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Speed Bump Power Generator

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Senior Project
Proposal
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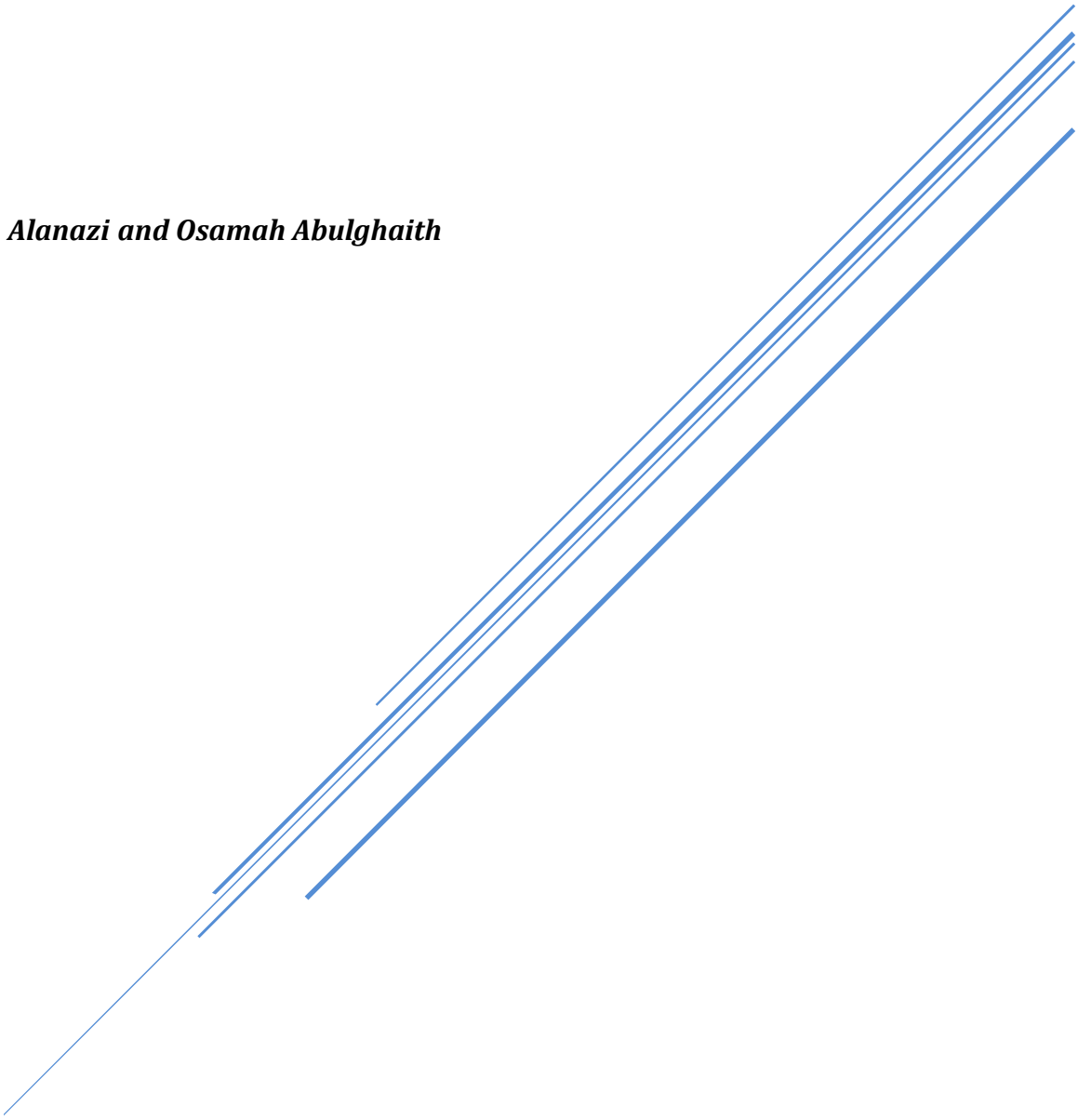
By: Sultan Alanazi and Osamah Abulghaith



Contents

Abstract

A large amount of energy is wasted by the vehicles on the speed breakers through friction. Energy can be produced by using the vehicle weight and speed. The team proposes a smart speed breaker that generates power (Speed bump power generator). The device allows vehicles to pass from both sides. The system makes use of mechanical assembly with metal sheets with linkages that press down with spring arrangement.

Using the motion and weight of vehicles was the method that the team relied on to design the device. The mass of the vehicles allows the top plate to move the rack which convert the vertical motion to horizontal through the pinion which helps to rotate the generator. Welding, cutting, drilling were the manufacturing prosses that that team used to build the device. Using weld process to join the outside structure of the device while using cutting to shape the top and bottom plate. Drilling process was used to join the parts of the whole device by screws.

The advantage of speed bump power generator is that electricity is generated throughout the year as long as there is the movement of vehicles. The amount of power generated is about 12 Volt. The speed bump generator can produce power that can be used to control traffic speeds therefore it ensures the safety of the pedestrians. Speed bump generator works in all weather conditions and it is environmentally friendly.

Keywords: electricity, speed bump power generator, power, rack and pinion, vehicles motion, manufacturing, environmentally friendly.

1. Introduction

a. Description:

A large amount of energy is wasted by the vehicles on the speed breakers through friction, every time it passes over it. Energy can be produced by using the vehicle weight and speed. So, the team will propose a smart speed breaker that generates power. The reciprocating motion of the speed breaker is converted into rotary motion using the rack and pinion arrangement. The team will design a smart speed pump that can pass vehicles coming from both sides and yet generate energy from it. The system makes use of mechanical assembly with metal sheets with linkages that press down with spring arrangement. The system makes use of the speed breaker press and then uses a rack and pinion arrangement to press down and run generator motor thus generating energy. The spring mechanism is used to drive the speed breaker back into the original position.

b. Motivation:

Nowadays, most people rely on vehicles for transportation which cause crowding. This can benefit and motivate to generate power from vehicles motion. This source of power is environment-friendly because it doesn't include any chemical materials.

c. Function Statement:

- The Function of this project is to generate power provided by vehicles motion.
- The Function of the gears are to must mesh with other gears to transmit altered torque and rotation in order to allow the project to generate power from vehicles motion.

b. Requirements

- The hydraulic system must be moved up and down at least 6 in.
- The project must generate at least 10 Watts, per stroke.
- The project must generate the power for at least 3 seconds, per stroke.
- The Project must Store Energy 50 Amp/H.
- The dimension must be about 600*400*600 mm
- The gears must mesh with other gears to transmit altered torque and rotation.
- The gears must support the load of at least 1000 Ib.
- The gears diameter must start from 2.50 - 3.70
- The weight of the gears must start from 0.1Ib - 0.32Ib.
- The top plate must turn to the first position and not more that 5 seconds

c. Success Criteria:

- The gears should meet all the safety requirements.
- The gears should not make noise.
- The gears should have low weight.

d. Scope of Effort:

The gears will control the speed and change the direction of the motion which allows the project to use a DC motor that is any of rotary electrical machines that converts direct current electrical energy into mechanical energy.

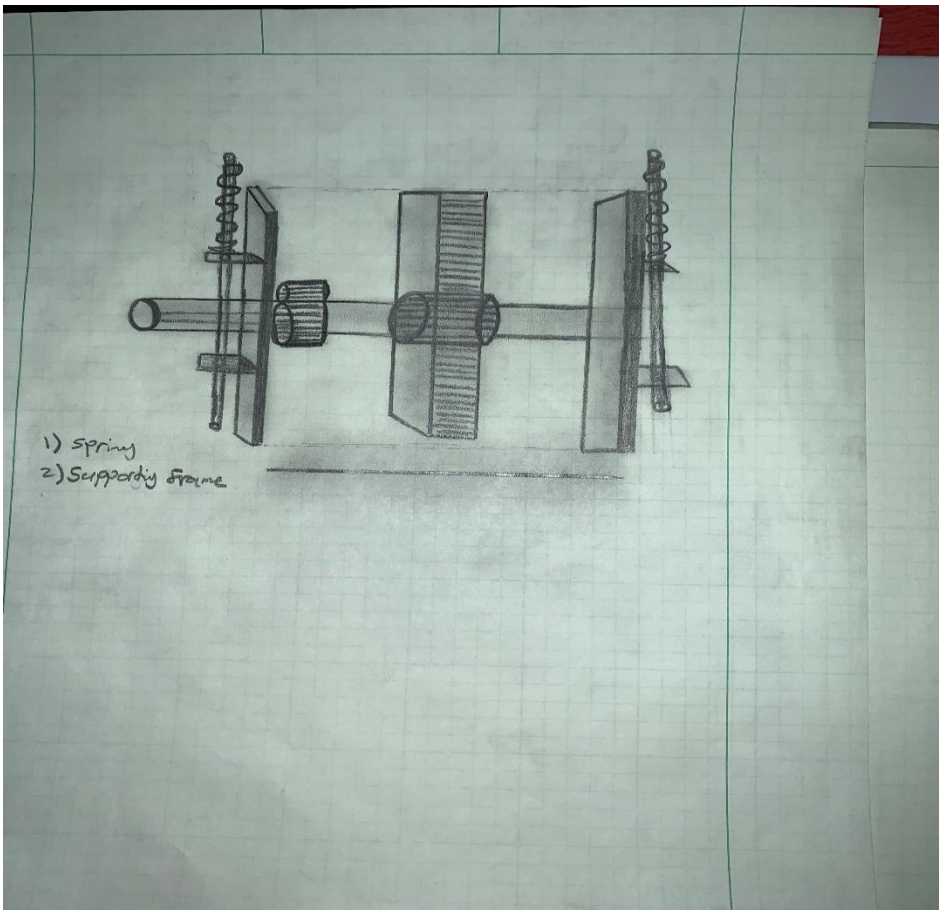
e. Benchmark:

Solar Energy relies on sunny whether to convert the sun's energy into electricity. The Mechanical Speed Pump Power Generator relies on cars motion, which means that the project must be placed on the roads that are crowded most of the year.

● The project would be very successful if it generates electricity from vehicle motion and store the power to be used in the least crowded times.

2. Design Analysis

a. Design Description (picture):



b. Approach:

The rack & pinion, spring arrangement is fixed at the speed breaker which is mounded bellow the L-shapes window. The spring is used to return the inclined L shapes window in same position by releasing the load. The pinion shaft is connected to the supporter by end bearings as shown in fig. The larger sprocket also coupled with the pinion shaft, so that it is running the same speed of pinion. The larger sprocket is coupled to the small cycle sprocket with the help of chain (cycle).

c. Benchmark:

Solar Energy relies on sunny whether to convert the sun's energy into electricity. The Mechanical Speed Pump Power Generator relies on cars motion, which means that the project must be placed on the roads that are crowded most of the year.

d. Performance Predictions:

- The perforce predictions of the project:
- The rack will transfer the vertical motion to pinion#1.
- The pinion#1 will change the vertical motion to horizontal.
- The shaft will move pinion#2(Driver) which allows the pinion#3(Devin) to rotate the generator.

e. Description of Analyses:

The analyses that have been made on the gears part is about the gear ratio, tangential and radula forces, and arrangement of rack and pinion. Analyses are presented in Appendix A.

f. Scope of Testing and Evaluation:

Testing each part of the machine separately to make sure the parts are ready and efficient**.**

3. Methods and Construction:

a. Method:

The rack & pinion, spring arrangement is fixed at the speed breaker which is mounded bellow the L-shapes window. The spring is used to return the inclined L shapes window in same position by releasing the load. The pinion shaft is connected to the supporter by end bearings. The larger sprocket also coupled with the pinion shaft, so that the large sprocket is running the same speed of pinion. The larger sprocket is coupled to the small cycle sprocket with the help of chain (cycle). This larger sprocket is used to transfer the rotation force to the smaller sprocket. The smaller sprocket is running same direction for the forward and reverse direction of rotational movement of the larger sprocket. This action locks like a cycle pedaling action. The fly wheel and gear wheel is also coupled to the smaller sprocket shaft. The flywheel is used to increase the

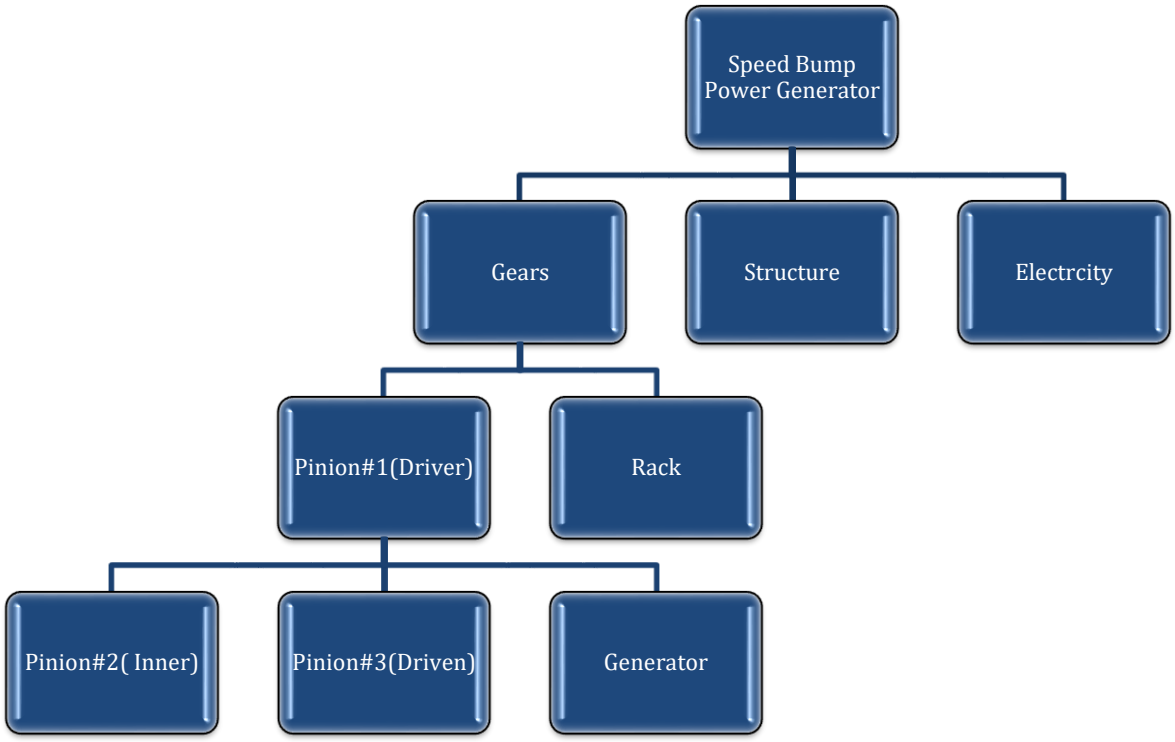
rpm of the smaller sprocket shaft. The gear wheel is coupled to the generator shaft with the help of another gear wheel. The rack will be attached to the top plate of the speed breaker, once the top plate moves down will move the rack with vertical motion. The pinions will be placed into a shaft and mech with the rack in order to convert the vertical motion to horizontal. This cycle will allow the generator to covert power.

b. Construction:

The shaft is needed to reduce the diameter in both end sides from 15 mm to 12 mm in order to fit in supporting plate of the device and rotate smoothly. The team should consider that the length of the whole diameter must be 120 mm and the length of the end sides must be 20 mm. The lathe machine with 4-Jaw Chuck will be the best equipment to manufacture the shaft due to the accuracy of rotation. In addition, the rack is needed to drill two holes in one side with diameter of 7 mm in order to be attached to the top plate of the device. The depth of the holes must be 10 mm. Drilling machine is the best solution for such a situation because the equipment has the ability to drill vertically with more accuracy at small area. The team should consider starting with drill of 5 mm before moving to 7 mm in order to be more accurate. Estimated time of manufacturing the shaft and the rack is 3 hours that can be divide into; 2 hours for the shaft and one hour for the rack.

