

## Design and Fabrication of Low Cost Portable Lawn Mower

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**Abstract:** In current days, grass cutter machines are operated by fuel and electrical energy which are costly and requires high maintenance. Hence, in this study, a hand-held operated machine for grass cutting was designed and fabricated by using locally available materials. Important aspects such as durability, strength, and light weight were taken into design considerations for better performance characteristics. 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. As a result, the generated torque 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 portable lawn mower can be used to maintain and trim grass in gardens, home, schools or yards.

**Keywords:** grass cutter, bicycle frame, lawn mower, hand-held, battery, portable

**INTRODUCTION**

Grass cutter machines have become very essential to our daily living in maintaining the yards. Furthermore, environmental awareness on usage of grass cutting machines has caught a great interest among consumers. As a result, consumers are searching for ways to reduce and solve their own carbon footprints. Moreover, environmental pollution keeps increasing and it can be experienced in our daily life, particularly in our homes. Based on a study, it is reported that 70% of Malaysian home citizens are utilizing fuel powered lawn mowers for their daily grass cutting routine [1].

Thus, high maintenance is needed in order to maintain a lawn mower. For instance, one should change the fuel or oil regularly so that the lawn mower works efficiently during the process of grass cutting. Furthermore, this will incur extra variable cost since the fuel price has been increased lately [2].

In order to overcome these issues, an eco-friendly lawn mower needs to be designed and fabricated in order to support the green technology initiatives. In this study, a newly designed lawn mower was fabricated which powered through a rechargeable battery. Besides that, the grass cutting machine was fabricated at low cost by taking consideration on important aspects such as lightweight, durable, and environmental friendly.

A lawn mower is a machine that uses cutting blades or strings which is used to cut the grass in gardens or yards at an even length. The working principle of the lawn mower is to provide a high speed rotation to the blades, which aids in cutting the grass through generated kinetic energy. The main parts of this prototype lawn mower consist of a DC motor, a pulse width modulation (PWM) device for controlling the motor, bicycle frame and wheels as the body structure, and a rechargeable battery. For safety operation, the motor will be controlled by a PWM device as since the motor has a high rotational speed of 19,300 RPM. As for the cutting head, nylon strings will be used as the trimmer instead of traditional cutting blades due to cost effectiveness, safety, and flexibility. Besides that, since the motor delivers a minimum torque value, hence nylon strings are much more suitable since it is lighter in weight [3].

With reference to current literature availability, there are many variation of lawn mowers that are exist in the global markets, which may not fulfil the performance and operational cost criteria. The main concentration of this study is to design and fabricate a lawn mower which is cost effective, feasible and easy operation. With the help of this portable lawn mower, consumers can easily maintain and beautify their yards and gardens without any hassle. Nevertheless, there are few design requirements that must satisfy the study objectives which are:

- To design and fabricate the lawn mower which is light in weight.

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- To design and fabricate the lawn mower which is feasible in size.
- To design and fabricate the lawn mower which is cost effective.
- To design and fabricate the lawn mower which operates around acute areas.

### METHODOLOGY AND DESIGN ANALYSIS

#### Overall Design of the Lawn Mower Body Structure

Before the actual fabrication process was carried out, the lawn mower was designed and simulated using Autodesk Inventor Professional 2016 software which is shown in Figure-1. The body structure of the lawn mower had three main components which were the bicycle handle, the wheels and the base. The handle and the wheels will be used as the navigation panel to control the lawn mower while the base acts as the support where the motor and the battery will be attached to it.

