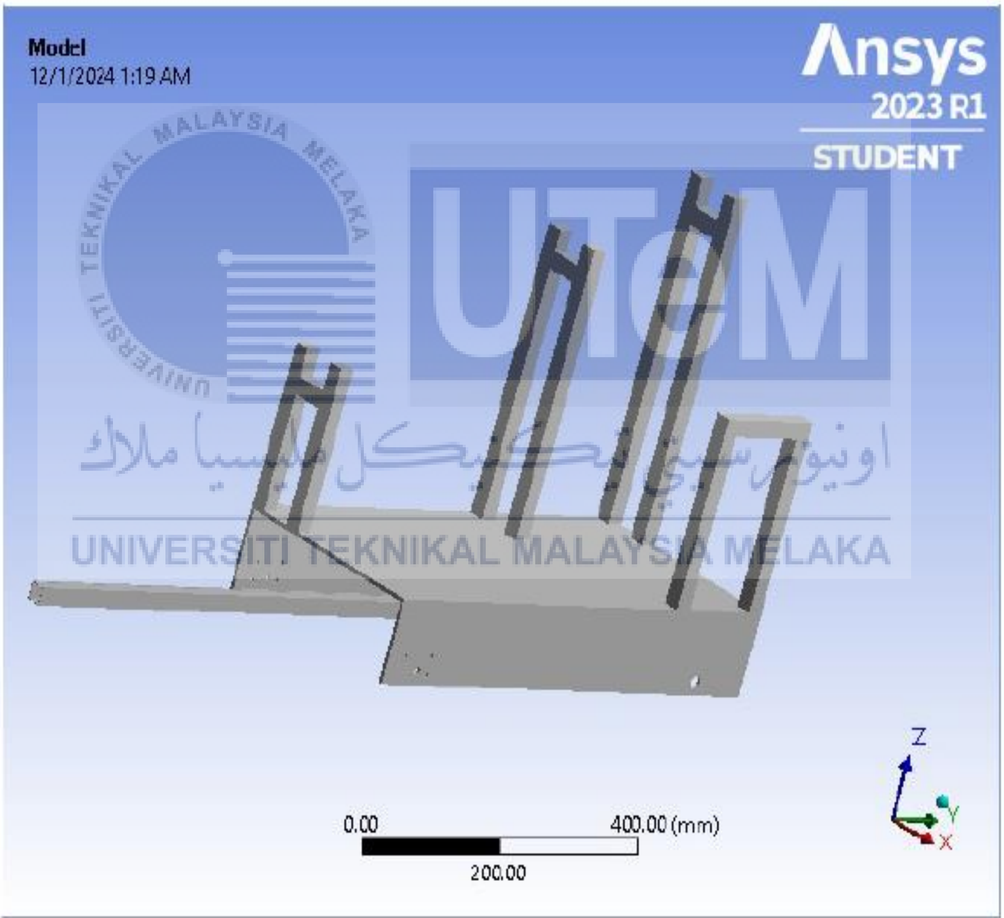
13. What value are you willing to pay for this new design of a grass cutter holder *

- RM 90-RM 150
- RM 150-RM 200
- RM 200-RM 300

APPENDIX C : Full report static analysis on Ansys software

Project*

First Saved	Thursday, January 11, 2024
Last Saved	Thursday, January 11, 2024
Product Version	2023 R1
Save Project Before Solution	No
Save Project After Solution	No



Units

TABLE 1

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4)

TABLE 2
Model (A4) > Geometry Imports

Object Name	*Geometry Imports*
State	Solved

TABLE 3
Model (A4) > Geometry Imports > Geometry Import (A3)

Object Name	*Geometry Import (A3)*
State	Solved
Definition	
Source	C:\Users\Mizan\Desktop\ansys megat\Body holder.igs
Type	Iges
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;DS

Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	Program Tolerance
Stitch Tolerance	0.0000001
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

Geometry

TABLE 4
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\Mizan\Desktop\ansys megat\Body holder.igs
Type	Iges
Length Unit	Millimeters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	340. mm
Length Y	1440. mm
Length Z	610. mm
Properties	
Volume	4.4454e+006 mm³
Mass	34.897 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	18457
Elements	9502
Mesh Metric	None
Update Options	
Assign Default Material	No
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent

