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Senior Design Project Report

Design of Robot Lawn Mower

Team 08

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Abstract

A robot lawn mower is a machine that is fully capable of cutting grass without human involvement. They are fully autonomous in their operation, and will cut grass at a desired preset length by the user. Cutting grass manually is a method that is still being used today; however, it is a very time-consuming task. With a robot lawn mower; places like public parks, sport fields, and residential gardens, can save time and labor costs by opting to use a robotic lawn mower. Furthermore, our robotic lawn mower utilizes a solar panel and a rechargeable battery for operation; thus, being more environmentally friendly and saving energy costs. Moreover, our automated solar grass mower is fully capable of grass cutting without the need of any human interaction. Our aim is to reduce costs by relying on renewable energy, and eliminate the need for human involvement to operate the machine.

Acknowledgments

We would like to record our appreciation for our project advisor Dr. Fraj Alshmri for his continuous contribution and guidance towards this project. Furthermore, we thank the chairman of the mechanical engineering department Dr. Faramarz Djavanroodi for his support.

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Abstract

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Chapter 1: Introduction

1.1 Project Definition

This project is about the design, fabrication and performance evaluation of a solar powered grass cutting machine. A lawn mower is a device with revolving blades that cuts the grass in the lawn evenly. Lawn mowing is the process of trimming grasses to a specific height usually for aesthetics, garnishing, or sport purposes. A grass cutting machine can be powered by petroleum or diesel electrically, or with a solar power panel that charges a battery inside the machine. petroleum or diesel-powered grass cutters are usually noisy and produce emissions. Opting for a solar powered option can be cost-effective in the long term, in addition to producing no emission.

In this project we will design and manufacture a new type of grass cutter to be more advance, also more helpful. In this project, we will change the old lawn mower and replace it with disk cutter work in two different directions, and we will make the grass cutter simple and cheap, also this cutter will help to cut sleepy grass. We will design our solar grass cutter to be environmentally friendly; In addition to keeping the machine working without wires or gasoline.

1.2 Objectives

- Design a small-scale grass cutting machine
- Design a cutting blade with different height adjustments
- Utilize solar energy to reduce costs and emissions
- Easily transportable machine

1.3 Applications

- Sports Field
- Playgrounds

- Residential Gardens and Lawns
- Public Parks

Chapter 2: Literature Review

2.1 Project Background

In the past and till today, many facilities, such as hotels, hospitals, schools, etc. rely on human involvement to cut and trim grass in their facility. A laborer may use a power lawn mowing device but he/she would still need to manually operate the device, this is mainly due to the fact that in the past most automatic lawn mowers were expensive and unreliable; however, recent advancements in technology changed that perception, in today's market there are many options for an automatic lawn mower, with different capabilities and price range.

Much of the market lawn mowers use cylinder mowing blades; mainly because of the cheaper costs to make these blades and ease of use; however, we found a significant disadvantage to using this type of cutting blades, mostly because this type of mower can generally only cut short grass and is best suited to formal lawned areas. Instead, we chose a rotary disk mower blade. First, it can handle tough conditions while maintaining clean cutting performance, maneuverability, and durability. Second, it offers more cutting width options. Third, due to the high cutting efficiency it can trim or cut lawns faster than other alternatives; as a result, it reduces overall cutting time.

2.2 Previous Work

According to M. W. Priest, "Many of these everyday activities involve the use of small internal combustion engines, such as those used extensively for lawn care and maintenance. These engines fall into a group classified as small utility engines, a group that is dominated by the petrol-powered two-stroke and four-stroke engines used to drive lawn-mowers. In some areas in the US, the contribution of lawn-mowers to total hydrocarbon emissions was found to be as high as 13% (Yumlu, 1994)." We can conclude that small combustion engines same as those found in lawn cutting devices, can significantly raise hydrocarbon emissions; therefore, more solar operated lawn mowers are needed in the market to reduce the harmful emissions emitted from petrol and diesel engines (see table 1) [1].

Table 1. Emissions rates and fuel consumption of 2-stroke engines

| Age (yr) | Engine ID No | CO | CO ₂ | CH ₄ | NMHC | NO _x as NO ₂ | Fuel Cons (ml/min) |
|----------|--------------|-----|-----------------|-----------------|------|------------------------------------|--------------------|
| 0.01 | 10 | 563 | 707 | 19.0 | 219 | 0.54 | 16.6 |
| 3 | 4 | 782 | 695 | 21.1 | 325 | | 21.3 |
| 3 | 9 | 319 | 648 | 6.6 | 92 | 0.28 | 10.3 |
| 5 | 8 | 697 | 816 | 21.3 | 246 | 1.31 | 19.5 |
| 7 | 6 | 887 | 511 | 33.0 | 519 | 2.61 | 25.7 |
| 9 | 1 | 817 | 970 | 19.0 | 216 | - | 21.2 |
| 12 | 7 | 941 | 533 | 43.1 | 476 | 1.96 | 25.7 |
| 15 | 5 | 838 | 767 | 27.1 | 249 | 0.66 | 20.9 |
| 21 | 2 | 890 | 496 | 42.6 | 494 | 0.84 | 25.3 |
| 22 | 3 | 574 | 1226 | 5.94 | 97 | 3.38 | 17.4 |
| Average | | 731 | 737 | 23.9 | 293 | 1.45 | 20.4 |