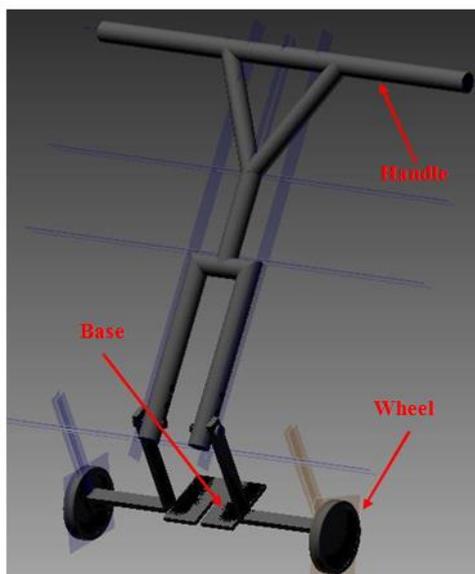


Fig-1: Body structure of the lawn mower

There are few advantages of this newly designed lawn mower. Firstly, the mower has two wheels which allows the user to maneuver the mower freely. Moreover, the weight of the lawn mower will be supported by the training wheels and hence less effort or workforce is required by the user. Besides that, since the cutting head will be installed in front of the base, therefore the lawn mower will be able to operate around acute areas such as trees or fences. With this simple design concept, the weight of the lawn mower can be reduced immensely. The lawn mower was designed in an ergonomic approach where the structure can be adjusted with the help of adjustable screws as shown in Figure-2. Moreover, this enables the user to adjust the height or the angle based on his/her preference.

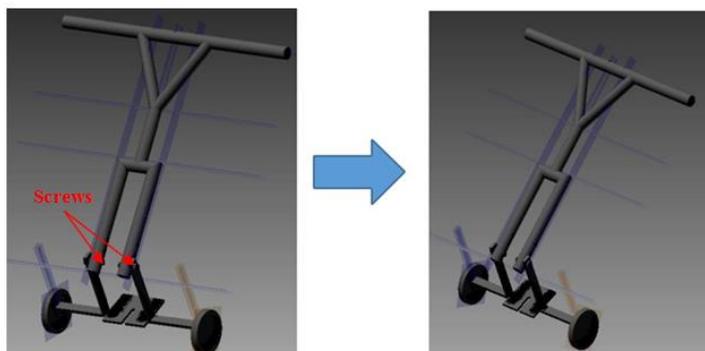


Fig-2: Height and angle adjustment for the lawn mower

### Material Selection for the Base

There are few materials such as wood, aluminum, mild steel or composite were considered beforehand for the mower base. However, wood material was selected for the base since it is cheaper, low in density, corrosion resistance, and locally available in markets [4]. Besides that, since lightweight criteria are one of the desired requirements, thus wood will be the most suitable candidate.

### Selection of Electric Motor

Selecting a suitable electric motor is one of the important criteria in designing a lawn mower since the motor is the one that drives the generated torque to the cutting head to trim the grass. Moreover, the size of the motor shall be small enough so that it will fit perfectly inside the lawn mower base. Most of the electric motors which are available in the markets are expensive and large in size [5]. In addition, these motors are used for heavy duty lawn mowers since the cutting blades require a large amount of horsepower and rotational speed [6]. However, for the current prototype mower, a DC motor was used since the cutting head will be using strings instead of cutting blades. Moreover, for string trimmer, it only requires minimum rotational speed of 3000 RPM and voltage of 10V [7]. Thus, a Banebots RS-550 DC motor was chosen since it satisfied those minimum requirements. Table-1 shows the specification of the DC motor.

**Table-1: Motor specification [8]**

Specification	Banebots RS-550 DC
Operating Voltage (V)	6-14.4 (12V nominal)
Angular speed, (RPM)	19,300
Load Current (A)	1.3
Stall Current (A)	85
Stall Torque (mN.M)	498.2
Weight (kg)	0.218
Shaft diameter (mm)	3.2
Shaft Length (mm)	7.6

### Selection of Battery

For the rechargeable battery, GPP1245 lead acid battery was chosen due to its long lasting performance. Moreover, the battery was found to be compatible with the DC motor compared to other variation of batteries. Table-2 shows the specification of the battery.

**Table-2: Battery specification [8]**

Specification	GPP1245 Lead Acid Battery
Operating Voltage (V)	12
Ampere Hour, (Ah)	4.5
Load Current (A)	1.35

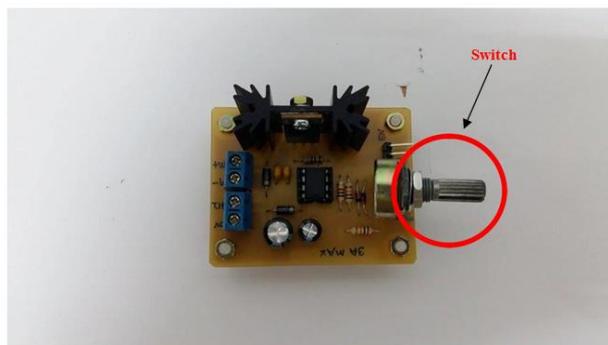
### Design of the Cutting Head

For the lawn mower cutting head, nylon strings were used instead of traditional cutting blades since it is flexible, affordable, lighter and easily replaceable [7]. Besides that, since the stall torque generated by the motor has a minimal output value (Table-1), therefore usage of strings would provide an optimum result. The string trimmer also able to operate in acute areas due to its flexibility in nature.

