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Mechanical Footstep power generator

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MECHANICAL FOOTSTEPS POWER GENERATOR

By

Investigator:

Mohammed Aljohani

Project Partners:

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1. INTRODUCTION

A. MOTIVATION:

This project was motivated by the need for a device that would generate electricity from human motion, especially footsteps. Electricity is a very important resource in people daily life. There are numerous sources from which are able to generate electrical energy. The major sources of energy include but are not limited to coal, natural gas, petroleum, and nuclear energy. Most of these sources have adverse effects on the environmental inclusion such as air pollution; for example, from coal energy generation plants which then cumulatively leads to effects such as increase in rates of global warming.

This project seeks to establish an environmentally friendly way of generating electric power from human motion. Such a system could be highly effective for installation in places that expect frequent mobility of a large population such as in educational institutions like universities and subway station entrances and platforms.

B. FUNCTION STATEMENT:

The function of this statement is to generate electrical power from human motion.

C. REQUIREMENTS:

1) This device is required to have the ability and capacity to store the energy generated 6kw/h.

2) The device should be able to support the weight of an average human being which is approximately 137 pounds.

3) Once activated the top plate of the device must return to the initial position with displacement not lasting more than 5 seconds.

4) The displacement must be compensated appropriately to prevent overshoot in the device. It must be 1 inch.

5) The device should measure 50 centimeters in length, 35 centimeters wide and a thickness of 25 centimeters.

D. SUCCESS CRITERIA:

1) The project must meet all the requisite safety criteria.

2) The device developed should also be relatively small and lightweight without compromising its functionality.

3) The device should be manufacturable with ease.

4) Its construction materials need to be easily accessible and inexpensive so as to minimize the cost of production per unit.

5) To be able to generate optimum functionality of the device must be installed in areas where there is a large population density.

E. SCOPE OF EFFORT:

The project will only seek to harness the energy generated by the impact of the foot on the floor during the gait cycle.

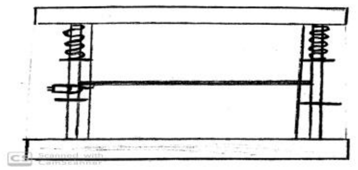
2. DESIGN & ANALYSIS

A. APPROACH: PROPOSED SOLUTION:

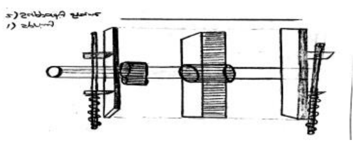
The solid works design and dimensions are represented in **Appendix B**, and analyses are presented in **Appendix A.** The analysis contains only the structure, and the design will be performed efficiently when all the dimensions, loads and requirements are met completely.

B. DESIGN DESCRIPTION:

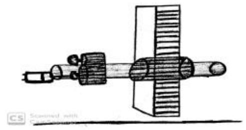
The design for whole device comes with top plate, base plate, 3 gears, 1 rack with pinion, rod supports, left/right side support and generator.



A1) Design (Sketch for top plate and base plate with springs).



A2) Design (Sketch for rack and pinion with shaft and rod Supports).



A3) Design (Sketch for rack and pinion and two gears)

C. BENCHMARK:

Wind turbines are one of the sources of green energy as depend on wind currents to turn the turbines and generate electricity and also inexpensive to maintain since propulsion is natural. Similarly, the device is seek to develop would have zero negative impact on the environment and would be inexpensive to maintain since it depends on human moment to produce electricity, also; not be affected by shifts in weather patterns; unlike wind turbines whose productivity solely depends on the natural wind direction. This new device would be fully dependent on human motion which is entirely under people control to operate.

D. PERFORMANCE PREDICTION:

The performance of the project will be as described below:

1) The footstep power generator electricity provided by human motion.

2) The displacement must be compensated appropriately to prevent overshoot in the device. It must be 1 inch.

3) Once activated the top plate of the device must return to the initial position with displacement not lasting more than 5 seconds.

E. DESCRIPTION OF ANALYSES:

- A1: Finding the maximum permissible torque for a shaft of known dimensions, trying to calculate the max. Permissible for the shaft and knowing the whole dimensions can use for shaft.
- A2: Measuring one force on the beam to try how the average human weight 137 lb. will be on the device.
- A3: Measuring the two forces on the beam for human motion, just example if two humans' motion be on the steel beam how will be good for steel and nothing will happen for the steel such as broken.
- A4: trying to get exact measure for top plate that will work in device, and if trying to make it bigger can change the volume to higher to be good.
- A5: trying to get exact measure for base plate that will work in device, and if trying to make it bigger can change the volume to higher to be good. But in the base plate the length should be bigger than the top plate.
- A6: L-bracket measure it and want to know how can bending the bracket by 90 degree to get the exact measure and be work in device to hold the Rod Support with base plate.
- A7: Measuring the Left/right side support to know how can support the load for one force on the top side support.
- A8: Measuring the punch hole for top plate and base plate, Shear stress and strain for punch hole to Top plate and Base plate and avoid the extra space.
- A9: calculating the shear stress for top plate that help the device to know how and will be good for human.
- A10: Calculating the shear force and bending moment Diagram to know if the steel of top plate will be bending for 137 lb. for human motion or not.
- A11: Calculating the Spring's constant and how far the stretched or compressed and using the Hooke's Law to measure constant and compressed. $F = - kx$.
- A12: Box measuring, trying to measure how can making a box for the device to be in good condition and how can use size for the box.

F. SCOPE OF TESTING AND EVALUATION:

Mechanical testing includes testing each parts of the machine/robot individually followed by the complete testing after which the project is ready to be used.

3. CONSTRUCTION

A. METHOD:

The complete diagram of the power generation using footsteps. L-shapes window is inclined in certain small angle which is used to generate the power. The pushing power is converted into electrical energy by proper driving arrangement.

The rack & pinion, spring arrangement is fixed at the footsteps which are 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 it 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.

- Method of construction:

One of the major factors that determined the nature of the generation system was environmental issues. constructing a device that generated power while conserving the environment was the most critical factor that motivated the idea of coming up with this generation system. The system is designed in a way that the people movement will be utilized to generate electricity. The footstep power generator basically translates the oscillatory motion to circular and later to electricity. The construction of the system includes measurement, manual cutting, drilling and welding.

- Manufacturing issues:

Most of the material purchased did not conform to the measurement of the parts of the generator. Getting materials with similar measurements was impossible. In addition, some materials are not locally available. The last problem is the cost of the material. For instance, the price of steel is relatively high.

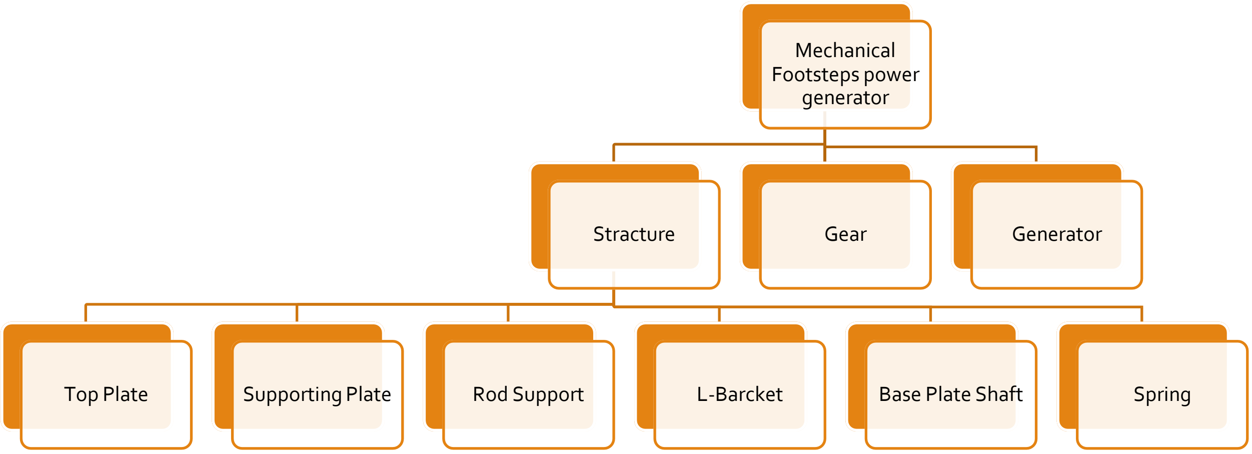
- Methods used in to solve the problem:

In order to get the correct measurement, measurement and manual cutting of the materials were done. Where the screws were needed, drilling was done to ensure that the bolts were fitted correctly. Other methods used in connecting different parts include welding. Welding was done were permanent attachment was needed. To ensure that enough time to make the cutting and measurement was available; all the materials were ordered in time.

B. FOOTSTEP ARRANGEMENT:

This is made up of mild steel. The complete set up is fixed in this model footstep. The two L-shapes frame is fixed in the above two ends of the track. Bellow this L-shapes window, the actual power generation arrangement is constructed.

C. DRAWING TREE



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4. TESTING METHOD

A. INTRODUCTION:

Footstep power generator is a project with three major parts; structural, gearing, and generating power. In this proposal the focus major will be on structural. Testing the functionality of the generator is important. In order to ensure that the generator setup is fully functional, various tests are done on the materials. Also, after the system is assembled, various tests will be carried to find the efficiency of the generation system and the possibilities of the system breakdown. The tests done before assembling include; verification of the materials purchased, the measurement verification, and verification that the materials ordered were supplied as instructed. After assembling the following will be tested: the power of the generator, the efficiency, reliability of the system and probability of breakdown after installation.

A. METHOD/**APPROACH**:

- *Performance testing:*

This test involves a process of finding out the responsiveness and stability of the footstep power generation system. The test will provide information regarding the production capacity of the generator. This approach will test the average power the power generation system can produce at different environmental aspects.

- Usability testing:

This method of test determines the easiness of using generation system. The system should be easy to use. Different users will be requested to use the generator while being observes. Qualitative data will be collected for the analysis

- Security testing:

Security test will be carried to determine if there are any risk involved when operation the footsteps power generation system.

B. TEST PROCEDURE DESCRIPTION:

To verify if the materials are supplied are as ordered a procedural check is done. Ticking of every material that is supplied will be done. The missing materials will be marked with cross (X) for reordering. Also, the measurements verification will be done. Every component of the systems will be measured to verify if the measurement conforms to the calculated measurement. After assembling, the system average power will be measured, the efficiency, and the continuity of power generation.

C. DELIVERABLE:

- *Right positions for holes*
- *Correct dimension for Top plate and Base plate*

The maximum power and minimum power will be recorded and compared with the expected average power of the generation system of 6 KW/hr. In regard to the easiness of system usability, the system should be easy to use. The opinion of the selected users is recorded and analyzed to find the usability of the system.

- Design Testing

The major principle behind the operation of this system is use of footstep to generate power. To ensure that the generator works properly, each part including gears and movement of every part that is moving will be tested after assembling the generator working. The above proposed power generating system works as a generator that produces medium power using few footsteps. Its power generation is basically on small scale and therefore its performance test is done on small scale. For the generator to be efficient, a single stem should generate some power. Therefore, a piezoelectric sensor is used to test the force, acceleration and the pressure needed to produce some power. The voltmeter is connected to the system to measure the output of the generator.

- **Deliverables and testing issues**

- The amount of energy that is produced during people movement is stored in battery. Finding the type of battery that is long lasting is an issue. Also, the criteria of determining the changing time taken by the battery is a challenging issue. Also, the termination of power output is important. The generator has a minimum force which when exerted on the plate leads to production of power. The minimum force that can produce power is subject to the strength of the spring. Selection the right spring with the correct spring constant is necessary. Getting a spring with a spring constant that corresponds with the calculated figure is a problem.
- The power output is calculated in terms of voltage and current when a force is applied on the footsteps. The readings are made through the use of multimeter. A single step load produces 1.56 W volts. The maximum no load current produced is 60 mA but for maximum load current is 250 mA. Production of power in a continuous manner will only be possible when there is a continuous movement of people on the footstep generator.
- Another issue is determination of the correct rack and pinion gears that have maximum efficiency in regard to transfer of force that leads to production electricity. The gears determine the change in the speed, torque and the direction of the power source. They create a mechanical advantage through the gear ratio. Therefore, the efficiency of the gears depends on the number of teeth of the gears.

5. BUDGET

A. PART SUPPLIERS, SUBSTANTIVE COSTS, SEQUENCE OR BUYING ISSUES:

The material for the main sections of the design such as Top Plate, Base plate, Rod Support comes from Onlinemetals.com. Since buying mass quantities of nuts and bolts is not suited for constructing just a single pair. So, before purchasing the materials from Onlinemetals.com, making sure of the size in good condition.

B. DETERMINE LABOR & ESTIMATE COSTS:

Central Washington University personnel will be assisting with Welding of the sections that needs be weld, there are no labor costs

C. LABOR:

As mentioned above, there will be no labor costs due to the construction being contained solely to CWU personnel. If any additional services such as welding are needed, will be recorded here and in **Appendix D**.

D. ESTIMATE TOTAL PROJECT COSTS:

The estimate total for the project will be around $300 dollars. Also, each part should be separate and each one has different price. Otherwise, some of parts are coming together such as left-side support and right-side support.

E. FUNDING SOURCES:

- **Expected project cost:** ***(There are no funding Sources)***

The initial cost of the project was $300. The purchase of some parts was purchased separately as gears, rack and pinion. However, purchasing a steel plate of 0.24” thickness for the left and right-side support.

- **Cost change due to change in design:**

No cost was incurred due to change in the design. The total manufacturing cast summed to $350.

- **Cost due to errors:**

Some of the items that were bought were not conforming to measurements. The item that needed repurchase was A569/ASTM A1011 (MD steel- 20-0001) which costs $35. The only option was to buy another item. There was no additional labor cost as fixed it. No external labor was needed.

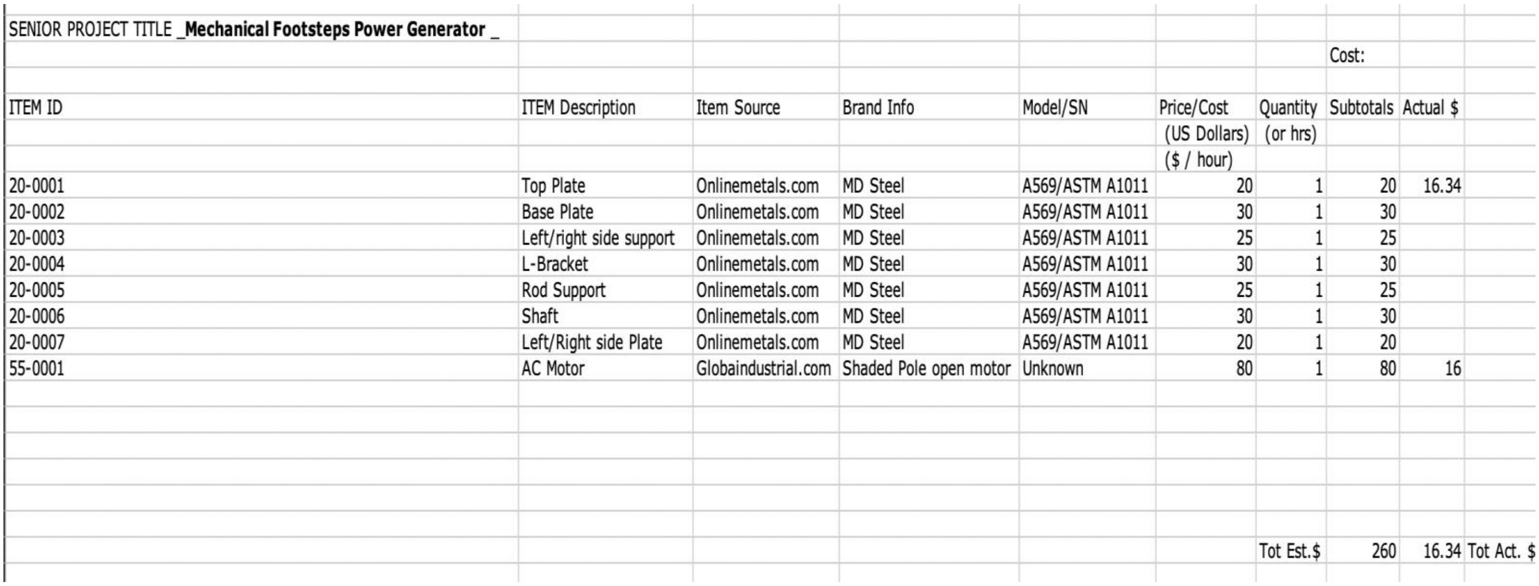
- **Method used to resolve the issue:**

Purchase of new MD steel- 20-0001 and refaxing it afresh. Adjusting the sizes of the materials was the only option. Manual cutting was done to ensure that the measurements were as had calculated.