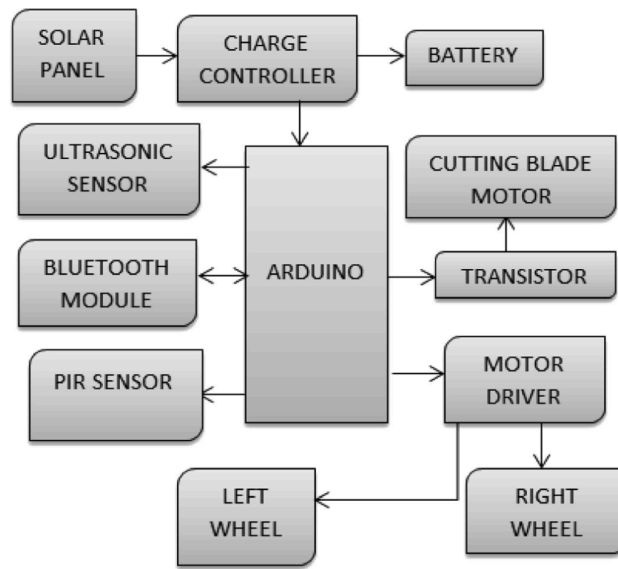


Figure 1. Block Diagram of System [2]

In Babangida project they used a glasscutter which is powered using the sunlight energy that is extracted from photon energy disordered in its movement. A force used to drive those energies or the movement of photo during this process. The battery is being protected from overcharging using a regulator which controls the electrons that is entering or leaving the battery and it will stop the charges from moving once the battery is full by means of disconnecting it from the solar panel circuit.

2.3 Comparative Study

Grass cutter projects using different mechanisms have been created by many people from different fields. While researching and looking at some of these existing projects to get the positive things they have done to add into our project and the drawbacks of their projects so that we can avoid them when developing our project, I have seen a similar project which was created by a group of students from ISL Engineering College, Hyderabad and their project's aim was to develop a hand-held solar operated grass cutting machine using locally available materials such as bicycle frame and wheels considering some important aspects such as durability, strength, and light weight of the overall project. The lawn mower was powered by a 12V/1.35A rechargeable battery which drives the DC motor up to a rotational speed of 19,300 RPM to generate high torque that will be transferred to the cutting head mechanism for efficient grass cutting. The entire configuration set up was mounted on a wooden base which attached together with a bicycle frame and a set of wheel arrangement. This manually driven portable lawn mower can be used to maintain and trim grass in gardens, home, schools or yards [3].

The second project was basically a study of the existing grass cutting machines and the differences that were added to the modern ones and it was developed by a group of mechanical engineers from DES's COET Dhamangaon Rly, India. The research was intended to review the technological development for making efficient and cost-effective grass cutter and the main aim was to study the various developments in the grass cutter machines and their performance. Current technology commonly used for cutting the grass by the manually handled device. It was found that various types of grass cutter available in market are running by means of solar, electric and internal combustion engine. Grass cutters are available in market having some limit to cut grass at some height. It was concluded that the modern grass cutter machine having better efficiency as compare to old machines because of using the engine and better material of blades and it also reduces the man power. A lawn mower which is simply called as a grass cutter machine becomes very popular today and it is very commonly used for furnishing soft grasses. Now it is necessary for cleaning gardens. Since it is easily operating machine so now it is used for various application.



Figure 2. Rotary Blade

The third project was developed by a group of electrical engineers from India. They have innovated a lawn mower robot that uses a solar panel to power its components and is controlled using a mobile phone application using Bluetooth. Many projects are using conventional principles such as internal combustion engines or manual ones which are really common, but if we think about the labor cost and fuel cost in case of the combustion engine, we may consider using the renewable free source of power (sunlight). It has different components that are attached to it with different functions such as solar power to provide the necessary power, an ultrasonic sensor to avoid any obstruction and Bluetooth module to connect to a mobile device. Its motor works on different RPM based on the stored energy or supplied one through the solar power or battery.

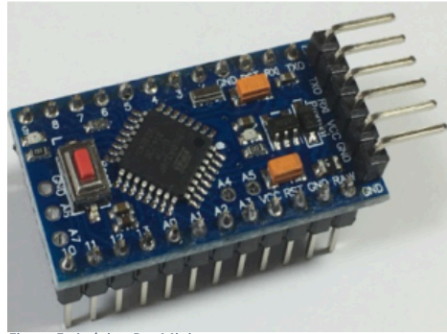


Figure 5: Arduino Pro Mini.



Figure 4: Ultrasonic Sensor.



Figure 6: PIR Sensor

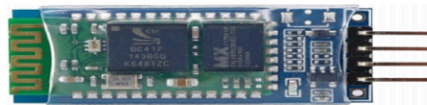


Figure 7: Bluetooth Module.

Figure 3. Lawn mower robot components [2]

