"DESIGN AND PERFORMANCE ANALYSIS OF SOLAR LAWN MOWER"

A project report submitted in partial fulfillment of the requirements for the degree of

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

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CERTIFICATE OF APPROVAL

*This is to certify that the project entitled "**DESIGN AND PERFORMANCE ANALYSIS OF SOLAR LAWN MOWER**" is hereby approved as a creditable engineering study carried out and presented in a satisfactory manner to narrate its acceptance as prerequisite to the degree for which it is submitted.*

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*We hereby recommend that the Project presented under my supervision by Suraj Biswas(18700716002),Subhrojoty Chakraborty(18700716004), Subhradip Mondal(18700716005),Subhankar De Sarkar(18700716006),Souvagya Bhowmik(18700716010),Soumyajit Adhikari(18700716011),Shubhadip Halder (18700716013) entitled "**DESIGN AND PERFORMANCE ANALYSIS OF SOLAR LAWN MOWER**" be accepted in partial fulfilment of the requirements for the degree of Bachelor of Technology in Mechanical Engineering.*

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Abstract

These days we are facing the problems like pollutions, power cut problem etc. In order to overcome theseproblems, we have thought about the device, which can be performing its functions without causing any of these problems.So we have thought of doing the project on cutting grass, this uses the renewable source of energy for its operation like solar energy. This project aims at developing a portable solar operated grass cutting device, as there is power shortage. Sowe have decided to make a solar energy operated device. Solar panel is connected to the battery. Then by connectinginverter to battery dc current is converted to ac current. This will run the ac motor. This motor is connected to bladeshaft by the help of belt drive. This will rotate the blade in high speed, cut the grass. This device will help in building ofEco-friendly system. Current technology commonly used for cutting the grass is by the manually handled device. In thispaper used novel technology. So in this paper we are trying to make a daily purpose robot which is able to cut the grassesin lawn. The system will have some automation work for guidance and other obstacle detection and the power source thatis battery and a solar panel will be attached on the top of the robot because of this reduces the power problem.

Chapter 1

INTRODUCTION

1.1 INTRODUCTION:

The first lawn mower was invented by Edwin budding in 1830 in trump, just outside Stroud, in Gloucestershire,England. Budding's mower was designed primarily to cut the grass on sports grounds and extensive gardens, as a superioralternative to the scythe, and was granted a British patent on august 31, 1830. [1]in 1995, the first fully solar powered roboticmower became available. The mower can find its charging station via radio frequency emissions, by following a boundary wire,or by following an optional guide wire.This can eliminate wear patterns in the lawn caused by the mower only being able to follow one wire back to the station.

A robotic lawn mower is an autonomous robot used to cut lawn grass. A typical robotic lawn mower requires the user to set up aborder wire around the lawn that defines the area to be mowed. The robot uses this wire to locate the boundary of the area to betrimmed and in some cases to locate a recharging dock. Robotic mowers are capable of maintaining up to 20,000 m 2 (220,000 Sq.) of grass.Automated solar grass cutter are increasingly sophisticated, are self-docking and some contain rain sensors if necessary, nearly eliminating human interaction. Robotic lawn mowers represented the second largest category of domestic robots used bythe end of 200possibly the first commercial robotic lawn mower was the mow robot, introduced and patented in 1969 and alreadyshowing many features of today's most popular products. In 2012, the growth of robotic lawn mower sales was 15 times that ofthe traditional styles. With the emergence of smart phones some robotic mowers have integrated features within custom apps toadjust settings or scheduled mowing times and frequency, as well as manually control the mower with a digital joystick.

1.2 OBJECTIVES:

The objective of our project is to design and automatic lawn mower which operates on solar energy and avoids the drawback of old lawn mowers. The purpose is to avoid energy crisis in India and reduces the human efforts, operating cost and maintenance cost. Also solar based grass cutter keeps the environment clean and healthy. It is used for cutting different types of grasses for various applications. The whole machine operates on the solar energy stored in battery. The IR sensor is used for the obstacle detection to avoid any damage of the human, object and animal. Also we are using relay to control the motor connected to blades as a switch. The prototype is charged from sun by using solar panel.

Chapter 2

LITERATURE REVIEW

PrafulUlhe, Manish D. Inwate, Fried D.Wankhede, Krushnkumar S. Dhakte [1]

In this paper they have prepared manually operated grass cutter with spiral roller blades due to spiral blades increases the efficiency of cutting. For adjusting the height reel cutter is component placed on grass cutter. The battery can be charged during working conditions and it also having AC charging. For collection of cut grass a box is placed over grass cutter so the cut grass put outside the lawn. It is having light in weight and compact in design.

T. Karthick, S. Lingadurai, K. Muthuselvan, M. Muthuvanesh, C. Pravin Tamilselvan [2]

In this paper author fabricated grass cutting machine with rotary blades by using solar energy. The solar energy is trapped in the photovoltaic cell to generate electricity. The cells may be grouped in the form of panels or arrays. Solar panel is placed such that to absorb high intensity from sun and it will incline at 450. The main function of solar charger is increased current during batteries are charging and also disconnect when they are fully charged. By considering ground clearance, they can adjust the height of grass.

Vicky Jain, SagarPatil, Prashant Bagane, Prof. Mrs. S. S. Patil [3]

They have prepared wireless grass cutter. They have used solar panel so it is not required to charge battery externally and battery is continuously charged at constant voltage when grass cutter is in working. The battery is getting charged by using day light and we can use it as per our convenience. Because of two DC motor both forward and backward motion of grass cutter can simultaneously possible.

Chapter 3

COMPONENTS AND WORKING PRINCIPLE OF THE MODEL

3.1 INTRODUCTION:

As one of the important purposes of this project is to make the Grass Cutter as cheap as possible, so the structure should be made by light material. We have used PVC Agricultural Pipe which is very light in weight and it can take load also. The total weight of the project is approximately 5 kg. We have used 12.5V battery to provide sufficient power to move the lawn mower.

