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H.F. Hauff Outrigger: Vertical Arm

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H.F. Hauff Outrigger Project: Vertical Boom

By

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H.F. Hauff Outrigger Project: Vertical Arm

By Juan Tovar

H.F. Hauff is a company based out of Yakima which specializes in farming equipment. One of their products is a trailer which has a wind machine attached to it. In order to keep the fan's thrust from tipping the trailer over, the trailer needs outriggers to extend out. The outriggers also serve as a way to level out the trailer in uneven surfaces. The outriggers are what needed to be designed. This portion of the project was the vertical arm which extends from the horizontal arm, and goes towards the ground to raise the trailer. The project consisted of three stages. The first stage was to design the vertical arm. The design consisted of three segments of square tubing which all fit within each other. The actuation mechanism was to be cable, as opposed to hydraulic in order to reduce cost. The design was made on SolidWorks and drawings were generated. The second stage was the construction of the device. Since the design was a new design, it was constructed out of plastic as a proof of concept. The third stage was to test the device. Because the device was constructed simply as a proof that the design would function, it would not support a load. What could be tested was the actual extension and compacting sizes. This would demonstrate whether the arm could level out the trailer in the required grade of slope. Keywords: <Agriculture>, <leveling>, <trailer>

1: INTRODUCTION

Motivation:

There are agricultural farms that require the use of fans. However some farms (vineyards in particular) find the fans too expensive to retrofit into their farm, or unsightly. Hauff has developed a self-contained fan that operates on a trailer, therefore it is mobile. Sometimes the environment leaves the trailer in uneven/unlevel terrain. To correct this, a device is needed to level the trailer.

Function Statement:

A device that extends vertically to level the trailer.

Requirements:

- This device must be able to support 5000 lbs.
- Be on 7"x12" Trailer
- Counter moment caused by 20 foot tower with 2000 lbs of thrust
- It must weigh no more than 700 lbs.
- Must counteract moment created by fans thrust.
- The device must articulate on x, y, and z axis.
- Must level out trailer within +/-5 degrees of true level.

Engineering Merit:

This project has many engineering criteria. The movement of the device will involve dynamic movements as well as kinematics. There will need to be strength and safety factors built into the device.

Success Criteria:

The device lifts, supports and maneuvers around obstacles successfully. The device should store out of the way. The device should be simple to deploy and store.

Scope of this effort:

The scope of this project will be the mounting points necessary to mount onto the trailer. There will be an outrigger designed and manufactured for the actual use on a trailer.

Benchmark:

There are outriggers that are on heavy machinery such as excavators. They can articulate on two axis. They are fairly compact and can support a large amount of weight. There is also a current trailer offered on the market, which uses trailer jacks. This benchmark has 4 manually operated jacks with no automation or leveling devices.

Success of the project:

Success of the project would be that the design functions and is produced by Hauff.

2: DESIGN & ANALYSIS

Approach:

The trailer requires two booms to be extended out away from the trailer. The trailer has an oscillating fan mounted on the 12 foot by 7 foot trailer. The fan is on a 20 foot tower and has a thrust output of 2000 pounds. The trailer weighs approximately 5000 pounds total. In order to level and counter the moment caused by the fan, a system of four outriggers will be devised. There will be

Benchmark:

There is one similar product that is currently manufactured. The product is manually operated and uses 4 trailer jacks that are used on the tongue of a trailer. The problem with this design is that all four legs have to be manually raised and lowered. This will add a significant amount of time to the deploying and storing process of the outrigger. The benchmark product also does not have any sort of leveling device installed. The benchmark must be leveled out by human estimation, which takes time and effort. It also is a source of error. An image of the current benchmark can be seen in appendix

Analyses:

In order to support the total trailer weight, as well as stabilize the trailer in inclines up to 15%, the booms must be adjustable to a certain length. There is also a moment created from the fans thrust. The total moment created can be located in figure A2, at a value of 40,000 lbft. This must be counted by the mass of the trailer, in order to keep the trailer from tipping over with the force of the fan.