Parameter Key	ANS;DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	Program Tolerance
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 5
Model (A4) > Geometry > Parts

Object Name	*Body holder-FreeParts|PartBody*
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Treatment	None
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	340. mm
Length Y	1440. mm
Length Z	610. mm
Properties	
Volume	4.4454e+006 mm³
Mass	34.897 kg
Centroid X	-23.362 mm
Centroid Y	50.378 mm
Centroid Z	71.178 mm
Moment of Inertia Ip1	2.8193e+006 kg·mm²
Moment of Inertia Ip2	1.1681e+006 kg·mm²
Moment of Inertia Ip3	3.1175e+006 kg·mm²
Statistics	
Nodes	18457
Elements	9502
Mesh Metric	None

TABLE 6
Model (A4) > Materials

Object Name	*Materials*
State	Fully Defined
Statistics	
Materials	1
Material Assignments	0

Coordinate Systems

TABLE 7
Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Mesh

TABLE 8
Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Use Geometry Setting
Defaults	
Physics Preference	Mechanical
Element Order	Program Controlled
Element Size	Default
Sizing	
Use Adaptive Sizing	Yes
Resolution	Default (2)
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Span Angle Center	Fine
Initial Size Seed	Assembly
Bounding Box Diagonal	1600.4 mm
Average Surface Area	15842 mm²
Minimum Edge Length	6.0 mm
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Aggressive Mechanical

Target Element Quality	Default (5.e-002)
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	18457
Elements	9502
Show Detailed Statistics	No

Static Structural (A5)

TABLE 9
Model (A4) > Analysis

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 10
Model (A4) > Static Structural (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Off
Solver Pivot Checking	Program Controlled
Large Deflection	Off

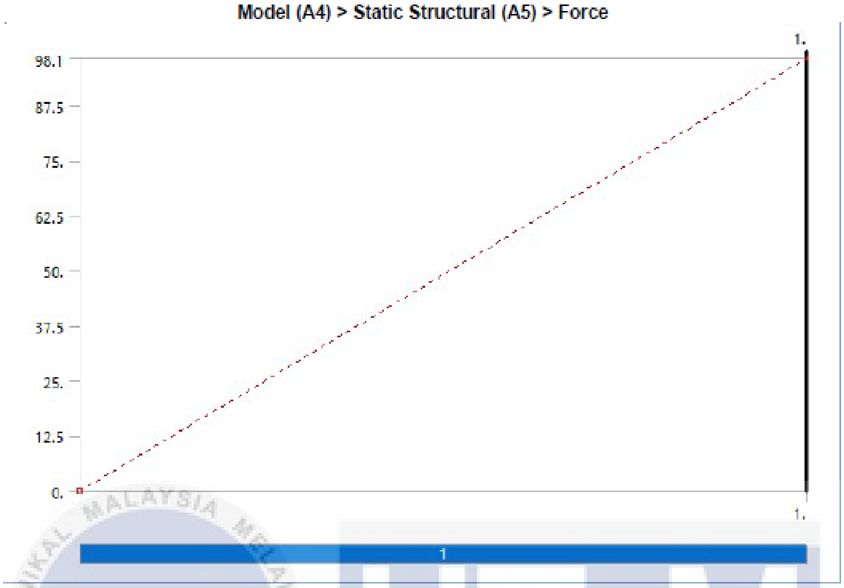
Inertia Relief	Off
Quasi-Static Solution	Off
Rotordynamics Controls	
Coriolis Effect	Off
Restart Controls	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
Combine Restart Files	Program Controlled
Nonlinear Controls	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Program Controlled
Advanced	
Inverse Option	No
Contact Split (DMP)	Off
Output Controls	
Stress	Yes
Back Stress	No
Strain	Yes
Contact Data	Yes
Nonlinear Data	No
Nodal Forces	No
Volume and Energy	Yes
Euler Angles	Yes
General Miscellaneous	No
Contact Miscellaneous	No
Store Results At	All Time Points
Result File Compression	Program Controlled
Analysis Data Management	
Solver Files Directory	C:\Users\Mizan\Desktop\ansys megat\analysis\holder_files\dp0\SYS\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Contact Summary	Program Controlled
Delete Unneeded Files	Yes
Nonlinear Solution	No
Solver Units	Active System
Solver Unit System	nmm