The specifications of the component which has used to design the solar powered lawn mower are-

Components	Specifications/features
Solar Panel	10 watt
Battery	12.5 V
Motor Driver	5 amp
PVC Pipes	Dia. 32mm
Servomotor	9 kg (capacity)

Table-1: Specification of components

3.2 BRIEF DESCRIPTION OF SOME BASIC COMPONENTS:

3.2.1. *Arduino Uno R3:*

The Arduino Uno r3 is a microcontroller board based on a removable, dual-inline-package (dip) atmega328 avr microcontroller. It has 20 digital input/output pins (of which 6 can be used as pwm outputs and 6 can be used as analog inputs). Programs can be loaded on to it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, which makes it a very easy way to get started working with embedded electronics. The r3 is the third, and latest, revision of the Arduino Uno. The Arduino Uno is an open-source microcontroller board based on the microchip atmega328p microcontroller and developed by arduino.cc. The board is equipped with sets of digital and analog input/output (i/o) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital pins, 6 analog pins, and programmable with the Arduino ide (integrated development environment) via a type b usb cable. It can be powered by a usb cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

Fig. 1: Ardunio Uno R3

3.2.2. Ultrasonic Sensor:

As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic sensors measure the distance to the target by measuring the time between the emission and reception.An optical sensor has a transmitter and receiver, whereas an ultrasonic sensor uses a single ultrasonic element for both emission and reception. In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately. This enables miniaturization of the sensor head.

Fig. 2: Ultrasonic Sensor

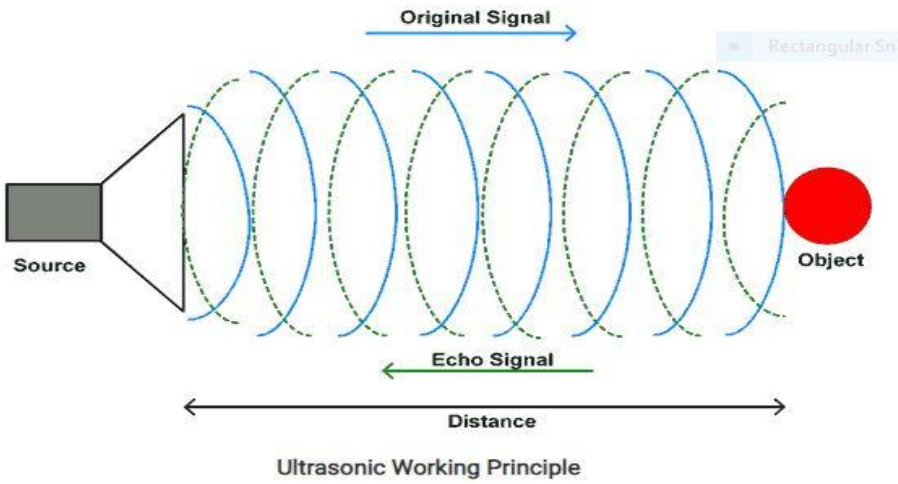


Fig. 3: Ultrasonic working Principle

3.2.3. Servo Motor:

Servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.
servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft. The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

Fig. 4: Servo Motor

3.2.4. Motor Driver*:*

Motor drives are circuits used to run a motor. In other words, they are commonly used for motor interfacing. These drive circuits can be easily interfaced with the motor and their selection depends upon the type of motor being used and their ratings (current, voltage). A motor controller or driver might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.