The cutting of the materials and assembling days were scheduled on different days. The initial day to ensure that all parts conformed to the listed measurement was 20 January 2020. However, the day was extended. A four-day allowance because the item was purchased online. The working days were extended from January 20 to 24th.

- ***<u>Each part has different plate:</u>***

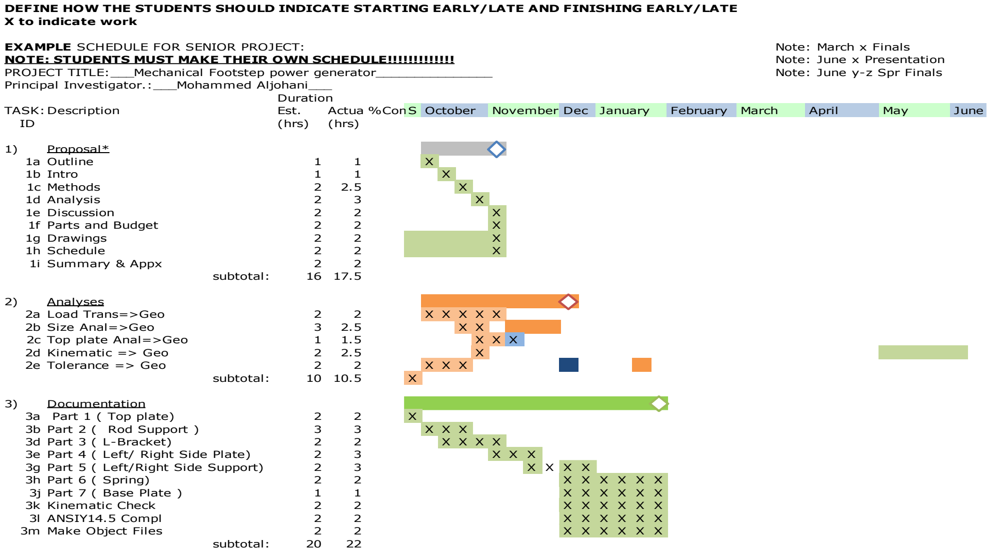
<u>Parts (structure)</u>	***<u>Cost</u>***
1) Top Plate	*$20*
2) Rod Support	*$25*
3) L-Bracket	*$30*
4) Left/ Right Side Plate	*$20*
5) Left/Right Side Support	*$25*
6) Base Plate	*$30*
7) Spring	*$20*



SENIOR PROJECT TITLE **_Mechanical Footsteps 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	Top Plate	Onlinemetals.com	MD Steel	A569/ASTM A1011	20	1	20	16.34	
20-0002	Base Plate	Onlinemetals.com	MD Steel	A569/ASTM A1011	30	1	30		
20-0003	Left/right side support	Onlinemetals.com	MD Steel	A569/ASTM A1011	25	1	25		
20-0004	L-Bracket	Onlinemetals.com	MD Steel	A569/ASTM A1011	30	1	30		
20-0005	Rod Support	Onlinemetals.com	MD Steel	A569/ASTM A1011	25	1	25		
20-0006	Shaft	Onlinemetals.com	MD Steel	A569/ASTM A1011	30	1	30		
20-0007	Left/Right side Plate	Onlinemetals.com	MD Steel	A569/ASTM A1011	20	1	20		
55-0001	AC Motor	Globaindustrial.com	Shaded Pole open motor	Unknown	80	1	80	16	
						Tot Est.$	260	16.34	Tot Act. $

6. SCHEDULE

A. 6-A:



DEFINE HOW THE STUDENTS SHOULD INDICATE STARTING EARLY/LATE AND FINISHING EARLY/LATE
X to indicate work

EXAMPLE SCHEDULE FOR SENIOR PROJECT:
NOTE: STUDENTS MUST MAKE THEIR OWN SCHEDULE!!!!!!!!!!!!!
PROJECT TITLE:___Mechanical Footstep power generator________________
Principal Investigator.:___Mohammed Aljohani___

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

TASK: ID	Description	Duration Est. (hrs)	Actua (hrs)	%Con
1)	Proposal*			
1a	Outline	1	1	
1b	Intro	1	1	
1c	Methods	2	2.5	
1d	Analysis	2	3	
1e	Discussion	2	2	
1f	Parts and Budget	2	2	
1g	Drawings	2	2	
1h	Schedule	2	2	
1i	Summary & Appx	2	2	
	subtotal:	16	17.5	
2)	Analyses			
2a	Load Trans=>Geo	2	2	
2b	Size Anal=>Geo	3	2.5	
2c	Top plate Anal=>Geo	1	1.5	
2d	Kinematic => Geo	2	2.5	
2e	Tolerance => Geo	2	2	
	subtotal:	10	10.5	
3)	Documentation			
3a	Part 1 (Top plate)	2	2	
3b	Part 2 (Rod Support)	3	3	
3d	Part 3 (L-Bracket)	2	2	
3e	Part 4 (Left/ Right Side Plate)	2	3	
3g	Part 5 (Left/Right Side Support)	2	3	
3h	Part 6 (Spring)	2	2	
3j	Part 7 (Base Plate)	1	1	
3k	Kinematic Check	2	2	
3l	ANSIY14.5 Compl	2	2	
3m	Make Object Files	2	2	
	subtotal:	20	22	

B. B-6:

C. IN FALL QUARTER:

During the fall term, working in proposal to write the project and trying to do the analysis for parts, and the excel sheet for budget & parts. Also, how the device will be built together. The most time will be working in analysis and Solid work drawing to make the device in good condition.

D. IN WINTER QUARTER:

- **Manufacturing issues:**

Designing a complete and efficient working structure required much time. it is because, all the items and materials for manufacturing this footstep power generator required accurate and precise measurement. Such measurement cannot be found in the hardware whops. Therefore, the materials purchased needed adjustments through cutting, welding and precise measurement. Getting enough time for doing all the measurement and other things was limited. Therefore, there was need to create more time for the project to ensure that the project met the deadline. This was very challenging considering that other coursework's were waiting for me.

- **Solution to the manufacturing issues:**

To ensure that have enough time to sacrificed some of my leisure time and directed them into the project. Also, teamwork was another method that worked very well. Sharing of task with my project mates reduced the workload. And reduced the time needed to complete the project. Lastly, making orders on time ensured that the working materials ware available on time.

So, going to build the project and order some parts to work on it and will be working in Machine shop in Hogue hall to cutting the parts and drilling. Also, using the lather machine.

- **Manufacturing issues, modifications and methods for resolving:**

Issues 1 - the main issue was to obtain a top plate that had similar measurement because most of the steel materials found in the market have different dimensions

Methods used in solving the issue – To solve the issue of un-proportionally, the measurements of the top plate were manually cut so that the cut plate conformed to the measurement that required for top plate hence making it easier to work with the device.

Issue 2- getting the exact measurement of the base plate that would work with the device.

Method of solving – the measurements of the base plates was keenly done and to ensure efficiency the base plate was bigger than the top plate.

Issue 3 – L bracket issues. The issue was obtaining the right material with the recommended tensile stress for L bracket. Obtaining actual measurements for the L bracket was also an issue.

Method of solving- cutting and arranging the L brackets manually. Accurate measurements before cutting was done to ensure efficiency.

E. IN SPRING QUARTER:

During the Spring term, testing the project.

- For the Schedule sheet will be in **Appendix E.**

F. 6-C:

- ***Allocate task dates:*** *the task date at January 15th, working on the device.*
- ***Sequence:*** *Starting to order whole parts at December 20, and then working to build the device at January 20. In addition, trying to get whole measurement exact to fit.*
- ***estimate duration:*** *The estimate hours duration is 24 hours per week, and will be done at March 20.*

G. 6-D:

- ***Estimate total project time***

Estimating the total Project time is 2 months.

MANUFACTURING SCHEDULE ISSUES AND SOLUTIONS TO THE ISSUES.

During the fall term worked on conducting the project research and documentation. it worked on the analysis for parts, developed a budget and made the solid work drawings for the device. During the winter term focused on building the device. This was rather time consuming and demanding as all the parts were required to be precise in quality and measurement for the device to work as intended. Among the challenges faced were that it was difficult to acquire the parts required in the necessary measurements. Therefore, it had to cut and weld the acquired parts to the required specifications. This was the case with the top and bottom plates as well as the L bracket which had to manually cut and weld to meet our specifications. The Spring term was for conducting tests on the already built device.

7. PROJECT MANAGEMENT

In order to ensure that the project is cost effective, all calculations in terms of sizes, and the number of every material were calculated. In addition, the labor cost was calculated in terms of hours of working to minimize it cost and the number of working hours. The budget for completion of the whole project is $300. The project will be completed in parts and every part was done on different day and at a different cost. This strategy minimized cost pressure and also increased the accuracy and efficiency of working on the project.

The project was stated early October to ensure that there was enough time to work on every part of the system. Each part of the project was allocated an average completion time of about two hours. Starting to work on the project prevents working on the project on a rush which would bring inaccuracies and hence faulty of the generation system. The system is very sensitive in regard of functioning. Any fault in the system leads to nonperformance or poor performance.

A. HUMAN RESOURCE

With the help of the project to ask the advisor and staffs from mechanical engineering departments, were able to get more information related to the project.

B. PHYSICAL RESOURCE

Engineering books and lecture notes were very important. In addition, the challenges that people are facing in the towns was another factor that facilitated coming up with the idea of cost constructing an effective power generation system.

C. SOFT RESOURCES

Information from the internet and previous works related to green energy production and other methods of generating electricity was a major source of knowledge while coming up with this project.

D. FINANCIAL RESOURCE

Through cost sharing with the project mate, it managed to raise the $300 for the project. The cost will be shared equally to ensure that everybody has an equal contribution on the project.

8. DISCUSSION

A. DESIGN EVOLUTION

The previous methods of power generation require a lot of capital to set a stable and reliable power generation system. In addition, some of the methods have various negative effects on environment such as air pollution, noise pollution among others. For this reason, coming up with a system that is ecosystem friendly was a nice idea. Therefore, the thoughts of coming up with the best power generation system that is silent, cost efficient, ecofriendly and reliable led to evolution of Mechanical Footsteps Power Generator that meets all the above requirements

- ***Design manufacturing issues for Top plate:***

The top plate is the uppermost portion where the feet rest when people are walking. The main purpose is sustaining the weight of people walking through the generator. Getting a plate with similar measurement was a problem as most of the steel materials are available in market with different dimensions.

- *Methods used in solving the manufacturing issues:*

The plate measurement was cut manually to ensure that the plate measurement conformed to the construction measurement set. The material was cut at a length of 90 cm by 30 cm. Steel material available have measurements greater than this. Manual cut solved this problem.

- ***Design manufacturing issues for Base Plate:***

Getting the exact and correct measure of the base plate was a challenge. Another challenge was getting the exact measure of the base plate which would work with the device. It is because making the base plate big can change the volume.

- *Methods used in solving the manufacturing issues:*

Keen measurement was done before cutting the base plate. The base plate length was cut in a way that was bigger than the top plate to ensure that its efficiency is high. Also, to avoid manufacturing problems, the base plate materials were ordered on time. This ensured that measuring of the material was done on time with no hurry.

- ***Design manufacturing issues for L bracket:***

Getting the right material which has correct tensile stress was a problem. In addition, the material available has measurement that is different from the actual measurement of the L bracket designed for the project.

- *Methods used in solving the manufacturing issues:*

Manual cut and arrangement of the L bracket was done. The material was also ordered on time to facilitate its availability on time. To ensure that the L bracket was compatible with the rod support, the construction measurement was done before making any cutting and fixture.

Testing the device included visual verification of the required items for assembly. Measurement of the parts was also done to ensure they met the dimensional requirements for the device to maintain structural and operational integrity and efficiency. The performance of the device also was tested to determine its responsiveness to various amounts of weight applied under various environmental conditions. Tests were also conducted to determine the ease of usability of the device by users fitting various demographics. This was also followed by security tests to determine any kind of risk that could arise from using the device both during use and after use.

The tests led to discovery of issues such as inaccurate dimensions of some parts such as the top and bottom plates which were manually cut to achieve the required dimensions. Along the testing some issues that were a challenge included accounting and determining the minimum amount of force that could trigger the generator to produce power. Another challenge was in finding the spring with the right spring constant to achieve the right return displacement. The final challenge was in determining the right gear combination to allow efficient transfer of energy applied with minimum loss.

It is able to eventually develop a risk-free and ecofriendly mechanical footstep power generator in spite of the faced challenges. The device over the long term was also established to be a cost-effective method of electrical power generation.

B. PROJECT RISK ANALYSIS

The system is risk free. Nonperformance or faulty of the system does not have any risk. The effect of faulty on the system is only failure to generate power. The system is environmentally friendly and safe to use. The system is dependent on human movement. Therefore, the system depends on human movement which is renewable and implies that the system is only limited to work only on places with significant movement of people. Therefore, there are areas where the system can be installed. Lack of movement implies no power generation. Therefore, depending on this system only is risky due to irregular production. For instance, when the system is installed in school, the system will only be functional during school days. During holidays, the possibility of getting power from the insignificant.

For security purposes during the construction of the system the following protective gadgets will be necessary: gloves, Dust mask, eye protection, the welding mask, footwear, hearing protection and protective cloths.

C. SUCCESS

To ensure that the purchase of the construction material is ready, different calculations were necessary. For instance, finding the spring constant; these will determine the type of spring that need to be purchased, the material tensile stress and strain also needed to be calculated. Such calculation facilitated determination of the type of materials that are best for the system. So far, all calculations have been done and materials required with every material specification identified.

D. PROJECT DOCUMENTATION

Also, the system architecture has also been concluded. This system facilitates step by step construction of the system. The system architecture will ensure every detail of every part of the system is taken care of without skipping any procedure. To ensure that the project is successful everyone has a task to do. In addition, shared the cost of the project.

The challenges faced so far while working on the project is lack of the best materials to use. However, through intensified research and calculations and got the best materials. Getting the shop to buy the materials was an issue. Thanks to the online platforms. The materials are available on the online shops.

E. NEXT PHASE

Assembling of the system is the next phase of the project. Once the system is assembled, the performance of the system will be determined

9. CONCLUSION

Mechanical Footsteps Power Generator is a risk-free electricity generation system. Much of the energy that is wasted when people are moving is well utilized and transformed to electrical energy which can be used in schools and other institutions. This method of power generation is cost effective when used continually. Basically, the cost efficiency is realized in the long term. This method of power generation can be installed in areas such as malls, schools, colleges, at the railway stations or any other areas where people movement is intensive.

The production of electricity using this method is environmental conservative because power is produces without polluting the environment. Also, the power that is wasted by human while working is utilized by this system to produce electricity. Therefore, the system ensures maximum utilization of available energy. The energy source is renewable and is available continuously. Therefore, the method is very convenient than other methods of power generation. The power generated by this system can be used in the rural areas. The method is also very ecofriendly; the production does not require fueling, that produce smoke and other pollutants. The tests that have been done so far have confirmed that the system is best because being provides affordable energy solution to people.