In order to allow the trailer to operate at a 15% grade, there must be a minimum and maximum extension of the arms. The lengths of the arm are calculated in figure A4. These lengths will determine what size of pipe is needed in order to level out the trailer

The cable that has been selected for the mechanism is 1/4-inch steel cable. The max load that the cable is rated for is 6400 lbs, which is more than the max of 5000 lbs of the total weight trailer.

3. METHODS & CONSTRUCTION

Construction:

The outrigger was conceived and designed at Central Washington University. H.F. Hauff was involved in the conceptualization and the design requirements. The parts will be made at CWU as well as at H.F. Hauff's metal working shop. The materials will be provided and funded by H.F. Hauff.

The device functions as a three-piece leg which extends in a cable and pulley assembly. The legs are made of steel square tubing and are cut to the sizes specified in appendix figures B-4 through B6. These legs have internal pieces which are composed of two pulleys, a cylinder and rod, and a cable running through them. The leg is attached to a base plate with two nut and bolt fasteners.

The base plate is made to hold the cylinder and rod, and the leg. This plate has mounting that will attach to the horizontal outrigger with hardware. The baseplate is necessary in order to assemble and disassemble the vertical arm for maintenance.

Parts:

The device will be made out of metal tubing. There will be three segments. The segments will be connected together through a series of pulleys and cables. The segments will extend uniformly to the appropriate length by pulling cable. There is a drawing in figure B1.

The parts list is found in Appendix C.

Manufacturing issues:

Since most of the assembly will be made out of square tubing, there will be the issue of tolerances within the tubes which will slide inside of each other. The device will have pieces which have to fit in one another, making a tight fit.

Other issues will lie in the welding portion of the project. Pieces, such as the pulleys must be accurately welded in order to ensure there will only be vertical stresses on them. The same issue will lie on the feet of the assembly.

Manufacturing Issues:

During the construction phase of the project, the scope of the project was redirected to become a proof of concept. Instead of being made out of steel square tubing, the assembly was instead made out of PVC to demonstrate the functionality of the design. The direction of the project was changed 2 weeks into the 10 week manufacturing time, which then caused pressure to get construction done in a shorter amount, as well as source a different set of materials.

Discussion of assembly:

The assembly is completely made out of PVC except the steel pulley. The assembly is put together by starting from the internal parts and the outer shell being the last piece. The assembly is very straight forward where one could simply take the device apart and service it with hand tools. The most difficult part of the assembly process is the routing of the cables. This is difficult due to the narrow gaps between the pieces, but this only adds a small amount of time to the total time.

4. TESTING METHODS

The testing of this device will be done by mounting the device on the actual trailer in which it will be used. The trailer will then be placed on multiple inclines and surfaces that it would experience regularly. The testing procedure will be as follows:

Testing of level accuracy:

The system will be tested to determine how level the trailer was arranged. Since the outriggers main purpose is to level out the trailer, this is the most critical measurement. A level indicating the levelness of the trailer will be used to determine how accurately the system worked.

Testing of function:

The outriggers must actually support the trailer during use, without the use of the tires. Therefore, simply deploying the outrigger to determine whether the system functions and lifts the trailer will be a critical test.

The design of the vertical arm is constructed out of PVC. The actual device for real world application will be constructed out of steel. The PVC model can still be used to demonstrate the functionality of the device. The device has one internal pulley which may or may not have a mechanical advantage. Once the calculations located in the appendix are completed, it is proven that there is no mechanical advantage for the system. This test will gather data on the force put into the device and the force that is exerted. There should be a 1:1 ratio between force in and force out.

The test is to be conducted on April 10th. The schedule in appendix A4 outlines the timeline.