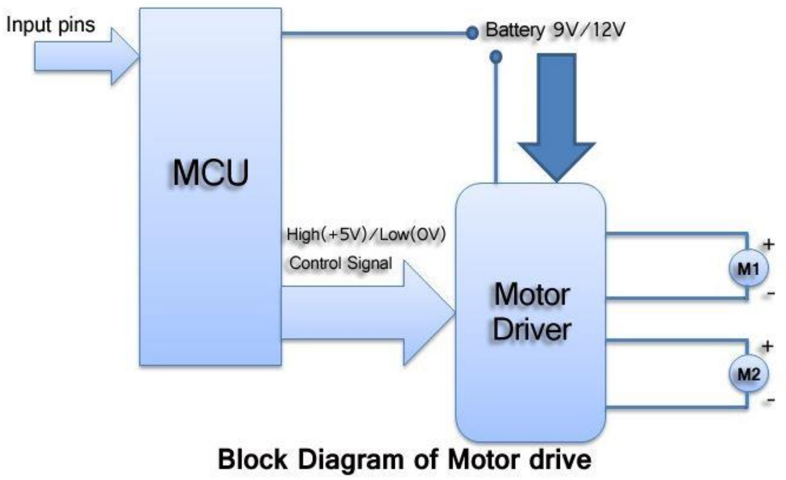


Fig. 5: Dual motor driver

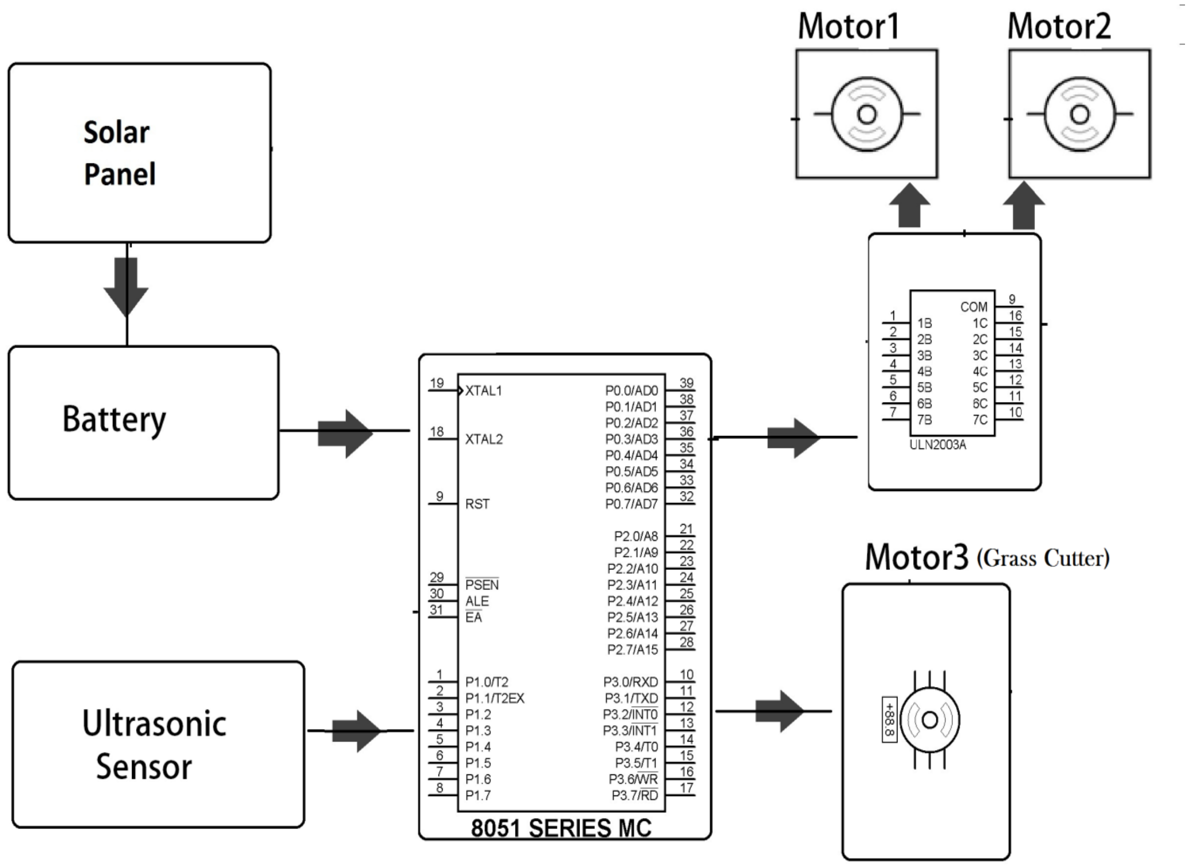
3.2.5. Solar panel:

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (pv) module is a packaged, connected assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.Photovoltaic modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells must be connected electrically in series, one to another.Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.

Fig.6: Solar Panel

3.3 BLOCK DIAGRAM AND WORKING OF THE PROJECT

3.3.1: Block diagram of the project:



3.3.2: Working of the project:

- Coming to the working of solar powered grass cutter, it has panels mounted in a particular arrangement at an angle of 45 degrees in such a way that it can receive solar radiation with high intensity easily from the sun.

- These solar panels convert solar energy into electrical energy. Now this electrical energy is stored in batteries. It stores the DC power.

- The Arduino Uno board interfaces the microcontroller with the DC motor and Ultrasonic sensor along with the solar panel. The Arduino Uno board has an USB which will be used to load the programs from computer.

- The Ultrasonic transducers or ultrasonic sensors find the obstacle.

- The motor is connected to the batteries through connecting wires. Between these a two motor driver is provided. It starts and stops the working of the motor.

- From this motor, the power transmits to the mechanism and this makes the blade to rotate with high speed and this makes to cut the grass.

Chapter 4

DESIGN AND PERFORMANCE ANALYSIS OF THE MODEL

4.1: STRUCTURAL DESIGN OF THE PROJECT:

We have designed the structure of the project in AUTOCAD and simulation by SOLIDWORKS software.