The team members have worked on designing and machining the cap of the top plate which was the most challenge of the whole device. The shape of the cap is almost hexagon which enhance some challenges that encountered the team. Bending the cap of the top plate is the issue that faced the team. At first, the team tried to use an end table in order to bent the cap, however, this method did not succeed. Then, the team came up with another idea which was using metal that already bent, and the team mortified it till take the required shape. This method solved the problem that encountered the team and allowed the team to be on the truck.

i. Drawing Tree: (Gears Part):



4. Testing Method:

a. **Introduction:**

Speed bump power generator is a project with three major parts; structural, gearing, and generating power. In this proposal the focus major will be on gearing and generating power. The structural testing will be with Osamah.

b. Method/Approach:

The gearing part test is going to focus on the ratio of the gears and the number of the teeth of the pinion and the rack. Also, the rack is going to act as support for the top plate, so it is going to be tested in order to meet the requirements of the project. Moreover, the testing method will consist of three aspects; the endurance, performance, and generating power. First, the endurance of the device will be tested and should support a load of 250 lb. Second, the performance of the device will be tested in order to meet the requirements such as moving the top plate up and down then return to starting position, and work smoothly. For example, the top plate must return to the original position after each stroke within three seconds. Final aspect that will be tested is generation of electricity. The device must convert 8 watts per stroke when the vehicle weights 250lb, and the amount should increase while increasing the load. The best way to test power is by using Multimeter or using a light bulb.

c. Test Procedure description:

The gearing part should be move back and forth flexibility in order to meet the requirements of the test method.
The amount of power generated by the generator is measured by multimeter. Finding the best method of determining the amount of power produced by the device is a challenge. In order to determine the power of the footstep, the multimeter is connected on the generator. When the force is exerted on the plate, the generator produces power. One of the engineering issues experienced during testing is that during application of force, the generator got broken. Therefore, the broken part has to be fixed. Determination of the minimum force that can produce a maximum power is a challenge.
In addition, during the test, it was evident that the minimum amount of force needed to produce some power is 500 lb. which imply that people with mass less than 500lb will not have any impact when they pass on the generator. Reducing the minimum load will ensure that the generator is efficient and maximizes the available resources.
The output of the generator is measure in voltage. The power generated is read through the use of multimeter. A single step produced a power of 10 watts. During construction of the generator determining the right materials that can withstand the force that will not break the generator is a challenge. Determination of the spring constant that will ensure that the return time is at minimum is a challenging thing. More trials were done to come up with the more efficient spring.

5. Budget

a. Discuss part suppliers, substantive costs and sequence or buying issues:

All the gearing parts will be ordered. The parts that should be ordered are rack gear, three spur gears, and shaft. The parts are presented in appendix C.

b. Determine labor or outsourcing rates & estimate costs:

The project will be self-design which means no need for extra labors.

c. Labor:

The project will be self-design which means no need for extra labors

d. Estimate total project cost:

The estimated cost of the whole project is about $216 including (Structural, gears, springs, and generator). The table cost is presented in appendix D.

e. Funding source(s):

The project will be self-funding.

f. The consumed budget for speed bump power generator is divided into three categories; first category is for buying parts that do not need machine and manufacture such as rack, pinion, and shaft. Second category is buying raw materials in order to machine and manufacture parts for the device such as, top and bottom plates, rod supports, and cap for the top plate. Third category is rebuying parts or raw materials instead of parts that have machined wrongly. 80% of the budget was used for buying and manufacturing the parts of the device, while 20% was used to solve the manufacturing issues. The team has spent $173 on buying all the needed parts. Moreover, all the needed parts were ordered, made, and done by group members based on the manufacturing plan and ahead of time which allows the team to be ready for testing the device. All the parts that Will be needed to build the device are ready and have no issue that may affect the building process.

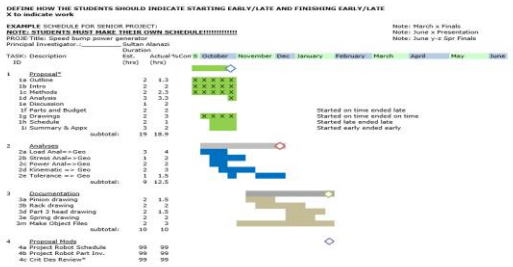
g. The original design of the device was not modified, so that the budget of the project was not changed. Also, the team members had great process which built and bought all the required parts for speed bump power generator based on the timeline and planning schedule.

h. During the test, the team members have countered some financial issues that made the team expended the budget by 10% in order to solve the issues. While the team members were testing the ability

of the device to support the load, the shaft that attached to the rod supporting got broken due to the heavy weight. The team members had to repurchase a new shaft that can support the required weight. The estimated percentage of the new shaft was 6%. Another issue that faced the team members during the test process was that the generator got broken due to the fast rotation. The rotation of the shaft destroyed the gears of motor. The team members repurchase a new generator that can support the required rotation. This issue expended the budget by 4% to be solved.

6. Schedule

a. High level Gantt Chart:



b. Define specific tasks, identify them, and assign times:

The task will be divided into three quarters; Fall, Winter, and Spring.
Fall Quarter: in this quarter, working on proposal in order to give a picture about whole project by doing green sheets analyzing, estimating cost, and having knowledge about the project.
Winter Quarter: this quarter is going to be about building and designing the project. The location of building the project is Machining shop in Hogue building. Spring Quarter is going to be the time to test the project and making sure is working.

c. Allocate task dates, sequence and estimate duration:

Allocate task dates: Working on the device, the task date is January 15th.
Sequence: Starting to order the parts for the project on December 20th, then starting to design the project on January 117th.

Estimate duration: the estimate hour duration is 24 hours per week, and the project will be done on March 20.

d. Estimate total project:

Estimate total project time is 2 months.

e. Gantt chart:

Gantt chart is presented in appendix E.

f. The team members have met the planned schedule and kept following the schedule. However, some challenges have countered the team one the bending process for the cap of the device. Using basic methods to bend the cap of the top plate was the biggest challenge because the tools that were used were unhelpful because the metal sheet did not take the required shape. Moreover, the team tried another method such as using an end table and hammer in order to bend the sheet metal, but this technique was failed also. Therefore, the team members decided to use metal that had already bent to modify the cap of the top plate till meeting the required shape which is going to allow the car pass over the device smoothly. This issue had affected the planned schedule for manufacturing parts; however, the team had solved the issue within a short time which allowed the team to get back on track.

g. During the construction and testing operations, the team members had encountered some manufacturing issues such as replacing and arranging the gears of the generator, readjusting the top plate to in order to return to the original position with the required time, and stabling the outside structure in order to hold the device after releasing the load. The team members had managed all the manufacturing issues which showed great improvements that led to the success of the project. However, the manufacturing issues that were resolved had costed the team more time than the planned schedule. This situation added an issue for the team members. The team members had to change the strategy and came up with new method in order to be on the truck so that the team members took advantage of Winter break and committed to do more work do redesign the some of the parts in order to avoid exists and future issues. This advantage helped the team to be back on the truck again

7. Project Management

a. Human Resources:

Sultan Alazani, the student of the Mechanical Engineering will take care the gear part of the project. Ibrahim Almarri will take of the generator part, and Osamah Abulghaith, the student

mechanical Engineering will take care of the structural part of the project. Also, the assistance of professors and technicians of the Mechanical Engineering Technology Department.

b. Physical Resources:

- Sprocket
- Gears
- Drilling Machine
- Metal cutter
- Holding Clamp
- Spanner
- Nuts
- Hammer
- Flywheel
- Spur gear
- Shaft

Processes involved are

- Drilling
- Machining
- Making Joints

c. Soft Resources:

- SOLIDWORKS
- YOUTUBE videos

d. Financial Resources:

Members of the team will be the financers of the project.

8. Discussion

a. Design Evolution / Performance Creep

Rack and pinion connection will be attached to the hydraulic system. The shaft and gears system will be attached to it which will convert the rotational motion to the linear motion. The dimensions of the gear, rack and pinion system will be according to the design which is already made up in SOLIDWORK. Connections of the motor, curve plates, spring will be made through fasteners. A proper assembly will be made according to the design at the end.

b. Project Risk analysis:

Some of the risks which are involved in this project are clothing grip and electrical contact hazard. Motors and generators are electrical devices and the risk of receiving electrical shock will be always there. By using the proper insulation with the wires and with the use of PPE the hazards will be avoided.

c. Successful

The project will be said as the successful if the all the connections are made according to the design. Proper connection of gear, with the rack and pinion will guarantee the success of the project. Success of the project will be determined by detecting the output power after applying the force on the top plate of the whole assembly.

d. Project Documentation:

A proper document of the project justification will be provided through which the necessity of this project will be explained. The other documents will be the proper schedule for the completion of project, estimated cost, required material and work breakdown structure which will be attached with the whole project report.

e. Next phase:

Project assembling process will be done in the next phase, in which order of gear, rack and pinion system will be placed. After that drilling machining and fastening process will take place. Whole project will be made in next phase.

f. Design manufacturing issues

One of the characteristics that the power pump generator should have is compatibility. Therefore, it has to be light and easy to carry. Considering this attribute, the materials that are used in manufacturing of speed pump power generator have to be medium sized. Also, the material used for manufacturing need to be long lasting. The material should not be affected by rust. Therefore, steel has to be used in manufacturing because it does not rust. Also, it has to be airtight. Construction of an air tight outside cover is a challenge. The most challenging thing is getting a materials sizes needed. It is because, steel sheets do not come with measurement that are exactly compatible to the size of the pump. Also, the price of steel is relatively expensive. To facilitate assembling of the pump structure, different steel sizes were required. Each part has a different measurement. Getting materials with similar measurement was a challenge.

g. Methods used in resolving the manufacturing issues

Having the fact that getting steel is a problem, online markets was the best option. Using online markets to such for companies that sell steel sheet and ordering on time. Making order on time ensured that the material arrived earlier. To ensure that the sheets met the measurements, the team made the cutting manually. Madding calculations and measurements of every part, including the angles. Each part was cut according to the identified measurement and angle. Joining was done by use of bolts and welding. Where

holes were needed the team made the drills manually. Also, the team welded the sheet to join them. This ensured that the structure was airtight. To ensure that the team succeeded in making complete payment of buying the parts. Also, the online shop allowed partial payments. Therefore, the team opted for partial payment to make complete purchase of the structure.

The team has done testing on the ability of the device to generate power and support the required weight which met with one of the project requirements stated that the device must support 500lb and generate 10 Watts. In addition, the test showed the ability of the device to generate 10 Watts per strike and could support 500lb which gives the team satisfaction and encouragement to do more work. On the other hand, the team has faced issue during the test process. The inside gears of the generator had misaligned due to the fast rotation of the shaft. However, the team had fixed the issue by rearrange the gears and tie them well.

One of the requirements that the team members has tasted was the smooth function of the top plate which stated that the top plate must return to the original position with no more than three seconds. However, during the test, the team has encountered issue that the top plate did not return to the original position after releasing the load due to the friction that occurred from the shaft. The shaft was holding and preventing the top plate from going to the original position at the required duration in each stroke. In order to deal with such an issue, the team members used oil in the end of the shaft to reduce the friction with the rod support during the rotation. This method helped the top plate to return to the original position within the required time which satisfied the project requirements.

9. Conclusion

a. Project identity

The design title of this project is “Speed Bump Power Generator”. Electrical energy will be achieved whenever the pressure will be experienced by the top part of whole setup. The method of the moving cars will be used to harness the electrical energy. This project will be used in the speed bumps for creating the electric power which will be stored in the battery.

b. The core of the project

The most important analysis for this project will the selection of gear ratio. There can be several advantages that can be achieved through the selection of proper gear ratio. The selected gear ration for this project is 2 which will enable the whole mechanism to achieve more rotation. That high speed rotation will further help to rotate the prime mover of generator in faster way. So, the efficiency of generating power will further increase.

c. The mechanism

1. The perforce predictions of the project:
2. The rack will transfer the vertical motion to pinion#1.
3. The pinion#1 will change the vertical motion to horizontal.