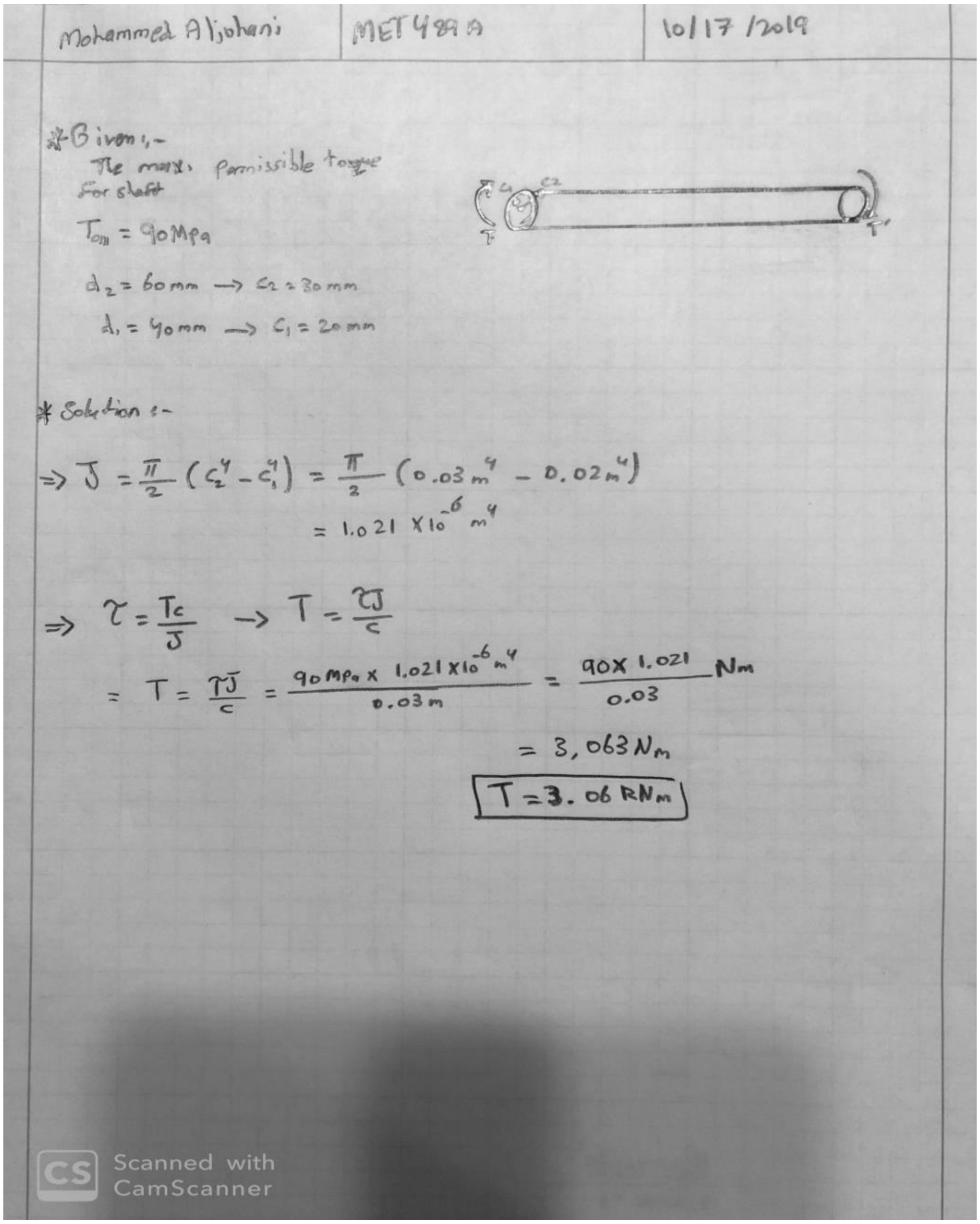
Although the method seems advantageous in most aspects, the amount of power that can be generated by this system may not be used in places where mass electricity is needed. The system is constructed to generate 6kw/h. Therefore, the system can only generate power for lighting and powering simple electricity gadgets. However, more improvement can be done to increase its production such as coming up with a method of stepping up the generated power.

10. ACKNOLEDGEMENTS

This project could not be completed without the support of the faculty and other advisers to this project. A large thanks goes to professor Charles Pringle, Dr. John Choi, and Dr. Craig Johnson for rendering some assistance with the project and taking his time to help with all the questions that were had up to this point. While this is a mostly group project the collaboration between other partners are an important part of the development process.

11. APPENDIX A – ANALYSES

A1: THE MAXIMUM PERMISSIBLE TORQUE FOR THE SHAFT WITH KNOWN DIMINUTION:



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*Given:-

The max. Permissible torque For shaft

$T_{all} = 90 MPa$

$d_2 = 60 mm \longrightarrow c_2 = 30 mm$

$d_1 = 40 mm \longrightarrow c_1 = 20 mm$

* Solution :-

$$\Rightarrow J = \frac{\pi}{2}(c_2^4 - c_1^4) = \frac{\pi}{2}(0.03 m^4 - 0.02 m^4)$$

$$= 1.021 \times 10^{-6} m^4$$

$$\Rightarrow \tau = \frac{Tc}{J} \rightarrow T = \frac{\tau J}{c}$$

$$= T = \frac{\tau J}{c} = \frac{90 MPa \times 1.021 \times 10^{-6} m^4}{0.03 m} = \frac{90 \times 1.021}{0.03} Nm$$

$$= 3,063 N_m$$

$$\boxed{T = 3.06 kN_m}$$

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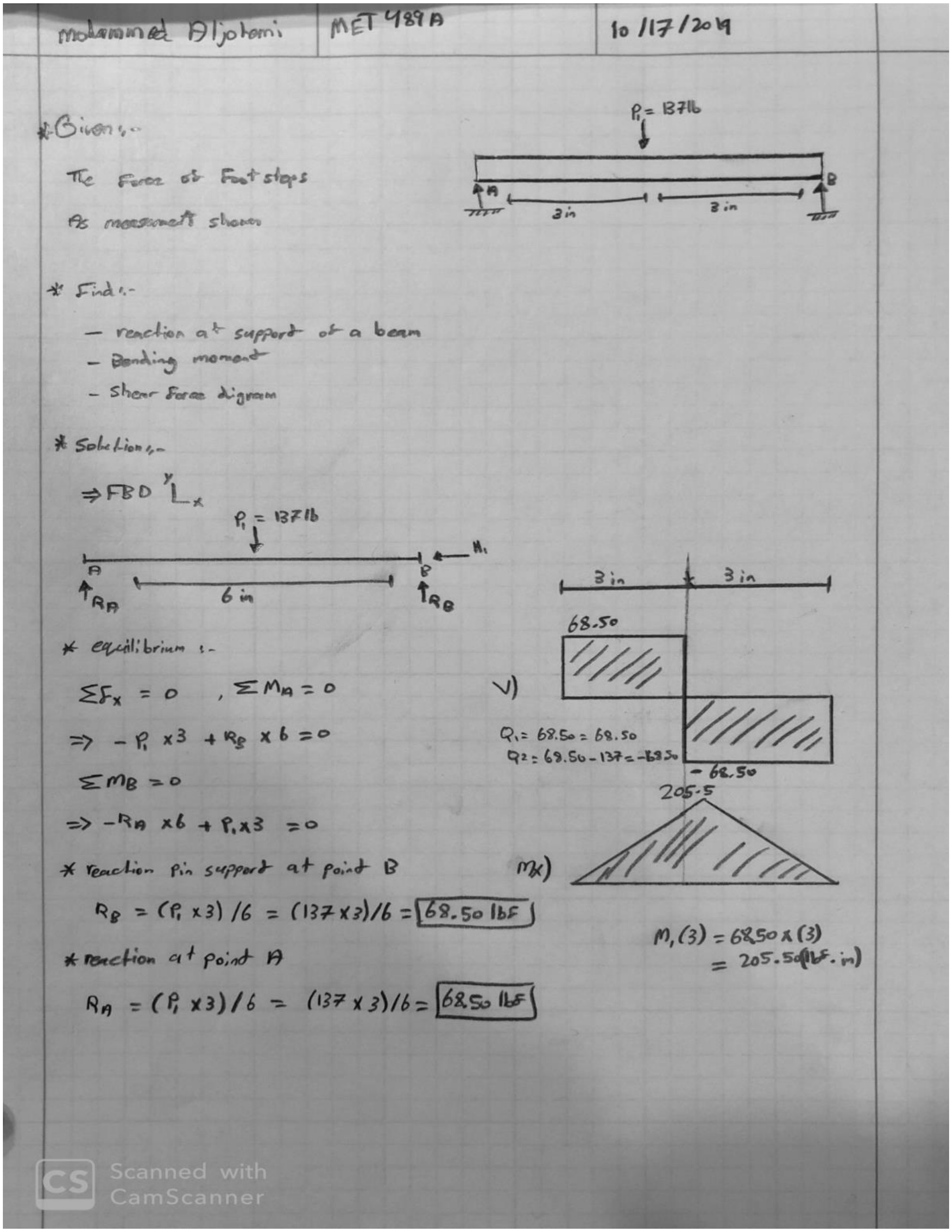
A2: ONE FORCE ON THE BEAM:



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*Given:-

The Force of Foot steps

As measurement shown

* Find:-

- reaction at support of a beam
- Bending moment
- Shear force digram

* Solution:-

⇒ FBD $^{y}L_{x}$

* equilibrium :-

$\Sigma F_x = 0 \quad , \Sigma M_A = 0$

$\Rightarrow -P_1 \times 3 + R_B \times 6 = 0$

$\Sigma M_B = 0$

$\Rightarrow -R_A \times 6 + P_1 \times 3 = 0$

* reaction pin support at point B

$R_B = (P_1 \times 3)/6 = (137 \times 3)/6 = \boxed{68.50 \text{ lbF}}$

* reaction at point A

$R_A = (P_1 \times 3)/6 = (137 \times 3)/6 = \boxed{68.50 \text{ lbF}}$

$Q_1 = 68.50 = 68.50$

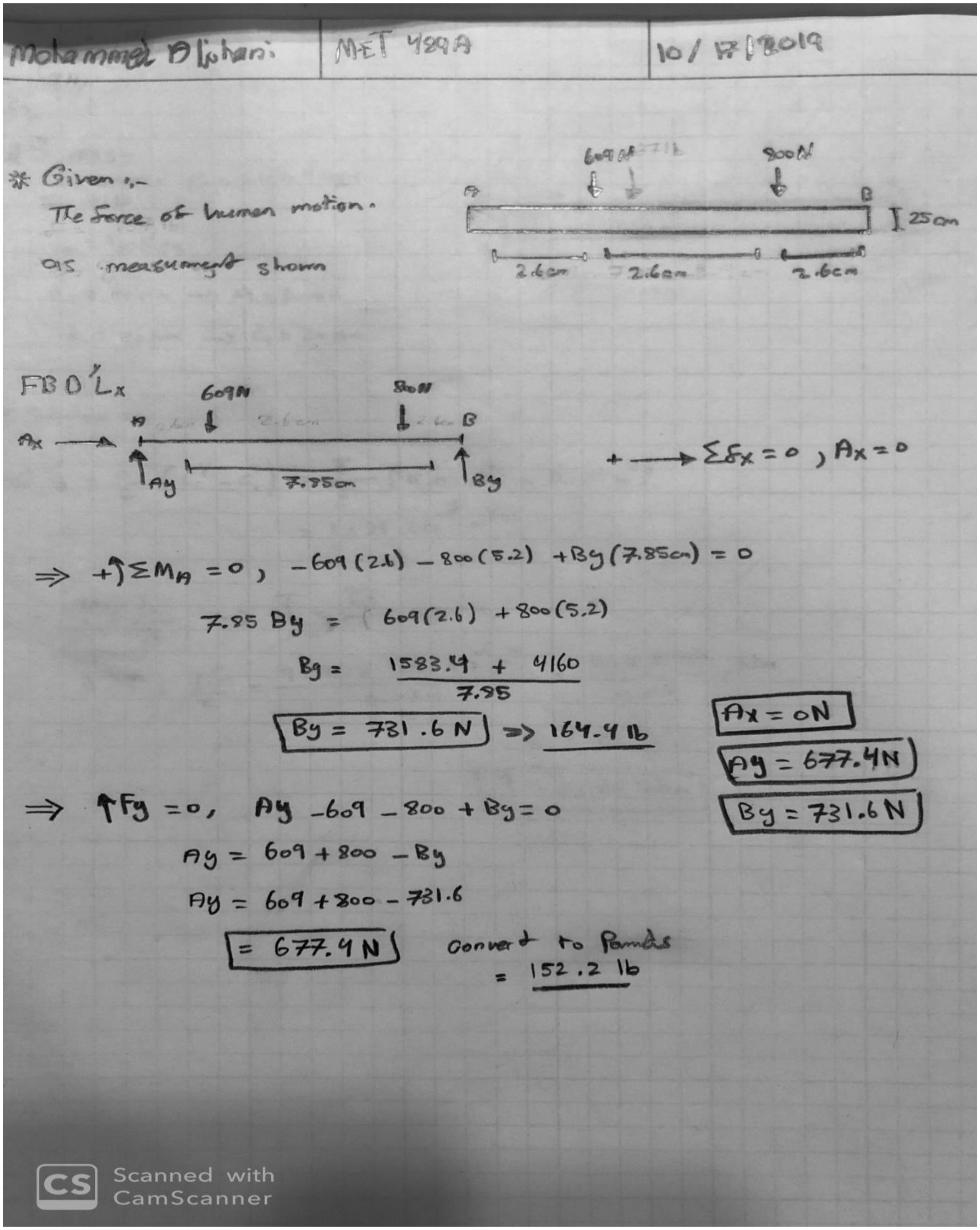
$Q_2 = 68.50 - 137 = -68.50$

$M_1(3) = 68.50 \times (3)$

$= 205.50 (\text{lbF} \cdot \text{in})$

Scanned with CamScanner

<u>A3:</u> TWO FORCES ON THE BEAM:



Mohammed Aljohani | MET 429A | 10/17/2019

* Given :-

The force of human motion.

as measurement shown

FBD $^y L_x$

$+\longrightarrow \Sigma F_x = 0$, $A_x = 0$

$\Rightarrow +\circlearrowleft \Sigma M_A = 0$, $-609(2.6) - 800(5.2) + B_y(7.85\text{cm}) = 0$

$7.85 B_y = 609(2.6) + 800(5.2)$

$B_y = \dfrac{1583.4 + 4160}{7.85}$

$\boxed{B_y = 731.6\text{ N}} \Rightarrow \underline{164.4\text{ lb}}$

$\Rightarrow \uparrow F_y = 0$, $A_y - 609 - 800 + B_y = 0$

$A_y = 609 + 800 - B_y$

$A_y = 609 + 800 - 731.6$

$\boxed{= 677.4\text{ N}}$ convert to Pounds $= \underline{152.2\text{ lb}}$

$\boxed{A_x = 0\text{N}}$

$\boxed{A_y = 677.4\text{N}}$

$\boxed{B_y = 731.6\text{N}}$

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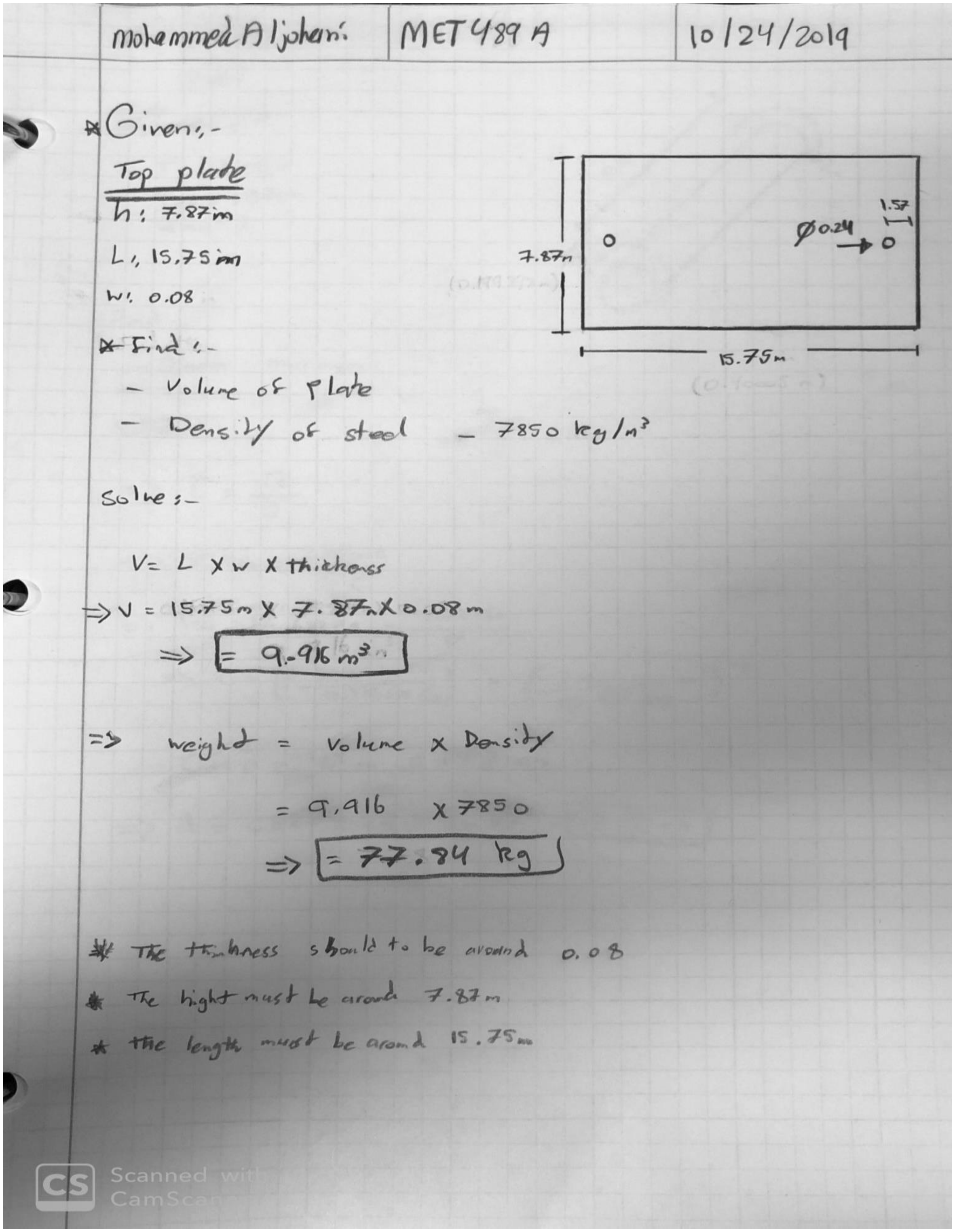
A4: THE WEIGHT OF TOP PLATE:



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★ Given:-

Top plate

h: 7.87 m

L: 15.75 m

w: 0.08

★ Find:-

- Volume of plate
- Density of steel — 7850 kg/m³

Solve:-

V= L X w X thickness

⇒ V = 15.75 m X 7.87 m X 0.08 m

⇒ $\boxed{= 9.916\ m^3}$

⇒ weight = volume x Density

= 9.916 x 7850

⇒ $\boxed{= 77.84\ kg}$

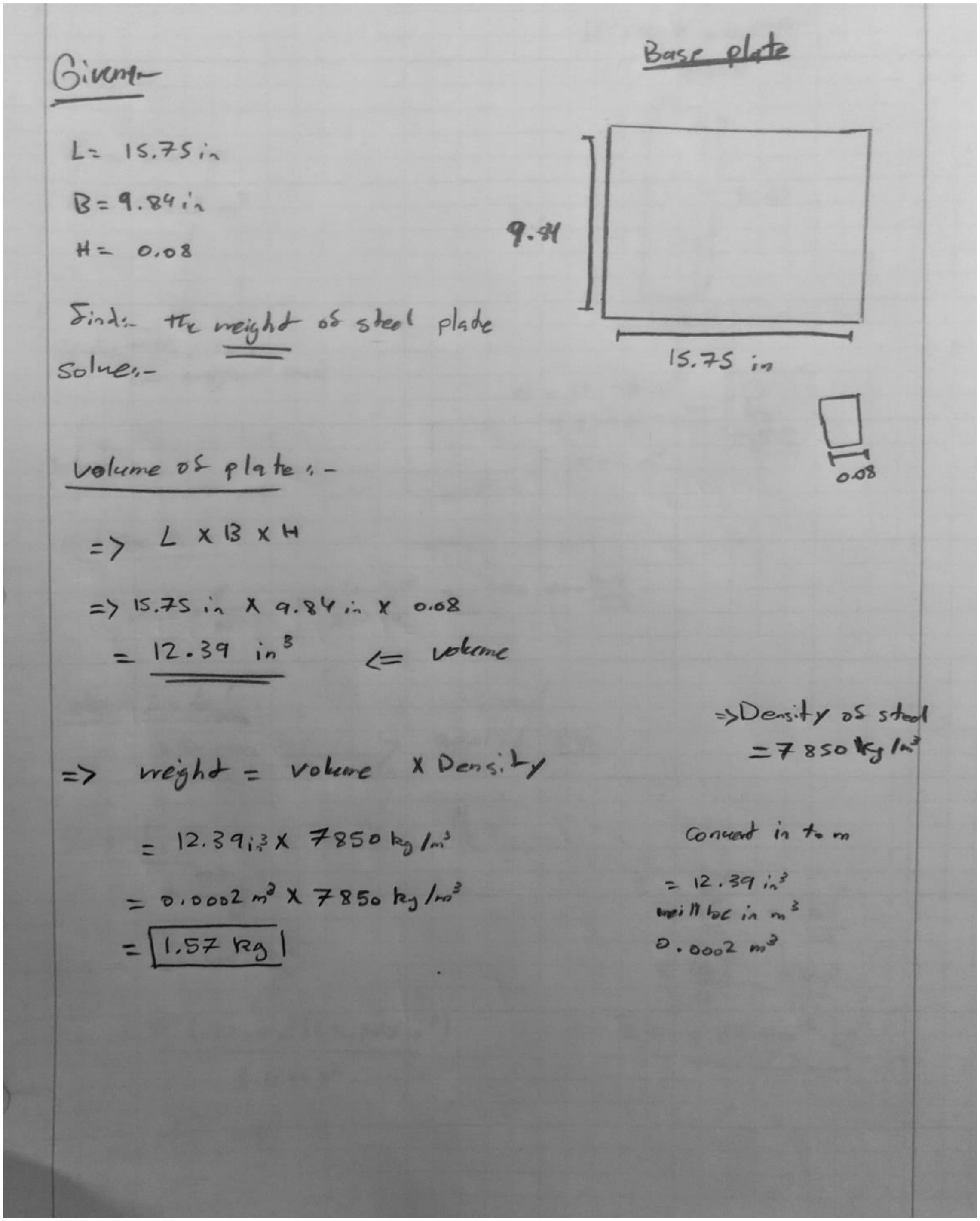
★ The thickness should to be around 0.08

★ The hight must be around 7.87 m

★ the length must be around 15.75 m

CS Scanned with CamScanner

A5: THE WEIGHT OF BASE PLATE:



Given:-

L= 15.75 in

B= 9.84 in

H= 0.08

Find:- the weight of steel plate

solve:-

Volume of plate:-

$\Rightarrow$ L x B x H

$\Rightarrow$ 15.75 in x 9.84 in x 0.08

$= \underline{12.39\ in^3}$ $\Leftarrow$ volume

$\Rightarrow$ Density of steel

$= 7850\ kg/m^3$

$\Rightarrow$ weight = volume x Density

$= 12.39\ in^3 \times 7850\ kg/m^3$

$= 0.0002\ m^3 \times 7850\ kg/m^3$

$= \boxed{1.57\ kg}$

Convert in to m

$= 12.39\ in^3$

will be in m^3

$0.0002\ m^3$

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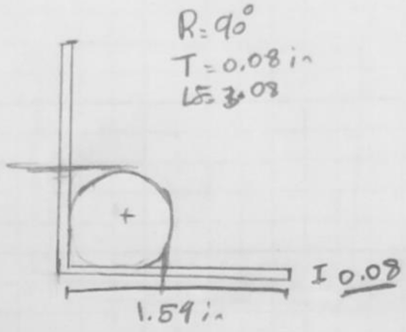
Given:-

Bend Allowance for 90° angles

for L-Bracket

=> metal slots

= material => steel



Solve:-

=> the neutral axis would be from the circle with a radius

$\Rightarrow \underline{BR + \frac{1}{2} MT} \Rightarrow 3.08 + \frac{1}{2} 0.08 = \boxed{3.12 \text{ in}}$

=> the circumference is $\underline{2\pi(BR + \frac{1}{2} MT)}$ for the whole circle.

$\Rightarrow 2\pi\left(3.08 + \frac{1}{2}(0.08)\right) = \boxed{19.60 \text{ in}}$

=> If we need only $\frac{1}{4}$ of the circle

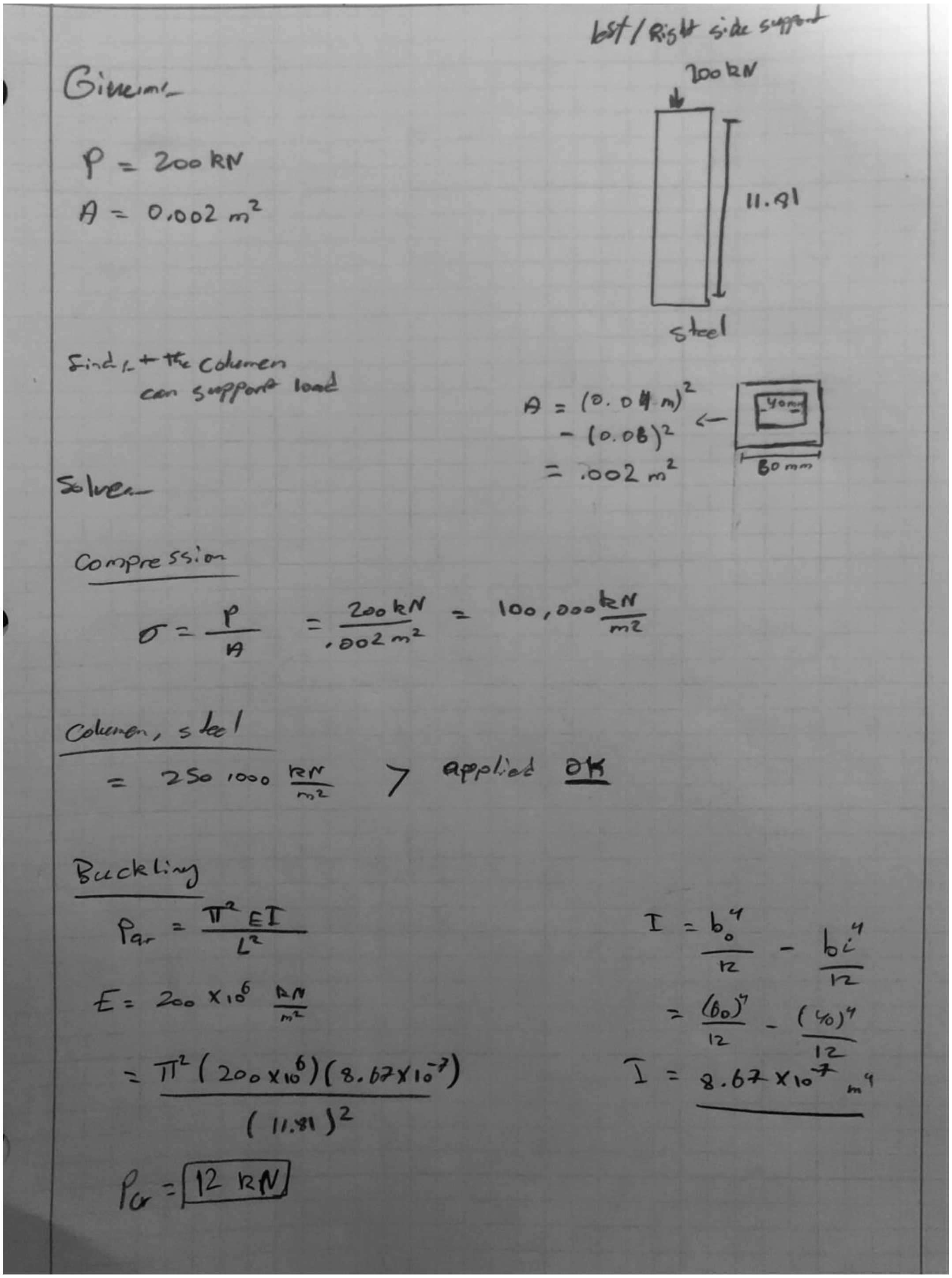
$\frac{2\pi}{4}\left(BR + \frac{1}{2} MT\right)$

$\Rightarrow \frac{2\pi}{4}\left(3.08 + \frac{1}{2}(0.08)\right) = \boxed{4.90 \text{ in}}$

=> Simplifies to => $BA = BR + MT$

$BA = 3.08 + 0.08 = \boxed{3.16 \text{ in}}$

Scanned with CamScanner



Given:

$P = 200\ kN$

$A = 0.002\ m^2$

Find if the column can support load

$A = (0.04\ m)^2 - (0.08)^2 = .002\ m^2$

Solve:

Compression

$\sigma = \frac{P}{A} = \frac{200\ kN}{.002\ m^2} = 100{,}000 \frac{kN}{m^2}$

Column, steel

$= 250{,}000 \frac{kN}{m^2} > \text{applied}$ OK

Buckling

$P_{cr} = \frac{\pi^2 EI}{L^2}$

$E = 200 \times 10^6 \frac{kN}{m^2}$

$= \frac{\pi^2 (200 \times 10^6)(8.67 \times 10^{-7})}{(11.81)^2}$

$P_{cr} = \boxed{12\ kN}$

$I = \frac{b_o^4}{12} - \frac{b_i^4}{12}$

$= \frac{(80)^4}{12} - \frac{(40)^4}{12}$

$I = 8.67 \times 10^{-7}\ m^4$

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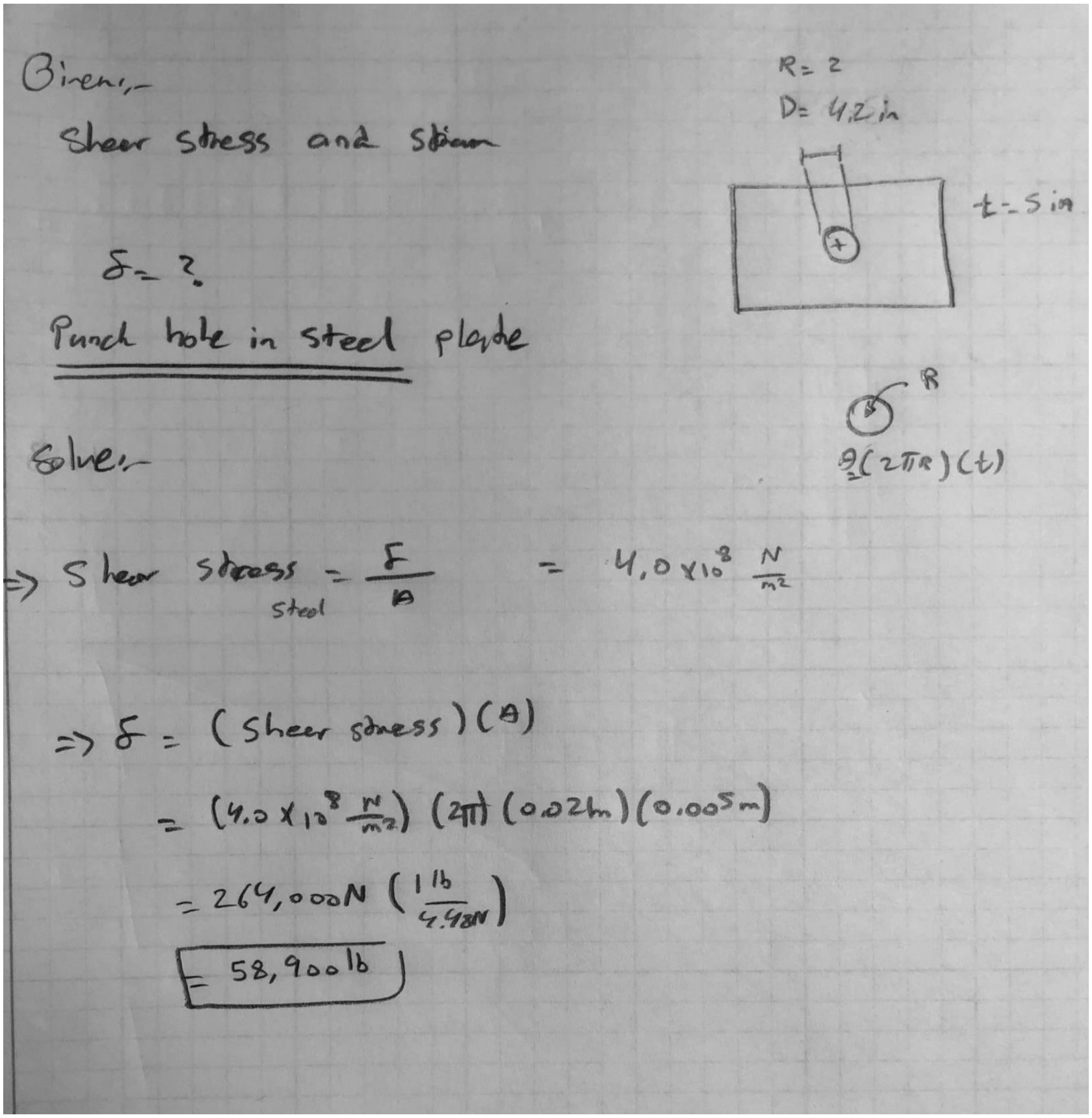
A8: SHEAR STRESS AND STRAIN FOR PUNCH HOLE TO TOP PLATE AND BASE PLATE