- **Images of various designed parts from AUTOCAD:**

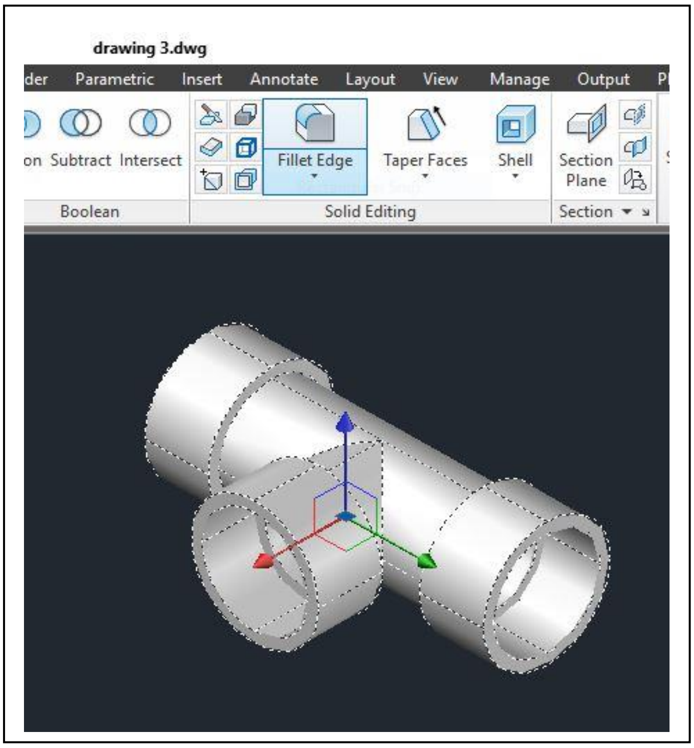


Fig.-7: T-Joint

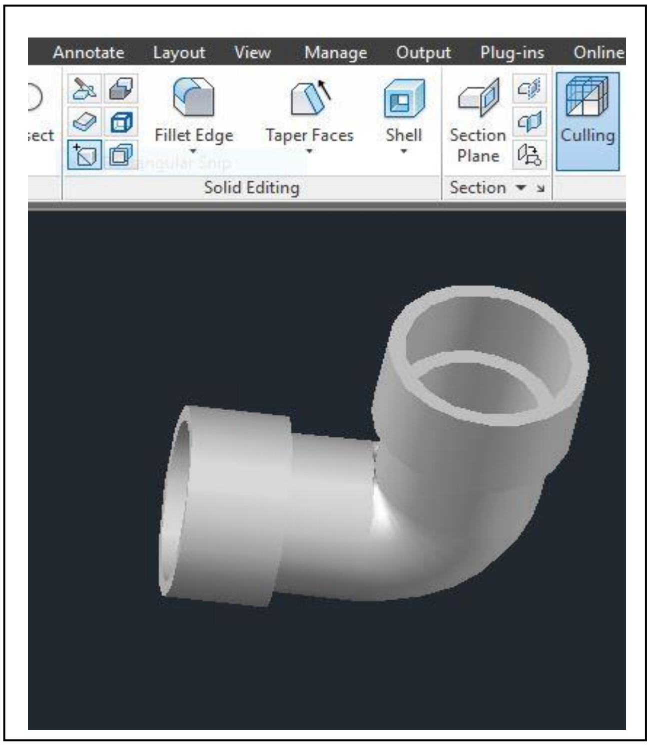


Fig.-8: L-Joint

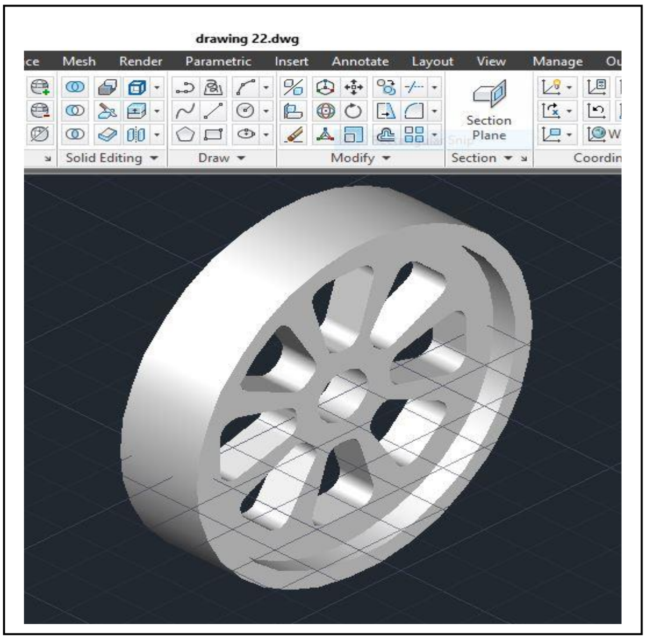


Fig.-9: Wheel

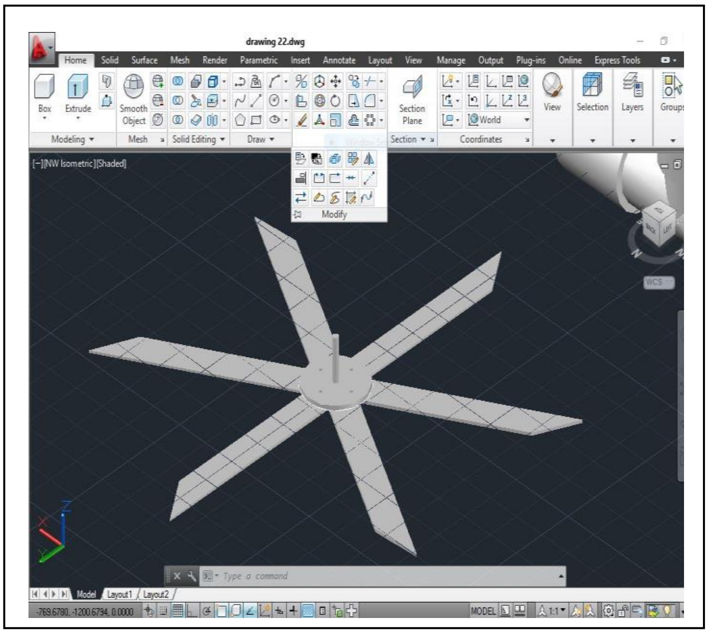


Fig.-10: Cutter

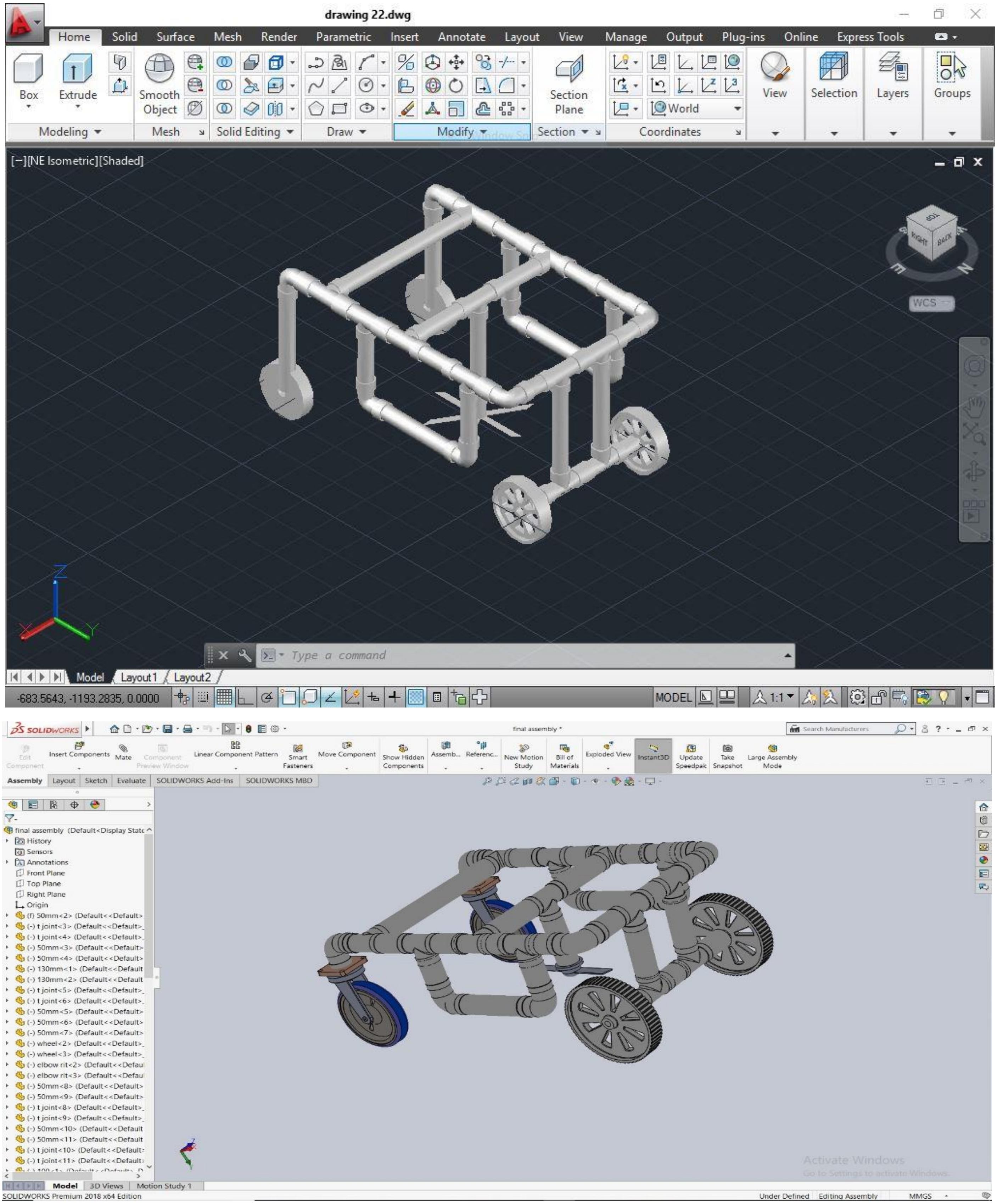
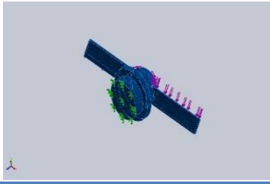
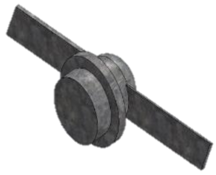