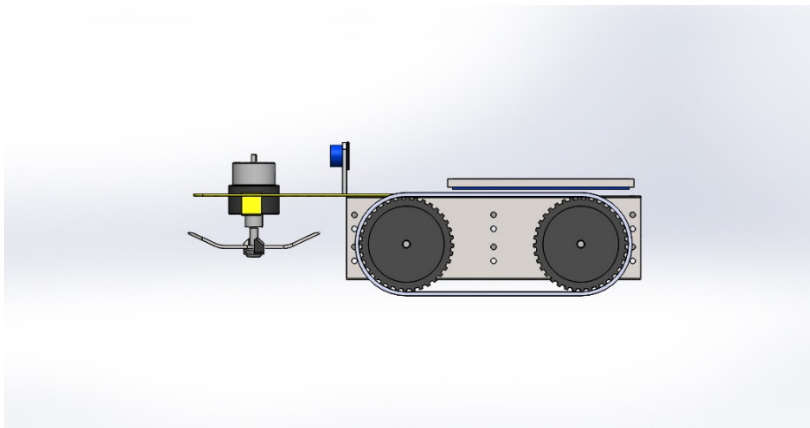
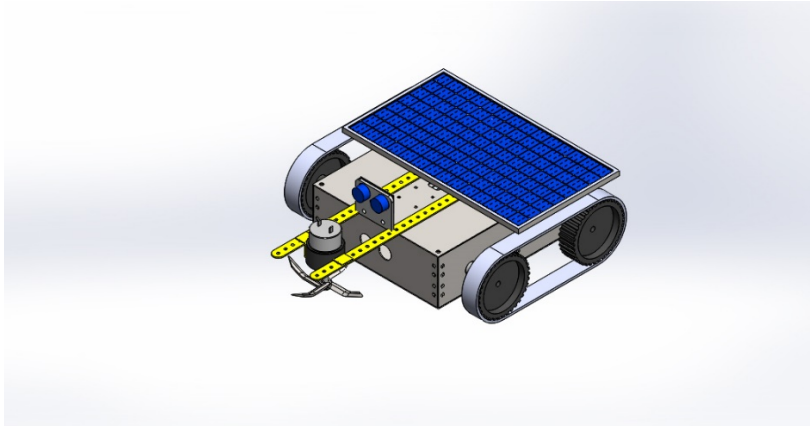
Some of the advantages that this project offers are:

- User friendly.
- Relatively small.
- Low cost.
- No labor cost.
- No emissions.
- Can be controlled remotely.

In our project, we are trying to make the new innovative concept mainly used in grass cutter machines such as stability, durability, easy movement, efficient, and most importantly cost saving by using special material of construction and using unique movement mechanism that allows easy movement of the machine and the blade while using the minimum power. Also, by integrating new setup of tank wheels, we will be able to move the machine on the roughest surface without compromising the stability of the entire structure while in operation as stability is one of the main factors that we concern about in our design.

Chapter 3: System Design

3.1 Design Constraints and Design Methodology



3.1.1: Geometrical Constraints

Many of our project's parts were electronics and since all of us have mechanical engineering background, it was a challenge for us to assemble and put the parts together. We were able to assemble the mechanical parts easily, but to assemble the wirings and the electrical parts along with the solar panel and test them in order not to damage any parts was not easy. Moreover, most of the parts were not easy to find in the local market, so we had to be really careful while testing them. In addition to that, we had also to make sure that the total weight of the machine is combatable with the amount of power that the solar panel can give so that the motor which is attached to the cutting mechanism can work effectively and for the longest possible duration.

In our project, we are trying to make the new innovative concept mainly used in grass cutter machines such as stability, durability, easy movement, efficient, and most importantly cost saving by using special material of construction and using unique movement mechanism that allows easy movement of the machine and the blade while using the minimum power. Also, by integrating new setup of tank wheels, we will be able to move the machine on the roughest surface without compromising the stability of the entire structure while in operation as stability is one of the main factors that we concern about in our design.

compatible with the amount of power that the solar panel can give so that the motor which is attached to the cutting mechanism can work effectively and for the longest possible duration.

3.1.2: Sustainability

The main challenge that we may face is when running the machine in winter where some amount of water or moisture remains on grass and during cutting plenty amount of moisture can get into the electronic parts even though if the system is insulated. Also, grass can get into the moving parts and can cause possible damage during the movement of the wheels.

3.2.3: Environmental

The working principle of the machine is environment friendly and can run without emitting any kind of pollution to the environment. It is basically using a clean source of power which heat from the sun and converts it to an electrical energy which is supplied to the electrical motor that running without producing any contaminants.

3.2.4: Social

The automated grass cutting machine can be used in house gardens where only small areas is needed to be cut since the design has some limitation due to the limited battery capacity which can be stored. It can be a useful tool to be obtained for keeping your small house yard clean and good looking with no electrical or even labor cost.

3.2.5: Economic

The project is intended to minimize electrical power usage and instead uses an available free source of power especially here in Saudi Arabia where the weather is mostly sunny. This can diversify our dependency on diesel or fuel operated machines and uses the green environment friendly source of power (Sun).

3.2.6: Safety

The main safety concern might be the location of the cutting blades which is located right in the front side of the machine which has a possibility to cause damages, but this obstacle has been overcome by placing a sensor in the front which detects any obstacle from a safe distance and changes its direction immediately before causing any damages.

3.2.7: Ethical

This project has similar previous works. Thus, we took some general ideas from them and we improved the work by our ideas to improve the design in terms of safety, economically, and sustainability.

3.2 Engineering Design standards

Standards and specifications are considered as documents describing the rules and conditions for how materials and products are manufactured, defined, measured, tested, and implemented, as they are used in order to establish basic lines and quality control in order to ensure the conditions. The selected components are the following; two types of screws, hex nut, and a battery. The screws and hex nut standard have been taken according to the IS standard. The standard of the battery is from SLA as you see in table 3.1.

Table 3.1: Engineering Standards

| Components | Engineering standard | Details |
|------------|----------------------|---|
| Screw (1) | IS (Indian Standard) | Slotted fat head screw IS 1365 – M2.5 x 12 |
| Screw (2) | IS (Indian Standard) | Slotted fat head screw IS 1365 – M6 x 16 |
| Hex Nut | IS (Indian Standard) | Hexagon Thin Nut (Chamfered) IS 1364 – 4 -M10-N |
| Battery | SLA | Rechargeable Sealed Lead-acid Battery 6V-1.2AH |
| Motor | IEC | 12V 1000 RPM DC Motor |

3.2.1: Screw (1)

The screw has been chosen from the toolbox from the SolidWork® software.

