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Senior Design Project Report

**Design of a Miniature Wind Turbine for
Automobiles**

**In partial fulfillment of the requirements for the
Degree of Bachelor of Science in Mechanical Engineering**

Team 3

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Abstract

Wind energy is one of the main source of energy these days. It is a part of the clean and renewable energy that we use in our lives. In some areas in the world, there are huge wind activities that should be utilized to produce energy. Many scientists are doing researches to improve the efficiency of wind turbine. In future, wind energy will be one of the most important sources which the human being will be relying on instead of fossil fuel energy. Wind energy has many challenges for instance, noise pollution or high costs of maintenance.

This project aims at designing a miniature wind turbine to be installed on top of an automobile and will be capable of charging a battery (12 V). This project involves the design and manufacture of the wind turbine to be attached on top of an automobile [to benefit from the harvest power from the wind speed due to height of automobile]. The project is anticipated to help drivers, especially truck drivers to avoid keeping the engine running for long periods of time and utilize energy during idle times. Keeping the engine running will cause air pollution, waste of fuel, maintenance costs, and environmental noise. The purpose of the current project is to be able to produce power from a wind source without compromising the current electromechanical system or efficiency of the automobile. The designed wind turbine will contain alternator, battery, fan, cavity, and design of a detachable fixture to be mounted on the roof of the truck.

Acknowledgments

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List of Acronyms (Symbols) used in the report:

Symbol	Definition
ρ	Density
m	Mass
P_m	Mechanical Power
C_p	Power Coefficient
u	Wind Velocity
T	Torque
A	Area
P_v	Wind Power
R	Ideal Gas Constant
k	Gas Constant
N	Angular speed (RPM)
M	Mach Number
T	Temperature
C	Fluid Velocity
p	Pressure
C_p	Specific Heat
P_0	Stagnation Pressure
T_0	Stagnation Temperature

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Chapter 1: Introduction

1.1 Project Definition

This project is about designing and manufacture a miniature of wind turbine, where the wind turbine must be attached to the top of the automobiles especially for trucks. The wind turbine contains the fan which receive the air to convert the mechanical energy to electrical energy by using alternator generator that to be connected to a battery charge. The design of the miniature wind turbine has supplied by cavity that includes a wide intake at the front to collect maximum amount of air directed to the fan. The project must be attached at the top of the truck whether by detachable magnetic or bolts to be screwed.

1.2 Project Objectives

The main important objectives in this project are:

1. Design a miniature wind turbine for automobile
2. Design a proper attachment and cabling
3. Harvest wind energy, reduce costs and pollutions for automobiles
4. Use clean energy to produce power

1.3 Project Specifications

This project is applicable to all types of vehicles such as cars and trucks. The miniature of wind turbine has been selected for this project which has the specifications as listed in table 1.1. Also, we have used electrical generator to recharge our battery by the givens in tables 1.2 and 1.3.

Table 1.1: The system measurements

Item	Size
Inlet nozzle (width)	590 mm
Outlet nozzle directed to the fan (width)	250 mm
The system length	660 mm
The system width	585 mm
The diameter of the fan cavity	310 mm
The width of the fan cavity	310 mm
The width of a single fan blade	120 mm
The length of a single fan blade	290 mm
Thickness of the blades and structure parts	3 mm
Number of blades used for the fan	6
Wight of the system	16 kg

Table 1.2: The output of the electrical generator

Maximum output power	969 W
Voltage	14.7 V

Table 1.3: The output of the battery

Voltage	12 V
Wight	9 kg

1.4 Applications

The main applications for the project are:

- To be used for trucks during idle times for charging electronic devices or cooking by electric furnaces
- To be used in camping for several proposes such as lighting
- To be used for people who drive for long journeys

Chapter 2: Literature Review

2.1 Project background

Nowadays a lot of new companies start relying on renewable energy rather than fuel in most machines, which are very helpful for our environment. As we see in streets, many trucks drivers are wasting fuel to use the energy of the truck during idle times. As a result of this behavior, they cause air pollution for the environment, noise pollution for the people, and maintenance costs. The World Health Organization (WHO) announced in 2012 that emissions which came from diesel combustion may cause cancer diseases. In 2014, the WHO released details showing that more than 7 million deaths are caused by indoor and outdoor air pollution. The black smoke from diesel engines is a part of outdoor air pollution contributed by buses and trucks [1]. Moreover, there are other type of pollution which trucks cause is noise pollution. According to the World Health Organization (WHO), studies released a report that includes the data analyzed environmental noise from planes, trains and vehicles, as well as other city sources, and then looked at links to health conditions such as bloods and hearts diseases, sleep disturbance, tinnitus, cognitive impairment in children, and annoyance [2].

As we know if we let trucks to work during idle times, costs will be raised due to two important factors, maintenance and fuel refilling. Thus, our project aims to prevent this problem and avoid the bad causes which have been detailed above. In table 2.1, data shows two variables; idling, and driving. In idling, the truck may cost around 2000\$ for fuel and 260\$. On the other hand, when the truck is driving, the cost of fuel is 9820\$ and for maintenance is 690\$ [3].

Table 2.1: Summary of the average variables [3]

Variable	Fuel (2004 US\$)	Maintenance (2004 US\$)	Fuel (at 2006 at-the-pump rates)
Idling	\$1855	\$260	\$3195
Driving	\$9820	\$690	\$16,910
Total	\$11,675	\$950	\$20,100

Simply, wind turbine is a system which receive air and convert it to produce energy. As any project, it should face many challenges and barriers. We as a group of the senior project, we should be aware about challenges and how to overcome them. The first challenge of our project was the location of Miniature Wind Turbine (MWT). It was decided to be located under the automobiles. This idea was not helpful due to two issues. The first issue was the lack of coming air. The amount of air that will pass under the automobiles is very limited. Thus, the turbine will not generate enough energy. The second issue was the safety of the system. The automobile may face problems on the road such as pitfalls or bumps and they will damage the system. After that, we decided to attach the (MWT) at the top the automobiles so it can receive the air without limitation and more safety.

The second challenge was the selection material of the cavity. At the beginning, we chose the metallic cavity to be installed in the system. However, we observed that (MWT) was heavy. Moreover, the angles of the metallic cavity were hard to deal with them due to the material that we have select. We overcame this challenge by replacing the material of the cavity to fiber glass. As a result, it became light and easy to design the angles and curves. We kept the shaft and the fans metallic to rotate strongly so that will produce more energy. The propose of using fiber glass in the cavity is to deal with the entrance and the angles so the air can pass as a laminar flow.

2.2 Previous Work

The first project was talking about the electric vehicle with charging facility in motion using wind energy. It was based on the concept of charging the batteries of an electric vehicle when it is in motion or propelling. Their project was done by using the energy of wind which is caused by the relative motion between the vehicle and the wind surrounding it. Wind turbines was mounted on the body of the vehicle to generate electricity in such a way that it must not create any additional drag force upon the vehicle. The table 2.2 shows the plane force and pressure over the two designs have been tabulated. The variation of force and pressure are identical for the both designs. The outlet pressure is increased for the modified design which indicates a reduction in form drag [4].

Table 2.2: Simulation results for pressure and forces [4]

Comparison Parameters	Conventional Design		Modified Design with ducts for turbine	
	Inlet	Outlet	Inlet	Outlet
Pressure(Pa)	2.29185	-1.24196	2.28742	0.240414
Force(Drag)(N)	45.9144	6.5354	15.5202	11.605

University of Mines and Technology made a project that aims to design of a wind turbine that will be mounted on the electric car to generate electrical power to charge the car batteries when it is in motion. The turbine is located on the roof of the car, where the velocity of air flowing around the car is highest due to its aerodynamic nature. Their design of a portable axis was horizontally, and the diffuser augmented wind turbine is adopted for the design which able to generate a higher power output as compared to the conventional normal wind turbine as shown in figure 2.1. Through their calculations on the power generated from the wind, a significant amount of electrical power (about 3.26 kW) is restored to the batteries when the car is moving at a speed of 120 km/h (see figure 2.2) [5].

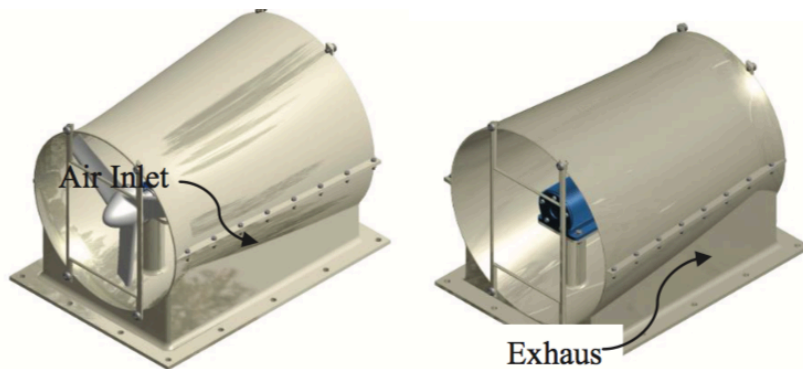


Figure 2.1: Isometric Views of the Wind Turbine [5]

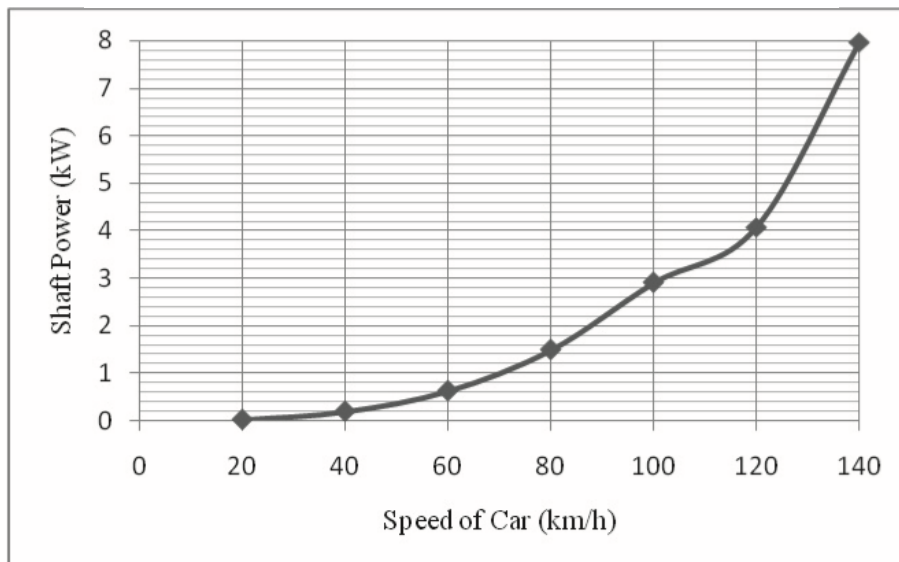


Figure 2.2: Graph of speed car versus shaft power [5]

According to University Tun Hussein Onn Malaysia, they made a project which investigates the characteristics of airflow with a flow guide installed and output power generated by wind turbine system being installed on a pickup truck. The wind turbine models were modelled by using SolidWorks 2015 software as shown in figure 2.3. In order to investigate the characteristic of air flow inside the wind turbine system, a computer simulation (by using ANSYS Fluent software) is used (see figure 2.4). In their conclusions, they had few models which have been designed and simulated, one without the rotor installed and other two with rotor installed in the wind turbine system. Also, they used three velocities for the simulation which are 16.7 m/s (60 km/h), 25 m/s (90 km/h) and 33.33 m/s (120 km/h) [6].