Fig. 11: Assembled structure of Lawn Mower by AutoCAD (top) and SolidWorks (bottom)

4.2: Simulation and Analysis of Blade by SolidWorks 2018:

4.2.1. Assumptions

Document Name and Reference	Treated As	Volumetric Properties
Boss-Extrude5 	Solid Body	Mass: 0.249045 kg Volume: 3.16449e-05 m^3 Density: 7870 kg/m^3 Weight: 2.44064 N



4.2.2. Study Properties:

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off

Table-2: Study properties of blade

4.2.3. Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Force	N
Torque	N-m
Angle	Degree
Pressure/Stress	N/m^2

Table-3: different units used in the project

4.2.4 Material Properties

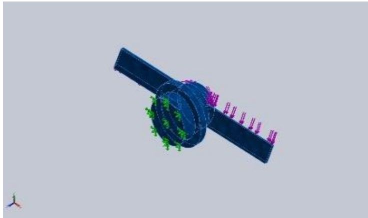
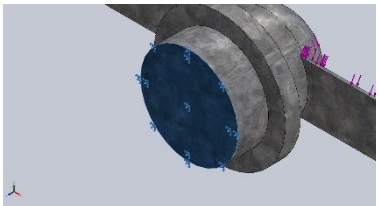
Model Reference	Properties	Components
	Name: **Galvanized Steel** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Yield strength: **2.03943e+08 N/m^2** Tensile strength: **3.56901e+08 N/m^2** Elastic modulus: **2e+11 N/m^2** Poisson's ratio: **0.29** Mass density: **7870 kg/m^3**	**SolidBody 1(Boss-Extrude5)(blade)**

Table 4: Material Properties of blade

4.2.5 Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** **1 face(s)** **Type:** **Fixed Geometry**

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**-0.355366**	**13.1378**	**-63.1208**	**64.4745**
Reaction Moment(N.m)	**0**	**0**	**0**	**0**

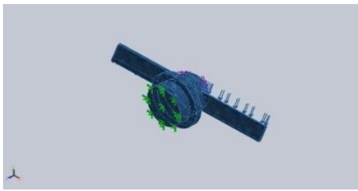
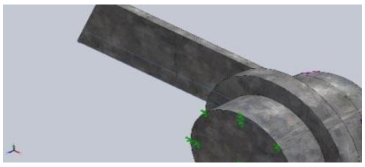
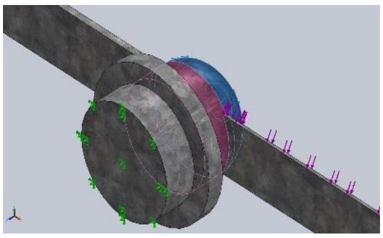
Load name	Load Image	Load Details
Force-1		**Entities:** **1 face(s), 1 Solid Body (s)** **Type:** **Apply normal force** **Value:** **50 N**
Force-2		**Entities:** **1 face(s)** **Type:** **Apply normal force** **Value:** **50 N**
Torque-1		**Entities:** **1 face(s)** **Reference:** **Face< 1 >** **Type:** **Apply torque** **Value:** **100 N.m**

Table-5: Applied load on blade

4.2.6 Mesh information details:

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	3.16411 mm
Tolerance	0.158205 mm
Mesh Quality Plot	High
Total Nodes	12151
Total Elements	7352
Maximum Aspect Ratio	5.7146
% of elements with Aspect Ratio < 3	99.1
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:01
Computer name:	