- Length: 12 mm
- Diameter of the head hex: 2.5 mm

3.2.2: Screw (2)

The screw has been chosen from the toolbox from the SolidWork® software.

- Length: 16 mm
- Diameter of the head hex: 6 mm

3.2.3: Hex nut

The hex nut has been chosen from the toolbox from the SolidWork® software.

- Diameter of the head hex: 10 mm

3.2.4: Lead Acid Battery

In figure 3.1, the images show the Battery pack that used for the project

- Voltage: 12 V
- Amp hours: 1.2
- Size: 97 * 25* 51 mm
- Weight: 0.30 kg



(Figure 3.1: The Lead Acid Battery)

3.3 Theory and Theoretical Calculations

3.3.1: The Consumed Electric Power of The Motor:

Power in its most simple form is work done over a set period of time. Power is transmitted to the load in a motor by transferring electrical energy according to the following scientific laws. The force used to transfer electrons in electrical systems is called voltage. The rate of charge flow through a material when a given voltage is applied is called current. The power of a device can be measured by multiplying the voltage by the corresponding current where is the input power of the motor and the voltage is and the current is, see equation (3.1) [1].

$$P = V * I \quad (3.1)$$

3.3.2: The Torque of The Electric Motor:

The torque is the twisting force that causes the motor to operate, and it is active from zero to one hundred percent of its working speed. The motor's output power is proportional to its speed and is measured in watts. The power of the motor is the result of the multiplication of the Torque T and the speed of the DC motor N by two times π over an hour, see equation (3.2) [2].

$$P = \frac{2 * \pi * N * T}{60} \quad (3.2)$$

The torque of the motor can be calculated by rewriting the equation (3.2):

$$T = \frac{P * 60}{2 * \pi * N} \quad (3.3)$$

3.3.3: The Solar Panel Power Output Calculation:

A solar cell is a battery that uses the 'photovoltaic effect' to transform light into electricity. They're also known as "photovoltaic cells" because of this phenomenon, as well as to distinguish them from solar thermal systems. The photovoltaic effect is a phenomenon that exists in many semiconducting materials like silicon. The power output of the solar panel is

the result of the multiplication between the voltage and the current is see in equation (3.4) [3].

$$W = V * I \quad (3.4)$$

3.3.4: Results

A) The Current **I** :

Step (1): Using equation 3.1 to find **I**

Where:

$$V = 12 \text{ V}$$

$$P = 5 \text{ W}$$

$$I = ?$$

$$P = V * I \quad (3.1)$$

$$5 = 12 * I$$

Step (2): rewriting equation 3.1 to find **I**

$$I = \frac{P}{V}$$

$$I = \frac{12}{5}$$

$$I = 2.4 \text{ A}$$

B) Torque of the motor:

Using equation 3.3 to find **T**

Where:

$$P = 5 \text{ W}$$

$$N = 1000 \text{ rpm}$$

$$T = ?$$

$$T = \frac{P * 60}{2 * \pi * N} \quad (3.3)$$

$$T = \frac{5*60}{2*\pi*1000}$$

$$\mathbf{T = 0.0477 Nm}$$

$$\mathbf{T = 44.7 Nmm}$$

C) The Solar Panel Power Output:

Step (1): Using equation 3.w to find **I**

Where:

$$V = 12 V$$

$$W = 5 W$$

$$I = ?$$

$$W = V*I \quad (3.1)$$

$$5 = 12*I$$

Step (2): rewriting equation 3.1 to find **I**

$$I = \frac{P}{V}$$

$$I = \frac{12}{5}$$

$$\mathbf{I = 2.4 A}$$

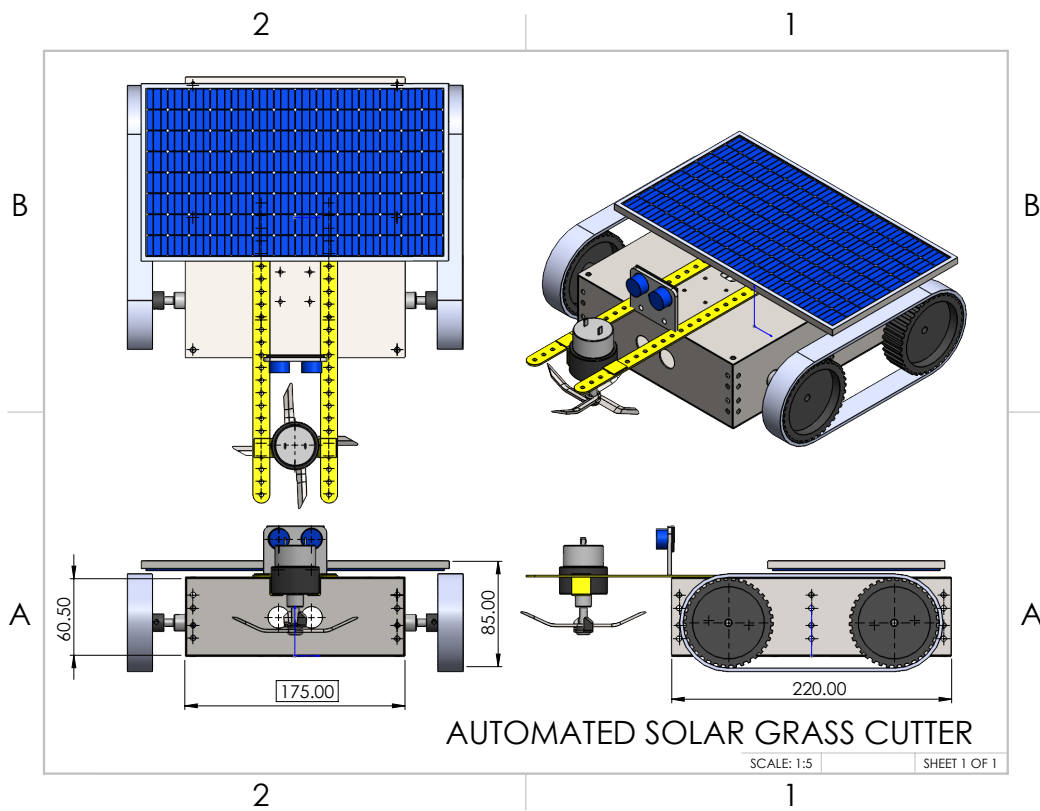
Final Results:

| | |
|------------------------------|---|
| The Current I | I = 2.4 A |
| Torque of the motor | T = 0.0477 Nm T = 44.7 Nmm |
| The Solar Panel Power | I = 2.4 A |

Our project depends on power, torque, and solar cell. Power in its most simple form is work done over a set period of time. Power is transmitted to the load in a motor by transferring electrical energy, and the torque will be a twisting force that causes the motor to operate, also the solar cell will give our device the energy.

3.4 Product Subsystems and Selection of Components

Figure 3.2 shows the 2d sketch of the machine in solid-works with front, top, right, and isometric views. The base unit essentially connects all the parts together. The cutting blade is connected to a rotary motor. The rotary blade is mounted on two thin bars of metal that extend forward using six screws. The system is powered by a 12V 1.2Ah Lead-Acid rechargeable battery, that is housed inside the metal base unit. The solar panel is 36 cm in length and 23 cm in width; with an overall area of 828 cm² (see figure 3.3). The system supports four wheels that are made of Polyethylene. The continuous track is also made from Polyethylene.



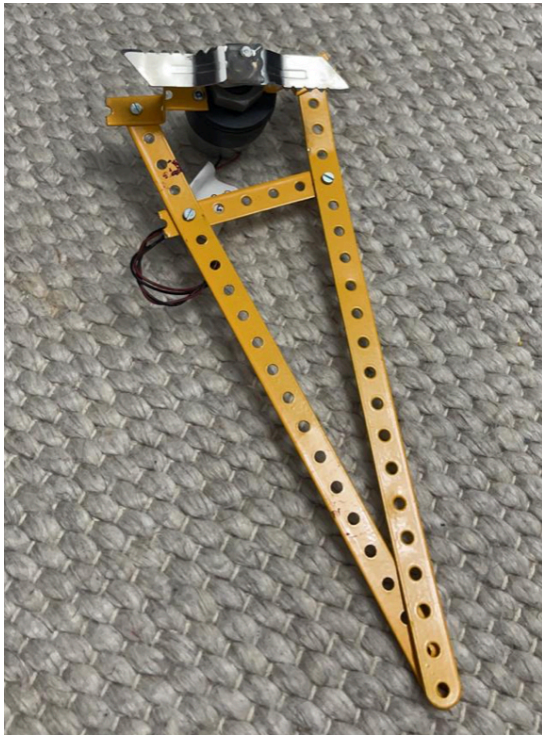
(Figure 3.2 2d solid-works sketch with front, top, right and isometric views)

3.5 Manufacturing and Assembly

For the cutting blade, we chose low carbon high alloy steel which provides important mechanical properties such as high impact resistance and high strength (see figure 3.4). Further, the blade is connected to two steel bars that provide rigidity even in windy conditions. In addition to added rigidity, the metal bars offer the option of adjusting the position of the blade. There are two shafts to connect the wheels each shaft has a 0.6 cm diameter and are made of carbon steel AISI 1065. The center of the machine houses the rechargeable battery, a 12V 1.2Ah Lead-Acid battery; a battery of this size was chosen because we should be able to generate enough power for the motor to rotate the blade as well as rotating the shaft to run at the desired speed. The housing is made of low carbon steel AISI 1018 (see figure 3.5).



(Figure 3.3 Solar Panel)



(Figure 3.4 Rotary Blade)



(Figure 3.5 Center Housing Unit)

3.6 Economic Evaluation

Our machine has no variable costs, only capital costs; and possible profits if the machine is to be sold. (see table 3.2)

Table 3.2: Costs and Profits

| | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|-----------------------|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| Capital Costs | | | | | | | | | | | |
| Equipment | 1600 SAR | | | | | | | | | | |
| Construction | 550 SAR | | | | | | | | | | |
| Total | 2150 | | | | | | | | | | |
| Operating Cost | | | | | | | | | | | |
| Energy | 0 | | | | | | | | | | |
| Electricity | 0 | | | | | | | | | | |
| Labour | 325 | | | | | | | | | | |
| Insurance | 100 | | | | | | | | | | |
| Taxes | 240 | | | | | | | | | | |
| Total | | | | | | | | | | | |
| Revenues | | | | | | | | | | | |
| Product 1 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| Product 2 | Not applicable | | | | | | | | | | |
| Product 3 | Not applicable | | | | | | | | | | |
| Total | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| Profits | -2215 | -1615 | -1015 | -415 | 185 | 785 | 1385 | 1985 | 2585 | 3185 | 3785 |

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

4.1.1: Ultrasonic Ranging Module HC - SR04

Ultrasonic Ranging Module HC - SR04 which is located in the front part of the machine for personnel and equipment safety was tested while the machine was running and the sensor was functioning properly. The sensor first detected an obstacle ahead within 30 cm distance and then rotates the machine by stopping one motor that is driving the wheels and keep the other one which located on the other side of the machine running in order to change the direction of movement. At the same time, the sensor sends a signal to the cutting machine motor to stop for safety reason until the front area or detection area clears of any obstacle.