TABLE 11
Model (A4) > Static Structural (A5) > Loads

Object Name	*Force*	*Fixed Support*	*Fixed Support 2*
State	Fully Defined		
Scope			
Scoping Method	Geometry Selection		
Geometry	1 Face	10 Faces	
Definition			
Type	Force	Fixed Support	

Define By	Vector	
Applied By	Surface Effect	
Magnitude	98.1 N (ramped)	
Direction	Defined	
Suppressed	No	

FIGURE 1
Model (A4) > Static Structural (A5) > Force



Solution (A6)

TABLE 12
Model (A4) > Static Structural (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	3. s
MAPDL Memory Used	593. MB
MAPDL Result File Size	6.3125 MB
Post Processing	
Beam Section Results	No
On Demand Stress/Strain	No

TABLE 13
Model (A4) > Static Structural (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Identify Element Violations	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

TABLE 14
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*	*Normal Stress*	*Maximum Shear Stress*
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
Definition				
Type	Total Deformation	Equivalent (von-Mises) Stress	Normal Stress	Maximum Shear Stress
By	Time			
Display Time	Last			
Separate Data by Entity	No			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Orientation			X Axis	
Coordinate System			Global Coordinate System	
Results				
Minimum	0. mm	1.6623e-004 MPa	-1.26 MPa	8.56e-005 MPa
Maximum	1.0189e-002 mm	2.2178 MPa	1.0798 MPa	1.1842 MPa
Average	3.5885e-004 mm	0.11056 MPa	-2.1121e-003 MPa	6.1588e-002 MPa
Minimum Occurs On	Body holder-FreeParts|PartBody			
Maximum Occurs On	Body holder-FreeParts|PartBody			
Information				
Time	1. s			
Load Step	1			
Substep	1			
Iteration Number	1			
Integration Point Results				
Display Option		Averaged		

Average Across Bodies		No

FIGURE 2
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

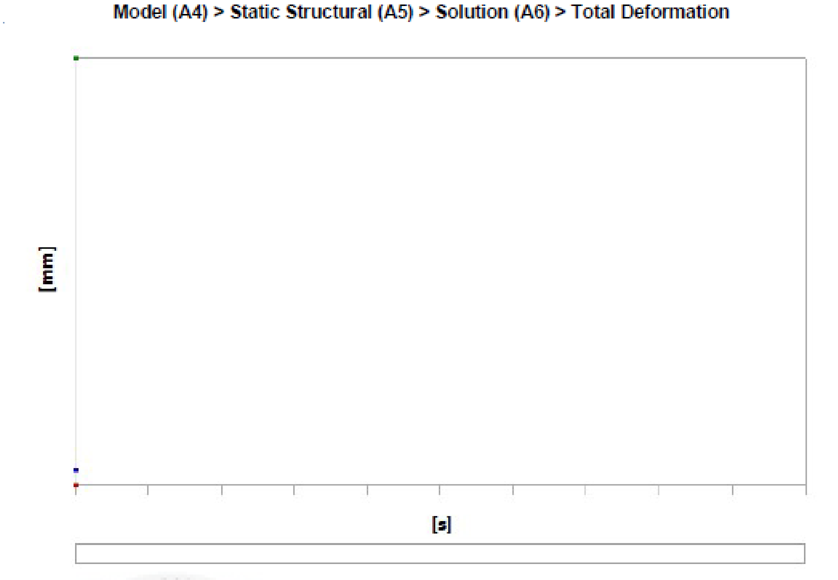


TABLE 15
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.	0.	1.0189e-002	3.5885e-004