Method:

The testing method is for numerical data. The resources for this test are 2 different types of scales. One scale is a standard countertop digital scale and the second is a tension scale which has a hook used to attach to the device. The countertop scale will be placed vertically so that when the vertical arm extends, it puts a force against it. The tension scale will be attached to the cable. The test will be conducted 4 times.

5. BUDGET/SCHEDULE/PROJECT MANAGEMENT

Cost and Budget:

A parts list is shown in Appendix C. The parts cost, source and identification information is given in Appendix D. Most parts will be provided from H.F. Hauff, from their fabrication shop. Pulleys for the device will be ordered and mounted onto the spring piston and on the middle section.

Some of the assemblies will require cutting and welding. There will only be turning of parts to reduce outer diameters if necessary

The cost of the project is supported by H.F. Hauff.

The labor for the project will consist of welding, and cutting. There will be no machined parts on the assembly, simply fabricating. This will make the overall labor of the project lower as well as not as time consuming.

Schedule:

The project is to be divided into three separate time blocks. In the first time block, design and analysis of the system is to be done. This time block is to be done in the months of September to December of 2016. The time will be used to do a complete working computer model of the assembly, and generate a part list and budget for the project.

The next block of time is between January and March of 2017. This time is to be used to do the actual construction of the system. The manufacturing will occur at Central Washington University, as well as at H.F. Hauff. A schedule will be followed.

The final block of time will be from the end of March until June. This time is to be used in the testing and data gathering of the functionality of the assembly. This time is very crucial in order to determine the success of the project.

6. DISCUSSION

Design Evolution:

The design went through a few iterations of the overall design. The function of the mechanism remained the same, but the materials used changed. The first design used round tubing to build the mechanism. Drawing inspiration from standard trailer jacks, round tubing seemed as a viable option. Unfortunately, due to the internals of the mechanism, round tubing made it more difficult in the manufacturing aspect of the device. Therefore, the design had to be redone using square tubing instead. The use of square tubing is a much more suitable choice.

The success of this project relies on the proper function of the design. Since there is no hydraulics or actuators in the system, the cables are the only mechanism that creates movement. The cost of the project is reduced by not including any hydraulic or electronic components and also reduce the maintenance on the device.

Project Risk Analysis:

During the project there were several risks that occurred. The main risk was that at the beginning of winter quarter, there was 2 weeks where there was no contact with H.F. Hauff. This caused a delay and put the entire project in jeopardy. The end result was the project turned into a usable product into a proof of concept.

There was no indication that the project was going to have to change format, but due to the short notice, the risk of not completing the project was removed by altering the direction of the project.

7. CONCLUSION

The Hauff outrigger design for the vertical boom has met the design requirements, and functions as is necessary. The device has been conceived, analyzed and modeled. The device has been designed with standard, readily available materials, and a parts list has been conceived. The device is illustrated in drawings that meet ANSI Y14.5 standards. The device is ready to be created.

This project meets all the requirements for a successful senior project, including:

1. Having substantive engineering merit in structural areas
2. Size and cost within the parameters of our resources
3. Being of great interest to H.F. Hauff

The construction of the final product was restructured after winter break. The construction of the device was originally intended to be out of steel and be able to be tested on the actual trailer. Once winter break was completed, the contact at H.F. Hauff had changed careers. At this point, the project became a proof of concept in order to complete the project and keep the budget as low as possible.

The proof of concept was constructed out of PVC as close to the dimensions as the actual design. The PVC square tubing proved to be a very accurate representation, and demonstrated the functionality of the design.

After completing the project, the design of the vertical arm is shown to be a viable alternative to a hand crank operated jack, or a hydraulic system.

8. ACKNOWLEDGEMENTS

H.F. Hauff sponsored the project.

Casey Mcfarlen mentored the project.

Dr. Craig Johnson, Professor Beardsley, and Professor Pringle mentored and guided the process of design, and analysis.