Given,-

Shear stress and strain

$F = ?$

Punch hole in steel plate

$R = 2$

$D = 4.2$ in

$t = .5$ in

R

$A = (2\pi R)(t)$

Solve,-

$$\Rightarrow \text{Shear stress}_{\text{steel}} = \frac{F}{A} = 4{,}0 \times 10^8 \frac{N}{m^2}$$

$$\Rightarrow F = (\text{Shear stress})(A)$$

$$= \left(4.0 \times 10^8 \frac{N}{m^2}\right)(2\pi)(0.02m)(0.005m)$$

$$= 264{,}000N \left(\frac{1 \text{ lb}}{4.48N}\right)$$

$$\boxed{= 58{,}900 \text{ lb}}$$

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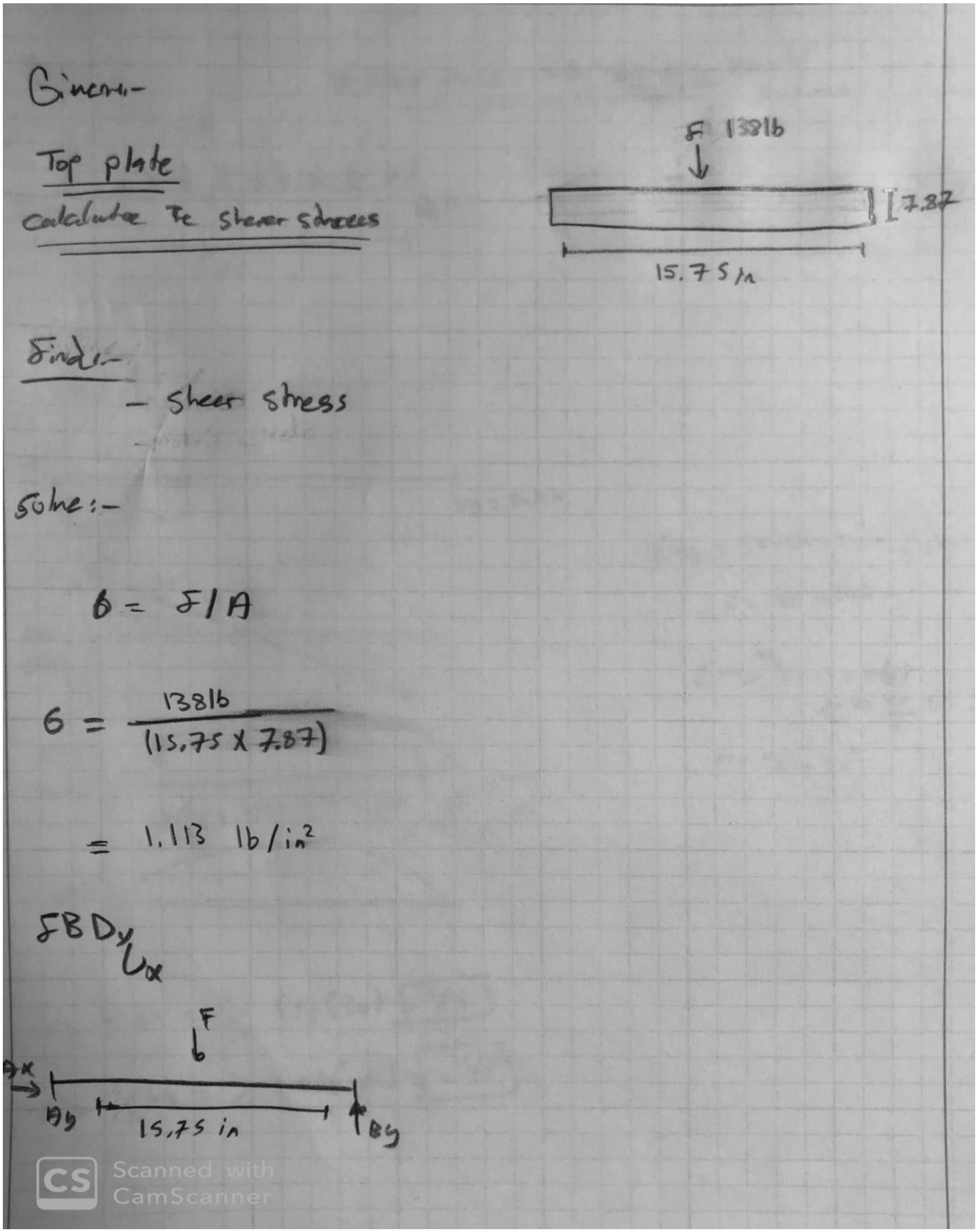
A9: SHEAR STRESS



Given:-

Top plate

Calculate the sheer stress

Find:-

– sheer stress

Solve:-

$$\sigma = F/A$$

$$\sigma = \frac{138lb}{(15.75 \times 7.87)}$$

$$= 1.113 \ lb/in^2$$

FBD:-

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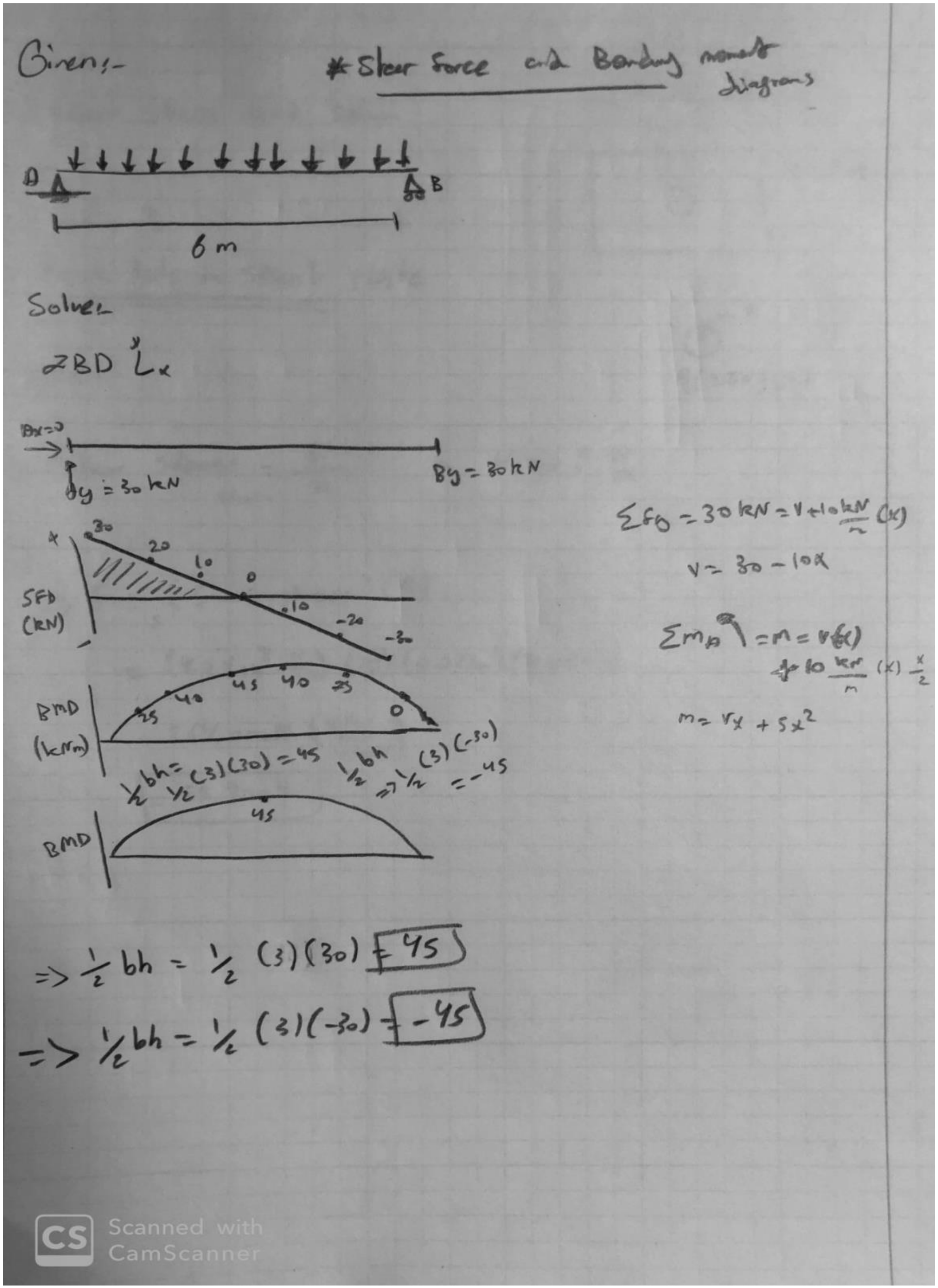
A10: SHEAR FORCE AND BENDING MOMENT DIAGRAM.(TOP PLATE)



Given:-

* Shear force and Bending moment diagrams

Solve:-

FBD

$\Sigma F_y = 30\text{ kN} = V + 10\frac{\text{kN}}{m}(x)$

$V = 30 - 10x$

$\Sigma M_A \circlearrowleft = M = V(x) + 10\frac{\text{kN}}{m}(x)\frac{x}{2}$

$M = Vx + 5x^2$

$\frac{1}{2}bh = \frac{1}{2}(3)(30) = 45$

$\frac{1}{2}bh \Rightarrow \frac{1}{2}(3)(-30) = -45$

$\Rightarrow \frac{1}{2}bh = \frac{1}{2}(3)(30) = \boxed{45}$

$\Rightarrow \frac{1}{2}bh = \frac{1}{2}(3)(-30) = \boxed{-45}$

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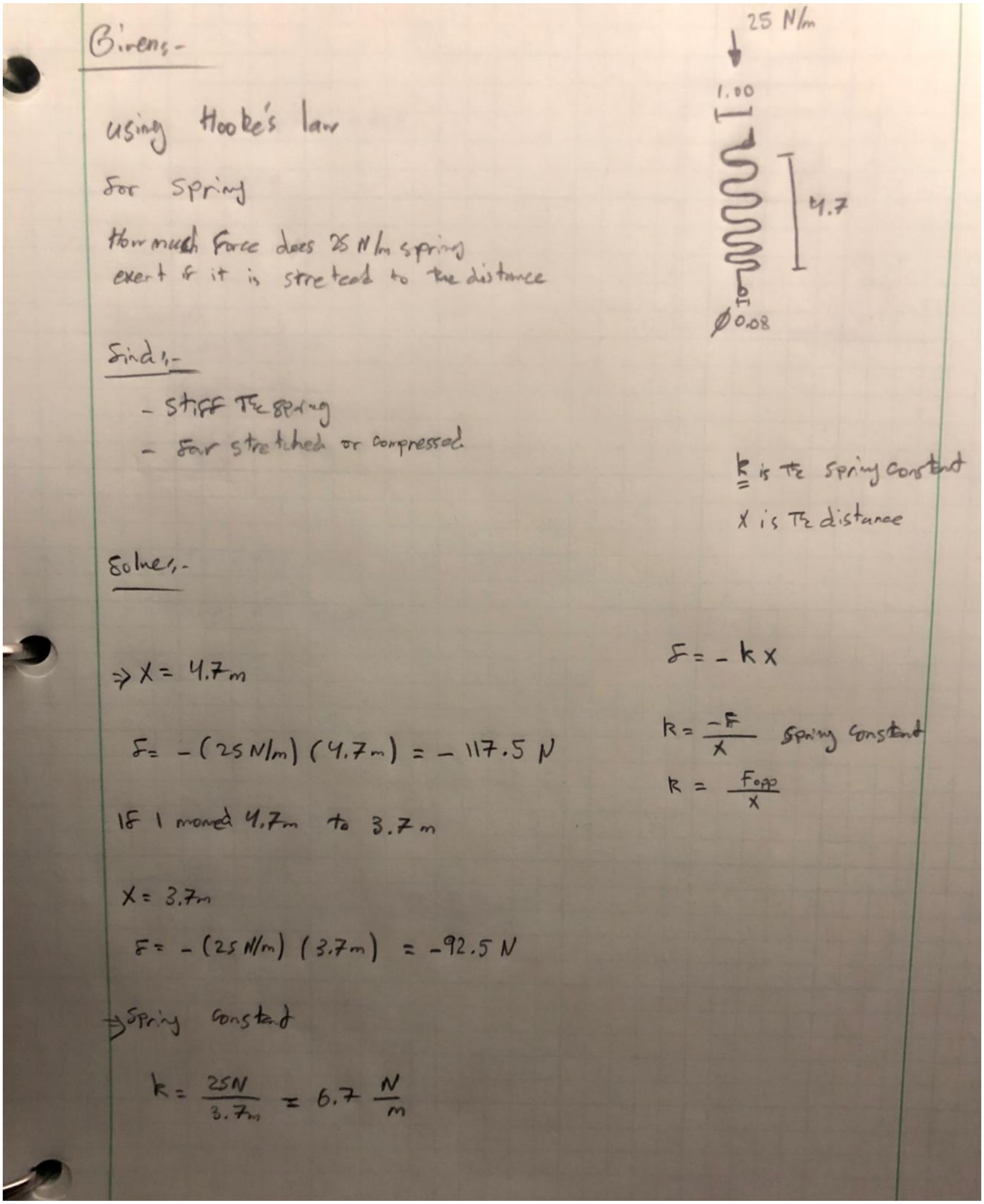
A11: SPRING CONSTANT AND COMPRESSED



Givens:-

using Hooke's law

for spring

How much force does 25 N/m spring exert if it is stretched to the distance

25 N/m

1.00

4.7

Ø0.08

Finds:-

- stiff the spring
- far stretched or compressed

k is the spring constant

x is the distance

Solves:-

$F = -kx$

$k = \frac{-F}{x}$ spring constant

$k = \frac{F_{opp}}{x}$

⇒ $X = 4.7m$

$F = -(25\,N/m)(4.7m) = -117.5\,N$

IF I moved 4.7m to 3.7m

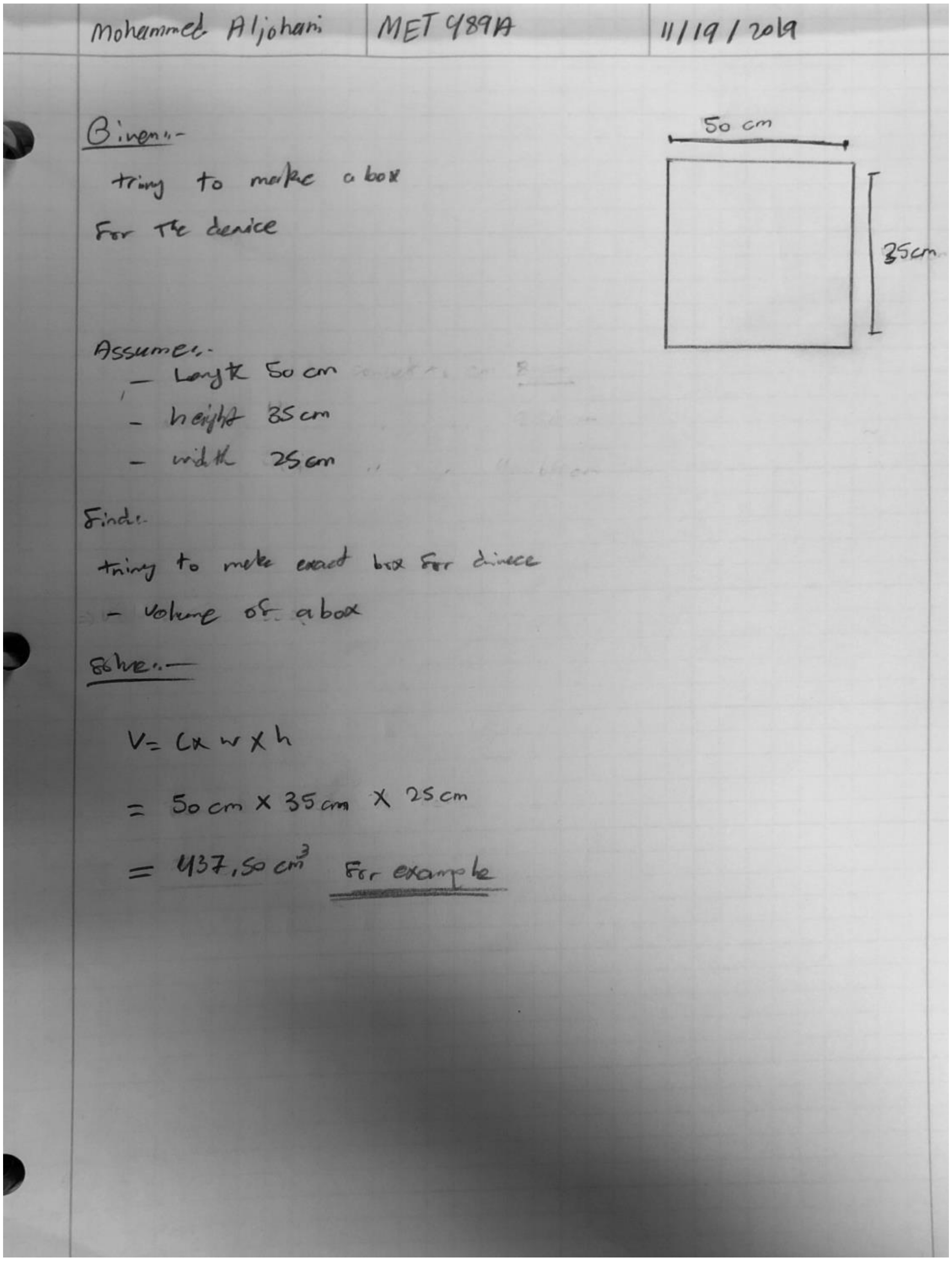
$X = 3.7m$

$F = -(25\,N/m)(3.7m) = -92.5\,N$

⇒ Spring constant

$k = \frac{25N}{3.7m} = 6.7\,\frac{N}{m}$

A12: VOLUME OF A BOX FOR THE DEVICE.