4. The shaft will move pinion#2(Driver) which allows the pinion#3(Devin) to rotate the generator.

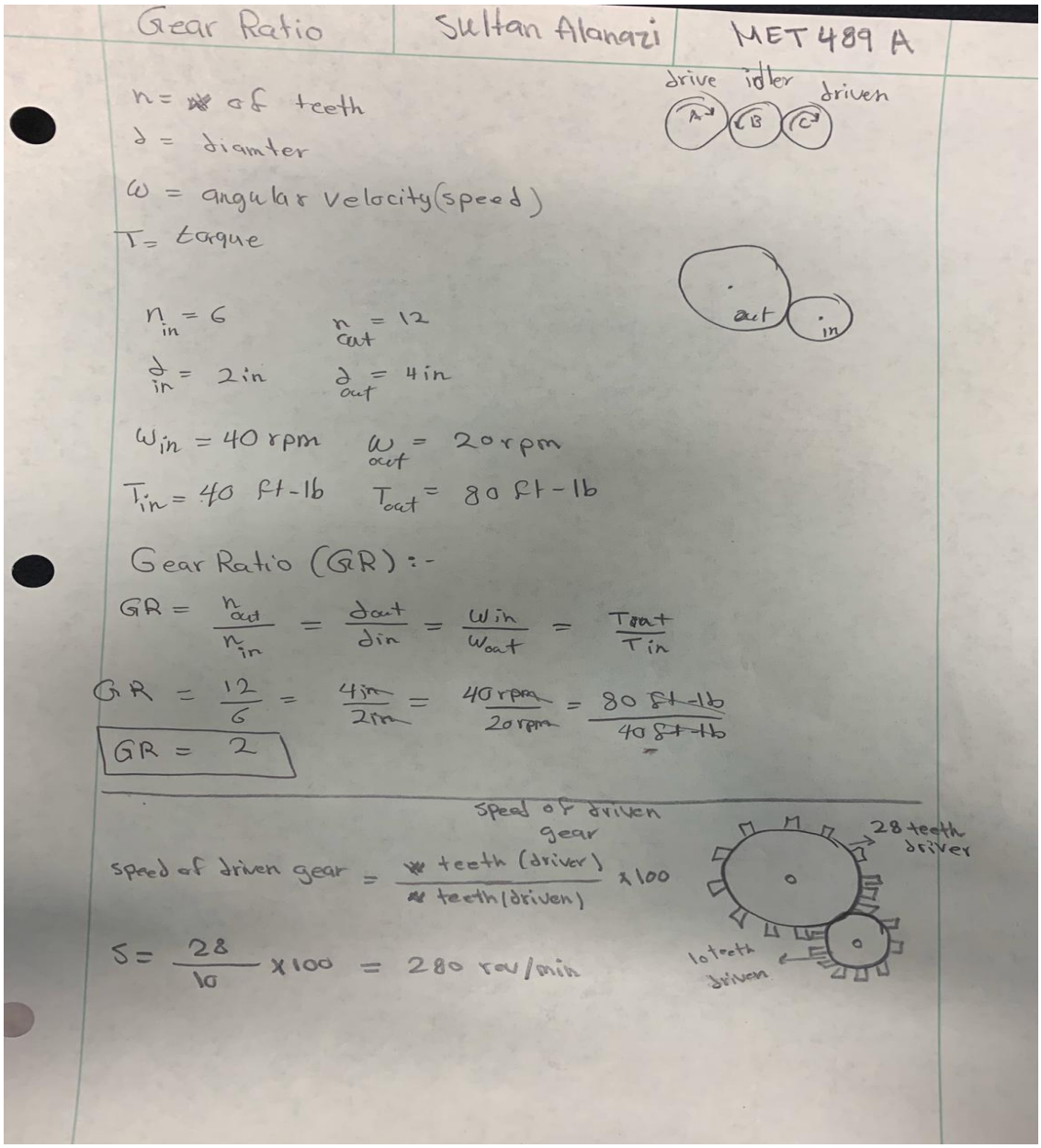
10. Acknowledgment:

Group members funded the whole project and do not have any sponsor. Group members have worked on machining and manufacturing the parts in Faisal Albalawy's Shop. Faisal Albalawy is a friend who has experience in Mechanical Engineering and have a shop with all the equipment that were needed for machining the parts. Faisal Albalawy is the mentor for the Speed Bump Power Generator.

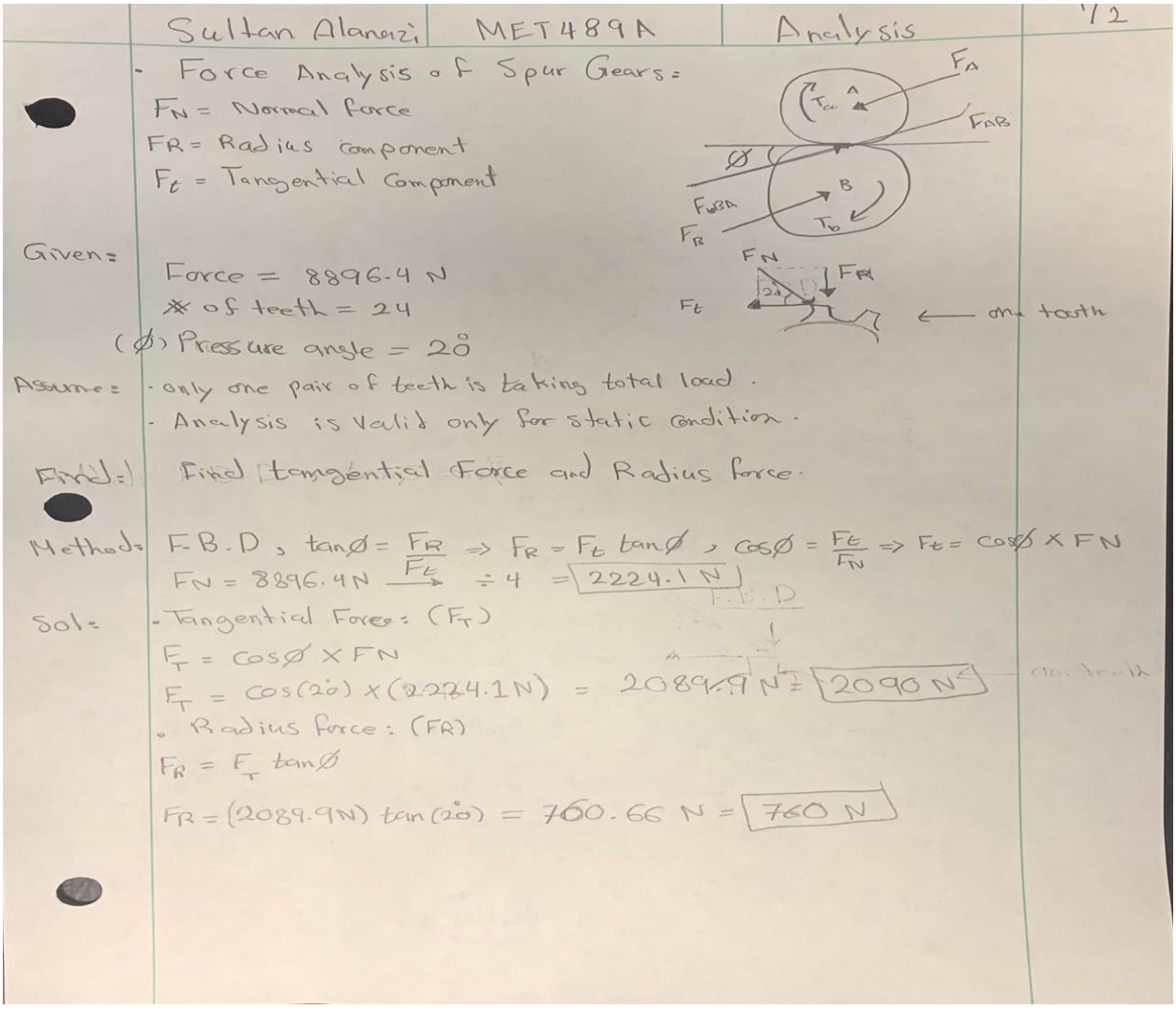
11. References:

Mott, Robert L., et al. Machine Elements in Mechanical Design. Pearson, 2018.

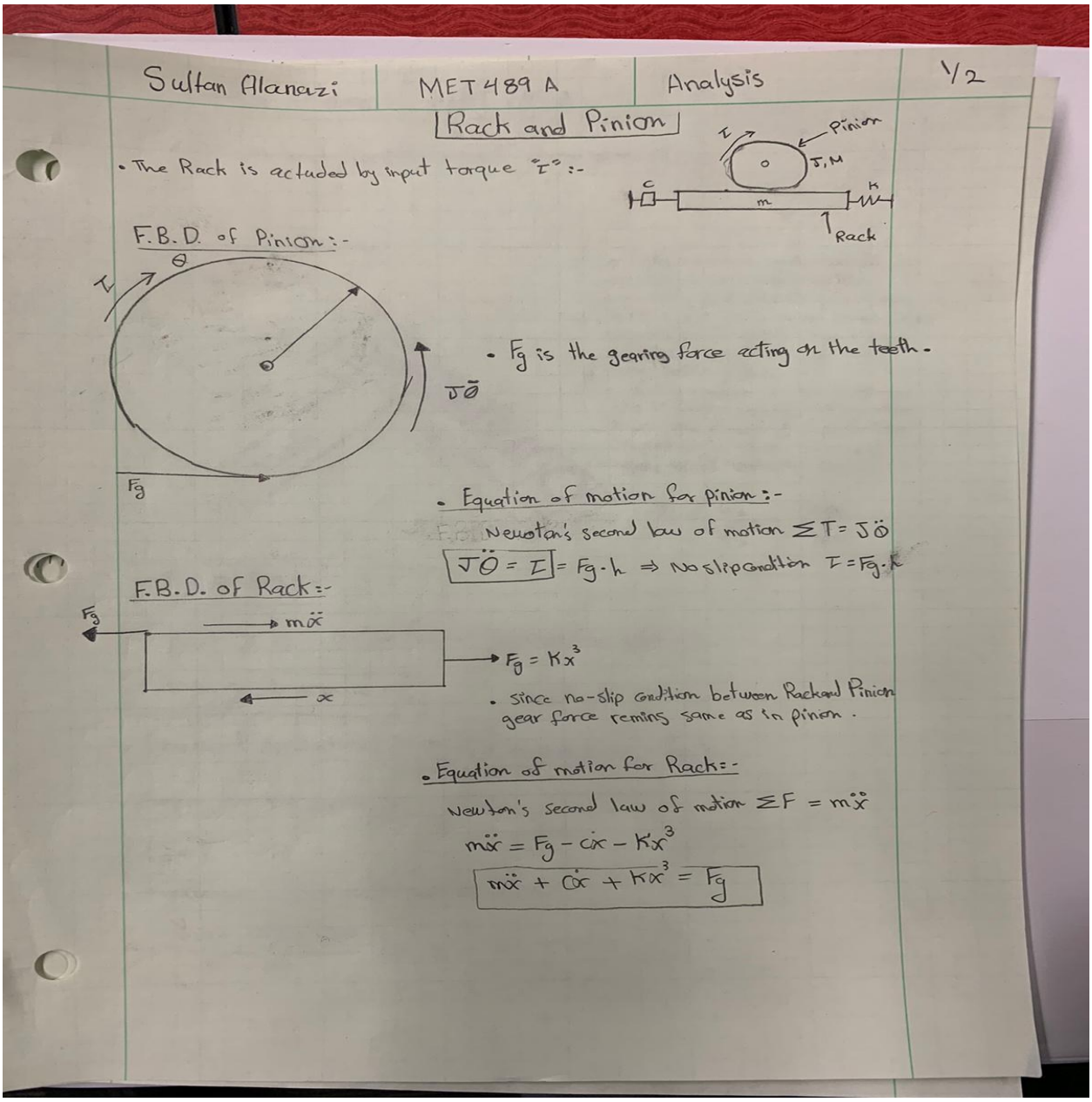
12. Appendix A. (Analysis)



A-1: Gear Ratio Analysis



A-2: Force Analysis of Spur Gears



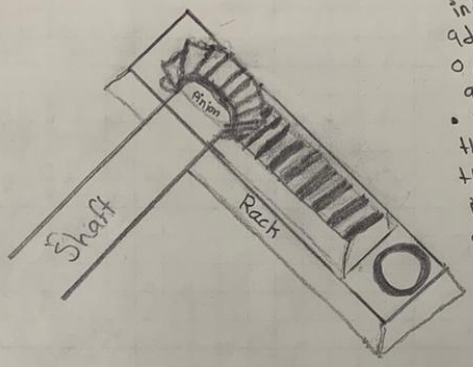
A-3: Force Analysis of Rack and Pinion

Sultan Alanazi | MET 489 A | Analysis | 2/2

Pinion and Rack Gears Arrangements:

ω: angular velocity.

N: # of teeth.