Appendix A: Analysis

Figure A1: Angle of inclination

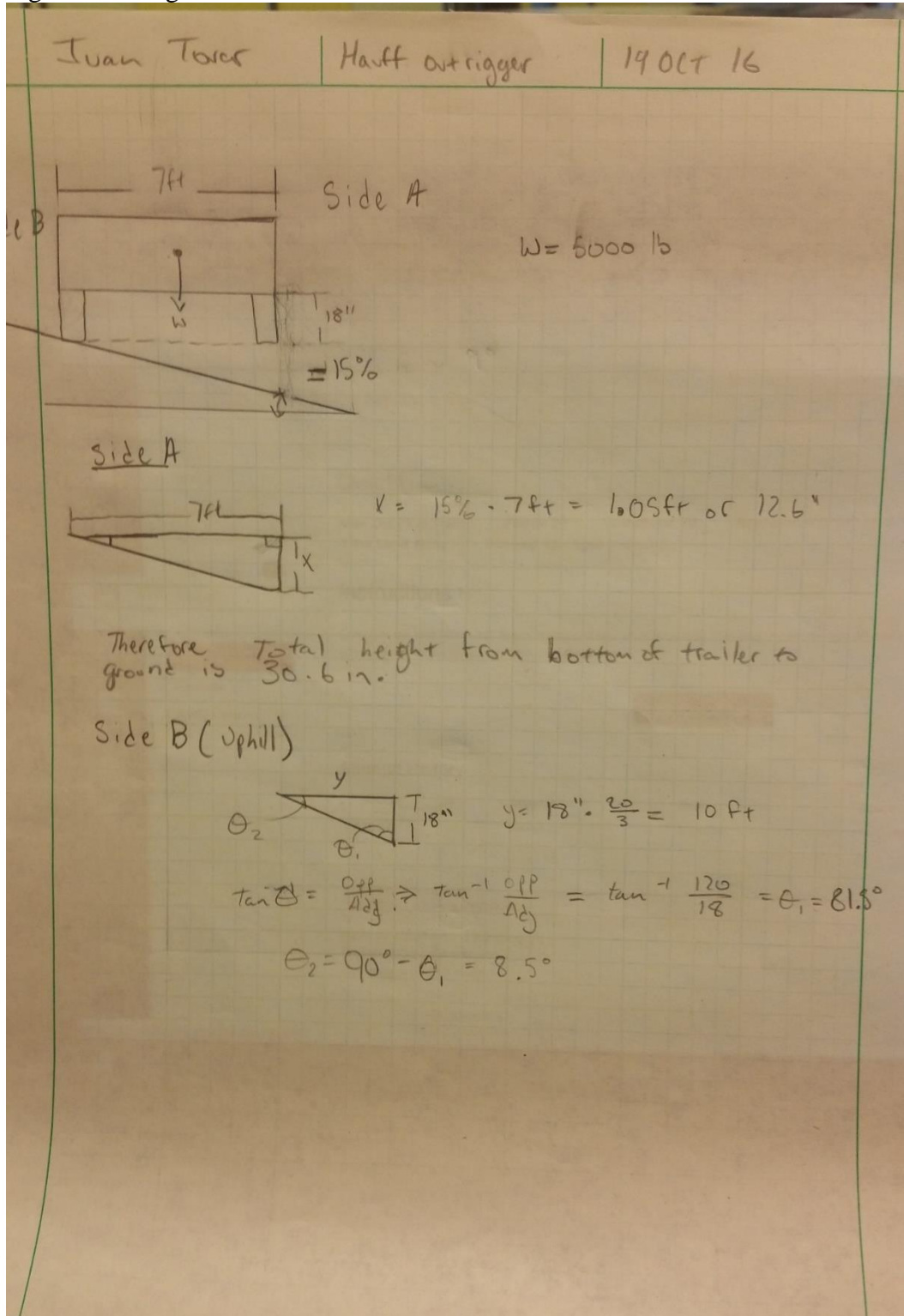