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Given:-

tring to make a box
For The device

50 cm

35cm

Assume:-

- Length 50 cm
- height 35 cm
- width 25cm

Find:-

tring to make exact box For divece

- volume of a box

Solve:—

$$V = L \times w \times h$$

$$= 50\,cm \times 35\,cm \times 25\,cm$$

$$= 437{,}50\,cm^3$$

For example

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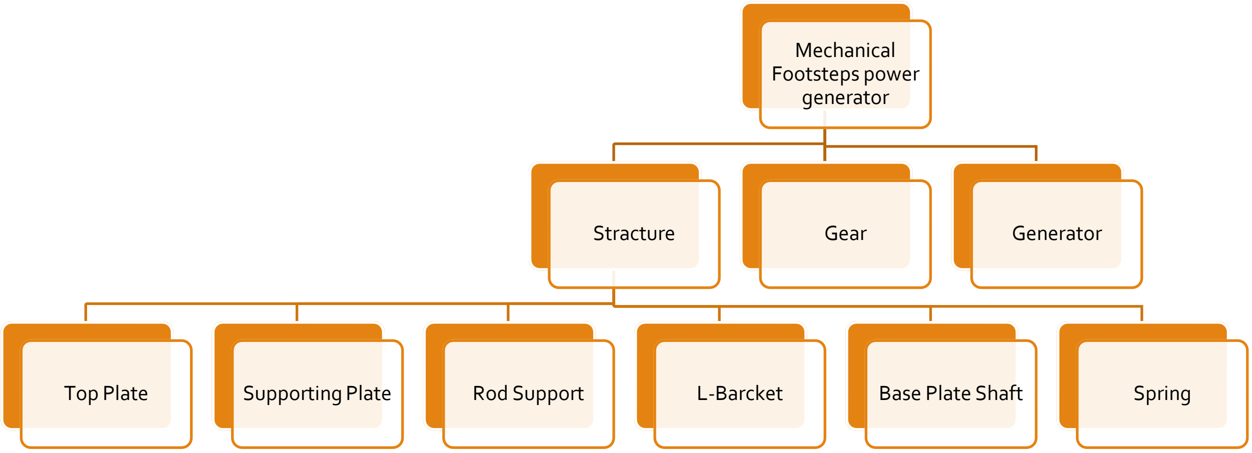
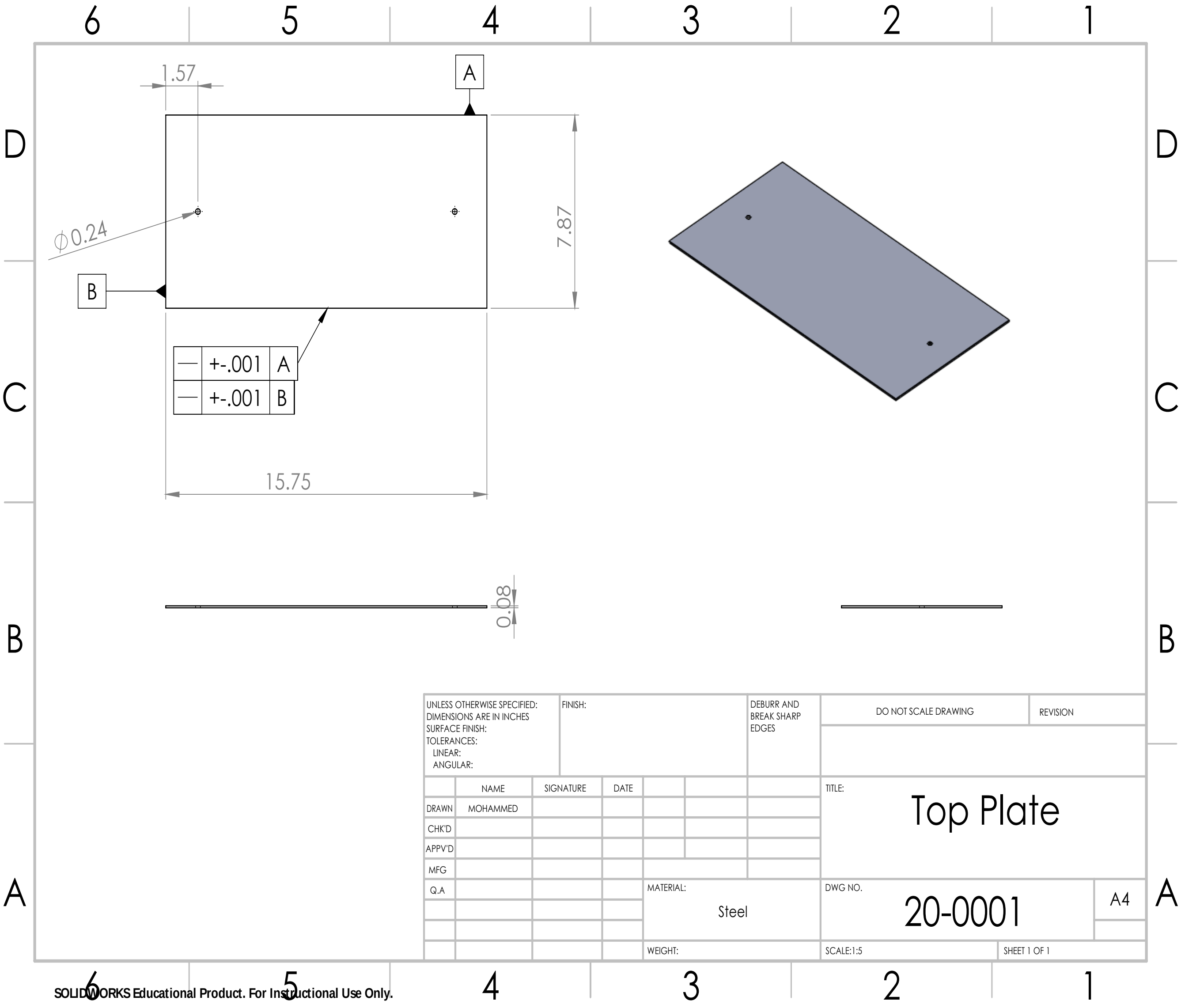
12. APPENDIX B

B1: (DRAWING TREE)



B2: (TOP PLATE)



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	MOHAMMED		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE: Top Plate

MATERIAL: Steel

DWG NO. 20-0001

A4

WEIGHT:

SCALE:1:5

SHEET 1 OF 1

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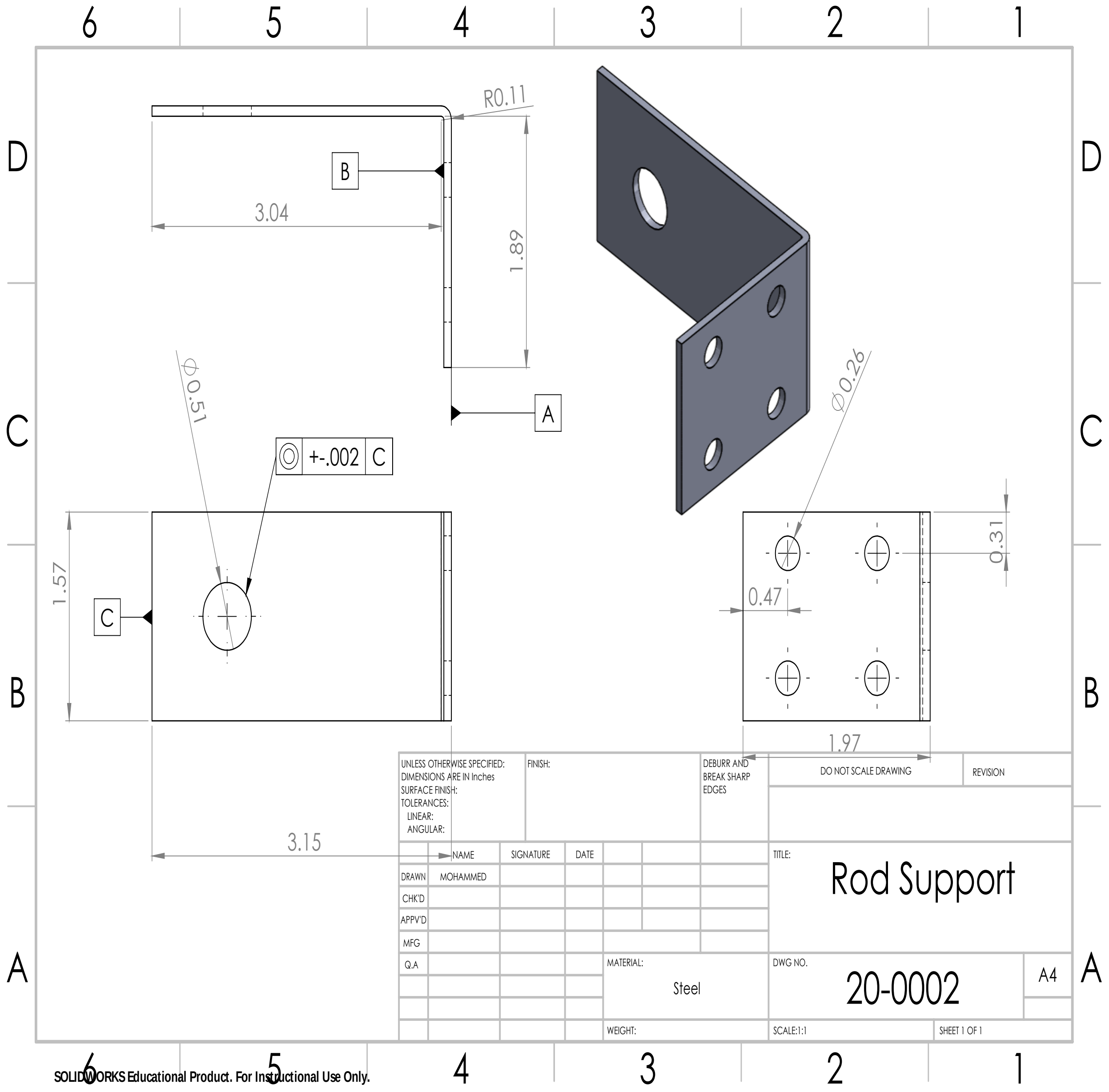
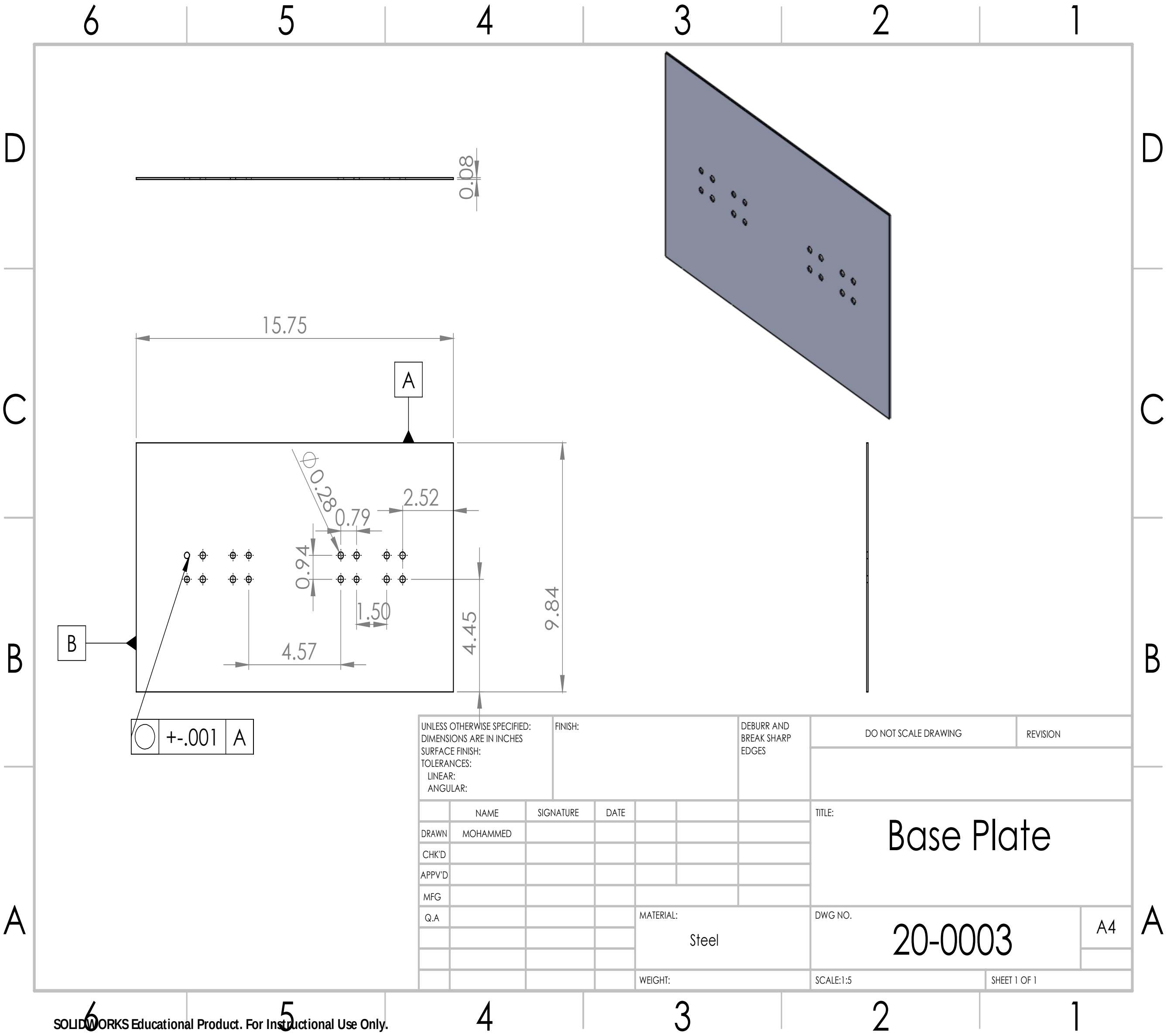
B3: (ROD SUPPORT)



B4: (BASE PLATE)



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	MOHAMMED		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE: Base Plate