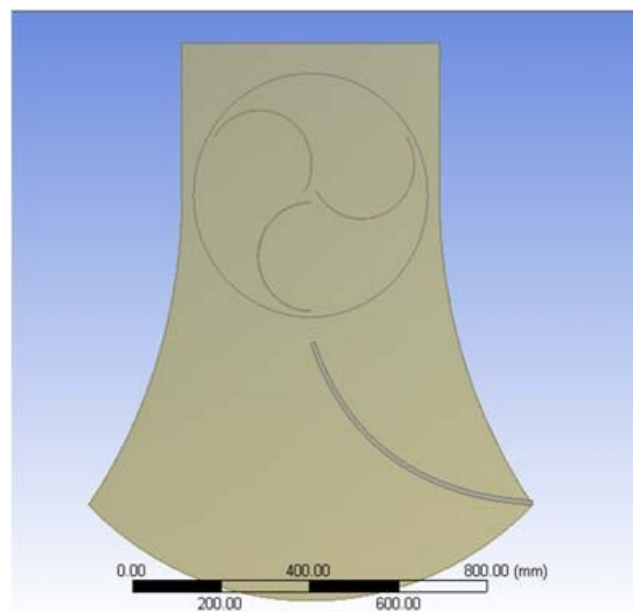


Figure 2.3: Location of the flow cavity in the turbine model [6]

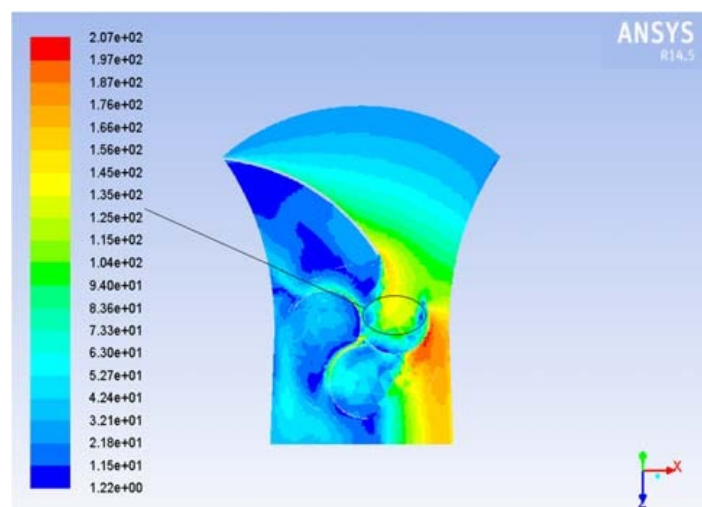


Figure 2.4: Velocity simulations [6]

2.3 Comparative Study

In reality, our project did not start from zero. We want to benefit from other people and their experiences. So, we went through some similar projects that may enhance our idea and improve our knowledge. Hence, members of TATI University College from Malaysia did a similar project; design of portable mobile phone charger using multi directional wind turbine extract. Their project was about a battery charger includes an application with mobile phones to address the design considerations and demonstrates the performance of the charger adapted to a practical application system. The result of their project shows that the mobile system for multi direction wind turbine was very useful and appropriate to be applied on vehicles as shown in table 2.3. Their design of mobile products will make users to install and more user-friendly. Based on their project they have succeed in charging of laptop and other high-power gadgets [7].

Table 2.3: The rate of speed motorcycle and voltage produce [7]

Motorcycle Speed (km/h)	Anamometer (m/s)	HMD Fan Voltage Produce (Vdc)	VMD Fan Voltage Produce (Vdc)
10	6.33	1.40	1.36
20	7.77	2.35	2.11
30	11.04	3.21	2.89
40	11.78	4.00	3.38
50	13.71	5.32	4.11
60	16.7	5.48	4.70
70	18.7	6.13	5.31
80	19.55	6.61	6.12
90	19.98	7.57	6.84
100	20.89	7.67	7.12

The second similar project was talking about design of wind turbine systems on a pickup truck. The miniature of wind turbine system was located at the roof of the pickup truck body (see figure 2.5). According to the testing that has been conducted, about 120 Watt of the wind power (at targeted speed of 120 km/h) was converted to electrical power as shown in table 2.4. Their blade design, configuration, and energy conversion system would increase the produced electrical power. The proper location to install the miniature of wind turbine was on the top roof of the pickup truck because it was the best place to get high wind velocity.

However, the issue was that wind turbine may change the aerodynamic performance of the vehicle [8].

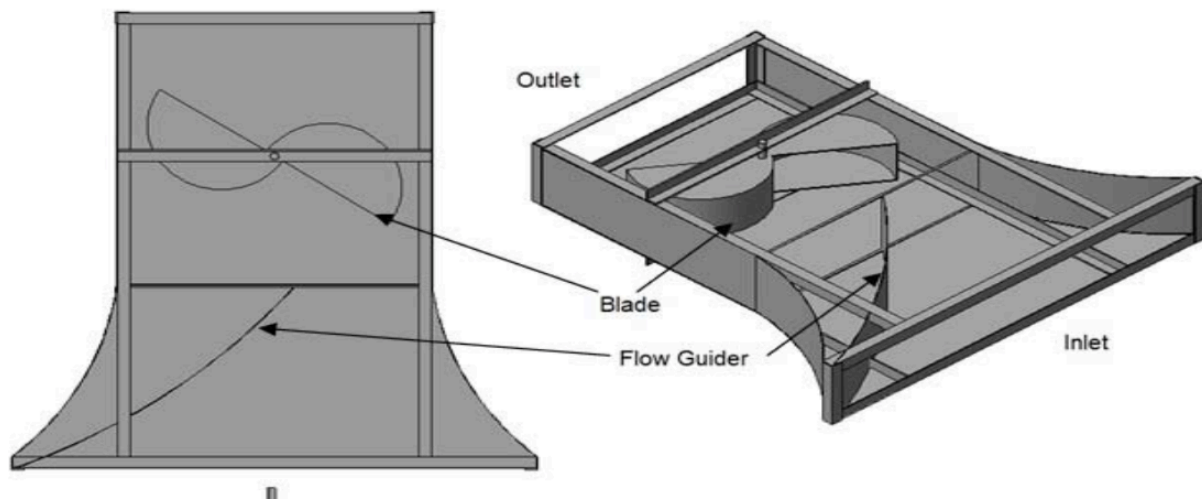


Figure 2.5: Model drawing of complete turbine system [8]

Table 2.4: The relationship of speed and the power [8]

No.	Speed (km/h)	Average Output power (W)
1	60	20.4
2	70	28.7
3	80	40.0
4	90	62.3
4	100	78.5
6	120	120.5

The third project was taking about designing and implementation of vehicle mounted wind turbine. Vehicle Mounted Wind Turbine (VMWT) was a located horizontally wind turbine system for vehicles. This project aims to design and implementation of VMWT which generate electricity from vehicle. Their project contains several smart features including high angular velocity of the turbine, convenient weight, practical shape and portability. It was observed that with ideal designing, VMWT can generate approximately 200 W of power at vehicle speed of 80 km/hr [9].

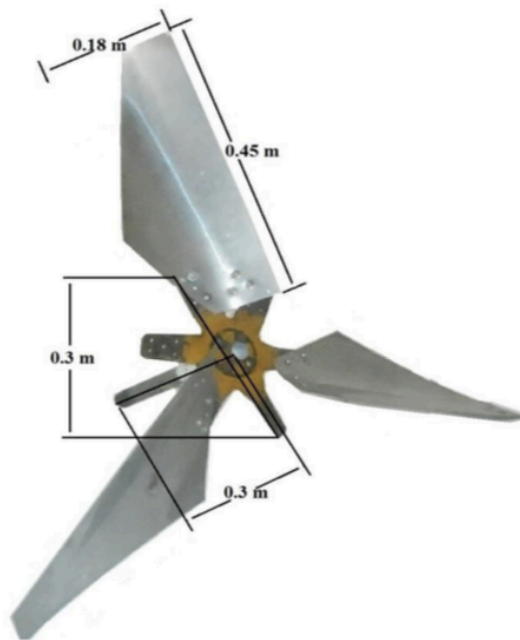


Figure 2.6: Turbine of VMWT [9]

Table 2.5: description of VMWT equipment [8]

Generator	Blades	Turbine
Model: HN1010B Input: 180V/5A RPM: 4000 Mechanical O/p: 2 hp Type: PMDC Efficiency: 60.35%	Length: 0.45 m Width: 0.18 m Weight: 1 kg (each) Total blades: 3 Orientation: Central	Swept area: 1 m Length: 0.45 m Weight: 6 kg (without generator) Type: HAWT Tail: No

In the first project, they succeed to make a charger that depends on the wind turbine which limited to charge phones. They mentioned that it could charge laptops and other high-power devices but not in the same efficacy with mobile phones. On the other hand, our project can charge almost all devices such as lights, electric devices, etc. In the second project, they used metal cavity for receiving air and they face some barriers like sharp edges and heavy. However, our cavity was designed using fiber glass to avoid the sharp edges and to get smooth flowing. Also, to make the system less heavy. The last project was about vehicle mounted wind turbine (VMWT). We benefited from their project in terms of equations, results, and components. However, we succeed to improve our project based on these data.

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1: Geometrical Constraints

When we started design and plan for our project, we faced familiar challenge which are lack of the parts that we need it for our project such as bearing to assist the rotating of the shaft. In the local market, we found a bearing with low quality, so it may affect negatively of the performance of the rotating for the shaft. Furthermore, one of the barriers is the volume of the system. We supposed to design the system with limited area to be fit with the roof of the automobiles. If we were able to design the system with a bigger area than area of the roof top of the vehicles, the system will give us higher electricity. The second barrier is the weight of the system. When we design the system, we should take considerations on the weight of the system. We designed our system with a minimal weight, so we can install it easily in any automobiles by using fiberglass as a cavity.

3.1.2: Sustainability

We may face a problem in terms of sustainability due to chance of getting corrosion. Because the blades of the turbine and the shaft are metallic materials. To avoid this problem, we used coating to prevent the metal components from corrosion.

3.2.3: Environmental

Most countries prefer to use eco-friendly energy sources to generate power. United States and China are two of the biggest countries in the world that has wind farms to generate wind energy. Our system depends on wind turbine to generate electricity. It reduces air pollution of the automobiles during idle times.

3.2.4: Social

Our system can be shared by multi people. Some people can use it to charge their cellphones while others are able to use it to operate electric furnace, water heater, or lights. Thus, the system shall have social impact.

3.2.5: Economic

In economic side, our system helps automobile drivers to save money by turn off the engine to use the battery during idle time instead of consuming the fuel which results high costs. Moreover, it will reduce maintenance costs due to turning the engine off during idle time.

3.2.6: Safety

One of the important of our system is safety of automobiles parts. keeping the engine running it will affect badly on the DEF (Diesel Exhaust Fuel) filer due to burning of oil which will increase emission of gas and low automobiles performance

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

Engineering standards should be followed in each components of our system. In this section, we described each component that have been selected for our project. The selected components are the following; screw, bearing, and motor. The screw standard has been taken according to ANSI metric. The standard of bearing has taken from NSK. The motor was taken from Delco-Remy international brand. It has been used for Toyota motor company in 1996. See table 3.1

Table 3.1: Engineering Standards

Components	Engineering Standard	Details
Screw	ANSI metric	B18.2.3.2M - Formed hex screw, M16 x 2.0 x 80 --38CS
Bearing	NSK	Deep Groove Ball Bearing 6300ZZ 10mm I.D, 35mm O.D
Alternator	Delco-Remy	DRA3053

3.2.1: Screw

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

- Length: 80 mm
- Thickness of the head: 5 mm
- Diameter of the head hex: 16 mm

3.2.2: Bearing

Ball Bearings 6300ZZ: OD 35-mm, and width 11-mm

The standard of the bearing is: Deep Groove Ball Bearing 6300ZZ [10].