FIGURE 3
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

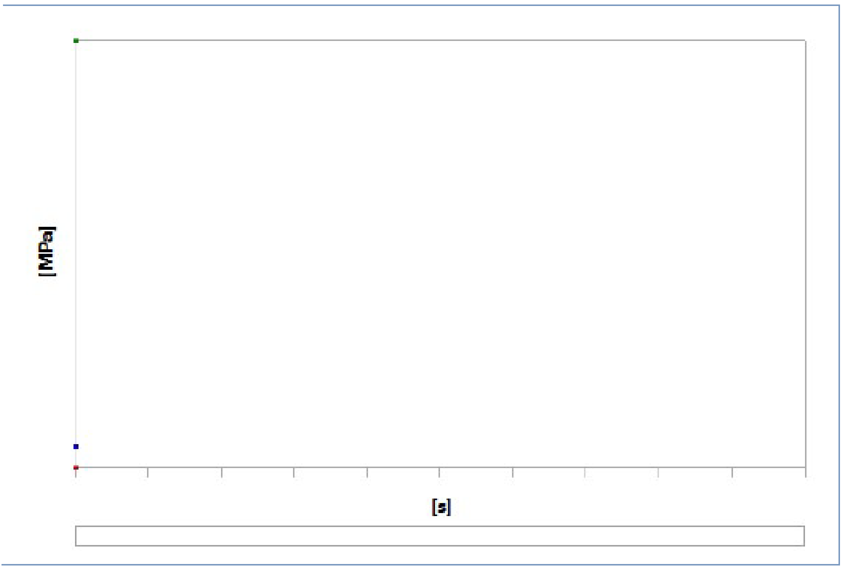


TABLE 16
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	1.6623e-004	2.2178	0.11056

FIGURE 4
Model (A4) > Static Structural (A5) > Solution (A6) > Normal Stress

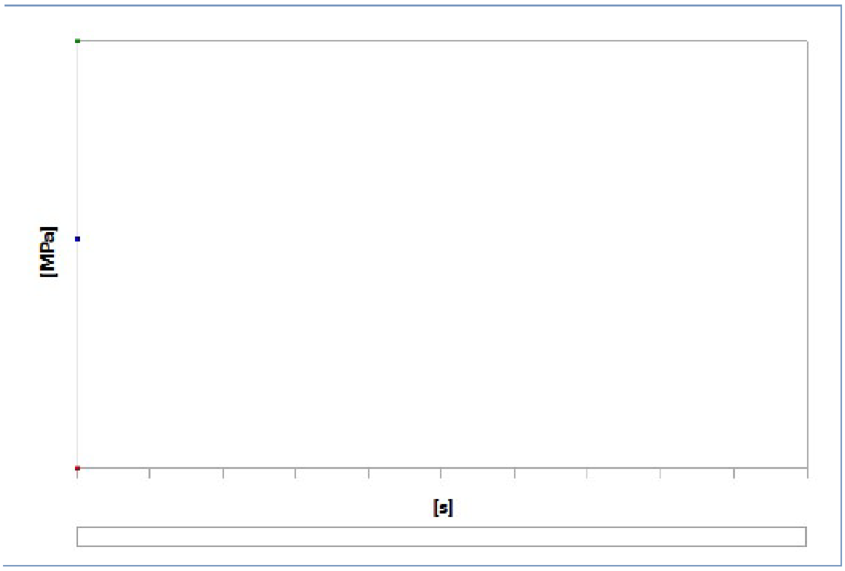


TABLE 17
Model (A4) > Static Structural (A5) > Solution (A6) > Normal Stress

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	-1.26	1.0798	-2.1121e-003

FIGURE 5
Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Shear Stress

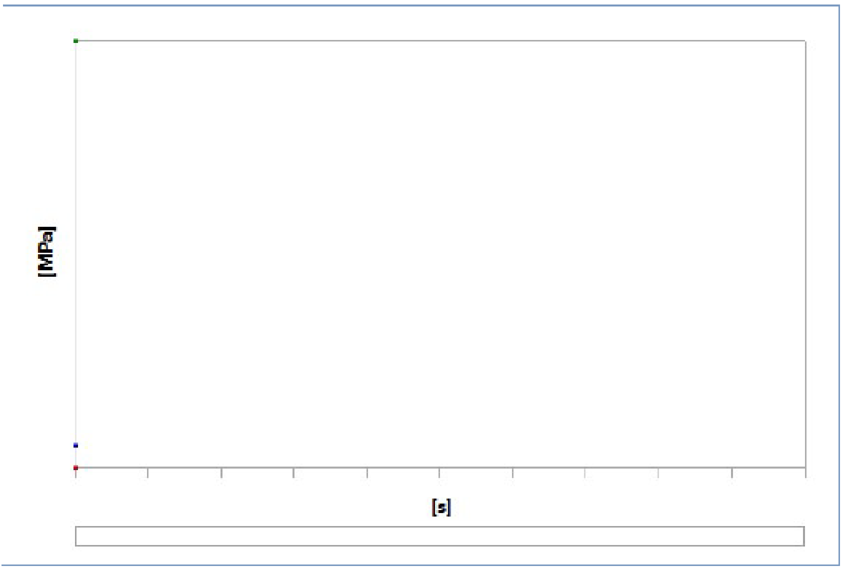


TABLE 18
Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Shear Stress

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	8.56e-005	1.1842	6.1588e-002