### Pulse Width Modulation Device

Pulse width modulation (PWM) device was used and attached together to the lawn mower mainboard. Since the motor has a high rotational speed of 19,300 RPM, therefore this device will help to control the speed in order to prevent

any mishap. Moreover, it able to withstand maximum load current and voltage of 3A and 12V respectively. The speed of the motor can be easily manipulated by controlling the switch which shown in Figure-3.



**Fig-3: Pulse Width Modulation (PWM) device**

#### **Assembly Methodology of the Lawn Mower**

For the lawn mower body structure, a castoff bicycle was dismantled to obtain the required bicycle frame and training wheels which shown in Figure-4. The training wheels were then mounted on the bicycle frame using bolts and nuts. This procedure is shown in Figure-5.



**Fig-4: Bicycle frame (left) and wheel (right)**



**Fig-5: Mounting the training wheels to the bicycle frame**

The base of the lawn mower was then constructed with a wooden block. Several L-brackets were installed on top of the base platform. This was done so that the battery and the motor will be placed securely. Then, the entire base was attached to the bicycle frame using bolts and nuts which displayed in Figure-6.



**Fig-6: Attaching the base to the bicycle frame**

After completing the fabrication of the lawn mower body structure, PWM device, general on/off switch, electric motor, and rechargeable battery were used for assembling the electrical components. The PWM device and the switch were attached into a small wooden block. Later, the bottom of the wooden block was chiseled to create a wiring connection pathway for the PWM device and the switch, which presented in Figure-7. The electric motor was then soldered with wires before attaching it to the supporting brackets on the wooden base, which depicted in Figure-8.



**Fig-7: Crafting wiring pathway for the electrical components**



**Fig-8: Attaching the soldered electric motor to the base**

A wire connector block and strings were used in fabricating the cutting head. Two pieces of strings were inserted into the connector slots as the trimmer mechanism. The cutting head was then inserted into the motor shaft as presented in Figure-9.



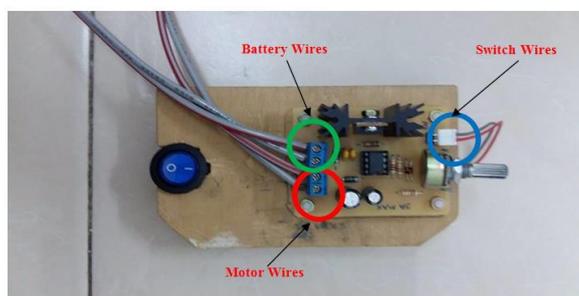
**Fig-9: Cutting head attached to the electric motor**

Next, the rechargeable battery was fitted inside the supporting brackets which shown in Figure-10.

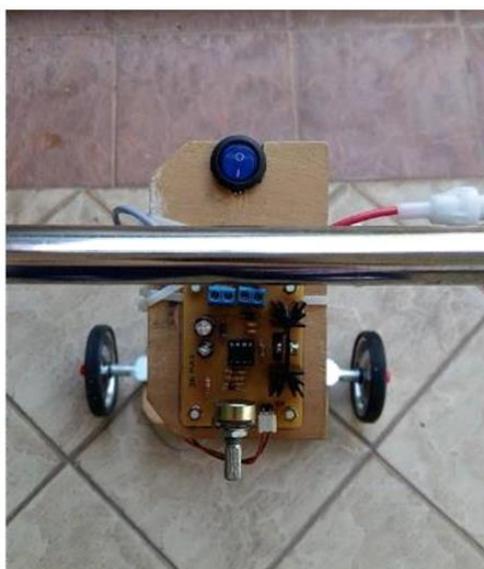


**Fig-10: Rechargeable battery attached to the base**

All the electric components (electric motor, PWM device, battery, on/off switch) were then assembled by connecting the wires together in order to have a complete circuit as shown in Figure-11. Moreover, a 10A fuse was used and connected to the PWM device and the electric motor in order to protect the electrical components from a sudden overcurrent discharge. Lastly, the mainboard was attached to the lawn mower handle which shown in Figure-12. The final prototype of the lawn mower is shown in Figure-13.