3.2.3: Alternator

In figure 3.1, the images show the selected alternator for the project and its properties [11]

- Diameter: 58 mm
- Pulleys: with v-ribbed belt pulley
- Voltage: 12 V
- Alternator charge current: 55 A
- Supplementary: with integrated regulator
- Number of ribs: 5
- Length: 32 mm



Figure 3.1: The Alternator [11]

3.3 Theory and Theoretical Calculations

3.3.1: Wind Turbine Performance:

An amount of wind mass m and density ρ_a that flows with speed u in the axial direction of the wind turbine has some kinetic energy. The available mechanical power P_m is the derivative of the kinetic energy with regard to time, see equation (3.1) [12].

$$P_m = \frac{1}{2} \times \rho_a \times A_v \times u^3 \quad (3.1)$$

C_p is the power coefficient which is the result of the electrical power (output power) P_{out} over the mechanical power (input power) P_{in} [12].

$$C_p = \frac{P_{out}}{P_{in}} \quad (3.2)$$

3.3.2: Wind Turbine Analysis:

in the nozzle, there is outlet velocity and inlet velocity. The inlet velocity is the air when it is entering the nozzle. It will be less than the outlet velocity which is the air when it is going out of the nozzle directing to the blades of the fan. This will achieve the purpose of the convergent nozzle so the velocity will be increased at the outlet point and give more forces to the blades to rotate. for the required data for calculation, see equation 3.3 for relationships between temperature and the velocity, equation 3.4 for the Mach number formula, 3.5 for the ratio of the stagnation temperature and static temperature, and 3.6 for the ratio of inlet to exit area

$$T_{01} = T_1 + \frac{c_1^2}{2c_p} \quad (3.3)$$

where T_{01} is the stagnation temperature, C_p is the specific heat, T_1 is the static temperature, and C_1 is the inlet velocity.

$$M_1 = \frac{c_1}{a_1} = \frac{c_1}{\sqrt{kRT_1}} \quad (3.4)$$

where a is the speed of the sound, and k is the ideal gas constant (for air $k = 1.4$)

$$\frac{T_{02}}{T_2} = \left[1 + \left(\frac{k-1}{2} \right) (M_2)^2 \right] \quad (3.5)$$

$$\frac{A_1}{A_2} = \frac{M_2}{M_1} \times \frac{\left[1 + \left(\frac{k-1}{2} \right) (M_1)^2 \right]^{\frac{k+1}{2(k-1)}}}{\left[1 + \left(\frac{k-1}{2} \right) (M_2)^2 \right]^{\frac{k+1}{2(k-1)}}} \quad (3.6)$$

in equations 3.7, 3.8, 3.9, and 3.10 are required to determine the outlet density which is contributed on the wind power equation.

$$\rho = \frac{P_1}{RT_1} \quad (3.7)$$

$$P_{01} = P_1 + \frac{1}{2} \left(\frac{P_1}{RT_1} \right) (C_1)^2 \quad (3.8)$$

$$\rho_1 A_1 C_1 = \rho_2 A_2 C_2 \quad (3.9)$$

3.3.2: Mechanics of the Wind Turbine:

T is the torque of the shaft, F is the resultant force, and r is the radius of the blades (hub) see the following equation (3.10) [13].

$$T = r F \quad (3.10)$$

3.3.3: Results

A) the outlet velocity C_2 :

We have the speed of the inlet velocity which will be the speed of the air:

$$C_1 = 100 \text{ km/h} = 27.78 \text{ m/s}$$

$$T_{02} = T_{01} = 293 \text{ °K} \text{ “Adiabatic process”}$$

$$T_{01} = 20 \text{ °C} = 293 \text{ °K}$$

$$A_2 = 0.026 \text{ m}^2$$

$$A_1 = 0.062 \text{ m}^2$$

$$C_2 = ? \text{ “the outlet velocity”}$$

$$P_{01} = 101320 \text{ Pa (1.0132 bar)}$$

Step (1): Using equation 3.3 to find T_1 ($C_p = 1005 \text{ J/kg.K}$):

$$293 = T_1 + \frac{(27.78)^2}{2(1005)}$$

$$T_1 = 292.616 \text{ °K}$$

Step (2): Now, we use equation 3.4 to find Mach number at the inlet:

$$M_1 = \frac{C_1}{a_1} = \frac{27.78}{\sqrt{1.4 \times 287 \times 292.616}} = 0.081$$

Step (3): Using equation 3.6 to find the Mach number at the outlet:

$$\frac{0.062}{0.026} = \frac{M_2}{0.081} \times \frac{\left[1 + \left(\frac{1.4 - 1}{2}\right) (0.081)^2\right]^{\frac{1.4+1}{2(1.4-1)}}}{\left[1 + \left(\frac{1.4 - 1}{2}\right) (M_2)^2\right]^{\frac{1.4+1}{2(1.4-1)}}}$$

$$\mathbf{M_2 = 0.197}$$

Step (4): Using equation 3.5 to find the static temperature at the outlet:

$$\frac{293}{T_2} = \left[1 + \left(\frac{1.4 - 1}{2}\right) (0.197)^2\right]$$

$$\mathbf{T_2 = 290.74 \text{ }^\circ\text{K}}$$

Step (5): Use equation 3.4 to find the outlet velocity of the nozzle:

$$C_2 = M_2 \times \sqrt{kRT_2} = 0.197 \times \sqrt{1.4 \times 287 \times 290.74}$$

$$\mathbf{C_2 = 67.33 \text{ m/s}}$$

Step (6): Find the static inlet pressure by using equation 3.8:

$$101320 = P_1 + \frac{1}{2} \left(\frac{P_1}{(287)(292.616)} \right) (27.78)^2$$

$$\mathbf{P_1 = 100856.597 \text{ Pa}}$$

Step (7): Find the density at the inlet by using equation 3.7:

$$\rho_1 = \frac{100856.597}{(287)(292.616)}$$

$$\mathbf{\rho_1 = 1.201 \text{ kg/m}^3}$$

Step (8): finally, find the outlet density from the continuity equation (equation 3.9)

$$\mathbf{(1.201)(0.062)(27.78) = \rho_2(0.026)(67.33)}$$

$$\mathbf{\rho_2 = 1.182 \text{ kg/m}^3}$$

B) The wind power P_v “see equation 3.1”:

$\rho_a = 1.182 \text{ kg/m}^3$ “the pressure at the outlet nozzle”

$A_v = 0.026 \text{ m}^2$ “the outlet area which is directed to the fan”

$u = 67.33 \text{ m/s}$ “the outlet velocity of the nozzle when the air speed is $27.78 \text{ m/s} = 100 \text{ km/hr}$ ”

$$P_v = \frac{1}{2} \times 1.182 \times 0.026 \times 67.33^3$$

$$P_v = 4690.15 \text{ Watt}$$

C) Summary of the calculations:

We repeated the same procedure of the calculations when the velocity at $100 \text{ km/hr} = 27.78$ above. Here is the table of the summary of the calculations which are the outlet velocity and the power of the wind. See table 3.2 for further information.

Table 3.2: Summary of the results

The required results	Wind Velocity			
	60 km/hr	80 km/hr	100 km/hr	120 km/hr
Inlet velocity of the nozzle (C_1)	16.67 m/s	22.22 m/s	27.78 m/s	33.33 m/s
Outlet velocity of the nozzle (C_2)	40.09 m/s	53.74 m/s	67.33 m/s	81.88 m/s
Angular speed (RPM)	2466	3087	4315	4935
The wind power (P_v)	1000.97 W	2390.86 W	4690.15 W	7764.36 W

3.4 Product Subsystems and selection of Components

The figure 3.2 shows the exploded assembly of the project. We can see various parts of the project including cavity, nozzle, the base, fan, and the alternator. The final shape of the assembly is showed at the left side of the figure while the right side shows the exploded parts and the dotted which explain how each part is fixed to each other. The base is the main part which is carrying all the parts. The fan is consisting of 6 blades welded to the shaft and it connected between the base holder and the pulley of the alternator. The circular cavity is connected at the middle of the base and it covers the fan. The alternator is placed above its rectangular base and connected by 2 screws to the base. Also, it has a pulley connecting to

the rotating shaft. the last part is the nozzle. It is a convergent nozzle which allow to harvest high amount of the air.

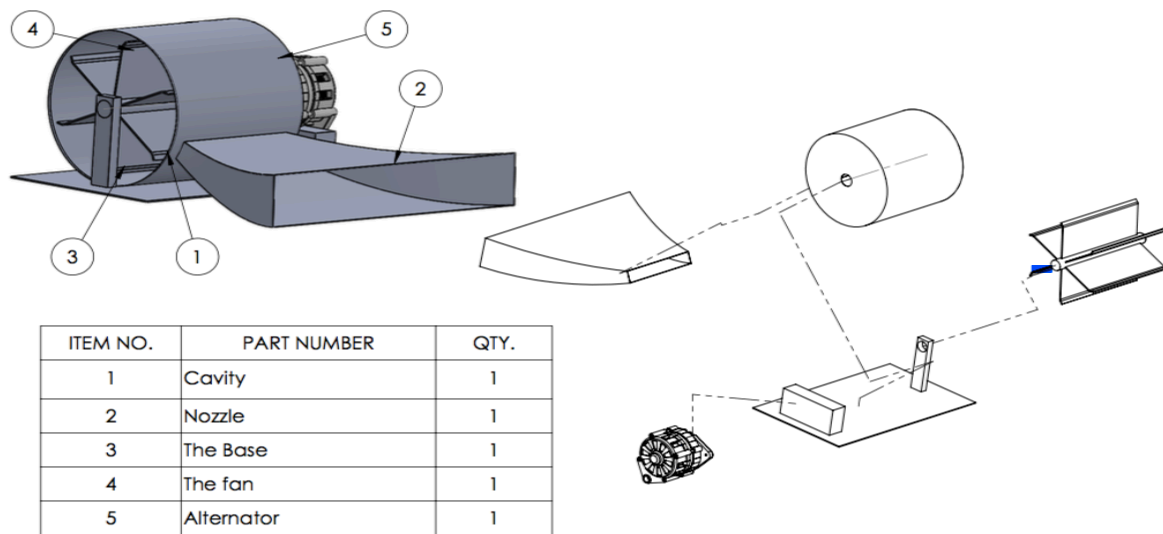


Figure 3.2: Exploded assembly of the system

3.5 Manufacturing and assembly (Implementation)

In terms of selection of materials, all the welded structural components are made from steel (1023 Carbon Steel Sheet). The first part is the fan which consist of six blades welded to the shaft (see figure 3.3). Also, all the edges of the blades are curved to assist the rotation due to incoming air flows. The second part is the nozzle. The purpose of choosing nozzle is to harvest maximum amount of air and push it to the outlet of the nozzle which helps to give the highest impact force on the fan blades. At the end of the nozzle, we bended it at 45° degree of angle to direct the air to edge of fan blade (see figure 3.4). The third part is the shaft. it was adjusted between two components which are bearing fixed to the base, and pulley fixed with the alternator. The fourth part is the cavity. We used a circular type of cavity to decrease the friction of the impact air and decrease the losses of the air which is flowing around the fan as shown in figure 3.6. The fifth part is the alternator. It is the only part that fixed with two screws adjusted on the base.



Figure 3.3: The blades of the fan welded to the shaft

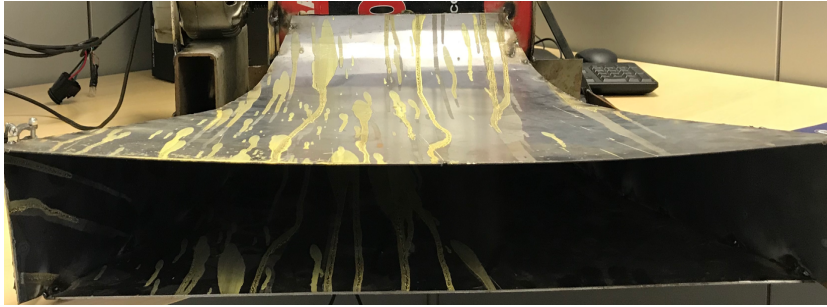


Figure 3.4: The nozzle



Figure 3.5: The cavity

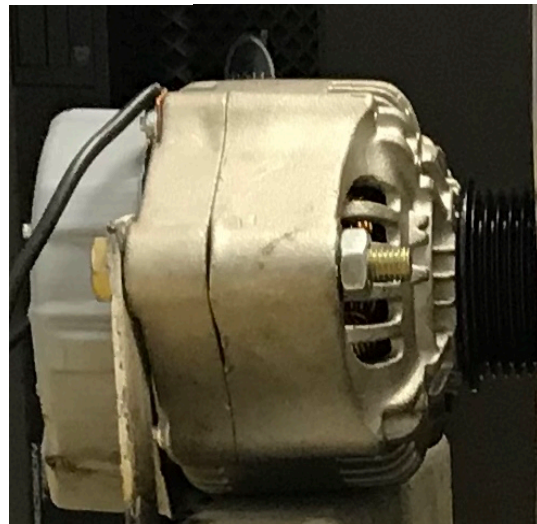


Figure 3.6: The alternator

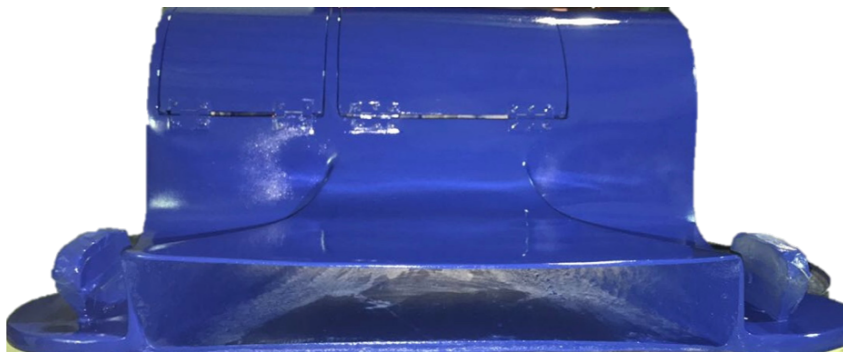


Figure 3.7: Front of the system after fiberglass



Figure 3.8: Back of the system after fiberglass

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

4.1.1: Tachometer

In this part, we did two different experimental setups. The first one was for calculating angular velocity of the shaft connecting to the alternator pulley and the second one was for calculating the values of the voltage and current. We did the first setup by using a pick-up car and three of us were at the cargo two are holding the system and one are measuring angular velocity by using tachometer. The tachometer has a laser and it was directed to the pulley and we put the sticker at the pulley, so the tachometer can read the speed of the pulley.