- Rack and Pinion Gears convert rotational motion into linear motion.
- putting a series of gears together into a gear train gives mechanical advantage based on the size of the gears and how they are interlinked.
- If the number of the teeth on the output gear (N_B) are greater than the number of teeth on the input (N_A), then, the input gear must rotate faster.

$$R = \frac{\omega_A}{\omega_B} = \frac{N_B}{N_A}$$

- Formulas:-

- Tangential force on the Rack (Horizontal application):-

$$F_r = m \cdot g \cdot \mu + m \cdot a + F_e$$

- (vertical Application): $\longrightarrow$ $F_r = m \cdot g + m \cdot a + F_e$

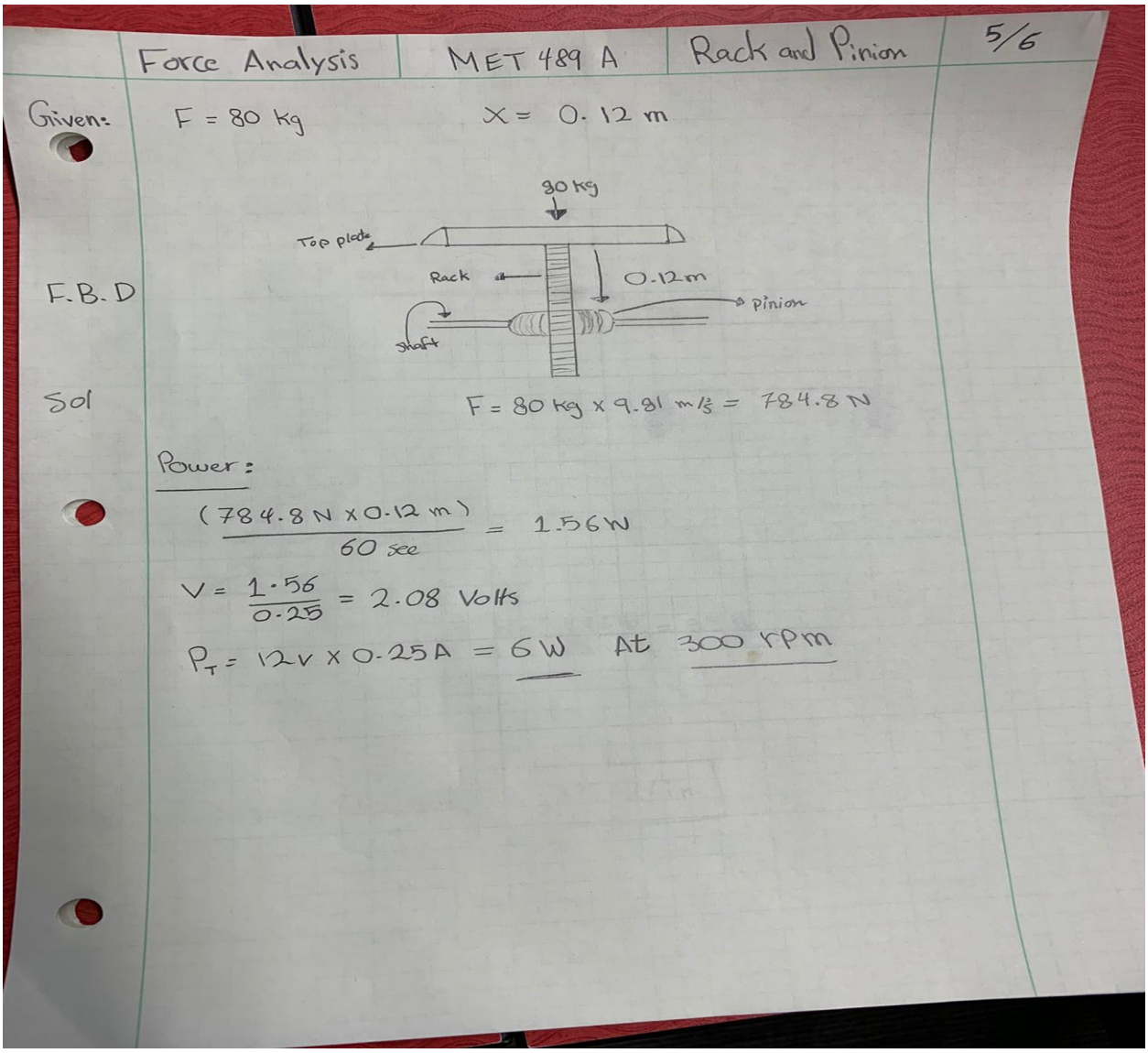
- Torque on the pinion:-

$$T_p = F_r \cdot r_p$$

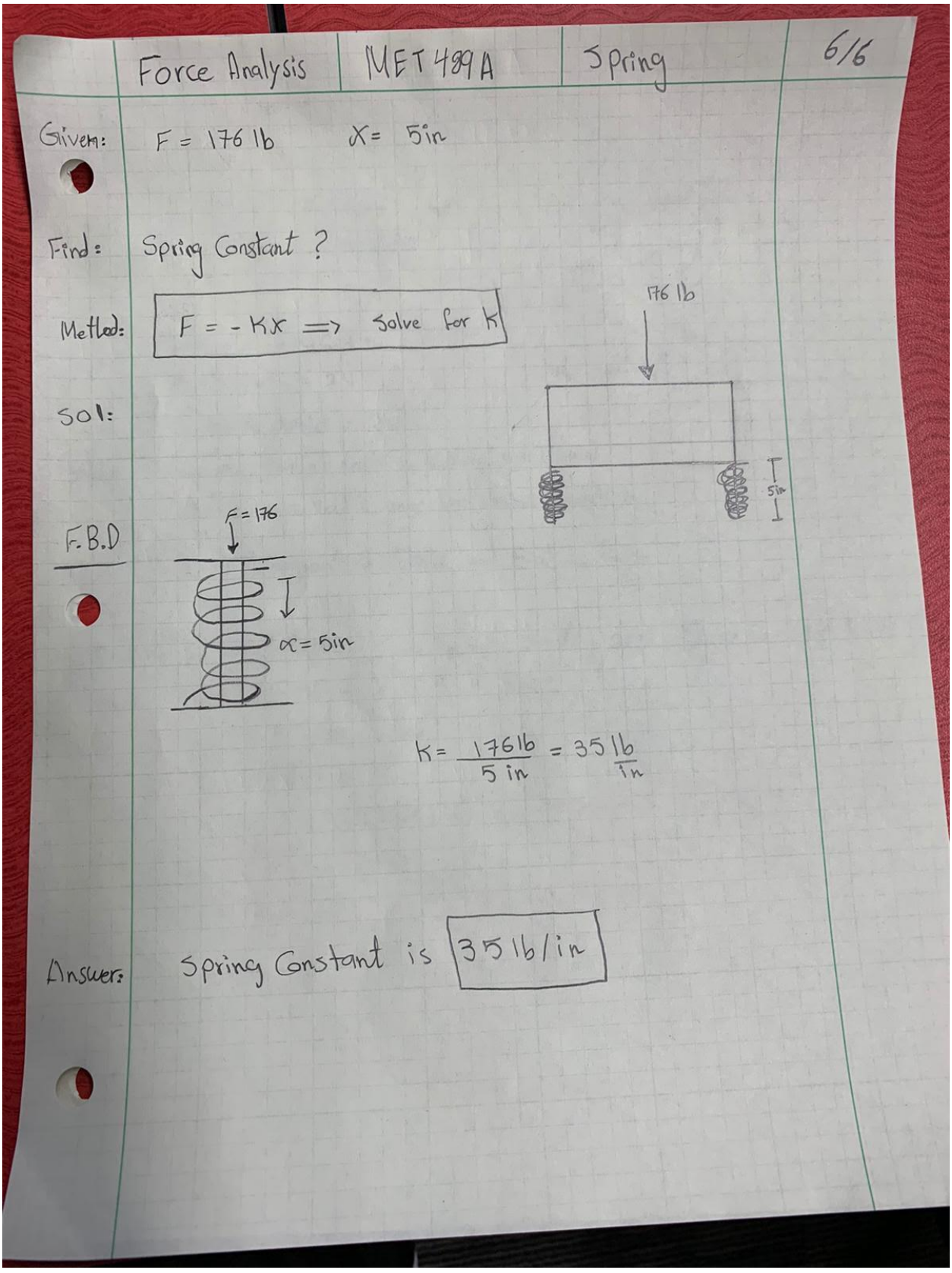
- Maximum rotational speed of pinion:-

$$n_p = \frac{V_{max} \cdot 60 \cdot 1000}{\pi \cdot d_p} \Rightarrow n_p = \frac{V_{max} \cdot 19,100}{d_p}$$

A-4: Rack and pinion Arrangements



A-5: Supporting Load Analysis of Rack and Pinion

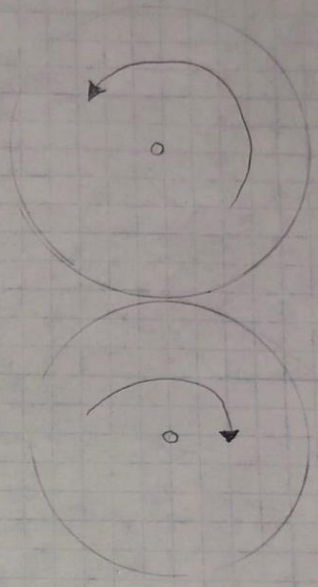


A-6: Spring Force Analysis

Sultan Alanazi | MET 489A | Kinematics of Gears | 1/2

Given: $P_d = 12$, $N_p = 11$, $N_G = 18$, $\phi = 20^\circ$

Find: D_p , Circular pitch , Addendum , Dedendum , Clearance , outside diameter , Root diameter



Assume: Spur gear

Method:

Sol:

For the pinion:-

* $D_p = N_p / P_d = 11/12 = \boxed{0.9167 \text{ in}}$

For the gear

$D_G = N_G / P_d = 18/12 = \boxed{1.5000 \text{ in}}$

* Circular pitch :-

$p = \pi / P_d = \pi / 12 = \boxed{0.2618 \text{ in}}$

* Addendum :-

$a = 1/P_d = 1/12 = \boxed{0.8333 \text{ in}}$

* Dedendum :-

$b = 1.25/P_d = 1.25/12 = \boxed{0.1042 \text{ in}}$

* Clearance :-

$c = 0.25/P_d = 0.25/12 = \boxed{0.0208 \text{ in}}$

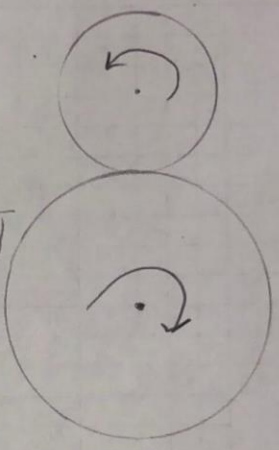
A-7: Kinematics of Gears (Helical Gear)

Sultan Alanazi | MET 489A | Kinematics of gears | 2/2

Given: $P_d = 12$, $N_p = 11$, $N_G = 18$, $\phi = 20^\circ$

Find: outside diameter , Root diameter , whole depth
working depth , tooth thickness , Center distance

Assume: Spur gear



Sol :

* outside diameter :-

Pinion → $D_{op} = (N_p + 2)/P_d = (11+2)/12 = 1.0833$ in

Gear → $D_{oG} = (N_G + 2)/P_d = (18+2)/12 = 1.667$ in

* Root diameter :-

Pinion → $D_{Rp} = D_p - 2b = 0.9167 - 2(0.1042) = 0.7083$ in

gear → $D_{RG} = D_G - 2b = 1.500 - 2(0.1042) = 1.2917$ in

* whole depth :-

$h_t = a + b = 0.0833 + 0.1042 = 0.1875$ in

* working depth :-

$h_k = 2a = 2(0.0833) = 0.1667$ in

* Tooth Thickness :-

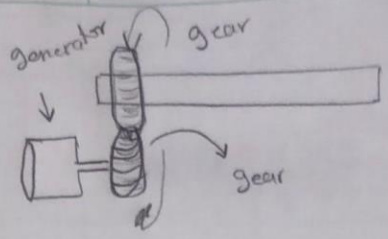
$t = \pi(2(P_d)) = \pi(2(12)) = 0.1309$ in

* Center distance :-

$C = (N_G + N_p)/(2P_d) = (18+11)/(2(12)) = 1.2083$ in

A-8: Kinematics of Gears (Spur Gear)

Sultan Alanazi | MET 489A | Gear Train | 1/2



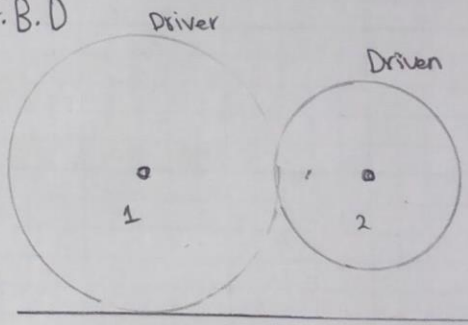
Given: (Two gears) * teeth of $T_1 = 40$
* teeth of $T_2 = 20$
Gear speed (n_1) = 100 rpm

Find: Torque = 10 N-m

- Gear Ratio . Gear speed . Torque generated by driven gear

Assume: Spur Gear

Method: Gear Ratio . Gear train - F.B.D



Sol:

- Gear Ratio = $\frac{T_2}{T_2}$

$G_R = \frac{20}{40} = 0.5$

- Gear Speed .. $(n_2 = n_1)/G_R$

$100/0.5 = \boxed{200 \text{ rpm}}$

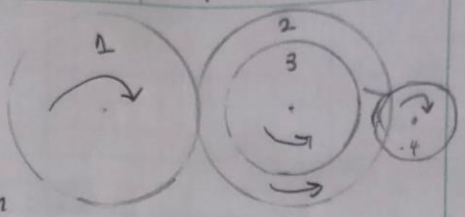
- Torque generated by driven gear:- $(T_{g_n} = G_R \times T_{g_D})$

$T_{g_n} = 0.5 \times 10 = \boxed{5 \text{ N-m}}$

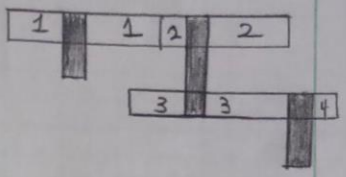
A-9: Gear Train Analysis

Sultan Alanazi | MET 489 A | Compound Gear Train | 2/2

Given: $T_1 = 40$ $T_2 = 30$ $T_3 = 30$ $T_4 = 10$



Find: Gear Ratio for Compound Gear Train



Assume: Gears 2 and 3 are on same shaft

Method: Gear Ratio

Sol:

- Calculate G_R of 1 and 2 :-

$$G_{R_{1-2}} = \frac{30}{40} = 0.75$$

- Calculate G_R of 3 and 4 :-

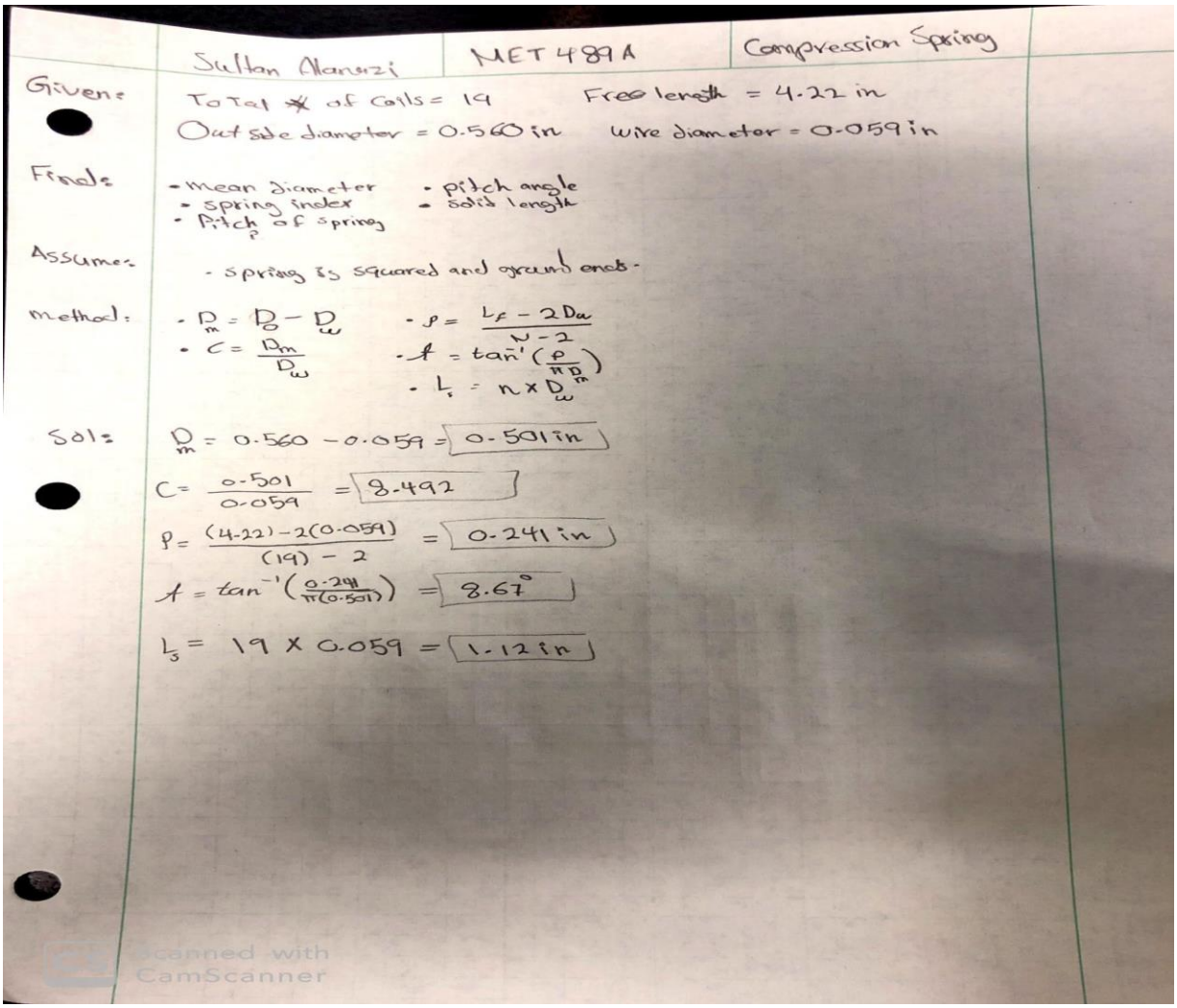
$$G_{R_{3-4}} = \frac{10}{20} = 0.5$$

- Calculate G_R of 1 and 2 – 3 and 4

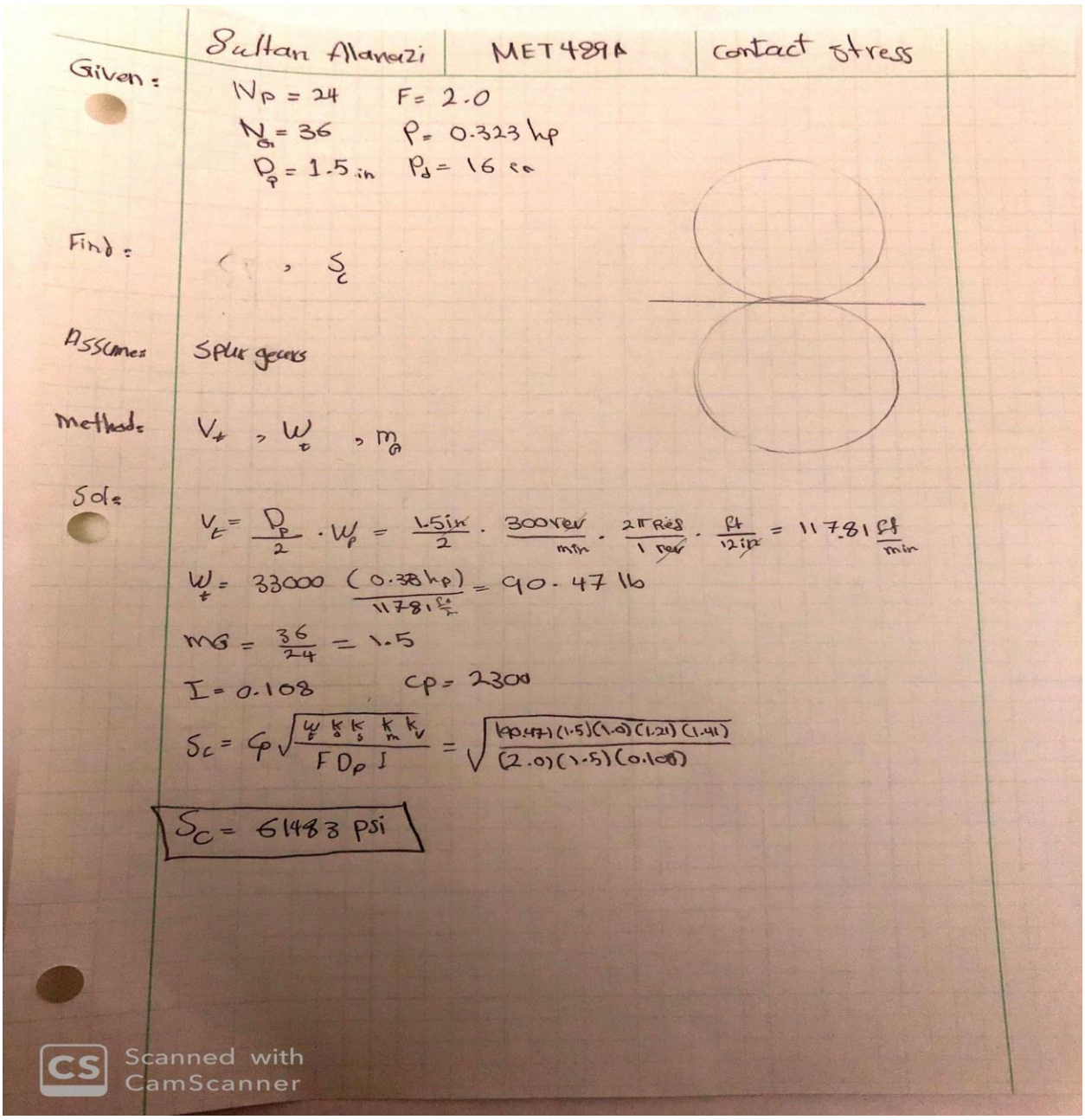
$$(G_{R_{1-2}} \times G_{R_{3-4}}) = (0.75 \times 0.5)$$

Resultant $G_R = 0.375$

A-10: Compound Gear Train Analysis



A-11: Compression Spring Analysis



A-12: Contact Stress of Gears

13. Appendix B

Drawing Tree: B1

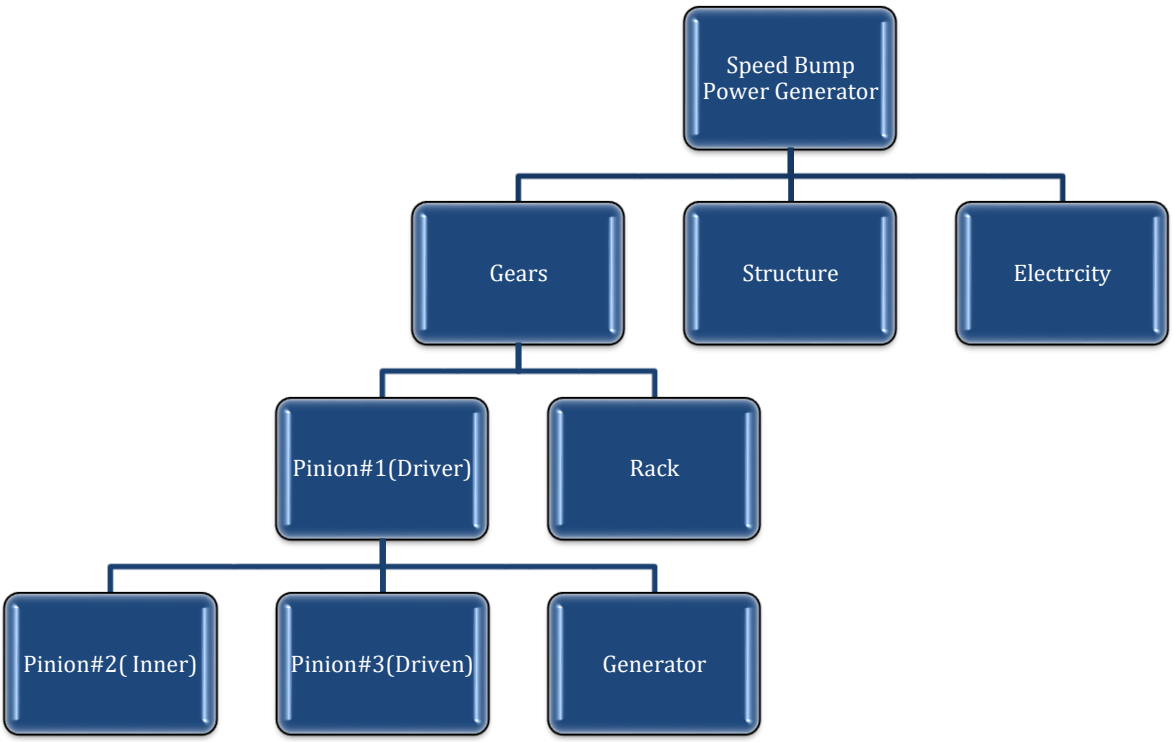
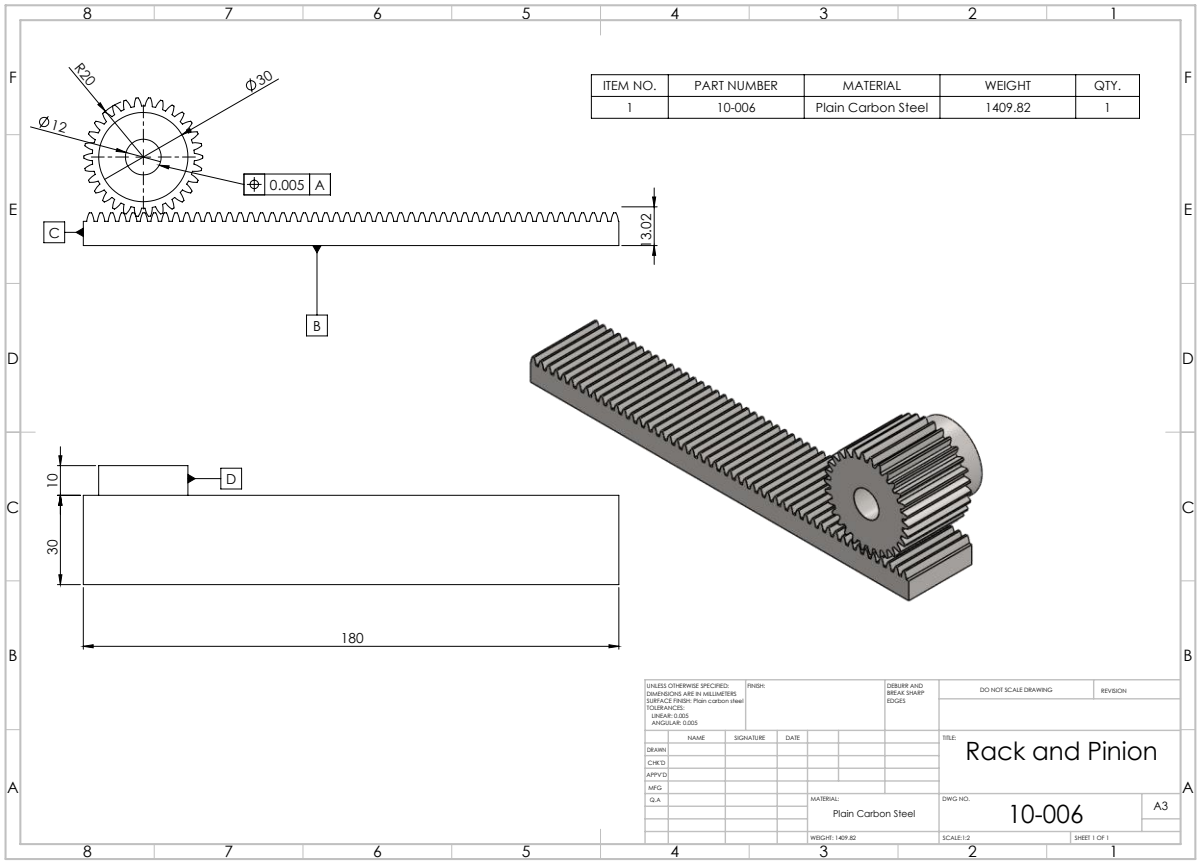