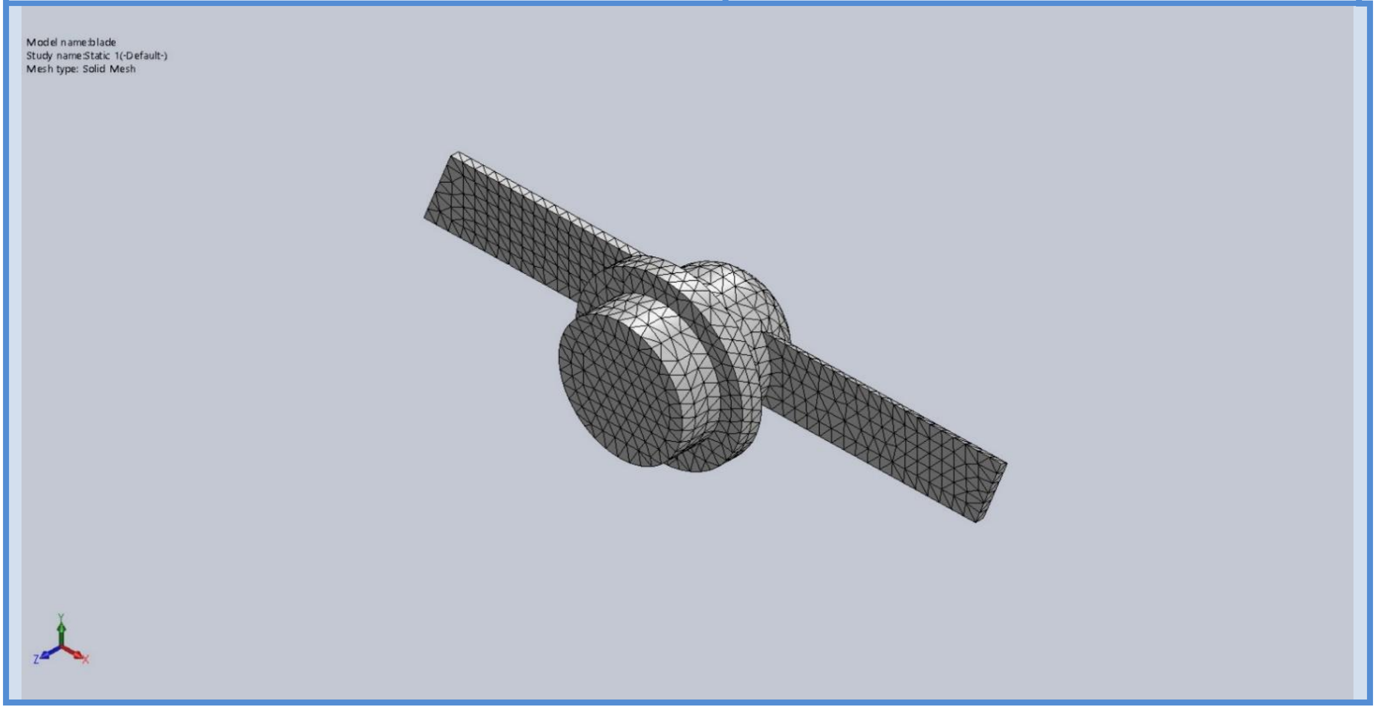


Table-6: Details of Mesh Information

Name	Type	Min	Max
Stress1	VON: von Mises Stress	4.633e+04 N/m^2 Node: 11206	1.065e+08 N/m^2 Node: 668