Wire connecting direct as following:

- 5V Supply.
- Trigger Pulse Input.
- Echo Pulse Output.
- 0V Ground



Specifications:

| | |
|--------------------------|--------|
| Working Voltage | DC 5 V |
| Working Current | 15mA |
| Working Frequency | 40Hz |
| Max Range | 4m |
| Min Range | 2cm |

| | |
|-----------------------------|--|
| Measuring Angle | 15 degree |
| Trigger Input Signal | 10uS TTL pulse |
| Echo Output Signal | Input TTL lever signal and the range in proportion |
| Dimension | 45*20*15mm |

4.1.2: Solar Panel:

The solar panel was installed on the top of the tracked robotic tank chassis in order to allow the panel to be exposed to direct sunlight to absorb the maximum amount of solar energy to supply the motors and the associated electronic parts as well as charging the battery with electric power.



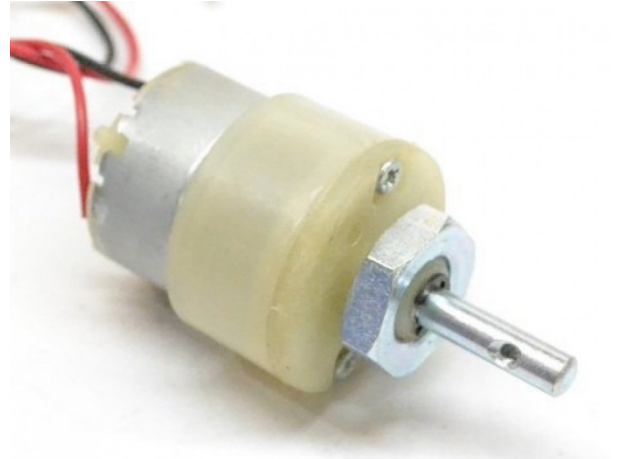
Specifications:

| | |
|---------------------------------------|------------|
| Rated Maximum Power (Pmax) | 5W |
| Power Tolerance | ±3% |
| Voltage at Pmax (Vmp) | 17.8V |
| Current at Pmax (Imp) | 0.28A |
| Open-Circuit Voltage (Voc) | 22.3V |
| Short-Circuit Current (Isc) | 0.3A |
| Temperature Coefficient (Pmax) | -0.48 %/°C |
| Maximum system voltage | 1000V DC |

| | |
|------------------------|----------------|
| Dimensions (mm) | 250 x 185 x 25 |
| Net weight | 1kg |

4.1.3: DC Motor

Three 1000 RPM DC motors are installed in this system; two of them to drive the wheels and the third one is to run the cutting machine. All three motors are identical and have the same specification. Field testing was done and the battery was capable to supply all three motors at the same time with same efficiency.



Specifications:

| | |
|--------------------------|--------------------------------|
| RPM | 1000. |
| Operating Voltage | 12V DC |
| Gearbox | Attached Plastic (spur)Gearbox |
| Shaft diameter | 6mm with internal hole |
| Torque | 0.5 kg-cm |
| No-load current | 60 mA(Max) |
| Load current | 300 mA(Max). |

4.2 Results, Analysis and Discussion

| | |
|-------------------------------------|--|
| Running Duration with Full Battery. | Around 3 hours without battery based on loads and surface. |
| Solar panel charging duration. | Around 5 hours based on the ambient Temp. |
| Free-load motor RPM | Around 500 RPM. |
| | |
| | |
| | |
| | |
| | |

Chapter 5: Project Management

5.1 Project Plan

There are several tasks in our project. One or more members are assigned to each task. Here you'll find all of the details about the tasks, team members, and the time required to finish each one. Tasks and durations are listed in table 5.1, and assigned members are listed in 5.2 table.

Table 5.1: Task and their durations

| # | Tasks | Start | End | Duration | |
|---|--------------------------------------|-----------|-----------|----------|--|
| 1 | Chapter 1: Introduction | 15/2/2021 | 20/2/2021 | 5 | |
| 2 | Chapter 2: Literature Review | 15/2/2021 | 20/2/2021 | 5 | Project Work |
| | | | | | Previous Work |
| | | | | | Comparative Study |
| 3 | Chapter 3: System Design | 23/2/2021 | 25/3/2021 | 31 | Design Constraints and Design Methodology |
| | | | | | Engineering Design Standards |
| | | | | | Theory and Theoretical Calculations |
| | | | | | Product Subsystems and selection of Components |
| | | | | | Manufacturing and assembly |
| 4 | Chapter 4: System Testing & Analysis | 1/4/2021 | 18/4/2021 | 18 | Experimental Setup, Sensors and data |
| | | | | | Results, Analysis and Discussion |
| | | | | | Project Plan |
| | | | | | Contribution of Team members |