Specifications:

- Non-Contact Measurement: 50 to 9999RPM $\pm(0.03\%+2)$
- Measuring Distance: 50 mm to 250 mm
- Auto Power Off: 30S
- MAX/MIN/AVG Functions: yes
- m/min m/sec ft/min ft/Sec in/min unit selection: yes
- Data Hold: yes
- Display Back light: yes
- Low Battery indication: yes
- Power Supply 4x1.5AAA Battery (Not Included)
- Package size: 19 * 11 * 6cm / 7.6 * 4.4 * 2.4in
- Package weight: 288g / 9.6 oz



Figure 4.1: Tachometer



Figure 4.2: pulley of the alternator

In figure 4.2. we can see the pulley of the alternator. The pulley was covered by a small paper to let the tachometer read. We direct the tachometer which has a laser to the rotating pulley. The tachometer will record the angular speed of the pulley in revolution per minutes (RPM).

4.1.2: Voltmeter

In the second setup, we took our system to the lab in the university. We inserted a belt around the pulley of the alternator connecting with a fixed motor. The purpose of this setup is to calculate the voltage and current by using voltmeter and the belt helps the process in terms of high torque. This setup was done under the supervision with Dr. Nader Sawalhi and Mr. Antonio the lab technician. The voltmeter has two sensors one is for positive with red color and the second is negative with black color. We put these sensors to the head of the cables which have metallic fixtures.

Specifications:

- Display: 4000 counts
- Range selection: Auto and manual ranges
- Over display: "O.L" is displayed(except AC/DC 600V ranges)
- Polarity: Automatic selection (only " - " is displayed)

- Battery low warning: Battery mark lights when the internal battery's power is below approx. 2.4V
- Sampling rate: 2 times / sec
- Operating temperature / humidity: 5~40°C / 5~31°C, 80%RH(Max)
- Storage temperature / humidity: -10°C~50°C, below 70%RH No condensation
- Environmental condition: Altitude 2000m or below, pollution degree II
- Power consumption: 7mW at DCV
- Continuous use time: About 150 hours at DCV
- Bandwidth: 40 to 400Hz
- Fuse / Battery: 0.5A/250V 1.5kA ϕ 5.2x20mm / R6P x 2
- Size / Mass: H176 x W104 x D46mm / 340g
- Standard accessories included: Hand strap, Instruction manual



Figure 4.3: Voltmeter



Figure 4.4: Alternator

In figure 4.4, we can see the alternator with two sources connected to two wires. These wires will transfer the energy resulted from the wind turbine to the battery. We used the voltmeter which has two sensors and put them to these sources to measure the voltage and current values.

Table 4.1: the testing parameters

Testing Parameters	Objective
Tachometer	To measure the angular velocity RPM
Voltmeter	To measure the voltages and currents
Belt	To give the pulley high torque
Motor	To rotate the belt

4.2 Results, Analysis and Discussion

Table 4.2: Data of the results

Wind Velocity (km/hr)	Voltage (V)	Current (A)	Electrical Power (W)	Wind Power (W)	Coefficient of Power (%)
60	14.63	10.04	146.8852	1000.97	14.67428594
80	29.76	15.42	458.8992	2390.86	19.19389676
100	64.52	19.32	1246.5264	4690.15	26.57753803
120	90.22	27.79	2507.2138	7764.36	32.29131313

In this section, there are wind velocity in km/hr, voltage and current produced in each velocity, electrical power which is the multiplication of the voltage and the current, inlet power which is the wind power, and the coefficient of power. See table 4.2. figure 4.3 and figure 4.4 show the graph of the velocity versus output power and the velocity versus the coefficient of power respectively.

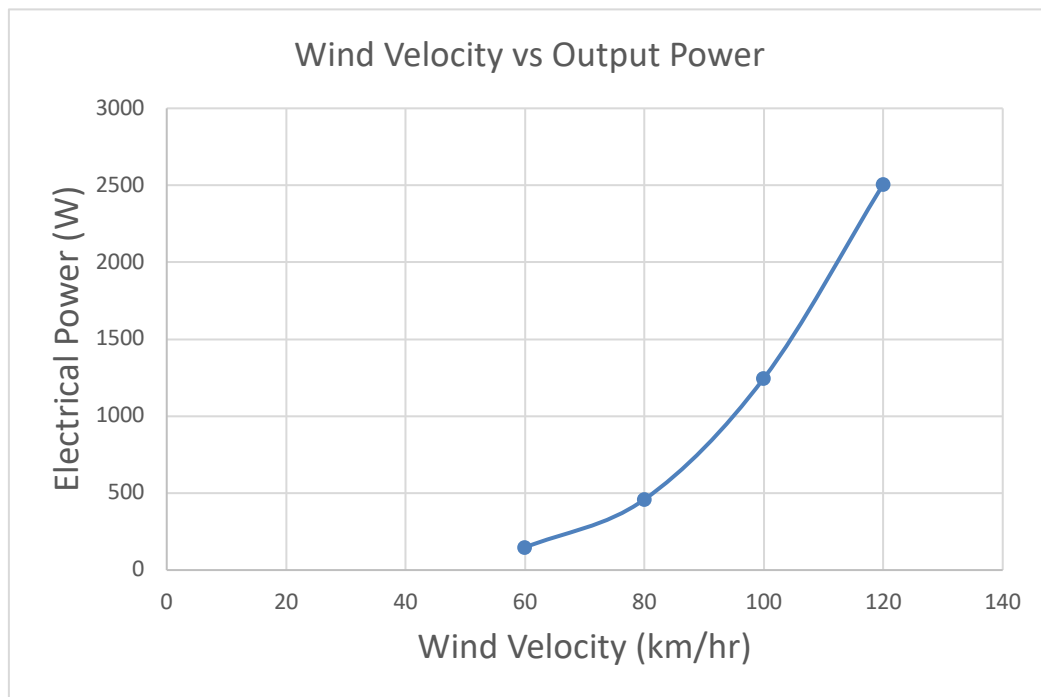


Figure 4.3: Graph of wind velocity versus electrical power

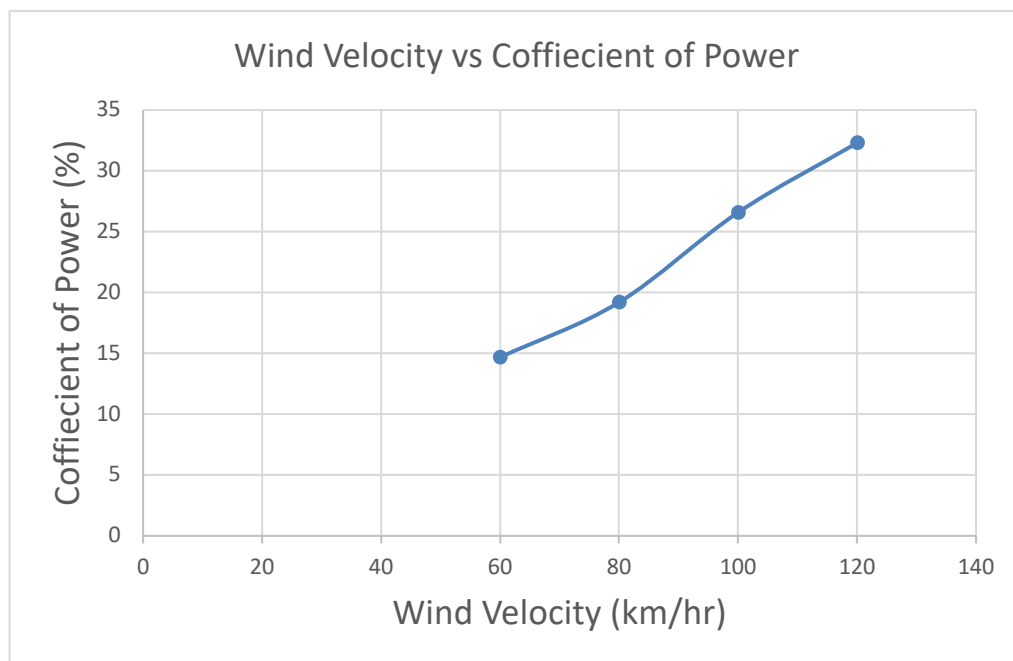


Figure 4.4: the graph of wind velocity versus coefficient of power

Chapter 5: Project Management

5.1 Project Plan

In our project, there are many tasks included. Each task is assigned to one or more members. Here is the all information about the tasks, team members, and the duration of each task to be completed. See table 5.1 for tasks & durations and table 5.2 for the assigned members.

Table 5.1: Tasks and their durations

#	Tasks	Start	End	Duration	
1	Chapter 1: Introduction	16/2/2018	20/2/2018	4	
2	Chapter 2: Literature Review	21/2/2018	27/2/2018	6	
					Project Background
					Previous Work
	Comparative Study				
3	Chapter 3: System Design	27/2/2018	1/4/2018	30	
					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	1/4/2018	5/4/2018	4	
					Experimental Setup, Sensors and data
	Results, Analysis and Discussion				
5	Chapter 5: Project Management	5/4/2018	13/4/2018	8	
					Project Plan
					Contribution of Team members
					Project Execution Monitoring
	Challenges & Decision				

		Making			
		Project Bill of Material & Budget			
6	Chapter 6: Project Analysis	Life Long Learning	13/4/2018	19/4/2018	6
		Impact of Engineering Solution			
		Contemporary Issues Addressed			
7	Chapter 7: Conclusion & Recommendation	Conclusion	19/4/2018	23/4/2018	4
		Future Recommendation			
8	Design of Prototype	Fan Shape	3/2/2018	9/2/2018	6
		Cavity			
		Location			
9	Parts Purchase	Car Battery	9/2/2018	14/2/2018	5
		Sensors			
		Light			
		Wires			
		Alternator			
10	Manufacturing	Structure Welding	14/2/2018	17/2/2018	3
		Grinding			
		Blades Bending			
11	Testing	Changing Different Wires	13/3/2018	14/3/2018	1
		At Different Speed	22/3/2018	26/3/2018	4
		Adding More Blades	10/4/2018	12/4/2018	2
		Retesting	13/4/2018	15/4/2018	2

Table 5.2: Tasks and assigned members

#	Tasks	Assigned Members
1	Chapter 1: Introduction	All
2	Chapter 2: Literature Review	Faris Alzahrani
		Talal Alsadhan
		Abdulaziz Alomar
3	Chapter 3: System Design	All
4	Chapter 4: System Testing & Analysis	All
5	Chapter 5: Project Management	Faris Alzahrani
		Talal Alsadhan
		Abdulaziz Alomar
6	Chapter 6: Project Analysis	Faris Alzahrani
		Talal Alsadhan
		Abdulaziz Alomar
7	Chapter 7: Conclusion & Recommendation	Faris Alzahrani
		Talal Alsadhan
		Abdulaziz Alomar
8	Design of Prototype	Mohammad Al Sulaiman
		Mohammad Alboroshaid
9	Parts Purchase	All
10	Manufacturing	Mohammad Al Sulaiman
		Mohammad Alboroshaid
11	Testing	All

5.2 Contribution of Team Members

The tasks in this project was assigned to one member or more members. It depends to the ability of doing the task and the time required to complete the task. Table 5.3 shows the tasks and the members with how many percentage of contributing for each member.