Material Data

Structural Steel

TABLE 19
Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

TABLE 20
Structural Steel > Color

Red	Green	Blue
132	139	179

TABLE 21
Structural Steel > Compressive Ultimate Strength

Compressive Ultimate Strength MPa
0

TABLE 22

Structural Steel > Compressive Yield Strength

Compressive Yield Strength MPa
250

TABLE 23
Structural Steel > Tensile Yield Strength

Tensile Yield Strength MPa
250

TABLE 24
Structural Steel > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
460

TABLE 25
Structural Steel > Isotropic Secant Coefficient of Thermal Expansion

Zero-Thermal-Strain Reference Temperature C
22

TABLE 26
Structural Steel > S-N Curve

Alternating Stress MPa	Cycles	Mean Stress MPa
3999	10	0
2827	20	0
1896	50	0
1413	100	0
1069	200	0
441	2000	0
262	10000	0
214	20000	0
138	1.e+005	0
114	2.e+005	0
86.2	1.e+006	0

TABLE 27
Structural Steel > Strain-Life Parameters

Strength Coefficient MPa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient MPa	Cyclic Strain Hardening Exponent
920	-0.106	0.213	-0.47	1000	0.2

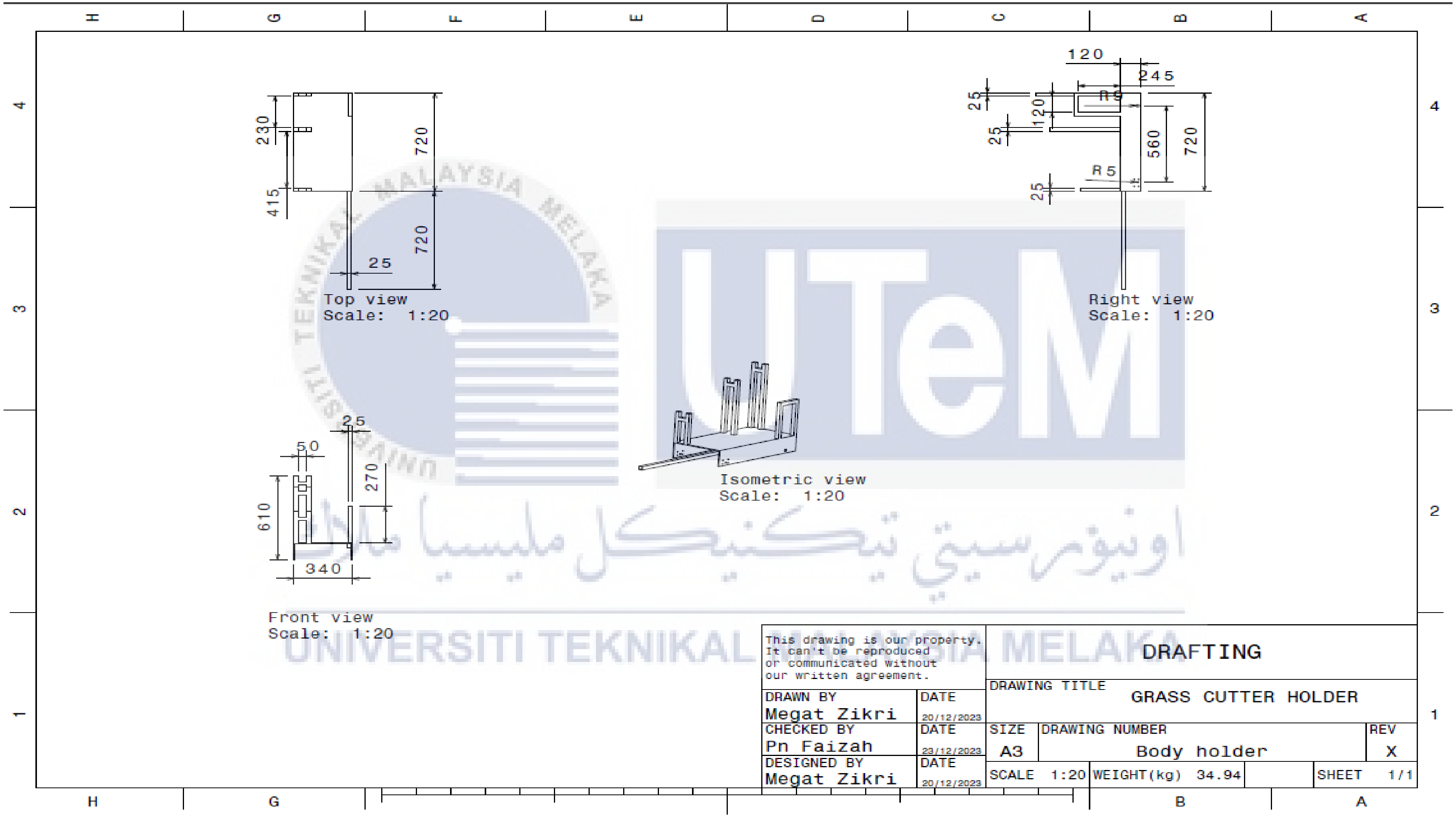
TABLE 28
Structural Steel > Isotropic Elasticity