Figure-B2



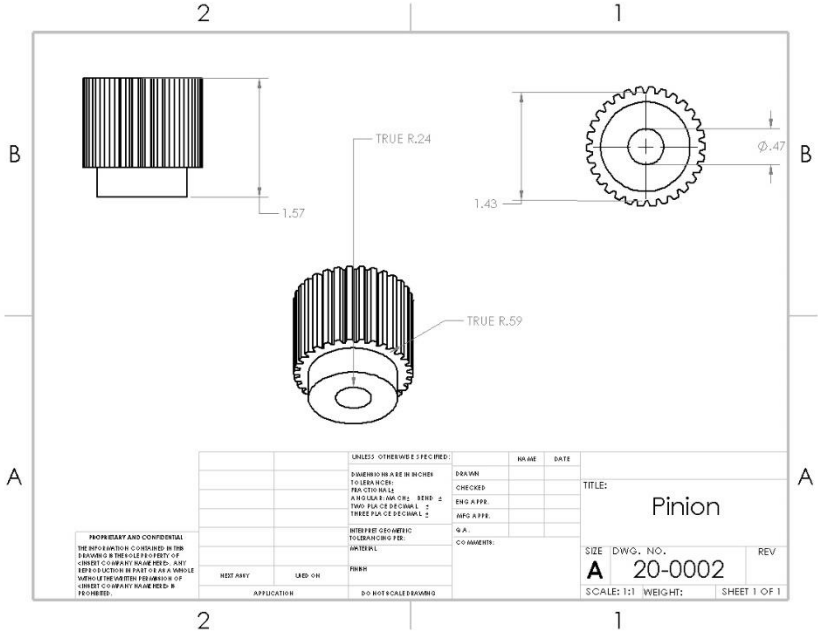


Figure-B3

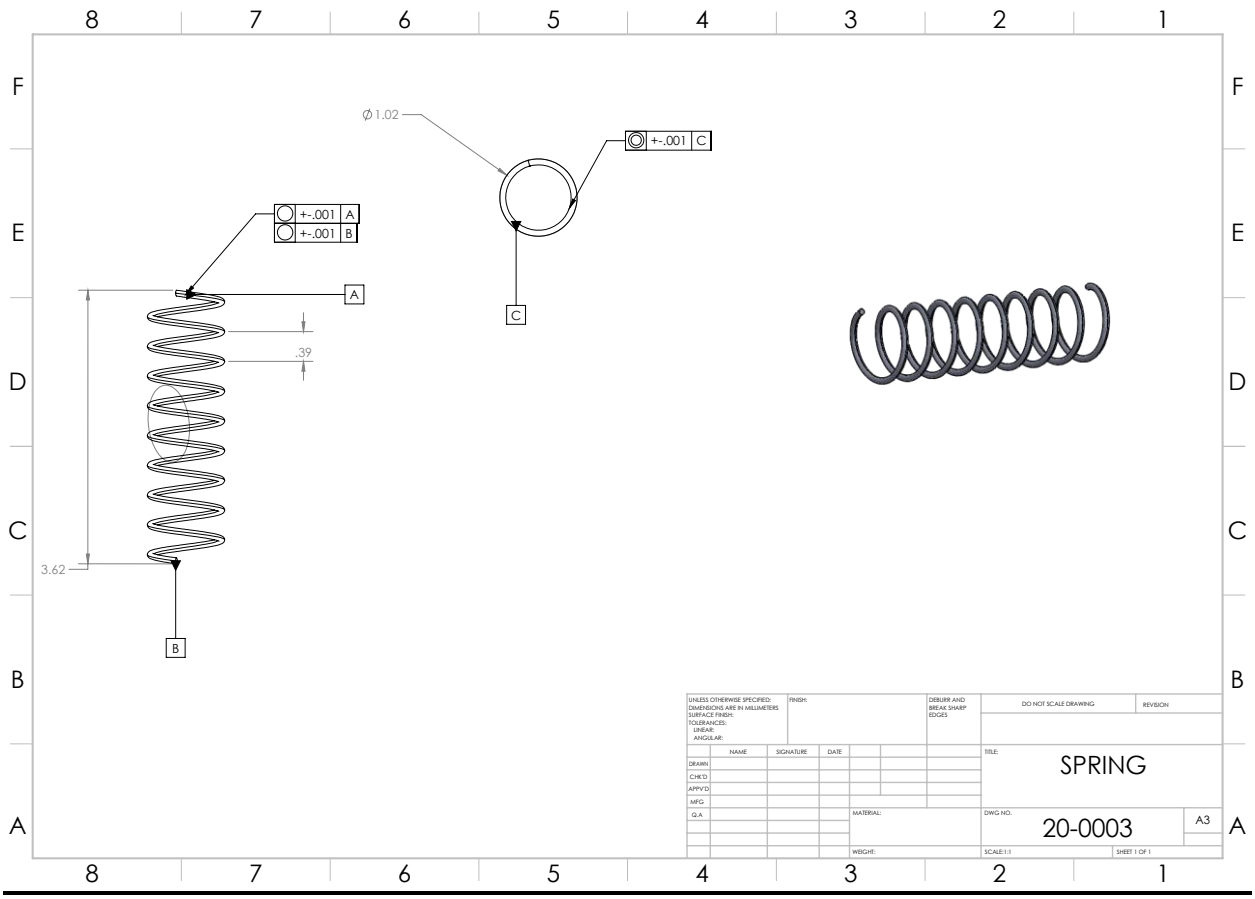


Figure -B4

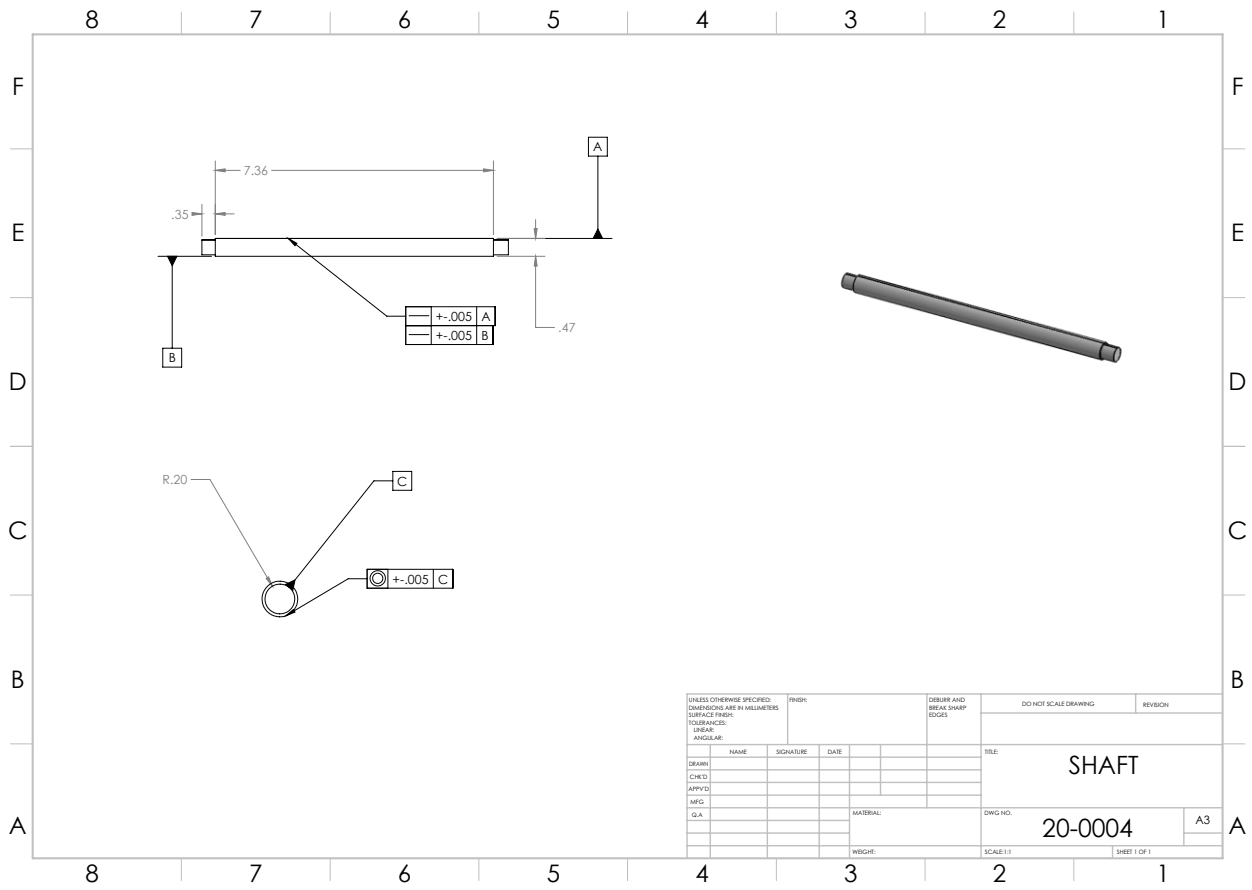


Figure -B5

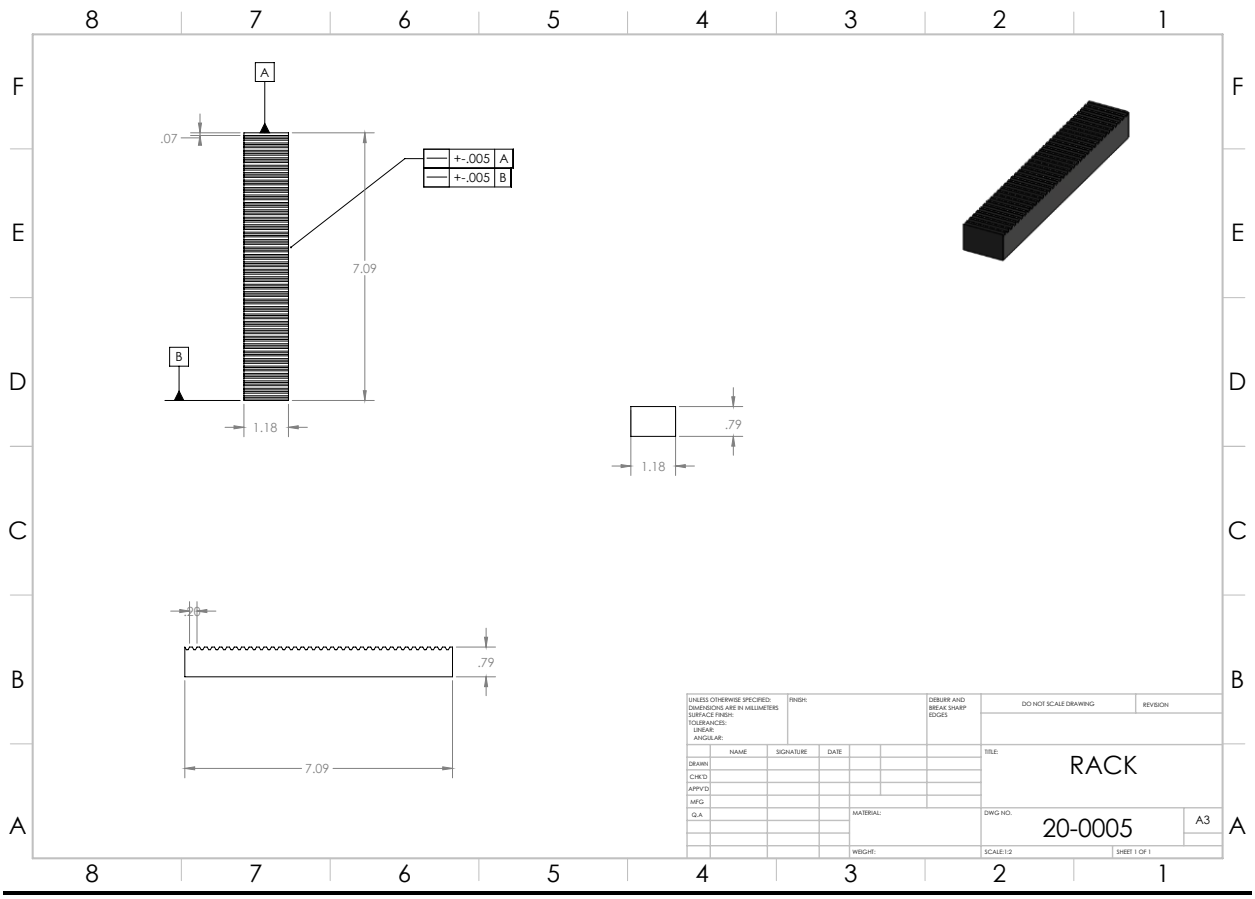

8
7
6
5
4
3
2
1
F
E
D
C
B
A
A
B
.07
+-.005 A
+-.005 B
7.09
1.18
.79
1.18
.20
.79
7.09
RACK
20-0005
A3

Figure -B6

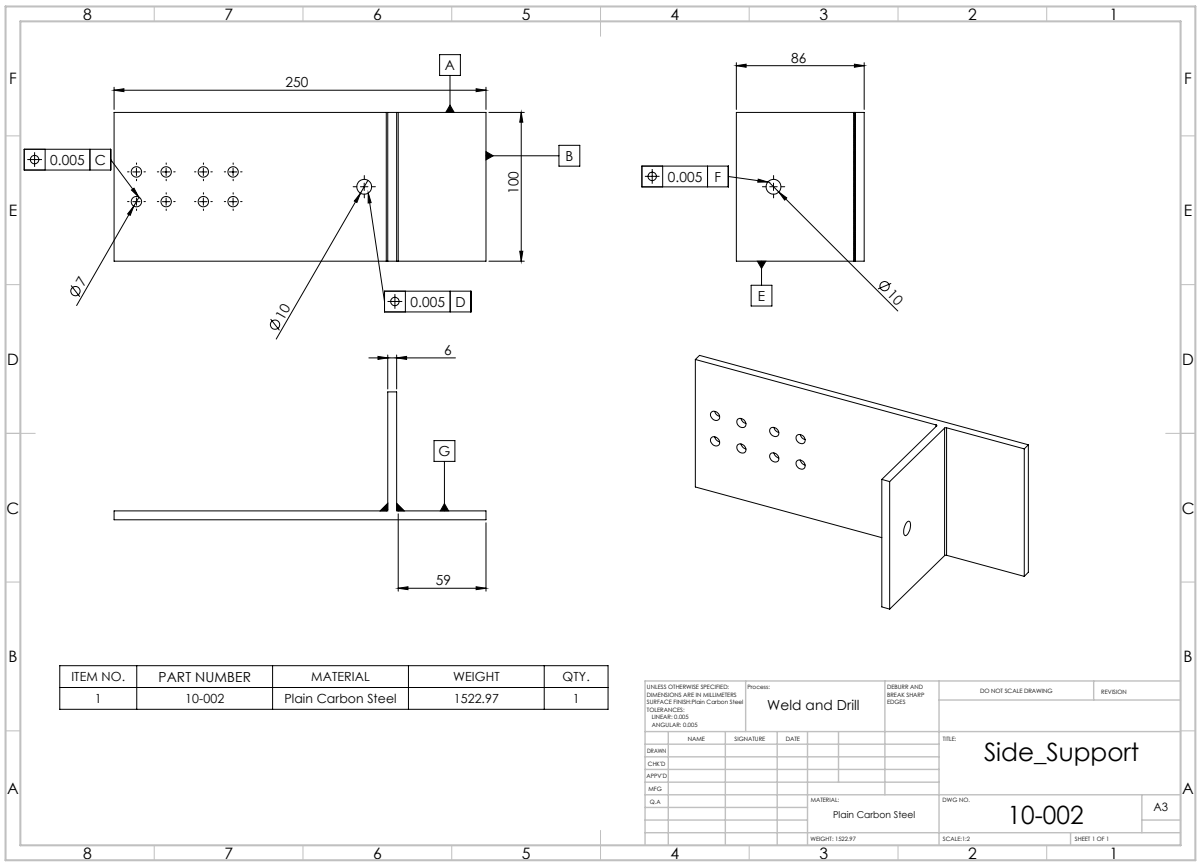

250
A
B
100
0.005 C
Ø7
Ø10
0.005 D
86
0.005 F
E
Ø10
6
G
59
ITEM NO. | PART NUMBER | MATERIAL | WEIGHT | QTY.
1 | 10-002 | Plain Carbon Steel | 1522.97 | 1
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH:Plain Carbon Steel TOLERANCES: LINEAR: 0.005 ANGULAR: 0.005
Process:
Weld and Drill
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME SIGNATURE DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
Side_Support
MATERIAL:
Plain Carbon Steel
DWG NO.
10-002
A3
WEIGHT: 1522.97
SCALE:1:2
SHEET 1 OF 1