Table 5.3: Tasks the contribution of the members

#	Tasks	Assigned	Cont. %	
1	Chapter 1: Introduction	All	100%	
2	Chapter 2: Literature Review	Project Background	Alzahrani	33%
			Alomar	33%
			Alsadhan	34%
		Previous Work	Alzahrani	34%
			Alomar	33%
			Alsadhan	33%
		Comparative Study	Alsadhan	33%
			Alomar	34%
			Alsadhan	33%
3	Chapter 3: System Design	Design Constraints and Design Methodology	Alzahrani	30%
			Alomar	30%
			Alsadhan	30%
			Al Sulaiman	10%
		Engineering Design standards	Alzahrani	50%
			Alsadhan	50%
		Theory and Theoretical Calculations	Alzahrani	50%
			Alsadhan	30%
			Alomar	20%
		Product Subsystems and selection of Components	Alboroshaid	30%
			Alsadhan	40%
			Alzahrani	30%
Manufacturing and assembly	Al Sulaiman	50%		
	Alzahrani	50%		
4	Chapter 4: System Testing & Analysis	Experimental Setup, Sensors and data	All	100%

		Results, Analysis and Discussion	All	100%
5	Chapter 5: Project Management	Project Plan	Alzahrani Alsadhan Alomar	100%
		Contribution of Team members		
		Project Execution Monitoring		
		Challenges & Decision Making		
		Project Bill of Material & Budget		
6	Chapter 6: Project Analysis	Life Long Learning	Alzahrani Alsadhan Alomar	100%
		Impact of Engineering Solution		
		Contemporary Issues Addressed		
7	Chapter 7: Conclusion & Recommendation	Conclusion	Alzahrani Alsadhan Alomar	100%
		Future Recommendation		
8	Design of Prototype	Fan Shape	Al Sulaiman & Alboroshaid	80%
		Cavity		
		Location	All	100%
9	Parts Purchase	Car Battery	All	100%
		Sensors		
		Light		
		Wires		
		Alternator		
10	Manufacturing	Structure Welding	Alboroshaid & Al Sulaiman	80%
		Grinding		
		Blades Bending		
11	Testing	Changing Different Wires	All	100%

		At Different Speed		
		Adding More Blades	Alboroshaid & Al Sulaiman	50%
		Retesting	All	20%

5.3 Project Execution Monitoring

During our project, we had many activities which relates to improve our project. These activities including the important meeting and events that related to our senior project. In table 5.4 shows the list of meeting and other events for our project during spring semester 2018.

Table 5.4: Dates of the activates and events

Time/Date	Activities/Events
One time a week	Assessment class
Weekly	Meeting with group members
Biweekly	Meeting with the advisor and co-advisor
15 Feb, 2018	Finishing first prototype
3 April, 2018	Midterm presentation
22, March, 2018	First test of the system
19 April, 2018	Finishing final prototype
21 April, 2018	Test the system
26 April, 2018	Final Submission of the report
3 May, 2018	Final presentation

5.4 Challenges and Decision Making

During the project phases, we faced some challenges that effect the progress of the project. Following challenges are the main challenges we have faced:

- 1) Equipment and devices problems
- 2) Testing and safety issues
- 3) Design problems

5.4.1: Equipment and Devices Problems

In our project we used various devices and tools. However, we faced some technical problems regarding to these devices. Hence, we succeed to solve these problems, so the devices were worked fine.

- Sensors

In sensors, we have used two types of sensors. The first is tachometer which measures the angular speed and the second type is voltmeter which measures the voltage and the current. In tachometer, we borrowed it from the university and it was not working perfectly and we could not get any read from it during the test so, we replaced a new one from the university and it was working fine. The second sensor is voltmeter. We purchased it from the market and it measured only for high value of voltages and current, so it was not fit with our system. So, we took another one from the university and we used it in the testing of the system and it was working fine.

- Alternator

At the beginning, we chose a car alternator to use it to generate electrical power by converting the mechanical energy to electricity. After many testing, we found that the alternator was not working efficiently, and it needs high torque to generate power. We solved this problem, so we purchased a new generator and we replaced it to the alternator. Hence, the generator works well, and it was specialized for wind energy purposes.

5.4.2: Testing and safety issues

In testing, we took our system and we fixed it by our hands at the top of the car. It was dangerous, but we did this as initial testing to collect the output data which are the angular

speed, voltage, and current. furthermore, we design and manufactured a new system that will be able to install it perfectly at the top of the automobiles, so we could do the testing without any safety issues.

5.4.2: Design Problems

In our system there was two main problems in the parts which are the fan and the cavity. The first part is the fan. We designed it carrying 6 blades and we found there was losses due to big gaps between the blades. So, we added more blades to be 12 blades. As a result, the fan was rotating more than it was and it assist the torque to increase. Hence, the efficiency of the turbine was increased. The second part is the cavity. The first design was metallic to see how the system work and how much output data will produce. We found some engineering problems because it was not insulated. In the final design, we chose fiberglass, so the system will be insulated, and it will prevent the system from losses.

5.5 Project Bill of Materials and Budget

Table 5.5 shows the materials that we purchased and their costs in Saudi Riyals (SR). This table includes also the manufacturing and failed part costs.

Table 5.5: Bill of materials

Materials	Costs (SR)
Car Alternator	215
Bearing	22
Voltmeter	50
Manufacturing for first prototype	400
Car Battery	200
Fiberglass	3800
Manufacturing for second porotype	300
Generator for Wind Turbine	1207
Total	6194

Chapter 6: Project Analysis

6.1 Life-long Learning

When we are working in our project, we have learned and gain some knowledge about the important skills which was required to complete our project. By working as a team, we succeed to improve our skills in time management, communicate in effective way with members of the group. In this part, we will discuss the skills and experiences which we have learned since we worked in our project.

6.1.1: Software Skills

In this project, we have learned various skills and experiences from some software, such as Solidworks and Microsoft Word. These two programs are familiar for us because we have used them during university life. We used some advanced skills in these programs which we have not use it before. For instance, we used our Solidworks skills to design our system part by part then, we used mate tools to assemble the parts together.

6.1.2: Hardware Skills

During our project, we used some new devices that aim us to collect the data. we used two types of sensors. First sensor was voltmeter which able to measure the voltage and current values. We learned how to use voltmeter and connect the wires to the battery to measure the values. The second sensor that we have used was tachometer which able to measure the angular speed of the rotating shaft. by doing our measurement, we aware about how to deal with tachometers which requires proper position to get clear data.

6.1.3: Time Management Skills

By our project life, we gain one of the important skills which is the time management. While we want to reach to our targets, we have to manage the time to fit with the tasks. We divided the tasks into specific deadline to be finished on or before the deadline. One of the tools that we used to manage our time is Gantt Chart. We divide our tasks and subtasks into start and end dates. Also, we kept updating the Gantt Chart with our advisors to keep them in touch about what we have done weekly.

6.1.4: Project Management

In our project, we divided the works between members of the group. Each one of the members has his own work which should be done individually. Then, we had a meeting two times a week to discuss and collect the work that have done by that member. Mostly, our group has divided to two teams. The first team was focusing on the research and report. While, the other team was focusing on the prototype and manufacturing.

6.2 Impact of Engineering Solutions

Our project has various impacts in terms of society, economy, and environment. In this section, there are all the impacts of our project in terms of what previously mentioned.

6.2.1: Society

Our project is an advantage in terms of society. It will help the society to charge their devices during long trips. Also, it can be installed easily in any type of automobiles. We can use the system to generate the power and utilize it for camping purposes.

6.2.2: Economy

Our project assists the people in terms of economy. It helps the drivers to produce the power, so they will not need the automobiles during idle time. This project was expected to cost approximately more than 8000 SR. after we finished the final project, we found that it costs around 6000 SR.

6.2.3: Environmentally

Our project helps the society to produce clean energy and prevent the drivers of the automobiles of using the engine power during idle time. So, it will reduce the pollutions and noise which resulted from the automobiles during idle time.

6.3 Contemporary Issues Addressed

We face a common issue in our gulf cooperation council (GCC) countries and Saudi Arabia. The first issue is the bad effects of air pollution on human body. There are many organs and bodily functions that can be harmed, the consequences including: respiratory diseases,

cardiovascular damage, headaches and anxiety, Irritation of the eyes, nose and throat and nervous system damage [14]. The second issue is consequences of the fuel consumption. We found that Saudi Arabia the region's largest economy represents 70% of the GCC's total demand for diesel and gasoline. So, the governments of Saudi Arabia and GCC decided to increase the prices of the fuels to reduce the fuel consumption [15].

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusions

In every project, people learn many things that assist them in the normal life. From this project, we gained the experiences, we improved our communication skills, and we learned new things. Also, we achieved important results from this project that will encourage us in terms of working in different projects in future. We proved that we can use wind energy to produce electrical power efficiently for the all people in all countries. In engineering science, our project is consisting various areas of engineering including; fluid mechanics, solid mechanics, and thermodynamics which help us to improve our background on these areas. In this project, we learned how to use various devices that are essential in our lives such as sensors. Moreover, we improved our skills regarding to engineering software such as solidworks. This project as any other project has some challenges. We faced a problem regrading to the alternator and it was a wrong choice. We found that alternator needs high torque to work perfectly so, we chose another alternator and it was working very well.

7.2 Future Recommendations

There are various ideas which can improve this project to make it works better. These ideas help the system to be used without technical issues. The first idea is to install a regulator to the battery which control the flow of voltage and current. We recommend using the regulator and connect it to the battery, so it can close the flow of voltage after the battery got fully charged. Furthermore, it is an advantage in terms of safety because if the battery keeps charging with no limitation, it may cause troubles and damages. We tried to install the regulator, but it need more time due to high awareness of electricity and circuit's knowledge.

The second idea is to attach a break system to the fan. It will aim the fan to stop after the regulator stop the voltages passing to the battery when it is full. The main objective of the break is to reduce the movement of the fan during the long trip and when the battery is fully charged. Furthermore, the break will prevent the fan from fatigue loading which is


deformation occurs under dynamic loading. This fatigue will effect on the performance of the fan. We recommend choosing a proper break that can rely on the regulator so it will send signal to the break to stop the fan from rotating to protect it increase the life of the fan.