**Fig-11: Assembled mainboard**



**Fig-12: Mainboard attached to the handle**



Fig-13: Front view (left) and side view (right) of the lawn mower

### FINDINGS AND DISCUSSION

#### To Design and Fabricate the Lawn Mower which is Light in Weight

The average weight of a commercial lawn mower which available in the markets is approximately 20 kg [9]. However, the weight of the prototype lawn mower is only about 5.5 kg. Thus, the weight has been reduced by 72.5% showing that the lawn mower is lighter in weight.

#### To Design and Fabricate the Lawn Mower which is Feasible in Size

The prototype lawn mower has been designed in ergonomic approach so that it is suitable to be used by any individual size. The dimensions of the lawn mower is shown in Figure-14 and Figure-15.

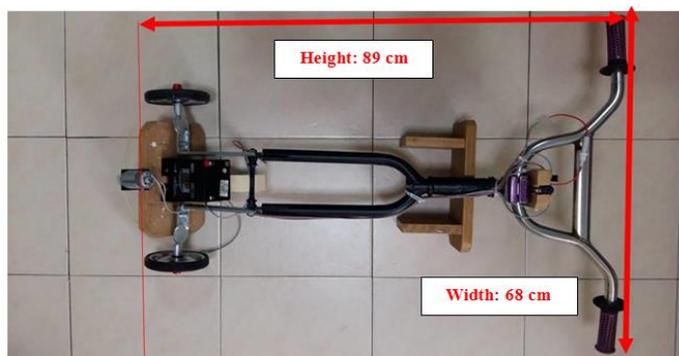


Fig-14: Dimension of the body structure

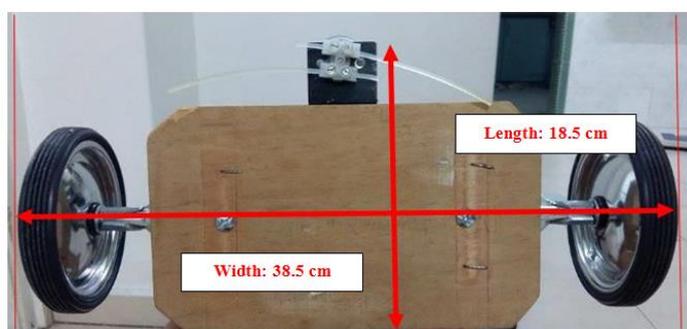


Fig-15: Dimension of the base

#### To Design and Fabricate the Lawn Mower which is Cost Effective

The average price of a commercial lawn mower which available in the markets is around RM 600 [10]. However, the total cost needed to fabricate the prototype lawn mower is only RM 140 which is 76.67% cheaper. Table-3 shows the details of the material cost which used to fabricate the lawn mower.

**Table-3: Cost of materials**

Parts and Components	Price (Ringgit Malaysia)
Rechargeable Battery	50.00
Electrical Components	5.50
Electric Motor	24.00
PWM Device	60.50
<b>Total Cost</b>	140.00

**To Design and Fabricate the Lawn Mower which Operates Around Acute Areas**

The lawn mower has been designed in such a way that it can be operated around acute areas such as trees, poles or fences. For instance, instead of using cutting blades, the mower uses strings as the trimmer to cut the grass which is more flexible. Moreover, it will not cause any damage to the cutting head component when the stings hit the trees or poles at high rotational speed. Figure-16 shows the lawn mower cutting the grass around the pole.



**Fig-16: Cutting the grass around the pole**

**CONCLUSION**

In a nutshell, the prototype lawn mower has been designed, fabricated and tested which meets all the above mentioned design objectives. Moreover, the usage of this machine makes the grass cutting process faster by reducing the cutting time. Besides that, it is lighter, environmental friendly and cost effective which is helpful for non-commercial use (home users) in maintaining and trimming the grass in gardens, home, or yards.

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