MATERIAL: Steel

DWG NO. 20-0003

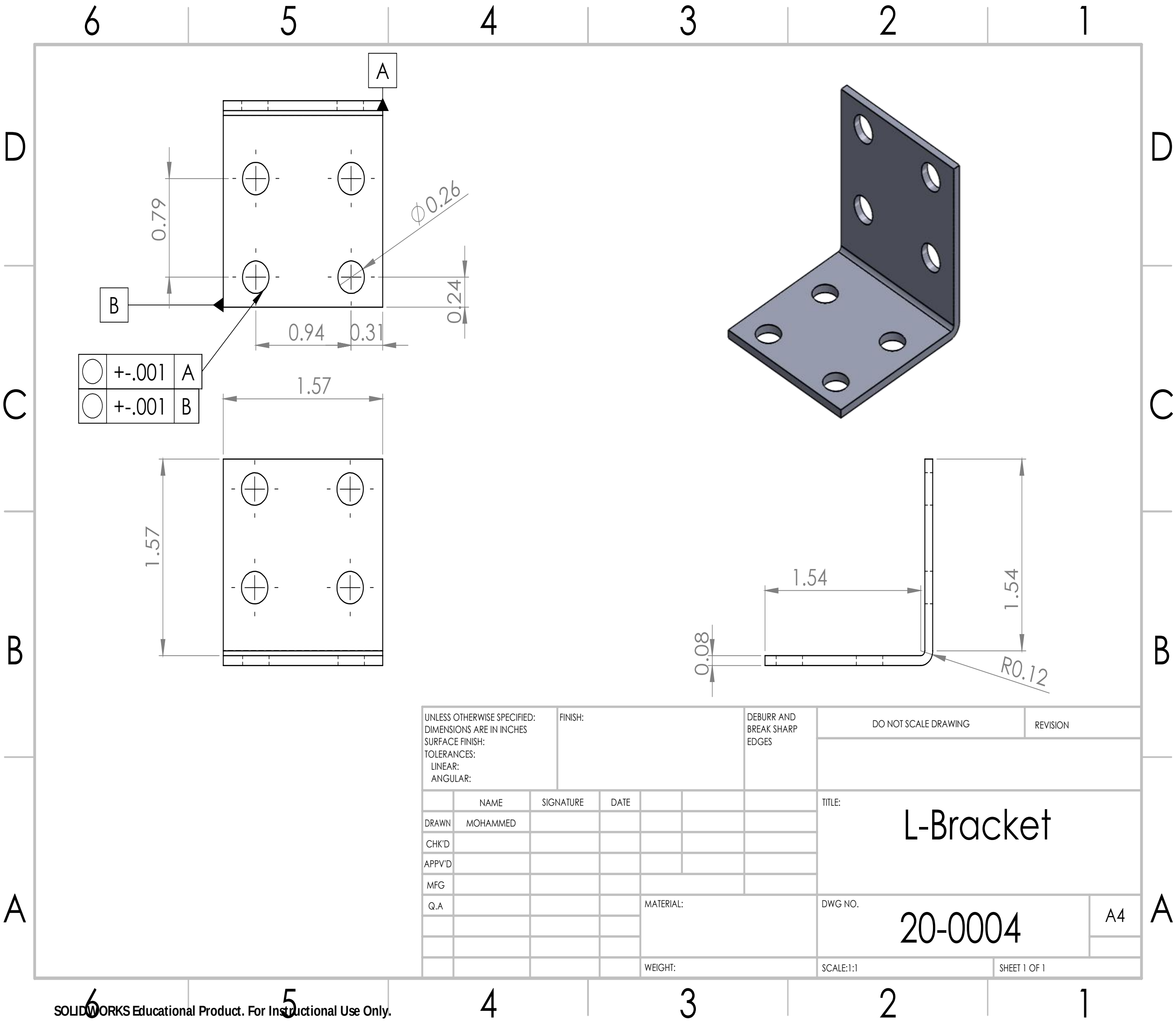
A4

WEIGHT:

SCALE:1:5

SHEET 1 OF 1

B5: (L-BRACKET)



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	MOHAMMED		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE: L-Bracket

MATERIAL:

DWG NO. 20-0004

A4

WEIGHT:

SCALE:1:1

SHEET 1 OF 1

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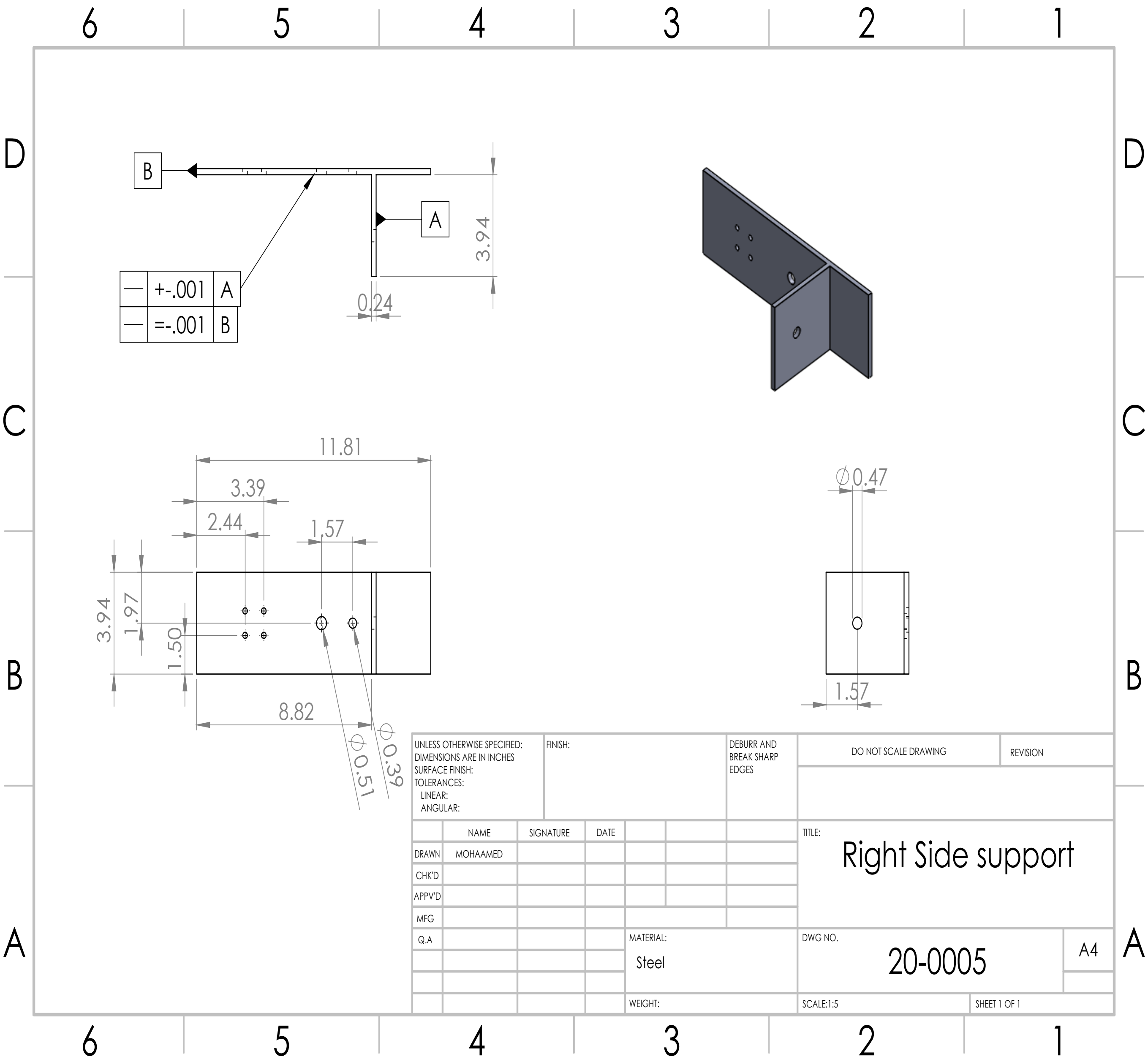
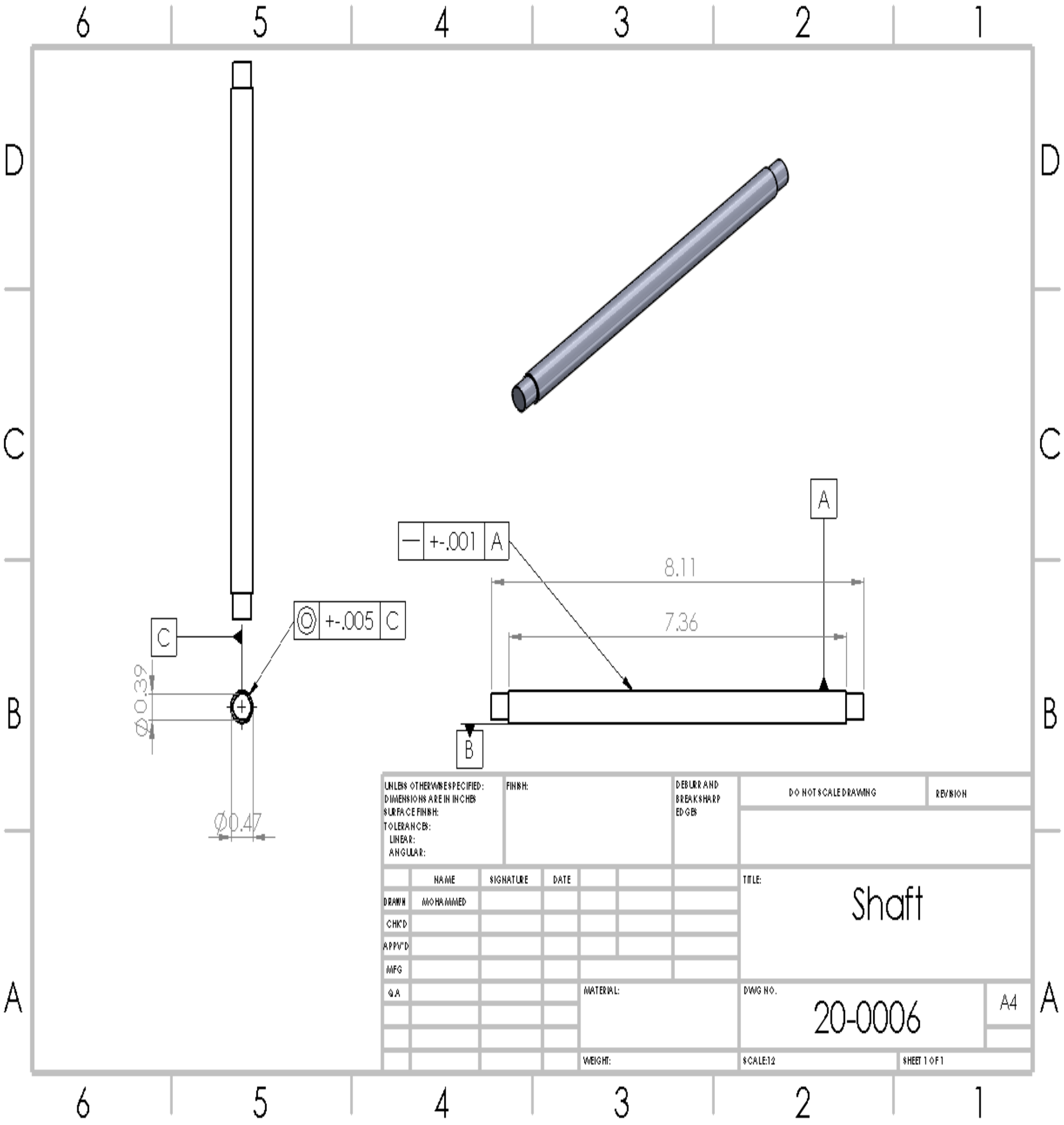
B6: (RIGHT/ LEFT SIDE SUPPORT)



B7: (SHAFT)



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	MOHAMMED		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE: Shaft

MATERIAL:

DWG NO. 20-0006

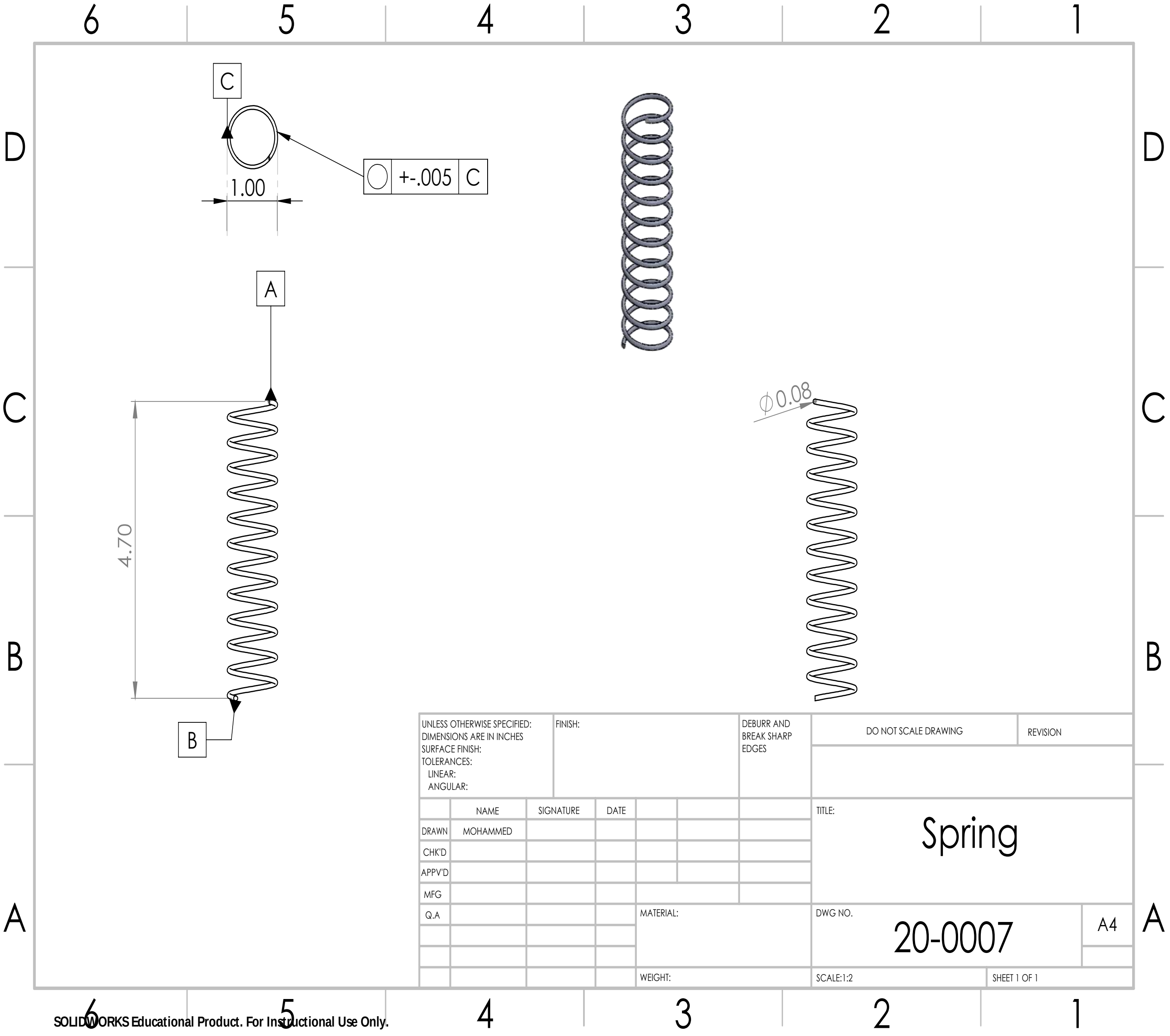
A4

WEIGHT:

SCALE:1:2

SHEET 1 OF 1

B8: SPRING



C
1.00
+-.005 C
A
4.70
B
ϕ0.08
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
MOHAMMED
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
WEIGHT:
TITLE:
Spring
DWG NO.
20-0007
A4
SCALE:1:2
SHEET 1 OF 1
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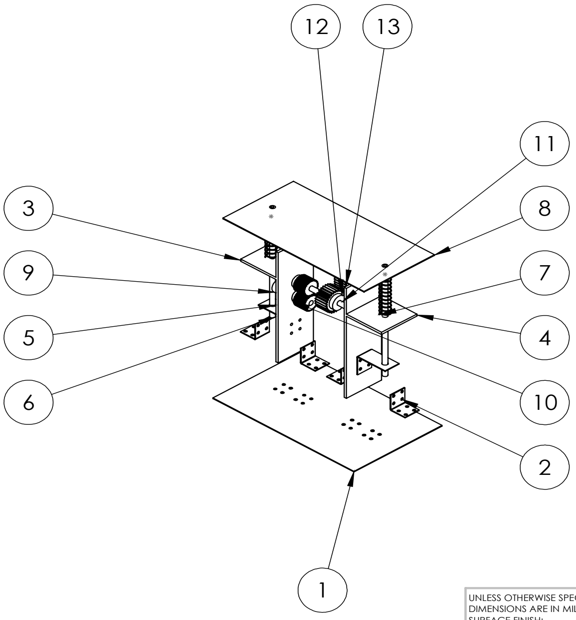
B9 Assembly Drawing



ITEM NO.	PART NUMBERS	QTY.
1	Base Plate	1
2	L Bracket	4
3	Right Side support	1
4	Left Side Plate	1
5	Rod Support	2
6	Top plate Support	2
7	Spring	2
8	Top Plate	1
9	Motor	1
10	Pinion	2
11	Shaft	1
12	Reak Gear	1
13	Rack	1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

Mechanical
Power Generator

MATERIAL:

DWG NO.