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Appendix A: Progress Reports

	SDP – Monthly MEETING REPORT
	Department of Mechanical Engineering Prince Mohammad bin Fahd University

SEMESTER:	Spring	ACADEMIC YEAR:	2017/2018
PROJECT TITLE	Design of a Miniature Wind Turbine for Automobiles		
SUPERVISORS	Dr. Muhammad Asad		

Month: February

#	Member Name	ID Number
1	Mohammad Al Sulaiman	201302093
2	Faris Alzahrani	201301367
3	Talal Alsadhan	201301178
4	Abdulaziz Alomar	201200090
5	Mohammad Alboroshaid	201302350

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Planning and Designing of the prototype	All	70%	
2	Abstract and Acknowledgement	All	100%	
3	Manufacturing and Assembling of the prototype	1 and 5	80%	
4	Chapter 1 and 2	2, 3, and 4	90%	
5	Chapter 3	All	30%	

List the tasks planned for the month of March and the team member/s assigned to conduct these tasks


#	Task description	Team member/s assigned
1	Chapter 3: System Design	All
2	Chapter 3: Computer Aided Design “CAD”	All
3	Chapter 4: System Testing	All
4	Chapter 4: System Analysis	All
5	Midterm Presentation	All

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome f:				
An understanding of professional and ethical responsibility.				
Criteria	None (1)	Low (2)	Moderate (3)	High (4)
f1. Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Fails to Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Shows limited and less than adequate understanding of engineering professional and ethical standards in dealing with public safety and interest	Demonstrates satisfactory an understanding of engineering professional and ethical standards in dealing with public safety and interest	Understands appropriately and accurately the engineering professional and ethical standards in dealing with public safety and interest
Outcome d:				
An ability to function on multidisciplinary teams.				
Criteria	None (1)	Low (2)	Moderate (3)	High (4)
d1. Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Understands and applies proper and accurate team work plans and allocate resources and tasks
d2. Ability to participate and function effectively in team work projects	Fails to participate and function effectively in team work projects	Shows limited and less than adequate ability to participate and function effectively in team work projects	Demonstrates satisfactory ability to participate and function effectively in team work projects	Understands and participates properly and function effectively in team work projects
d3. Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	3. Understands and communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (d1)	Criteria (d2)	Criteria (d3)	Criteria (f1)
1	Faris Alzahrani	4	4	4	4
2	Talal Asadhan	4	4	4	4
3	Mohammad Alboroshaid	4	4	4	4
4	Abdulaziz Alomar	4	4	4	4
5	Mohammad Alsulaiman	4	4	4	4

	SDP – Monthly MEETING REPORT		
	Department of Mechanical Engineering Prince Mohammad bin Fahd University		

SEMESTER:	Spring	ACADEMIC YEAR:	2018
PROJECT TITLE	Design of a Miniature Wind Turbine for Automobiles		
SUPERVISORS	Dr. Muhammad Asad and Dr. Nader Sawalhi		

Month: March

#	ID Number	Member Name
1	Mohammad Al Sulaiman	201302093
2	Faris Alzahrani	201301367
3	Talal Alsadhan	201301178
4	Abdulaziz Alomar	201200090
5	Mohammad Alboroshaid	201302350

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Chapter 3: Design Constraints and Specifications	2-3-4	100%	
2	Chapter 3: Testing	All	100%	
3	Chapter 3: Calculations	2-3-4	100%	
4	Chapter 3: Fabrication	All	100%	

List the tasks planned for the month of April and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	Redesign the blades	1 and 5
2	Remanufacturing with better material (fiberglass)	1 and 5
3	Chapter 4: System Testing and Analysis	2. 3. 4, 5
4	Chapter 5: Project Management	All
5	Chapter 6: Project Analysis	All
6	Chapter 7: Conclusion and Recommendation	All

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome f:				
An understanding of professional and ethical responsibility.				
Criteria	None (1)	Low (2)	Moderate (3)	High (4)
f1. Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Fails to Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Shows limited and less than adequate understanding of engineering professional and ethical standards in dealing with public safety and interest	Demonstrates satisfactory an understanding of engineering professional and ethical standards in dealing with public safety and interest	Understands appropriately and accurately the engineering professional and ethical standards in dealing with public safety and interest
Outcome d:				
An ability to function on multidisciplinary teams.				
Criteria	None (1)	Low (2)	Moderate (3)	High (4)
d1. Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Understands and applies proper and accurate team work plans and allocate resources and tasks
d2. Ability to participate and function effectively in team work projects	Fails to participate and function effectively in team work projects	Shows limited and less than adequate ability to participate and function effectively in team work projects	Demonstrates satisfactory ability to participate and function effectively in team work projects	Understands and participates properly and function effectively in team work projects
d3. Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	3. Understands and communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (d1)	Criteria (d2)	Criteria (d3)	Criteria (f1)
1	Mohammad Al Sulaiman	4	4	4	4
2	Faris Alzahrani	4	4	4	4
3	Talal Alsadhan	4	4	4	4
4	Abdulaziz Alomar	4	4	4	4
5	Mohammad Alboroshaid	4	4	4	4



SDP – Monthly MEETING REPORT

**Department of Mechanical Engineering
Prince Mohammad bin Fahd University**

SEMESTER:	Spring	ACADEMIC YEAR:	2017/2018
PROJECT TITLE	Design of Miniature Wind Turbine for Automobiles		
SUPERVISORS	Dr. Muhammad Asad & Dr. Nader Sawalhi		

Month: April

ID Number	Member Name
201302093	Mohammad Al Sulaiman
201301367	Faris Alzahrani
201301178	Talal Alsadhan
201200090	Abdulaziz Alomar
201302350	Mohammad Alboroshaid

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Chapter 4: System Testing & Analysis	All	100%	
2	Chapter 5: Project Management	Faris, Talal, and Abdulaziz	100%	
3	Chapter 6: Project Analysis	Faris, Talal, and Abdulaziz	100%	
4	Chapter 7: Conclusion & Future Recommendation	Faris, Talal, and Abdulaziz	100%	

List the tasks planned for the month of May and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	Create brochures, banner, and layer-covered report	All
2	Final Submission	All
3	Final Presentation	All

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

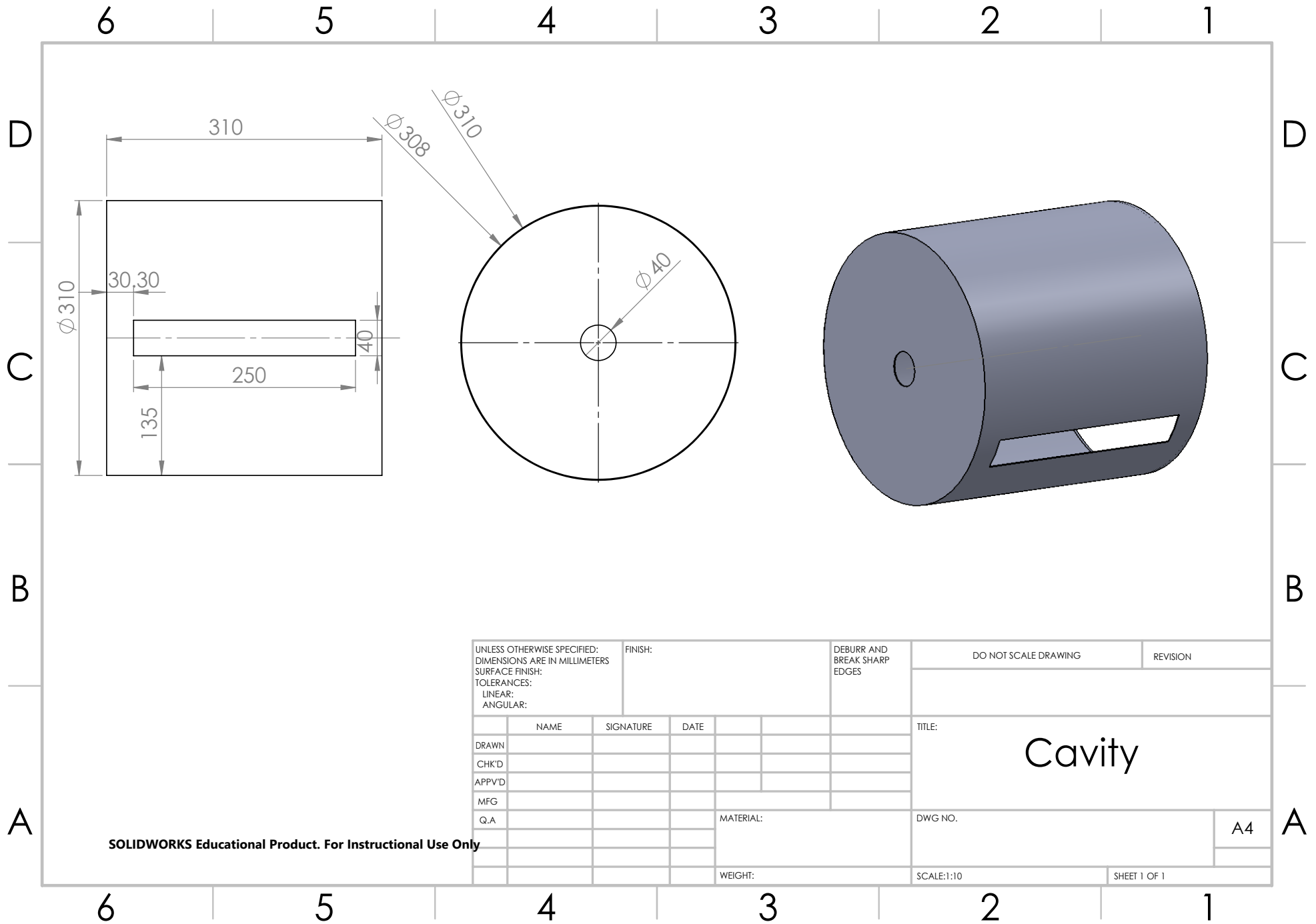
Outcome f:				
An understanding of professional and ethical responsibility.				
Criteria	None (1)	Low (2)	Moderate (3)	High (4)
f1. Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Fails to Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Shows limited and less than adequate understanding of engineering professional and ethical standards in dealing with public safety and interest	Demonstrates satisfactory an understanding of engineering professional and ethical standards in dealing with public safety and interest	Understands appropriately and accurately the engineering professional and ethical standards in dealing with public safety and interest
Outcome d:				
An ability to function on multidisciplinary teams.				
Criteria	None (1)	Low (2)	Moderate (3)	High (4)
d1. Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Understands and applies proper and accurate team work plans and allocate resources and tasks
d2. Ability to participate and function effectively in team work projects	Fails to participate and function effectively in team work projects	Shows limited and less than adequate ability to participate and function effectively in team work projects	Demonstrates satisfactory ability to participate and function effectively in team work projects	Understands and participates properly and function effectively in team work projects
d3. Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	3. Understands and communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (d1)	Criteria (d2)	Criteria (d3)	Criteria (f1)
1	Faris Alzahrani	4	4	4	4
2	Mohammad Al Sulaiman	4	4	4	4
3	Talal Alsadhan	4	4	4	4
4	Abdulaziz Alomar	4	4	4	4
5	Mohammad Alboroshaid	4	4	4	4

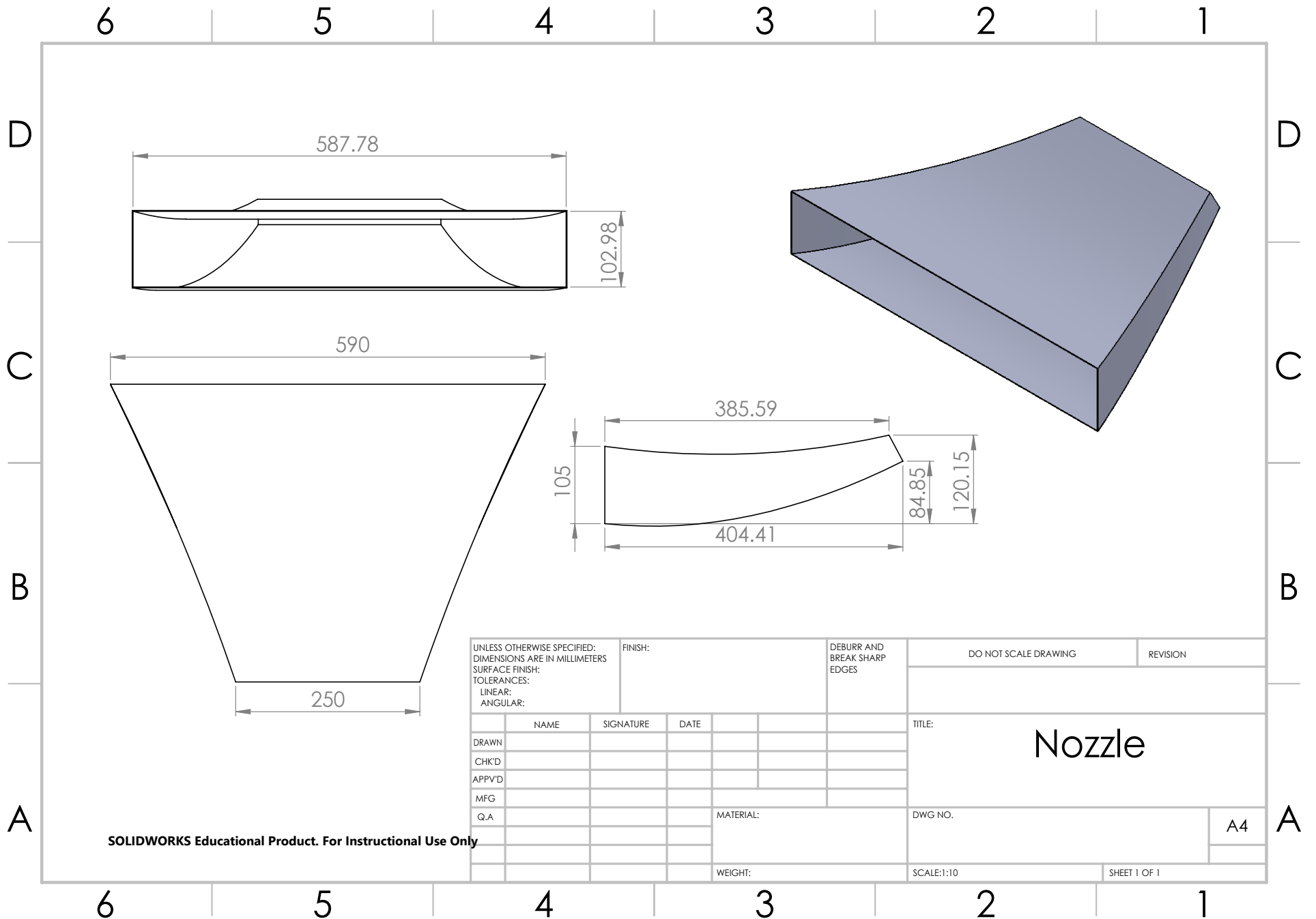
Appendix B: Engineering standards (Local and International)