| | | | | | |
|----|--|-----------------------------------|-----------|-----------|----|
| 5 | Chapter 5: Project Management | Project Execution Monitoring | 10/4/2021 | 18/4/2021 | 8 |
| | | Challenges & Decision | | | |
| | | Marking | | | |
| | | Project Bill of Material & Budget | | | |
| 6 | Chapter 6: Project Analysis | Life Long Learning | 7/4/2021 | 18/4/2021 | 11 |
| | | Impact of Engineering Solution | | | |
| | | Contemporary Issues Addressed | | | |
| 7 | Chapter 7: Conclusion & Recommendation | Conclusion | 12/4/2021 | 18/4/2021 | 6 |
| | | Future Recommendation | | | |
| 8 | Design of Prototype | Chassis | 30/1/2021 | 7/2/2021 | 7 |
| | | Solar panel | | | |
| 9 | Parts Purchase | Chassis | 7/2/2021 | 22/2/2021 | 16 |
| | | Solar panel | | | |
| | | Battery | | | |
| | | DC motor | | | |
| 10 | Building the prototype | Assembling | 8/4/2021 | 8/4/2021 | 1 |
| 11 | Testing | Testing the solar panel | 10/4/2021 | 18/4/2021 | 8 |
| | | Testing the sensor | | | |
| | | Testing the motor | | | |

Table 5.2: Tasks and assigned members

| # | Tasks | Assigned Members |
|----|--|------------------|
| 1 | Chapter 1: introduction | Sulaiman Alkrood |
| | | Ali Alnahwi |
| | | Omar Alharbi |
| | | Homoud Alnafjan |
| 2 | Chapter 2: Literature Review | Sulaiman Alkrood |
| | | Ali Alnahwi |
| | | Omar Alharbi |
| | | Homoud Alnafjan |
| 3 | Chapter 3: System Design | All |
| 4 | Chapter 4: System Testing & Analysis | Ali Alnahwi |
| 5 | Chapter 5: Project Management | Dhawi Aljar |
| | | Sulaiman Alkrood |
| 6 | Chapter 6: Project Analysis | Omar Alharbi |
| 7 | Chapter 7: Conclusion & Recommendation | Homoud Alnafjan |
| 8 | Design of Prototype | All |
| 9 | Parts Purchase | Dhawi Aljar |
| 10 | Building the prototype | All |
| 11 | Testing | All |

5.2 Contribution of Team Members

One or more members were assigned to the tasks in this project. It is based on the task's skill and the time taken to complete it. Table 5.3 lists the tasks and members, along with the percentage of each member's contribution.

Table 5.3: Tasks the contribution of the members

| # | Tasks | | Assigned | Cont.% |
|---------------------|--------------------------------------|--|------------------|--------|
| 1 | Chapter 1: introduction | | Sulaiman Alkrood | 33% |
| | | | Ali Alnahwi | 33% |
| | | | Omar Alharbi | 33% |
| 2 | Chapter 2: Literature Review | Project Background | Sulaiman Alkrood | 50% |
| | | | Ali Alnahwi | 50% |
| | Previous Work | Sulaiman Alkrood | 50% | |
| | | Ali Alnahwi | 50% | |
| | Comparative Study | Sulaiman Alkrood | 50% | |
| | | Omar Alharbi | 50% | |
| 3 | Chapter 3: System Design | Design Constraints and Design Methodology | Ali Alnahwi | 100% |
| | | Engineering Design standards | Homoud Alnafjan | 50% |
| | | | Dhawi Aljar | 50% |
| | | Theory and Theoretical Calculations | Dhawi Aljar | 75% |
| | | | Omar Alharbi | 25% |
| | | Product Subsystems and selection of Components | Sulaiman Alkrood | 100% |
| | | Manufacturing and assembly | Sulaiman Alkrood | 100% |
| Economic Evaluation | Sulaiman Alkrood | 100% | | |
| 4 | Chapter 4: System Testing & Analysis | Experimental Setup, Sensors and data | Ali Alnahwi | 100% |
| | | Results, Analysis and Discussion | Ali Alnahwi | 100% |
| | | Project plan | Dhawi Aljar | 100% |

| | | | | |
|----|--|-----------------------------------|------------------|------|
| 5 | Chapter 5: Project Management | Contributions of team member | Dhawi Aljar | 100% |
| | | Project Execution Monitoring | Sulaiman Alkrood | 100% |
| | | Challenges & Decision Making | Sulaiman Alkrood | 100% |
| | | Project Bill of Material & Budget | Sulaiman Alkrood | 100% |
| 6 | Chapter 6: Project Analysis | Life Long Learning | Omar Alharbi | 100% |
| | | Impact of Engineering Solution | Omar Alharbi | 100% |
| | | Contemporary Issues | Omar Alharbi | 100% |
| 7 | Chapter 7: Conclusion & Recommendation | Conclusion | Homoud Alnafjan | 100% |
| | | Future Recommendation | Homoud Alnafjan | 100% |
| 8 | Design of Prototype | Solid-works Design | All | 100% |
| 9 | Parts Purchase | Chassis | All | 100% |
| | | Solar panel | All | 100% |
| | | Battery | All | 100% |
| | | DC motor | All | 100% |
| | | Alternator | All | 100% |
| 10 | Building the Porotype | Assembly | All | 100% |
| 11 | Testing | Testing the solar panel | All | 100% |
| | | Testing the sensor | All | 100% |
| | | Testing the motor | All | 100% |

5.3 Project Execution Monitoring

To be able to reach satisfy the goals of the project and meet all the deadlines, as group we held many internal group meetings and meetings with our project advisor. Table 5.4 shows the dates of our meetings and the subject or activity discussed.