Figure-B7

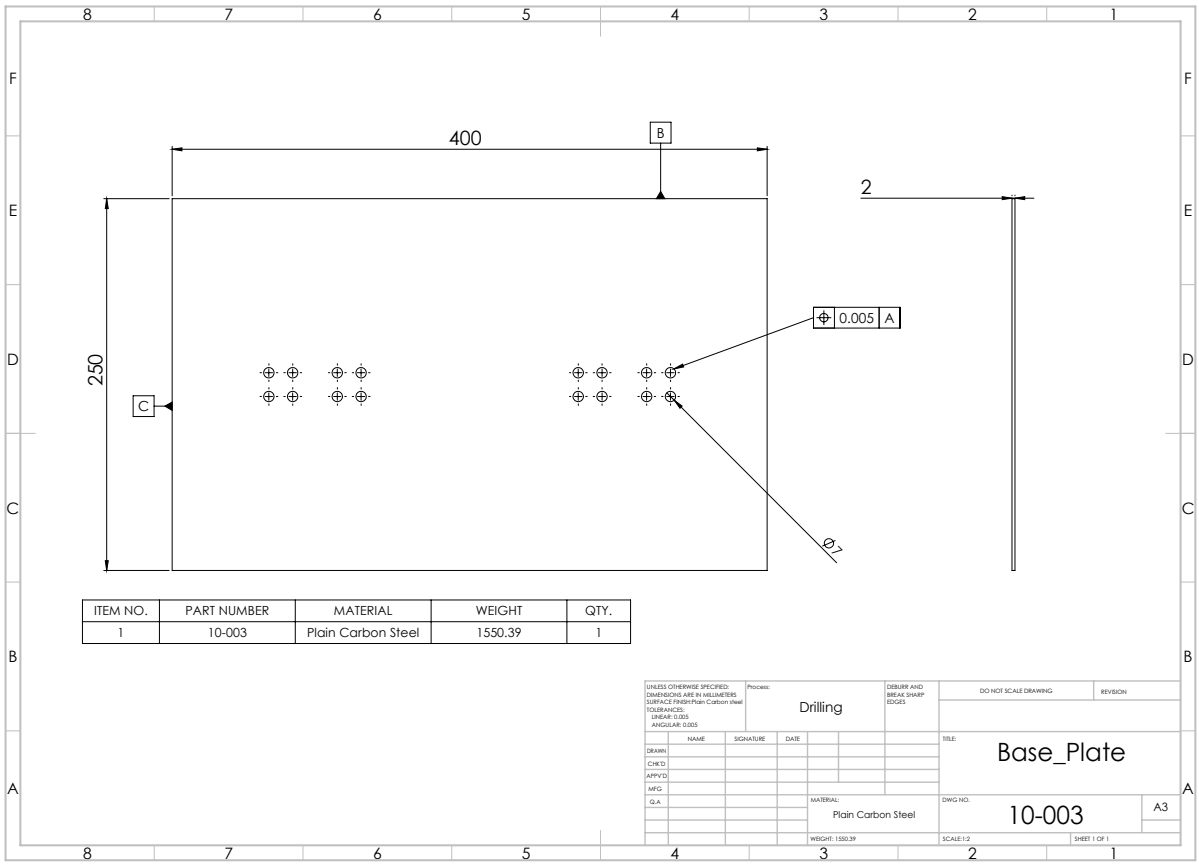

400
B
2
250
C
0.005 A
Ø7
ITEM NO. | PART NUMBER | MATERIAL | WEIGHT | QTY.
1 | 10-003 | Plain Carbon Steel | 1550.39 | 1
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:Plain Carbon steel
TOLERANCES:
LINEAR: 0.005
ANGULAR: 0.005
Process:
Drilling
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
Base_Plate
MATERIAL:
Plain Carbon Steel
DWG NO.
10-003
A3
WEIGHT: 1550.39
SCALE:1:2
SHEET 1 OF 1

FIGURE-B8

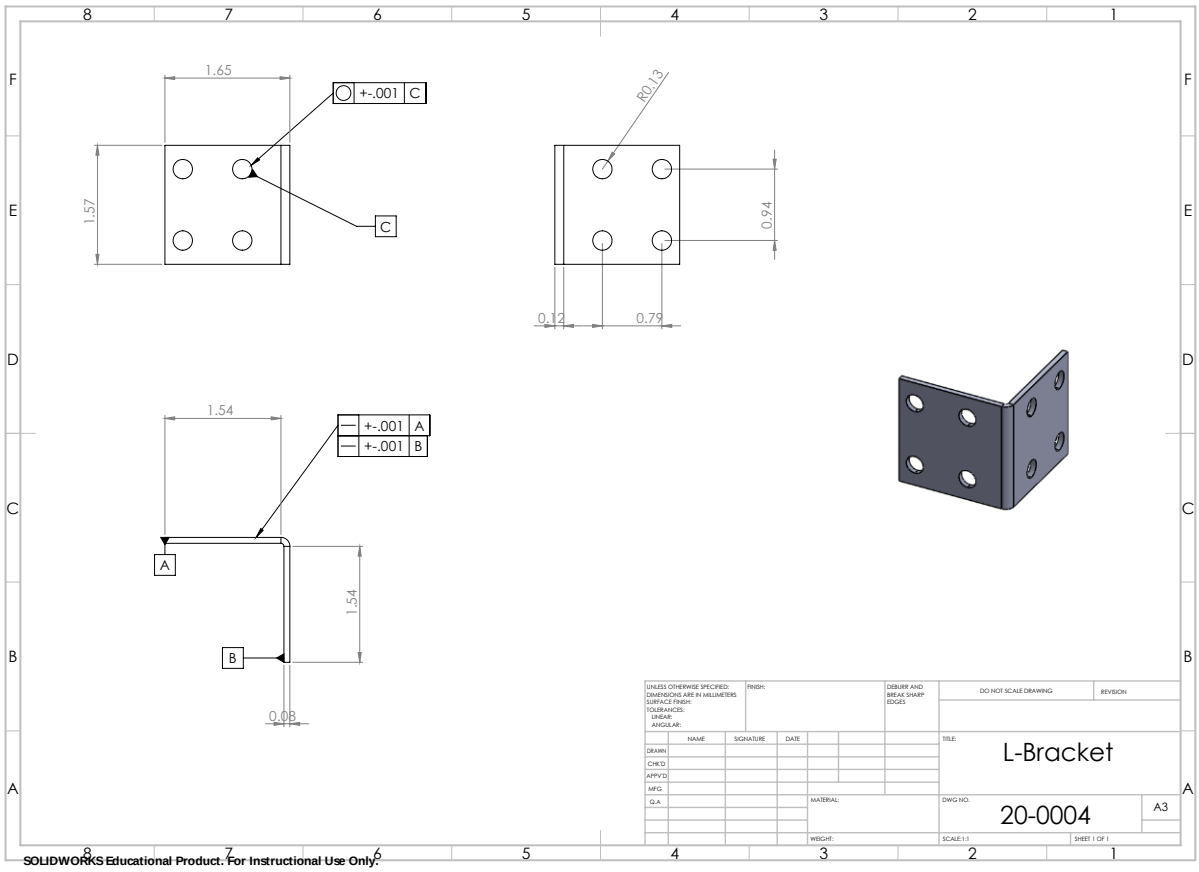

1.65
+-.001 C
C
1.57
R0.13
0.94
0.12
0.79
1.54
+-.001 A
+-.001 B
A
B
1.54
0.08
L-Bracket
20-0004
A3
SOLIDWORKS Educational Product. For Instructional Use Only.

Figure-B9

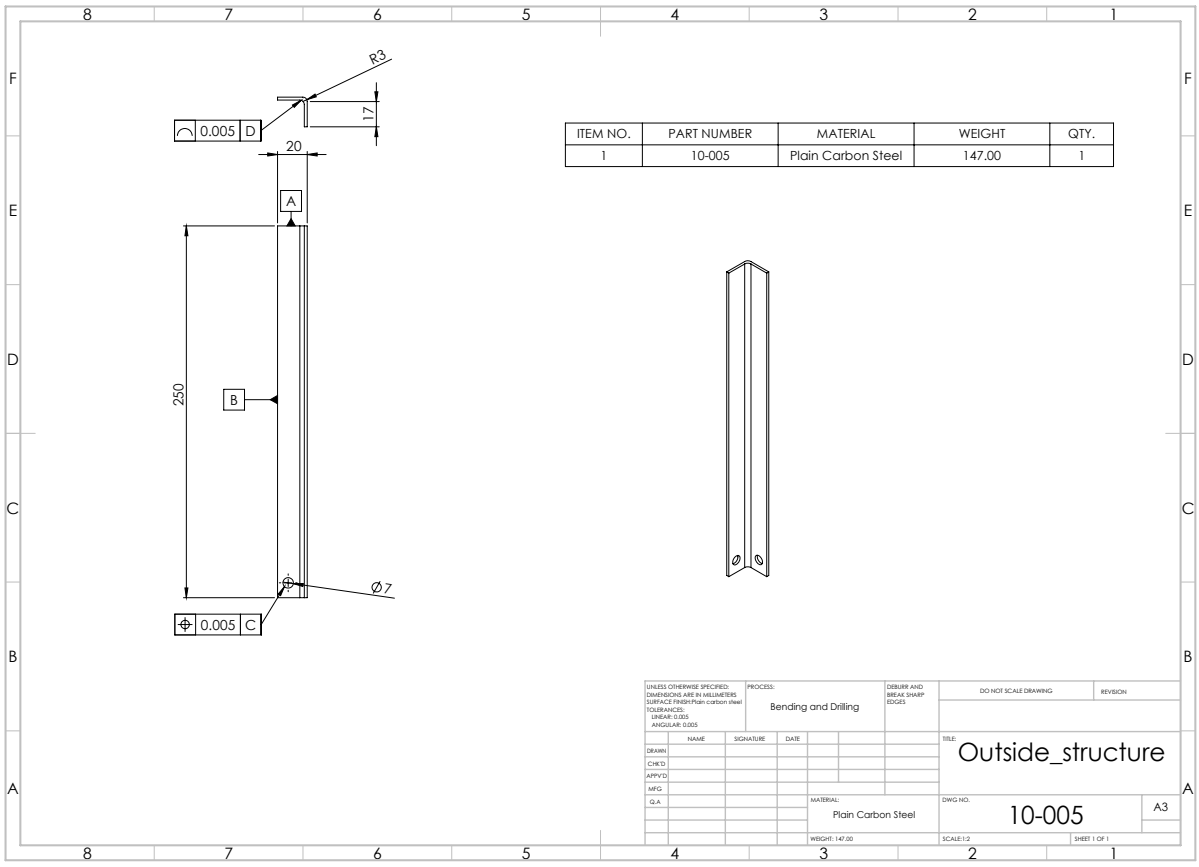

R3
17
0.005 D
20
A
250
B
Ø7
0.005 C
ITEM NO. | PART NUMBER | MATERIAL | WEIGHT | QTY.
1 | 10-005 | Plain Carbon Steel | 147.00 | 1
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:Plain carbon steel
TOLERANCES:
LINEAR: 0.005
ANGULAR: 0.005
PROCESS:
Bending and Drilling
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
Outside_structure
MATERIAL:
Plain Carbon Steel
DWG NO.
10-005
A3
WEIGHT: 147.00
SCALE:1:2
SHEET 1 OF 1

Figure-B10

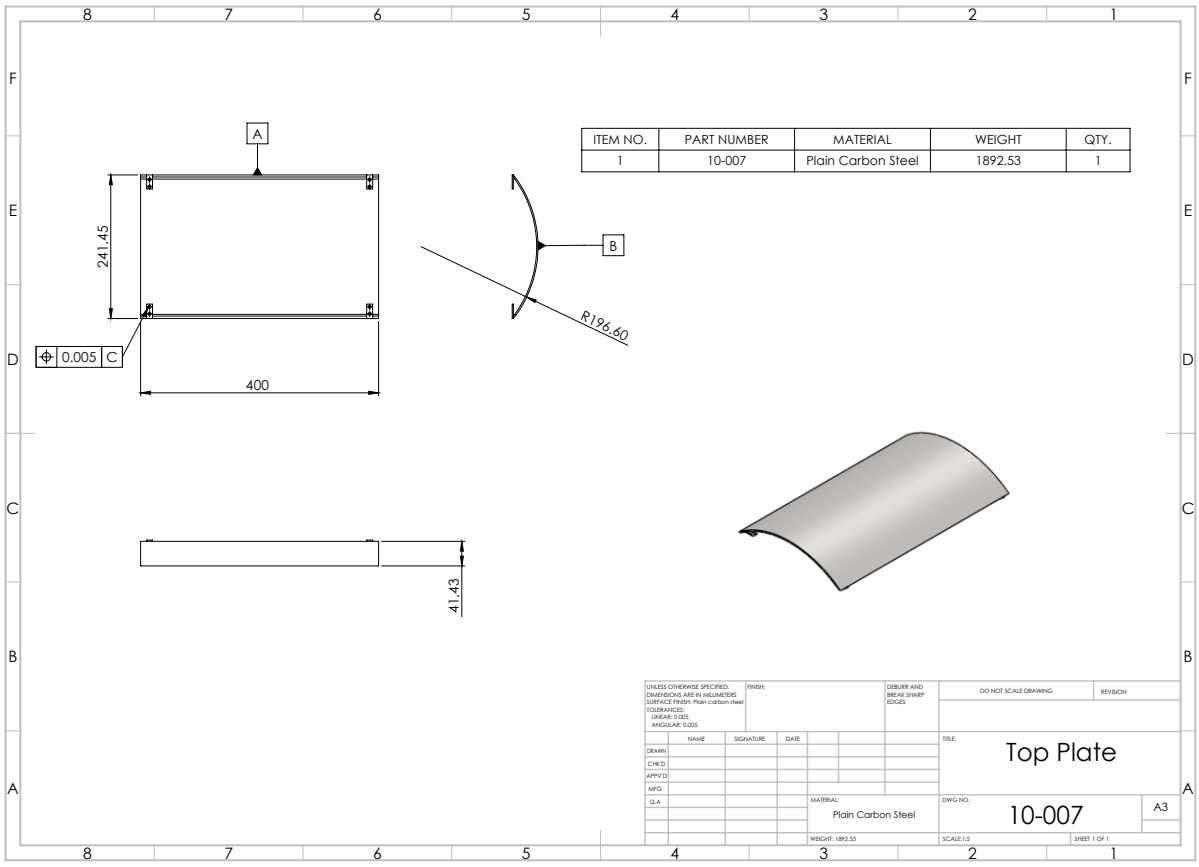

ITEM NO. | PART NUMBER | MATERIAL | WEIGHT | QTY.
1 | 10-007 | Plain Carbon Steel | 1892.53 | 1
241.45
400
0.005 C
R196.60
41.43
Top Plate
10-007
Plain Carbon Steel
A3