Components	Engineering Standard	Details
Screw	ANSI metric	B18.2.3.2M - Formed hex screw, M16 x 2.0 x 80 --38CS
Bearing	NSK	Deep Groove Ball Bearing 6300ZZ 10mm I.D, 35mm O.D
Alternator	Delco-Remy	DRA3053



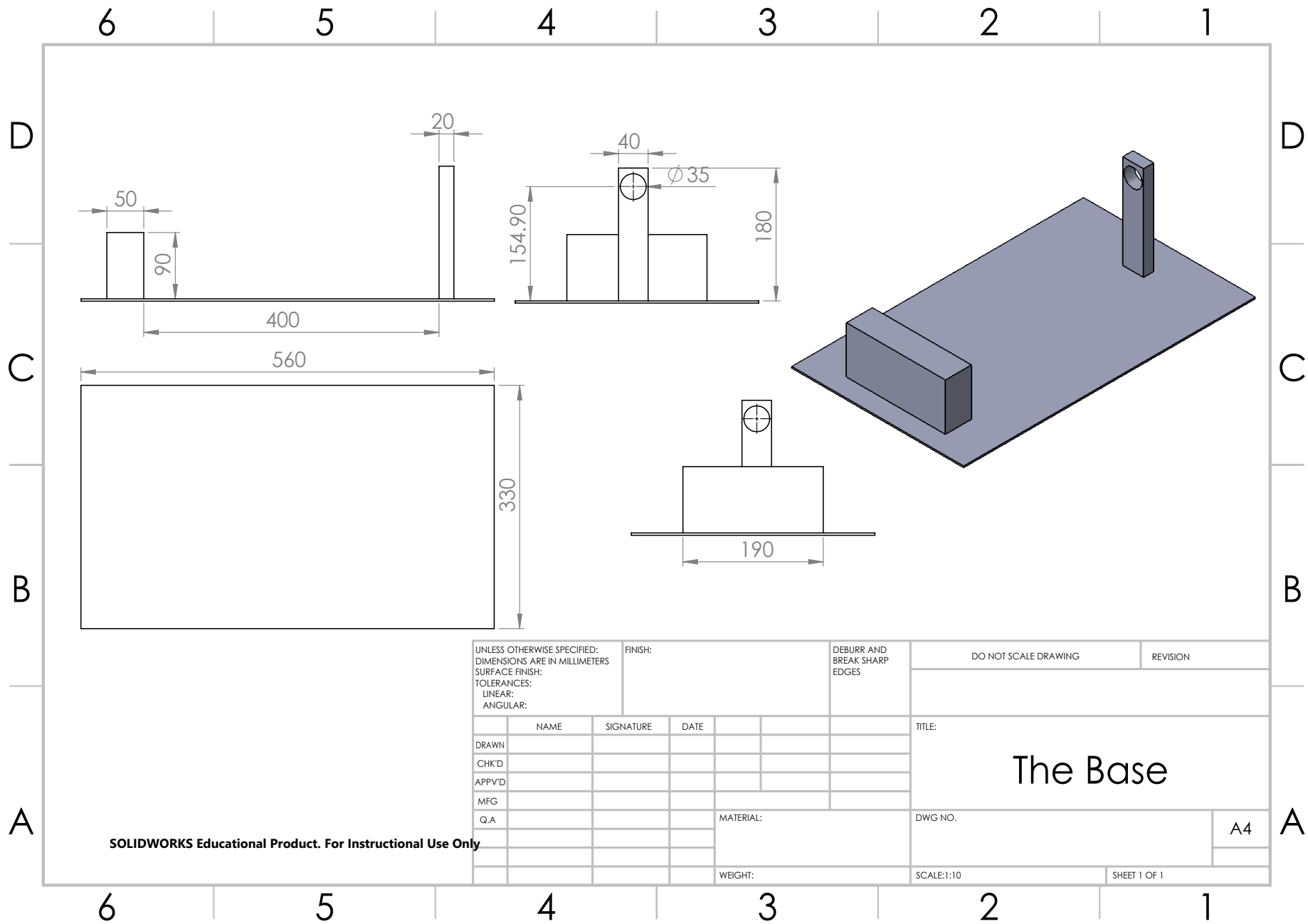
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DRAWN		SIGNATURE		DATE		TITLE: <h1>Cavity</h1>			
CHK'D									
APPV'D									
MFG									
Q.A						MATERIAL:		DWG. NO.	
								A4	
						WEIGHT:		SCALE:1:10	
								SHEET 1 OF 1	

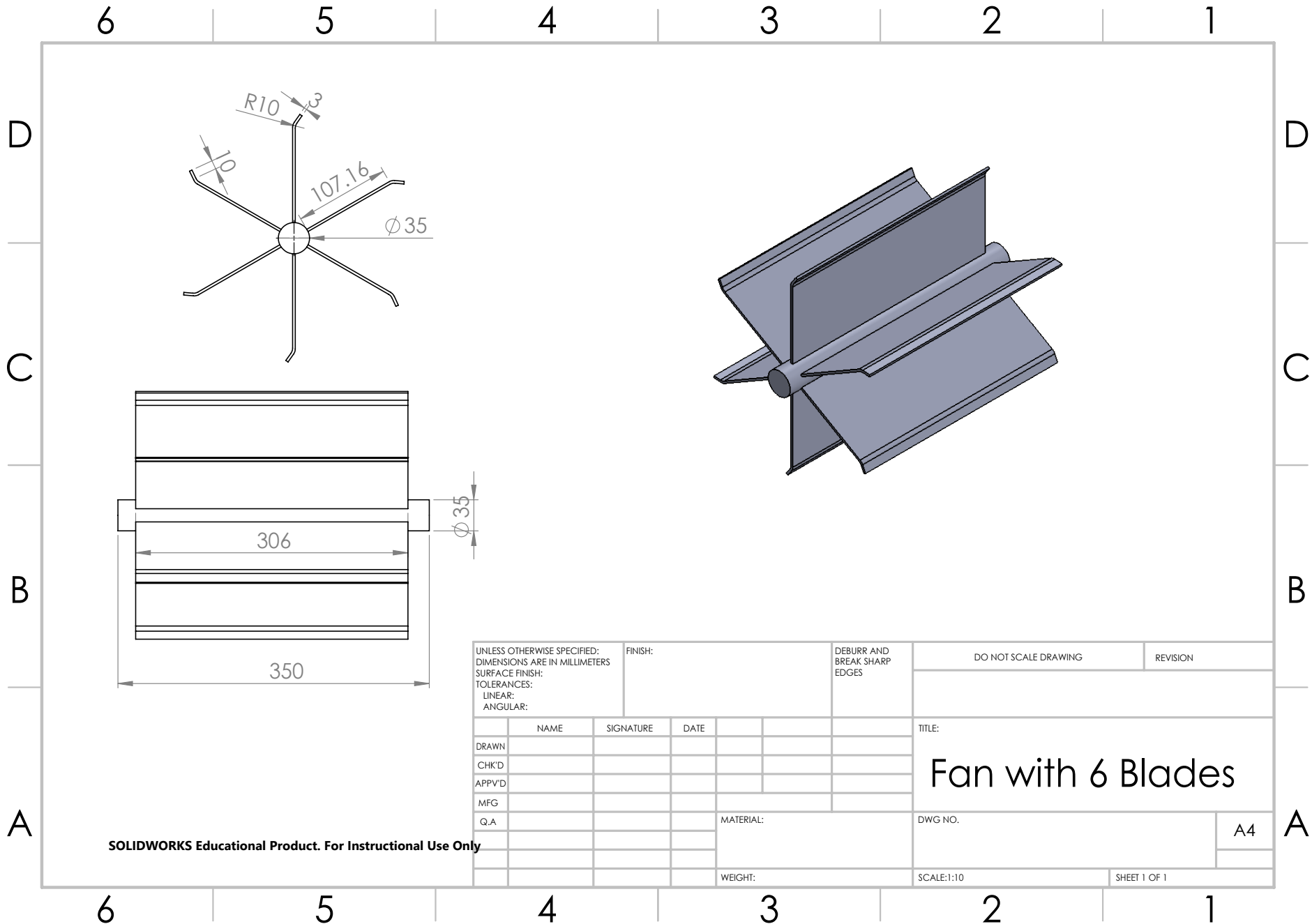
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UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS		FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
SURFACE FINISH:									
TOLERANCES:									
LINEAR:									
ANGULAR:									
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DRAWN									
CHK'D									
APPV'D									
MFG									
Q.A									
					MATERIAL:	DWG NO.			
						A4			
					WEIGHT:	SCALE:1:10		SHEET 1 OF 1	

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UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:				FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
DRAWN						TITLE:					
CHK'D						Fan with 6 Blades					
APP'V'D											
MFG						DWG NO.					
Q.A						MATERIAL:					
						WEIGHT:					
						SCALE:1:10					
						SHEET 1 OF 1					

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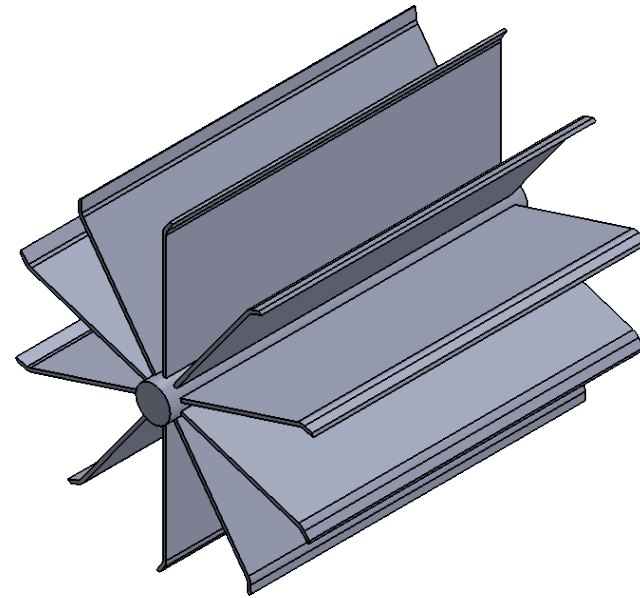
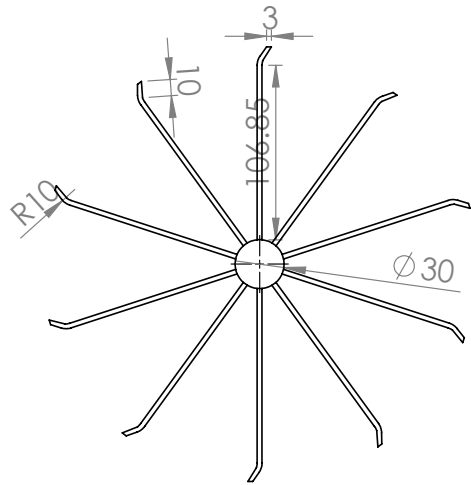
Fan with 6 Blades