Table 5.4 Dates of meetings

| Time/Date | Activity |
|----------------|-----------------------------|
| Weekly | Group Members Meeting |
| Biweekly | Meeting with Advisor |
| 2 April, 2021 | Start Assembling Prototype |
| 8 April, 2021 | Midterm Presentation |
| 9 April, 2021 | Finish Assembling Prototype |
| 11 April, 2021 | Test Prototype |
| 20 April, 2021 | Submit Final Report |
| 22 April, 2021 | Final Presentation |

5.4 Challenges and Decision Making

As the case with any long-term project, some challenges or obstacles are bound to surface and effect some aspects in the project. The main challenges we faced:

- Choosing the correct parts
- Overcoming safety challenges
- Minimizing costs

5.4.1: Choosing the correct parts

In the case of a robot lawn mower device or any robotic device. Choosing the correct parts is crucial to achieve satisfactory results. For example, choosing the correct battery size to power the device, if the battery voltage is too low the device will not operate properly; on the other hand, choosing a battery with a large capacity might lead to issues in fitting and installing as well as an

added cost. We were able to decided on the right size battery based on our individual assessment of our application.

5.4.2: Overcoming safety challenges

Because our robot includes a fast rotary blade, special attention was needed to making sure the safety aspect was fulfilled. An Ultrasonic Sensor HC-sr04 was chosen to overcome the safety concerns. The sensor is attached in the center forward face of the robot above the rotary blade and its function is to detect any movement or object in front of the robot and send a signal to simultaneously stop the blade from rotating and the robot from moving forward.

5.4.3: Minimizing costs

Since our project is about designing a robot, if each aspect isn't studies carefully such as the overall size of the robot and its functions, the costs of the parts can accumulate fast. This is avoided constantly going over what is needed to achieve the main objectives of the project without over-designing the robot.

5.5 Project Bill of Materials and Budget

We summarized our costs in Table 5.5 each material purchased and its cost.

Table 5.5 Bill of materials

| Materials | Costs |
|--------------------|--------------|
| DC Motor | 300 |
| Battery | 83 |
| Solar Panel | 410 |
| Ultrasonic Sensor | 49 |
| Wheels and Chassis | 450 |
| Total | 1292 |

Chapter 6: Project Analysis

6.1 Life-long Learning

When we working on our project, we gained some knowledge, also we gained dome experiences, and when we are working, we formed a helpful team. We improved our skills, also we sprite the work to have good time management, and have enough time to improve our mistakes. My team now have excellent skill, time management, and knowledge.

6.1.1: Software Skills

In our project, we had a good experience in programming. We use many applications to make good programing for our project to work very well, we used MATLAB, Microsoft Word, and Solid work. We developed our skills in programming.

6.1.2: Hardware Skills

When we are working on our project, we used some new advice. We used ultrasonic sensors to keep our device working without any accident with anything front it, also used battery to save the energy, and solar panel to get energy from the sun, and used tracked robot tank chassis to work easily in a different place.

6.1.3: Time Management Skills

In our project, we focus on time management before anything. We are working in specific time to get work done on time because that we make a plan for the project and make a schedule for any part for our project to keep us in the correct way, also sprite the work for all person to finish our work on time because that we have more time to fix any issue when it happens.

6.1.4: Project Management

In our project, we make a plan for any small steps, and each person has a specific work this way makes our team be more knowledgeable in what he does, also we made a lot of meetings to discuss where are we, and help anyone had an issue. We collect our work by week. We put everything in plan and do it to keep us working very well.

6.2 Impact of Engineering Solutions

Our task has different effects regarding society, economy, and environment. In this area, there are for the most part the effects of our undertaking as far as what recently referenced.

6.2.1: Society

In our project, we focus to help society on normal days because we made a robot to help people when they cut grass by making it easy, and automatic. Our project will make life easy.

6.2.2: Economy

The project is intended to minimize electrical power usage and instead uses an available free source of power especially here in Saudi Arabia where the weather is mostly sunny. This can diversify our dependency on diesel or fuel-operated machines and uses the green environment-friendly source of power (Sun).

6.2.3: Environmentally

The working principle of the machine is environment friendly and can run without emitting any kind of pollution to the environment. It is basically using a clean source of power which heat from the sun and converts it to electrical energy which is supplied to the electrical motor that running without producing any contaminants.

6.3 Contemporary Issues Addressed

In this project, we solve many issues faces on a normal day. The first one, old machine working manually we changed the idea, and make a robot can help the person who did this type of work, the second one, in our project we made it small size to be easy to keep in storage, and don't take large space, the last one, our project energy saving, and our robot can move anywhere, also more accurate in cutting.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusion

At conclusion now we have reached the last points of research that may have spoken extensively about (the topic of research) and we have been keen to provide through it the most important information, data and modern applications related to this topic through reliable sources, so that it is a starting point for every person who wishes to increase knowledge, research and exploration in this scientific research field. In this project we have showed how to make the grass cutter more efficient with the cheapest price by combining it with the solar panels in a detailed method. And at the end of the report; It is noteworthy that all the data and information that we have obtained through the report were obtained from reliable sources and concerned parties, given our keenness to make this field report accurate, correct and comprehensive of everything that is going on in the minds of this issue.

7.2 Future Recommendations

At the end of this scientific research; We emphasize that through research, exploration and reliance on internationally documented sources and references; It has been proven that the design of robot lawn mower is actually has a high degree of positivity for the distant future if the recommendations and suggestions presented through the research are implemented, in the future we would like to make the solar panel smaller and design a stronger grass cutter with less weight also we would like to change the battery to another brand that has more capacity than the one we're using right now and we hope to unleash the thinking of students, male and female students and researchers; So that they can present any new ideas, improvements or suggestions that would help in enhancing the degree of benefit to individuals and society as a whole through this research.

8. References

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