10-0000

A4

WEIGHT:

SCALE:1:10

SHEET 1 OF 1

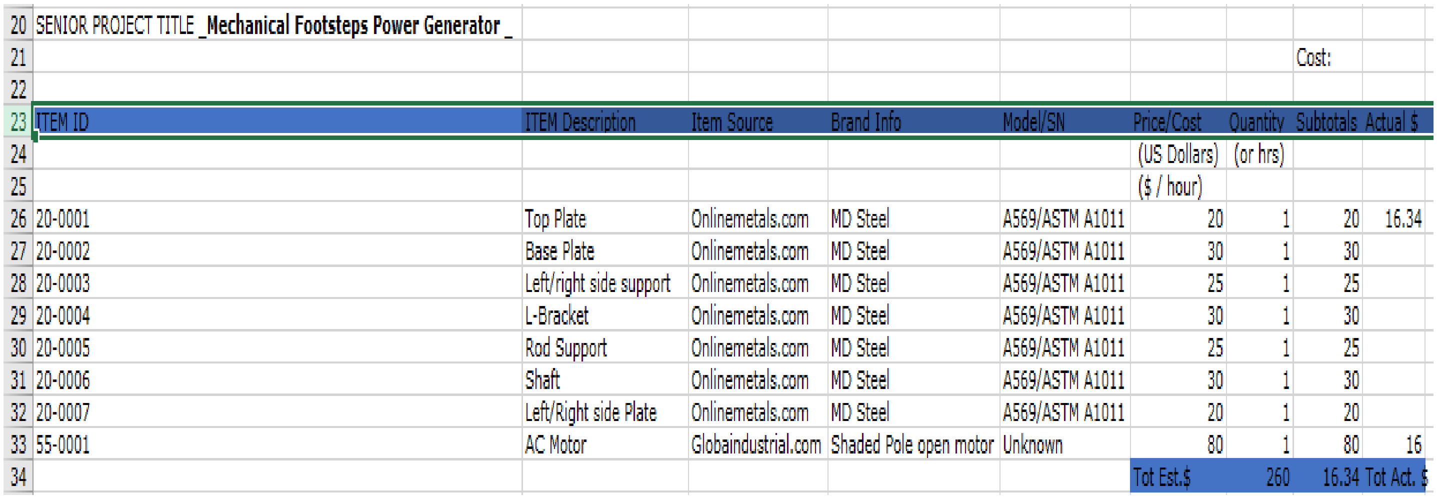
13. APPENDIX C – PARTS LIST

Part Ident	***Part Description***	***Source***	***Disposition***
MD Steel 20-0001	A569/ASTM A1011	Onlinemetals.com	Order
Rack 55-0001	FAAC Galvanized Steel Rack	Allsecurityequipment.com	Order
Pinion 20-0002	machined steel pinion gear	Amazon.com	Order
AC Motor 55-0002	Shaded pole open motor	Globalindustrial.com	Order

14. APPENDIX D -- BUDGET

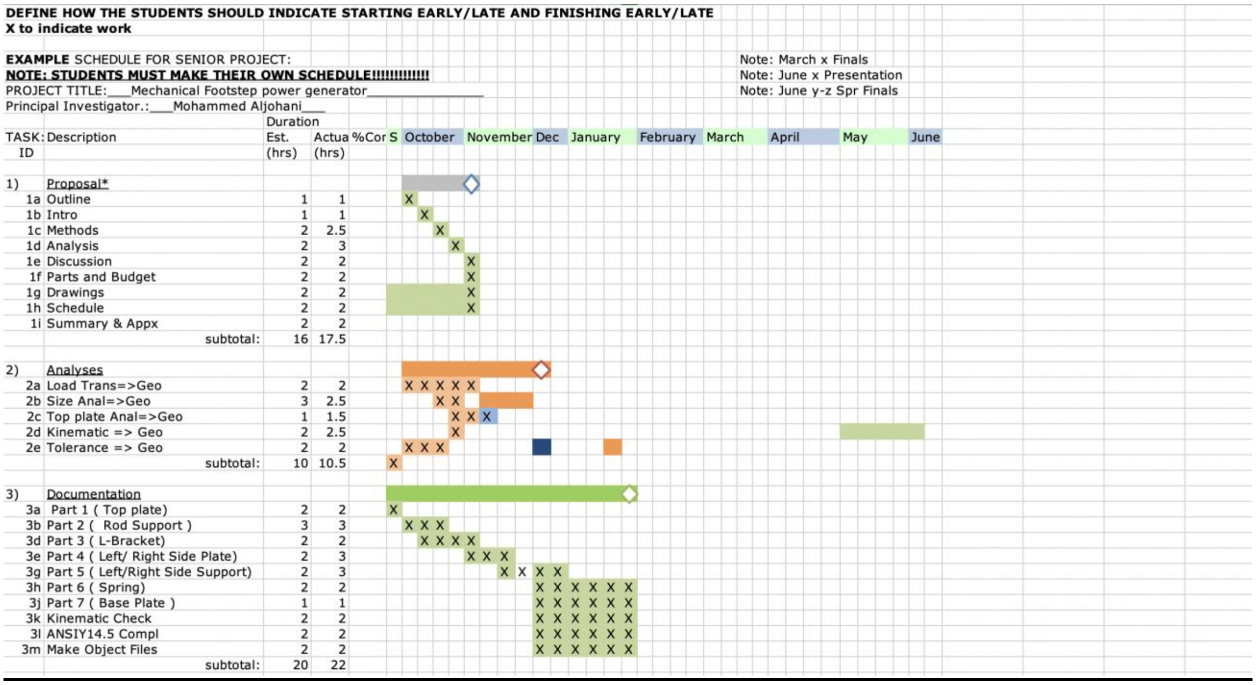
Part Ident	***Part Description***	***Source***	***Cost***	***Disposition***
MD Steel 20-0001	A569/ASTM A1011	Onlinemetals.com	$100.00	Order
Rack 55-0002	FAAC Galvanized Steel Rack	Allsecurityequipment.com	$35.00	Order
Pinion 20-0002	machined steel pinion gear	Amazon.com	$60.00	Order
AC Motor 55-0001	Shaded pole open motor	Globalindustrial.com	$80.00	Order
Cost Total:				$275.00

My partners will work in pinion, rack, gears and AC motor



20	SENIOR PROJECT TITLE _**Mechanical Footsteps Power Generator** _								
21								Cost:	
22									
23	ITEM ID	ITEM Description	Item Source	Brand Info	Model/SN	Price/Cost	Quantity	Subtotals	Actual $
24						(US Dollars)	(or hrs)		
25						($ / hour)			
26	20-0001	Top Plate	Onlinemetals.com	MD Steel	A569/ASTM A1011	20	1	20	16.34
27	20-0002	Base Plate	Onlinemetals.com	MD Steel	A569/ASTM A1011	30	1	30	
28	20-0003	Left/right side support	Onlinemetals.com	MD Steel	A569/ASTM A1011	25	1	25	
29	20-0004	L-Bracket	Onlinemetals.com	MD Steel	A569/ASTM A1011	30	1	30	
30	20-0005	Rod Support	Onlinemetals.com	MD Steel	A569/ASTM A1011	25	1	25	
31	20-0006	Shaft	Onlinemetals.com	MD Steel	A569/ASTM A1011	30	1	30	
32	20-0007	Left/Right side Plate	Onlinemetals.com	MD Steel	A569/ASTM A1011	20	1	20	
33	55-0001	AC Motor	Globaindustrial.com	Shaded Pole open motor	Unknown	80	1	80	16
34						Tot Est.$	260	16.34	Tot Act. $

15. APPENDIX E – SCHEDULE

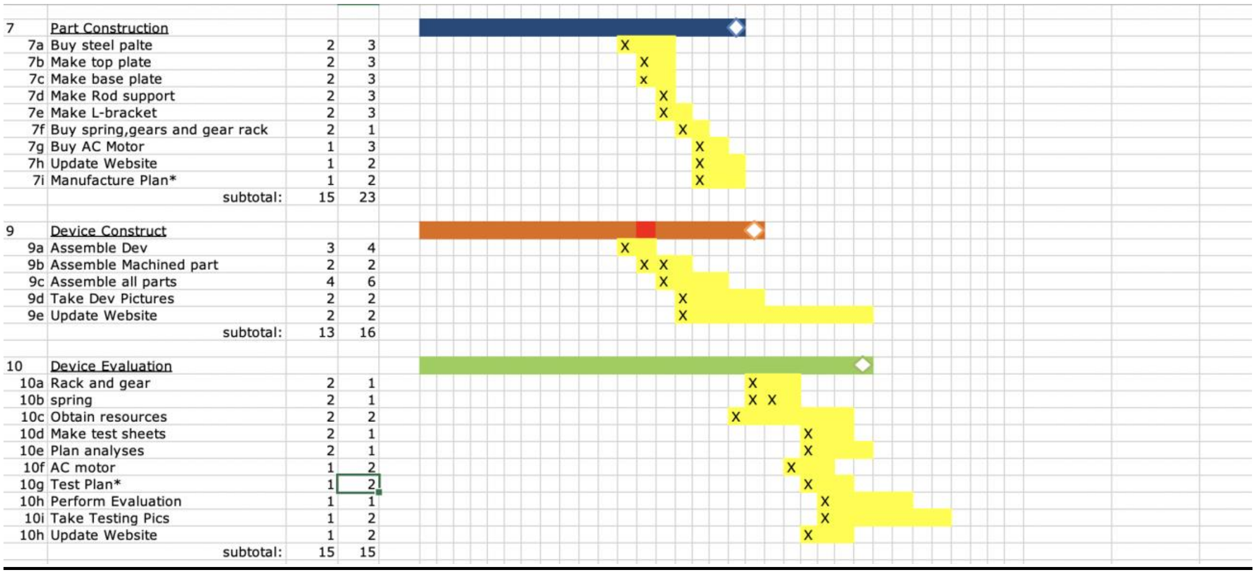


DEFINE HOW THE STUDENTS SHOULD INDICATE STARTING EARLY/LATE AND FINISHING EARLY/LATE
X to indicate work

EXAMPLE SCHEDULE FOR SENIOR PROJECT:
NOTE: STUDENTS MUST MAKE THEIR OWN SCHEDULE!!!!!!!!!!!!!
PROJECT TITLE:___Mechanical Footstep power generator________________
Principal Investigator.:___Mohammed Aljohani___

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

TASK: ID	Description	Duration Est. (hrs)	Actua (hrs)	%Cor
1)	Proposal*			
1a	Outline	1	1	
1b	Intro	1	1	
1c	Methods	2	2.5	
1d	Analysis	2	3	
1e	Discussion	2	2	
1f	Parts and Budget	2	2	
1g	Drawings	2	2	
1h	Schedule	2	2	
1i	Summary & Appx	2	2	
	subtotal:	16	17.5	
2)	Analyses			
2a	Load Trans=>Geo	2	2	
2b	Size Anal=>Geo	3	2.5	
2c	Top plate Anal=>Geo	1	1.5	
2d	Kinematic => Geo	2	2.5	
2e	Tolerance => Geo	2	2	
	subtotal:	10	10.5	
3)	Documentation			
3a	Part 1 (Top plate)	2	2	
3b	Part 2 (Rod Support)	3	3	
3d	Part 3 (L-Bracket)	2	2	
3e	Part 4 (Left/ Right Side Plate)	2	3	
3g	Part 5 (Left/Right Side Support)	2	3	
3h	Part 6 (Spring)	2	2	
3j	Part 7 (Base Plate)	1	1	
3k	Kinematic Check	2	2	
3l	ANSIY14.5 Compl	2	2	
3m	Make Object Files	2	2	
	subtotal:	20	22	



7	Part Construction		
7a	Buy steel palte	2	3
7b	Make top plate	2	3
7c	Make base plate	2	3
7d	Make Rod support	2	3
7e	Make L-bracket	2	3
7f	Buy spring,gears and gear rack	2	1
7g	Buy AC Motor	1	3
7h	Update Website	1	2
7i	Manufacture Plan*	1	2
	subtotal:	15	23
9	Device Construct		
9a	Assemble Dev	3	4
9b	Assemble Machined part	2	2
9c	Assemble all parts	4	6
9d	Take Dev Pictures	2	2
9e	Update Website	2	2
	subtotal:	13	16
10	Device Evaluation		
10a	Rack and gear	2	1
10b	spring	2	1
10c	Obtain resources	2	2
10d	Make test sheets	2	1
10e	Plan analyses	2	1
10f	AC motor	1	2
10g	Test Plan*	1	2
10h	Perform Evaluation	1	1
10i	Take Testing Pics	1	2
10h	Update Website	1	2
	subtotal:	15	15

16. APPENDIX F

The project will be design and build by the group members with the assistance of professors.

- Dr. Craig Johnson, advisor for Mechanical Engineering Technology.
- Prof. Charles Pringle, advisor for Mechanical Engineering Technology.
- Prof. John Choi, advisor for Mechanical Engineering Technology.
- Using book:
    - Machine Elements in Mechanical Design, 6 th ed., by Mott; Prentice Hall Publ., 2018.
- Solidwork
- Google

17. APPENDIX G

Testing	***Result***
one down and up cycle (136 lb)	***1.56 V output electricity***
One down and up cycle (145 lb)	***2.01 V output electricity***
One down and up cycle (152 lb)	***2.55 V output electricity***

MOHAMMED ALJOHANI

Experienced Mobily Telecom Company with excellent client and project management skills. Action-oriented with strong ability to communicate effectively with technology, executive, and business audiences. I was working in Mobily Telecom Company for over 2 years, So Mobily provides integrated services for three main sectors, namely individuals, business, and carriers. It has one of the largest wireless networks by coverage in Saudi Arabia. I had a great experience with this company. Furthermore, had the opportunity to be a supervisor, I became a supervisor for 1 year, I had many things to do such as sending Emails, put our Sales in Microsoft Excel. So, I am a current student at Central Washington University.

EXPERIENCE

DATE FROM 2012 – 2013

MOBILY TELECOM COMPANY, MOBILY

SALESMAN

EDUCATION

2017

ASSOCIATE OF ARTS, LANE COMMUNITY COLLEGE

2020

BACHELOR OF SCIENCE, CENTRAL WASHINGTON UNIVERSITY

2019

LICENSE, OSHA (OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION)

2019

MINOR OF SAFETY AND HEALTH MANAGEMENT, CENTRAL WASHINGTON UNIVERSITY.

☐ Skills

- Arabic Native Speaker Speaker
- Perfect communication Language

Languages

Arabic Native

English as second

18. APPENDIX J – JOB HAZARD

Engineering Technologies, Safety, and Construction Department

JOB HAZARD ANALYSIS

Prepared by: Mohammed Aljohani	Reviewed by: Approved by:

Location of Task:	Hogue
Required Equipment / Training for Task:	Hand Tool
Reference Materials as appropriate:	https://ehs.berkeley.edu/sites/default/files/jsa-library/fsdrillpress43.pdf https://ehs.berkeley.edu/job-safety-analysis-jsas-listed-topic

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	☐	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
	Clean the table.	**Eye injury from metal debris**	**Wear eye protection. Do not use compressed air.**
	Put material in vise or clamp, apply lubricant while drilling and drill	**Fall, Pinch points, Posture**	**Ensure PPE is worn. Ensure area is clear of all tripping hazards. Be aware of hand and finger location at all times Rotate job tasks when possible.**
	Unload the vise.	**Foot injury if the vise falls**	**Leave the vise secure on the table with T-pins until it is unloaded.**
	Start the threader/ cutter.	**Injuries due to catching the clothing**	**Don’t wear loose clothing while operating the threader/cutter. Wear eye protection. Wear long-sleeved shirt, gloves, and face shield**

File Name: MS-01
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