A4

6 5 4 3 2 1

D

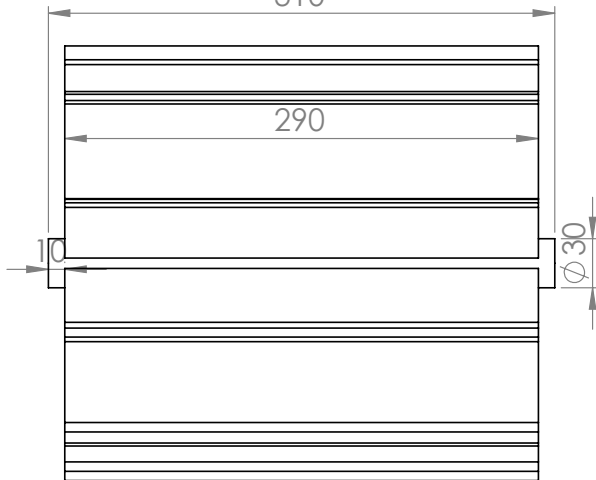
D



C

C

310



B

B

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DRAWN				NAME		SIGNATURE		DATE		TITLE:	
CHK'D										Fan with 12 Blades	
APPVD											
MFG										DWG NO.	
Q.A								MATERIAL:		A4	
								WEIGHT:		SCALE:1:5	
										SHEET 1 OF 1	

A

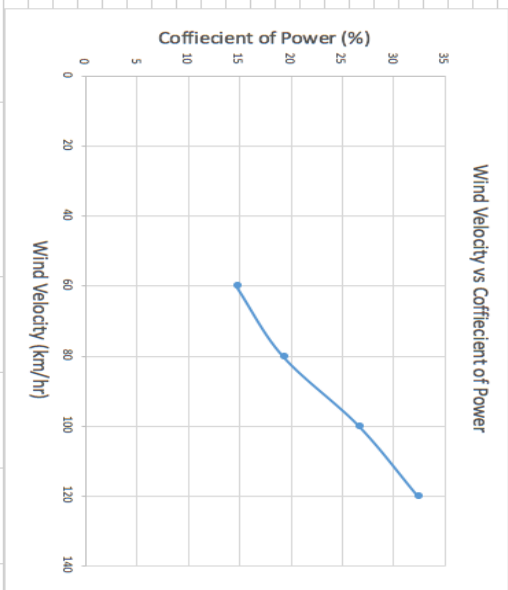
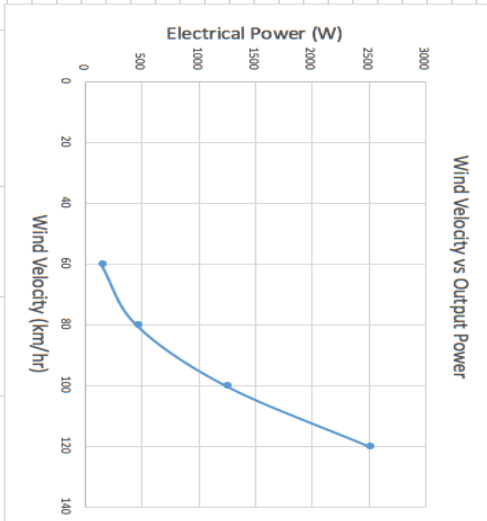
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6 5 4 3 2 1

Appendix D: Datasheets

Wind Velocity (km/hr)	Voltage	Current	Output Power	Inlet Power	Coefficient of Power (%)
60	14.63	10.04	146.8852	1000.97	14.67428594
80	29.76	15.42	458.8992	2390.86	19.19389676
100	64.52	19.32	1246.5264	4690.15	26.57753803
120	90.22	27.79	2507.2138	7764.36	32.29131313



Appendix E: Operation Manual

To run the prototype, please follow these steps:

- Adjust the system above the automobile, make sure the wires are connected to the poles of the battery
- You need to have two sensors; voltmeter and tachometer
- Let someone drive at your wanted speed
- Use voltmeter to measure the voltage and the current
- Use tachometer to measure the angular speed of the fan

The expected results from this operation are:

- Voltage and current (V & I)
- The angular speed (RPM or 1/min)

Appendix F: Gantt Chart



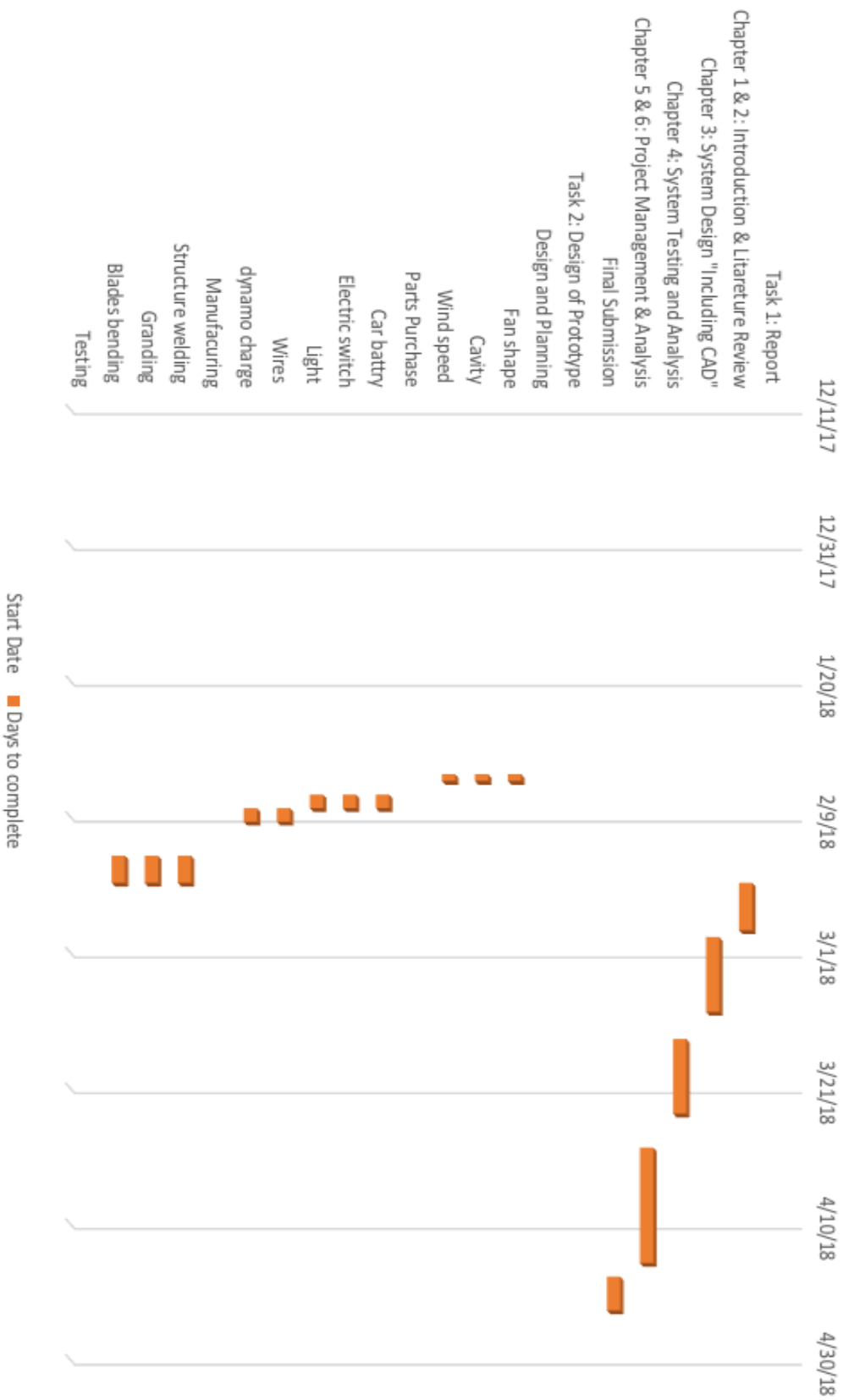
PRINCE MOHAMMAD BIN FAHD UNIVERSITY
College of Engineering
Department of Mechanical Engineering

Design of a Miniature Wind Turbine for Automobiles

Team 3

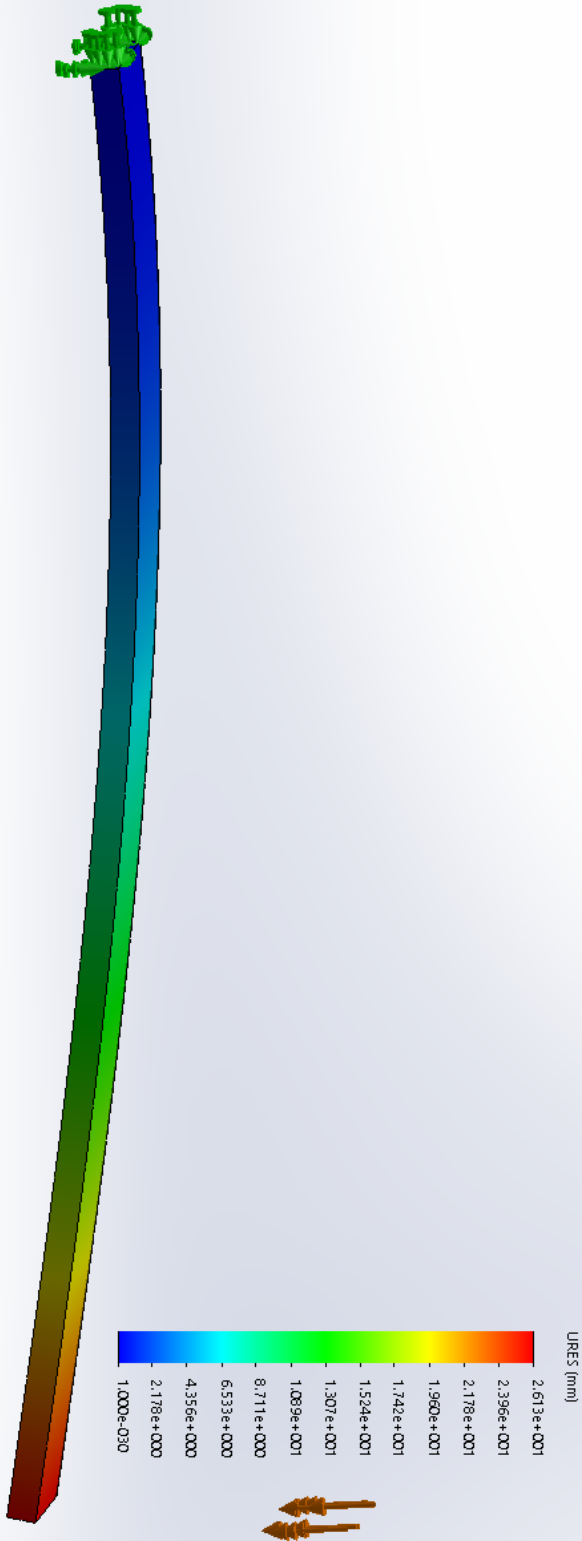
	Start Date	Days to complete
Task 1: Report		
Chapter 1 & 2: Introduction & Literature Review	19/02/2018	7
Chapter 3: System Design "Including CAD"	27/02/2018	11
Chapter 4: System Testing and Analysis	14/03/2018	11
Chapter 5 & 6: Project Management & Analysis	30/03/2018	17
Final Submission	18/04/2018	5
Task 2: Design of Prototype		
Design and Planning		
<i>Fan shape</i>	03/02/2018	1
<i>Cavity</i>	03/02/2018	1
<i>Wind speed</i>	03/02/2018	1
Parts Purchase		
<i>Car battery</i>	06/02/2018	2
<i>Electric switch</i>	06/02/2018	2
<i>Light</i>	06/02/2018	2
<i>Wires</i>	08/02/2018	2
<i>dynamo charge</i>	08/02/2018	2
Manufacturing		
<i>Structure welding</i>	15/02/2018	4
<i>Grinding</i>	15/02/2018	4
<i>Blades bending</i>	15/02/2018	4
Testing		
<i>At different speed</i>	25/02/2018	1
<i>Adding more blades</i>	28/02/2018	1
<i>Changing different wires</i>	01/03/2018	1

Gantt Chart of The Senior Project



Appendix G: CAD (Deflection Analysis)

Model name: analysis_sprt.d esign
Study name: Static 1 (-Default-)
Plot type: Static displacement Displacement
Deformation scale: 1



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