Figure-B11

14. Appendix C_ Part List

Power Generation using Speed Breakers

PART IDENT	PART DESCRIPTION	SOURCE	COST APPROX. (USD)	DISPOSITION
Spring	OD.24mm Length 160, wire dia. 2mm	Amazon	21.00	
Rack	L= 30 mm, B= 22 mm H= 180mm	Amazon	50.00	
Pinion gear (3)	OD. = 58mm Bore = 12mm Width = 40mm	Amazon	48.00	
DC motor	1000 RPM	Amazon	20.00	
MS frame	Mild steel	Local steel supplier	35.00	
shaft	Dia. 12mm x 206mm	Local steel supplier	13.00	
Curve plate	Mild steel	Local steel supplier	12.00	
Base Plate	Mild Steel	Local steel supplier	15	
Top Plate	Mild Steel	Local steel supplier	15	
Fasteners	M6, M5 bolts, nuts washers	Local hardware	17.00	
Side Support	Mild steel	Local Supplier	30	
Screws			15	
		Cost total:	**291.00**	

SENIOR PROJECT TITLE _**Speed Bump Power Generator**_

							Cost:		
ITEM ID	ITEM Description	Item Source	Brand Info	Model/SN	Price/Cost (US Dollars) ($ / hour)	Quantity (or hrs)	Subtotals	Actual $	
20-0001	Spring	Amazon.com	MD Steel	A569/ASTM A1011	21	1	21		
20-0002	Side Support	Amazon.com	MD Steel	A569/ASTM A1011	30	1	30		
20-0003	Base Plate	Amazon.com	MD Steel	A569/ASTM A1011	15	1	15		
20-0004	L-Bracket	Amazon.com	MD Steel	A569/ASTM A1011	30	1	30		
20-0005	Outside Structure	Amazon.com	MD Steel	A569/ASTM A1011	35	1	35		
20-0006	Rack & Pinion	Amazon.com	MD Steel	A569/ASTM A1011	98	1	98		
20-0007	Top Plate	Amazon.com	MD Steel	A569/ASTM A1011	15	1	15		
20-0008	Drawing Tree			Unknown		1	0		
						Tot Est.$	244	0	Tot Act. $

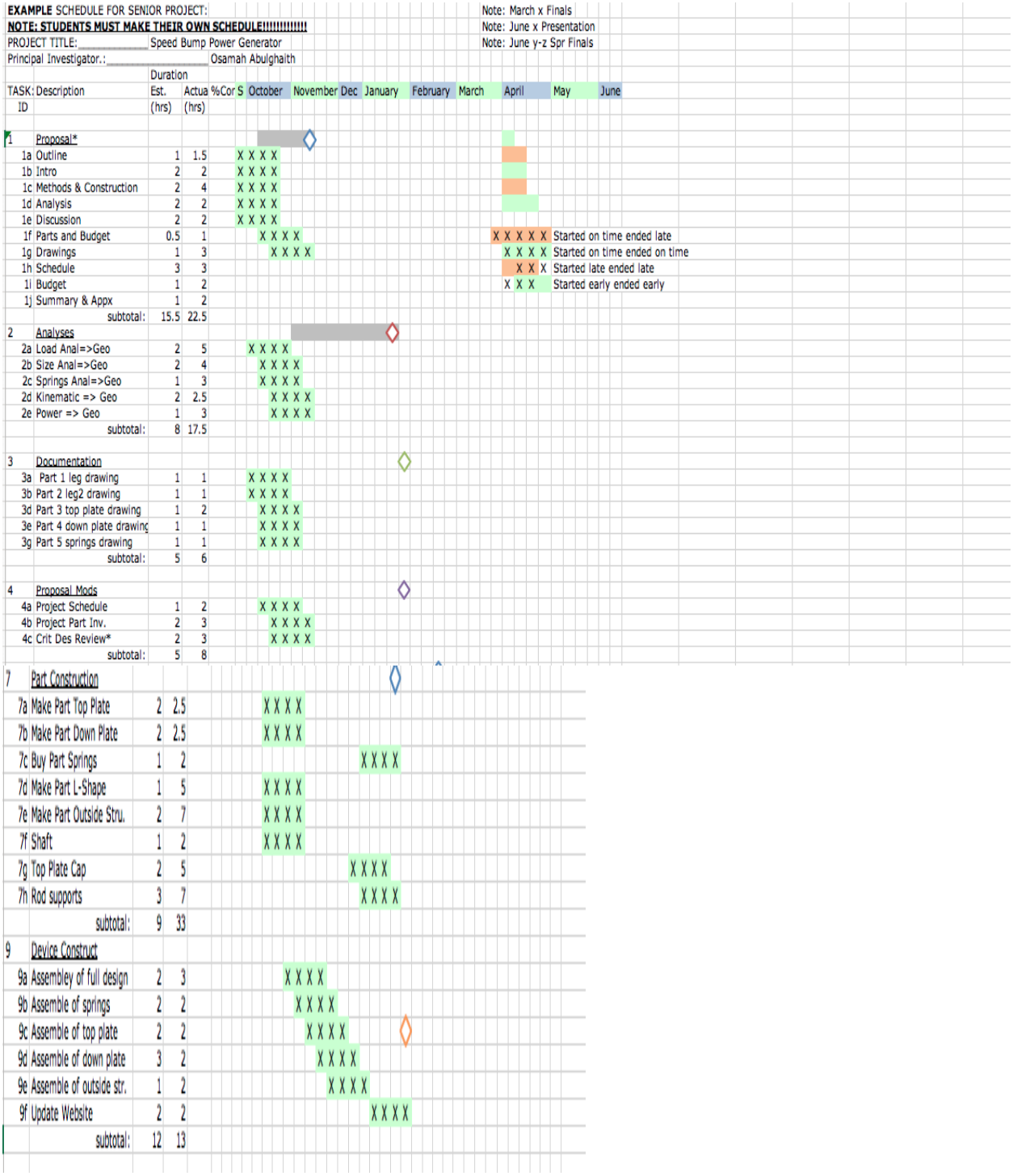
15.Appendix D:

Estimated Project Costs:

PART IDENT	**PART DESCRIPTION**	**COST Total (USD)**
Spring	OD.24mm Length 160, wire dia. 2mm	21.00
Rack	L= 30 mm, B= 22 mm H= 180mm	50.00
Pinion gear (3)	OD. = 58mm Bore = 12mm Width = 40mm	48.00
DC motor	1000 RPM	20.00
MS frame	Mild steel	35.00
shaft	Dia. 12mm x 206mm	13.00
Curve plate	Mild steel	12.00
Base Plate	Mild Steel	15

Top Plate	Mild Steel	15
Fasteners	M6, M5 bolts, nuts washers	17.00
Side Support	Mild steel	30
Screws		15
		291.00

16.Appendix E



EXAMPLE SCHEDULE FOR SENIOR PROJECT:
NOTE: STUDENTS MUST MAKE THEIR OWN SCHEDULE!!!!!!!!!!!!!
PROJECT TITLE:_____ Speed Bump Power Generator
Principal Investigator.:_____ Osamah Abulghaith

Note: March x Finals
Note: June x Presentation
Note: June y-z Spr Finals

TASK: ID	Description	Duration Est. (hrs)	Actua (hrs)	%Cor	S	October	November	Dec	January	February	March	April	May	June
1	Proposal*													
1a	Outline	1	1.5			X X X X								
1b	Intro	2	2			X X X X								
1c	Methods & Construction	2	4			X X X X								
1d	Analysis	2	2			X X X X								
1e	Discussion	2	2			X X X X								
1f	Parts and Budget	0.5	1			X X X X						X X X X X	Started on time ended late	
1g	Drawings	1	3			X X X X						X X X X	Started on time ended on time	
1h	Schedule	3	3									X X X	Started late ended late	
1i	Budget	1	2									X X X	Started early ended early	
1j	Summary & Appx	1	2											
	subtotal:	15.5	22.5											
2	Analyses													
2a	Load Anal=>Geo	2	5			X X X X								
2b	Size Anal=>Geo	2	4			X X X X								
2c	Springs Anal=>Geo	1	3			X X X X								
2d	Kinematic => Geo	2	2.5			X X X X								
2e	Power => Geo	1	3			X X X X								
	subtotal:	8	17.5											
3	Documentation													
3a	Part 1 leg drawing	1	1			X X X X								
3b	Part 2 leg2 drawing	1	1			X X X X								
3d	Part 3 top plate drawing	1	2			X X X X								
3e	Part 4 down plate drawing	1	1			X X X X								
3g	Part 5 springs drawing	1	1			X X X X								
	subtotal:	5	6											
4	Proposal Mods													
4a	Project Schedule	1	2			X X X X								
4b	Project Part Inv.	2	3			X X X X								
4c	Crit Des Review*	2	3			X X X X								
	subtotal:	5	8											
7	Part Construction													
7a	Make Part Top Plate	2	2.5			X X X X								
7b	Make Part Down Plate	2	2.5			X X X X								
7c	Buy Part Springs	1	2						X X X X					
7d	Make Part L-Shape	1	5			X X X X								
7e	Make Part Outside Stru.	2	7			X X X X								
7f	Shaft	1	2			X X X X								
7g	Top Plate Cap	2	5						X X X X					
7h	Rod supports	3	7						X X X X					
	subtotal:	9	33											
9	Device Construct													
9a	Assembley of full design	2	3				X X X X							
9b	Assemble of springs	2	2				X X X X							
9c	Assemble of top plate	2	2				X X X X							
9d	Assemble of down plate	3	2				X X X X							
9e	Assemble of outside str.	1	2					X X X X						
9f	Update Website	2	2						X X X X					
	subtotal:	12	13											

17.Appendix F

The project will be design and build by the group members with the assistance of professors. The project will be built in the machining shop and the welding shop with the assistance of technicians.

18.Appendix G

Report Testing: Tangential Force

$Angle_{(red)}$	$Force_{(N)}$	$F_R(N)$
0	44 N	7 N
0.5	48 N	12 N
3	71 N	17 N
3.5	82 N	22 N
5	86 N	26 N
5.5	91 N	31 N

19.Appendix H

Sultan Alanazi

300 E Helena Ave
Ellensburg, WA,98926
(541) 606-9498
sultan.alanazi@cwu.edu

I am student at Central Washington University in Mechanical Engineering Technology major-***Undergraduate***

EXPERIENCE

ARAMCO,Saudi Arabia — *Project Management, Volunteer*
Jul 2013 - Oct 2013
Pricing materials that the project need in order to start, and finding workable locations.

Al faisal Academy, Saudi Arabia — *Designer*
Sep 2011 - Apr 2012
Creating websites for commercial uses.

EDUCATION

Alamal, Saudi Arabia — *High school diploma*
Sep 2005
Industrial high school

Lane Community College, Eugene,OR — *Associate of science*
Spr 2016 - Win 2018
Associate of Science in engineering field.

Affiliation

The National Society of Collegiate Scholars — *Member Since February 2017 .*

SKILLS

Dealing with Technology
Working in Collaboration
Problem Solver
.

LANGUAGES

Arabic, English

20.Appendix J

JOB HAZARD ANALYSIS
{Insert description of work task here}

Prepared by: Sultan Alanazi	Reviewed by: Osamah Approved by:

Location of Task:	**Central Washington University**
Required Equipment / Training for Task:	The required equipment of Speed bump power generator are gloves, eye protection, and hearing protection.
Reference Materials as appropriate:	Machining, drilling, turning, and welding.

Personal Protective Equipment (PPE) Required (Check the box for required PPE and list any additional/specific PPE to be used in "Controls" section)						
						
Gloves	Dust Mask	Eye Protection	Welding Mask	Appropriate Footwear	Hearing Protection	Protective Clothing
☒	☐	☒	☐x	☒	☒	☒
Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.						

PICTURES (if applicable)	TASK DESCRIPTION	HAZARDS	CONTROLS
	1. Clean the table.	Eye injury from metal debris	Wear eye protection. Do not use compressed air.
	2. Load the vise.	Foot injury if the vise falls. Finger pinching while sliding the vise.	Don't let your fingers get under the vise unless you are lifting it from the table. Keep your eyes on the task.
	3. Start the drill.	None foreseen.	Feed with the appropriate pressure. Use the appropriate bit for the type of metal.

		Injury caused by breaking the bit.	Wear eye protection.
	4. Unload the vise.	Foot injury if the vise falls.	Leave the vise secure on the table with T-pins until it is unloaded.
	5. Changing mat blades.	Lacerations	Be aware of how you handle the blades. Handle all blades on the dull side, not the sharp cutting edge.
	6. Cutting mats.	Lacerations	Keeps hands away from blades when cutting. Use the pressure bar to hold the mat in place.
	7. Align material.	Cutting hand. Pinching hand between welding tips.	Wear gloves. Keep fingers from pinch point