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa	Temperature C
2.e+005	0.3	1.6667e+005	76923	

TABLE 29
Structural Steel > Isotropic Relative Permeability

Relative Permeability
10000

APPENDIX D : Drafting design



APPENDIX E : The full Arduino coding for the grass cutter holder

```
#include <Servo.h>
#include <AFMotor.h>
#define Echo A1
#define Trig A2
#define motor 10
#define Speed 255
#define spoint 103
char value;
int distance;
int Left;
int Right;
int L = 0;
int R = 0;
int L1 = 0;
int R1 = 0;
Servo servo;
AF_DCMotor M1(1);
AF_DCMotor M2(2);
void setup() {
  Serial.begin(9600);
  pinMode(Trig, OUTPUT);
  pinMode(Echo, INPUT);
  servo.attach(motor);
  M1.setSpeed(Speed);
  M2.setSpeed(Speed);
}
void loop() {
  Obstacle();
  Bluetoothcontrol();

}
void Bluetoothcontrol() {
  if (Serial.available() > 0) {
    value = Serial.read();
    Serial.println(value);
  }
  if (value == 'F') {
    forward();
  } else if (value == 'B') {
    backward();
  } else if (value == 'L') {
    left();
  } else if (value == 'R') {
    right();
  } else if (value == 'S') {
```

```
    Stop();
  }
}
void Obstacle() {
  distance = ultrasonic();
  if (distance <= 12) {
    Stop();
    backward();
    delay(100);
    Stop();
    L = leftsee();
    servo.write(spoint);
    delay(800);
    R = rightsee();
    servo.write(spoint);
    if (L < R) {
      right();
      delay(500);
      Stop();
      delay(200);
    } else if (L > R) {
      left();
      delay(500);
      Stop();
      delay(200);
    }
  } else {
    forward();
  }
}

// Ultrasonic sensor distance reading function
int ultrasonic() {
  digitalWrite(Trig, LOW);
  delayMicroseconds(4);
  digitalWrite(Trig, HIGH);
  delayMicroseconds(10);
  digitalWrite(Trig, LOW);
  long t = pulseIn(Echo, HIGH);
  long cm = t / 29 / 2; //time convert distance
  Serial.println(cm); // Print the distance for debugging
  return cm;
}
void forward() {
  M1.run(FORWARD);
  M2.run(FORWARD);
}
void backward() {
  M1.run(BACKWARD);
  M2.run(BACKWARD);
```

```
}
void right() {
  M1.run(BACKWARD);
  M2.run(FORWARD);
}
void left() {
  M1.run(FORWARD);
  M2.run(BACKWARD);
}
void Stop() {
  M1.run(RELEASE);
  M2.run(RELEASE);
}
int rightsee() {
  servo.write(20);
  delay(800);
  Left = ultrasonic();
  return Left;
}
int leftsee() {
  servo.write(180);
  delay(800);
  Right = ultrasonic();
  return Right;
}
```