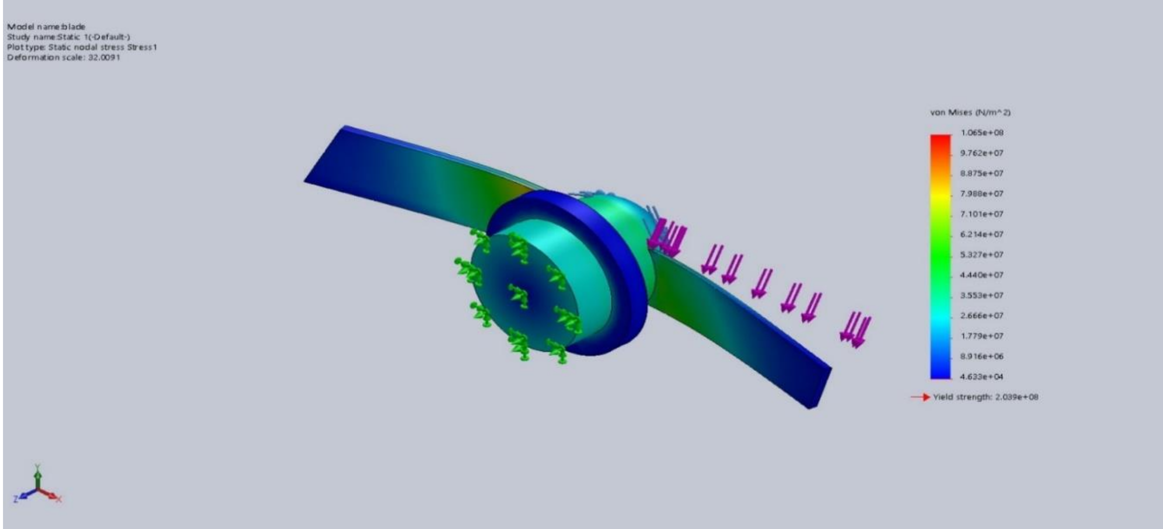


Fig. 11: Static stress analysis of blade

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 1	4.693e-01 mm Node: 630

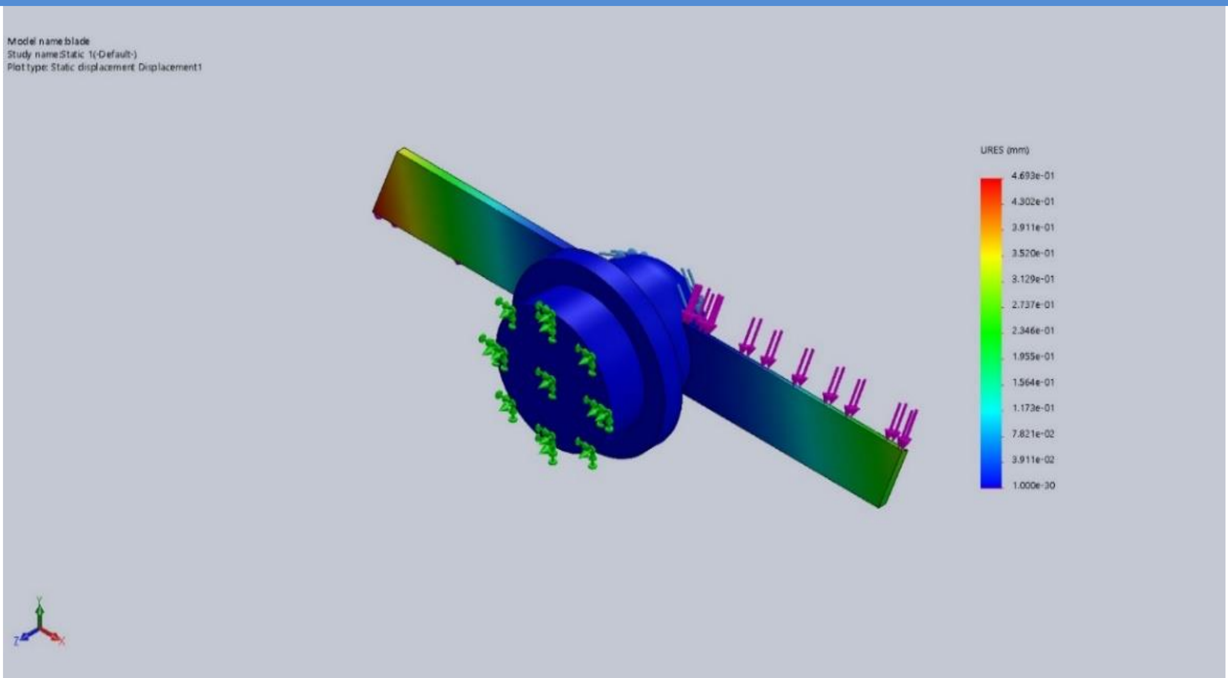


Fig. 12: Static displacement analysis of blade

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	2.304e-07 Element: 2653	2.489e-04 Element: 5956

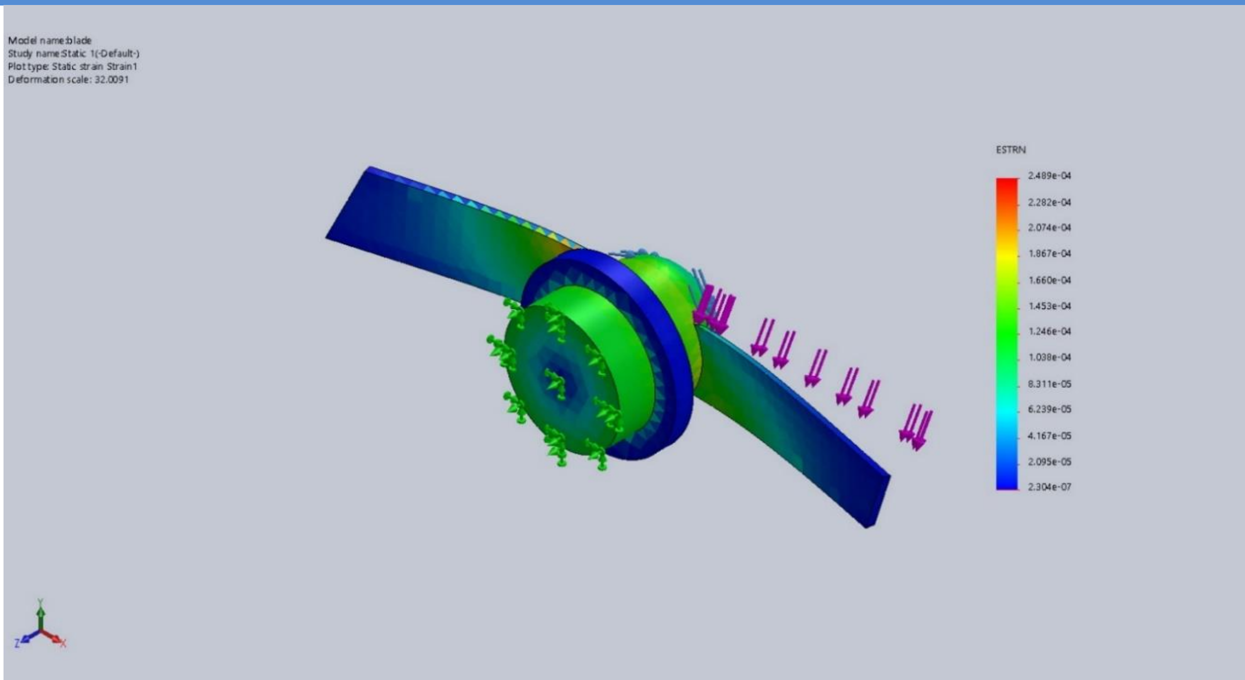


Fig 13: Static strain analysis of blade

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	-0.355366	13.1378	-63.1208	64.4745

Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

Chapter 5

ARDUINO PROGRAMMING

5.1: Arduino Programming:

The programming that has coded in the Arduino board is in the below-

```
#include <servo.h>        // include servo library
#include <newping.h>      // include newping library
// l298n control pins
constintleftmotorforward = 3;
constintleftmotorbackward = 6;
constintrightmotorforward = 5;
constintrightmotorbackward = 4;
#define trigger_pin  a1  // arduino pin tied to trigger pin on the ultrasonic sensor.
#define echo_pin     a2  // arduino pin tied to echo pin on the ultrasonic sensor.
#define max_distance 250 // maximum distance we want to ping for (in centimeters). maximum sensor distance is rated at 250cm.
servo servo_motor;  // servo's name
newpingsonar(trigger_pin, echo_pin, max_distance); // newping setup of pins and maximum distance.
booleangoesforward = false;
int distance = 100;
//char command;
void setup()
{
  // set l298n control pins as output
pinmode(rightmotorforward, output);
pinmode(leftmotorforward, output);
pinmode(leftmotorbackward, output);
pinmode(rightmotorbackward, output);
servo_motor.attach(9);   // attachs the servo on pin 9 to servo object.
servo_motor.write(115);   // set at 115 degrees.
delay(2000);              // wait for 2s.
  distance = readping();    // get ping distance.
delay(100);               // wait for 100ms.
```

```
  distance = readping();
delay(100);
  distance = readping();
delay(100);
  distance = readping();
delay(100);
  ///----testing----//
  /*if(serial.available () > 0){
    command = serial.read();
stop();
    switch(command){
      case 'f':
moveforward();
      break;
      case 'b':
movebackward();
      break;
      case 'l':
turnleft();
      break;
      case 'r':
turnright();
      break;
    }
  }*/
  //----end---//
}
void loop()
{
intdistanceright = 0;
intdistanceleft = 0;
delay(50);
  if (distance <= 10)
  {
movestop();
```

```
delay(300);
movebackward();
delay(800);
movestop();
delay(300);
distanceright = lookright();
delay(300);
distanceleft = lookleft();
delay(300);
    if (distanceright>= distanceleft)
    {
turnright();
delay(1000);
movestop();
    }
    else
    {
turnleft();
delay(1000);
movestop();
    }
  }
  else
  {
moveforward();
  }

    distance = readping();
}

intlookright()     // look right function for servo motor
{
servo_motor.write(50);
delay(500);
int distance = readping();
```

```
delay(100);
servo_motor.write(115);
  return distance;
}
intlookleft()      // look left function for servo motor
{
servo_motor.write(180);
delay(500);
int distance = readping();
delay(100);
servo_motor.write(115);
  return distance;
}
intreadping()      // read ping function for ultrasonic sensor.
{
delay(100);                    // wait 100ms between pings (about 20 pings/sec). 29ms should be the shortest delay between pings.
int cm = sonar.ping_cm();   //send ping, get ping distance in centimeters (cm).
  if (cm==0)
  {
    cm=250;
  }
  return cm;
}
void movestop()       // move stop function for motor driver.
{
digitalwrite(rightmotorforward, low);
digitalwrite(rightmotorbackward, low);
digitalwrite(leftmotorforward, low);
digitalwrite(leftmotorbackward, low);
}

void moveforward()    // move forward function for motor driver.
{
digitalwrite(rightmotorforward, high);
digitalwrite(rightmotorbackward, low);
```

```
digitalwrite(leftmotorforward, high);
digitalwrite(leftmotorbackward, low);
}

void movebackward()   // move backward function for motor driver.
{
digitalwrite(rightmotorforward, low);
digitalwrite(rightmotorbackward, high);
digitalwrite(leftmotorforward, low);
digitalwrite(leftmotorbackward, high);
}

void turnright()      // turn right function for motor driver.
{
digitalwrite(rightmotorforward, low);
digitalwrite(rightmotorbackward, high);
digitalwrite(leftmotorforward, high);
digitalwrite(leftmotorbackward, low);
}
void turnleft()       // turn left function for motor driver.
{
digitalwrite(rightmotorforward, high);
digitalwrite(rightmotorbackward, low);
digitalwrite(leftmotorforward, low);
digitalwrite(leftmotorbackward, high);
}
/*void stop()
{
digitalwrite(rightmotorforward, low);
digitalwrite(rightmotorbackward, low);
digitalwrite(leftmotorforward, low);
digitalwrite(leftmotorbackward, low);
}*/
```

Chapter 6

RESULT AND DISCUSSION

6.1 ***Results and calculations:***

Force required by cutting blade to shear the grass is given by-

F=T/R

Where T= shaft torque   R= radius of blade

But shaft torque is given by

T=P/2ΠN*60

Where P= power developed by shaft, N= speed in rpm

Electrical Power is given by; P = I * V

Where I= current V= voltage,

Now, I=25 amp,   V=12 V,   N=800 rpm

Applying those formula, we get,

Power developed by shaft,P=25*12=300watt

Shaft torque of the cutting motor, T=18000/2Π*800= 3.58 N-m

Force required cutting blade, F= 3.58/0.12=29.8N

Total Hours to get full charge by Solar Panel,

t= (Amp hour rating*100of full charge needed / Amp) *1.25

= {(7AH*1)/2.5} *1.25

=3.h hour

6.2 ***Discussion:***

The lawn mower, made up by Solar panel, DC motor, battery, blade, sensors, Arduino programming and so on, takes almost 3months. We have faced some technical failures like the motor driver was burned due to excessive current supplied from the battery, failure of the frame-structure, spoiling of the gear motor etc. But at last we are successfully able to run the lawn mower.

Chapter 7

COST OF THE PROJECT

7.1 **HARDWARE USED AND COSTING OF THE PROJECT:**

Components	Specification	Quantity	Cost(Rs.)
Gear Motor	300 rpm	2	300*2=600.00
Wheels	100 mm	4	100*4=400.00
Cutting Blade	thickness .5mm	1O	25.00
Motor(Used For Cutting)	500 rpm	1	100.00
Solar Panel	10 wt, 12v	1	630.00
Pvc Pipe,T & L Joint	32mm,34mm	15 ft.	1100.00
Clamp	-	5	110.00
Wire	Coppe-rwire	-	20.00
Black Tape	-	1	10.00
Arduino Uno R3 With Cable	r3	1	420.00
Ultrasonic Sensor	<1 M	1	80.00
Servo Motor	9kg	1	130.00
Motor Driver	5amp dual	1	100.00
Solar Charge Controller	12v	1	500.00
Bluetooth Module	-	1	230.00
Voltage Booster Module	400 khz	1	110.00
Switch + Charge Port		2+1	5*3=15
Acid Battery	12.5v 25amp	1	1300.00
Alolight Glue		1	30.OO
Breadboard		1	50.00
Jumper Wire		10	3.00
Led + Diode		5+5	3*10=30.00
Heat String		1	10.00
Tie Band		20	1*20=20.00
Resistor		5	1*5=5.00
Others		--	1000.00
			TOTAL =5,958.00

Table-8: Hardware used and costing of the project

CONCLUSIONS AND FUTURE SCOPE

8.1 Conclusions:

Today the most promising source of energy where everyone focusing is the concept of solar power and its utilization. Generally, we see people who had gardens use grass cutting machine manually to cut the unwanted grass. Those grass cutting machine are powered from normal household's power through cables or using petrol/diesel. Using cables creates messing problem and if there is any power cut, we can't use that grass cutting machine. Similarly, if we use petrol/diesel powered machine, it requires money and they create pollution through the smoke. Through this project, you are going to build a unique automatic solar grass cutter (grass cutting machine) which is powered by solar energy and it will overcome all the above mentioned problems.By using this system, we can preserve the non-renewable sources of energy such as petrol, gasoline etc. We can also reduce various forms of pollutions such as air pollution and noise pollution. Electricity is saved as we utilize solar energy that is renewable source of energy and is present in abundance.

8.2 Future scope:

- This project will be useful in backyard or garden, playgrounds, home, public-parks to remove the unwanted grass/weeds.
- As the grass cutter is eco-friendly, so there is a chance to use this machine widely.
- Size can be reduced to make it compact.
- Efficiency can be improved by increasing the battery capacity.
- More sensors can be incorporated for accurate results and improved automation.
- Programming can be enhanced to make the device perform different operations.

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