Figure A2: Moment analysis caused by fan

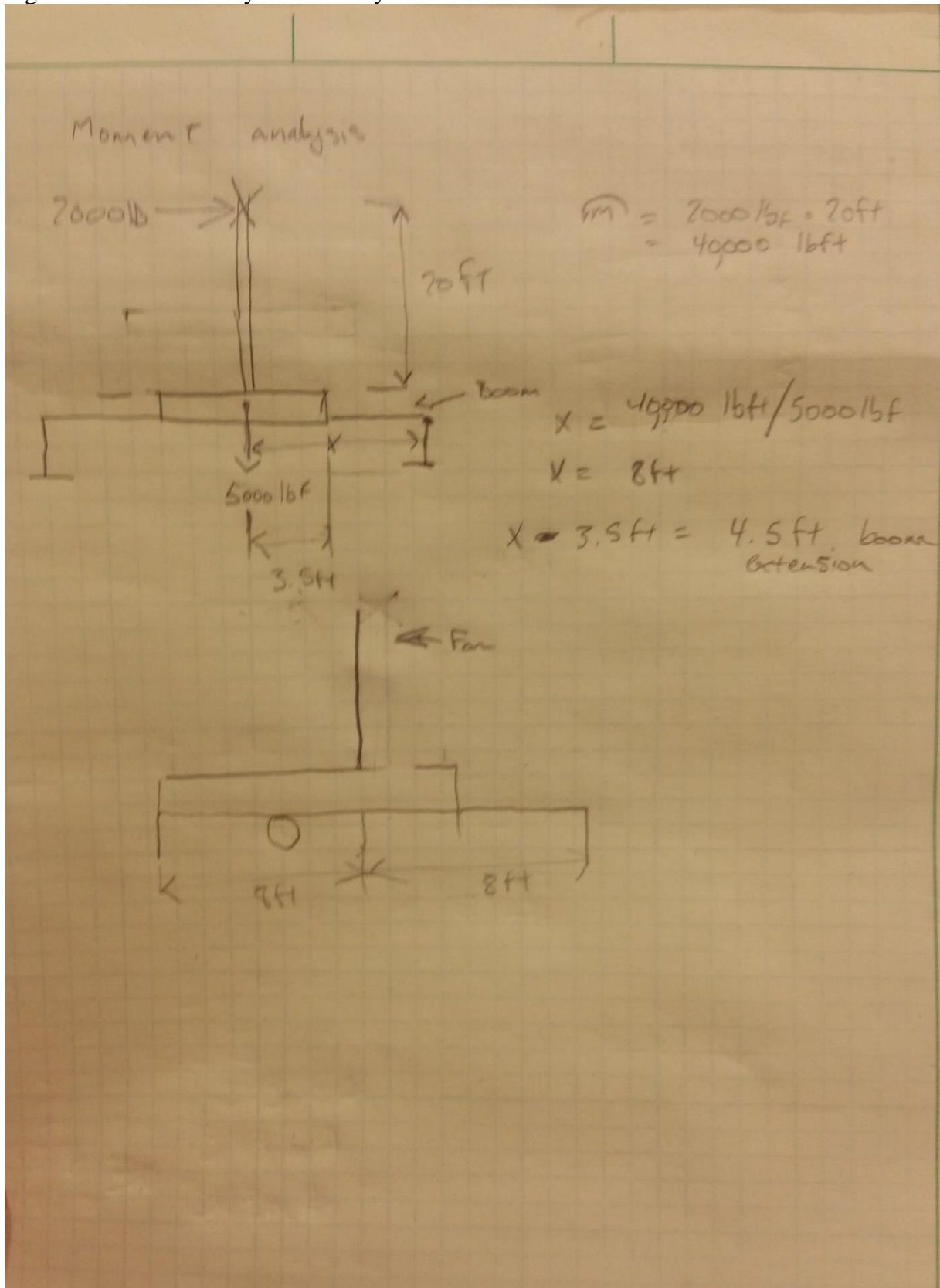


Figure A3: Analysis of system

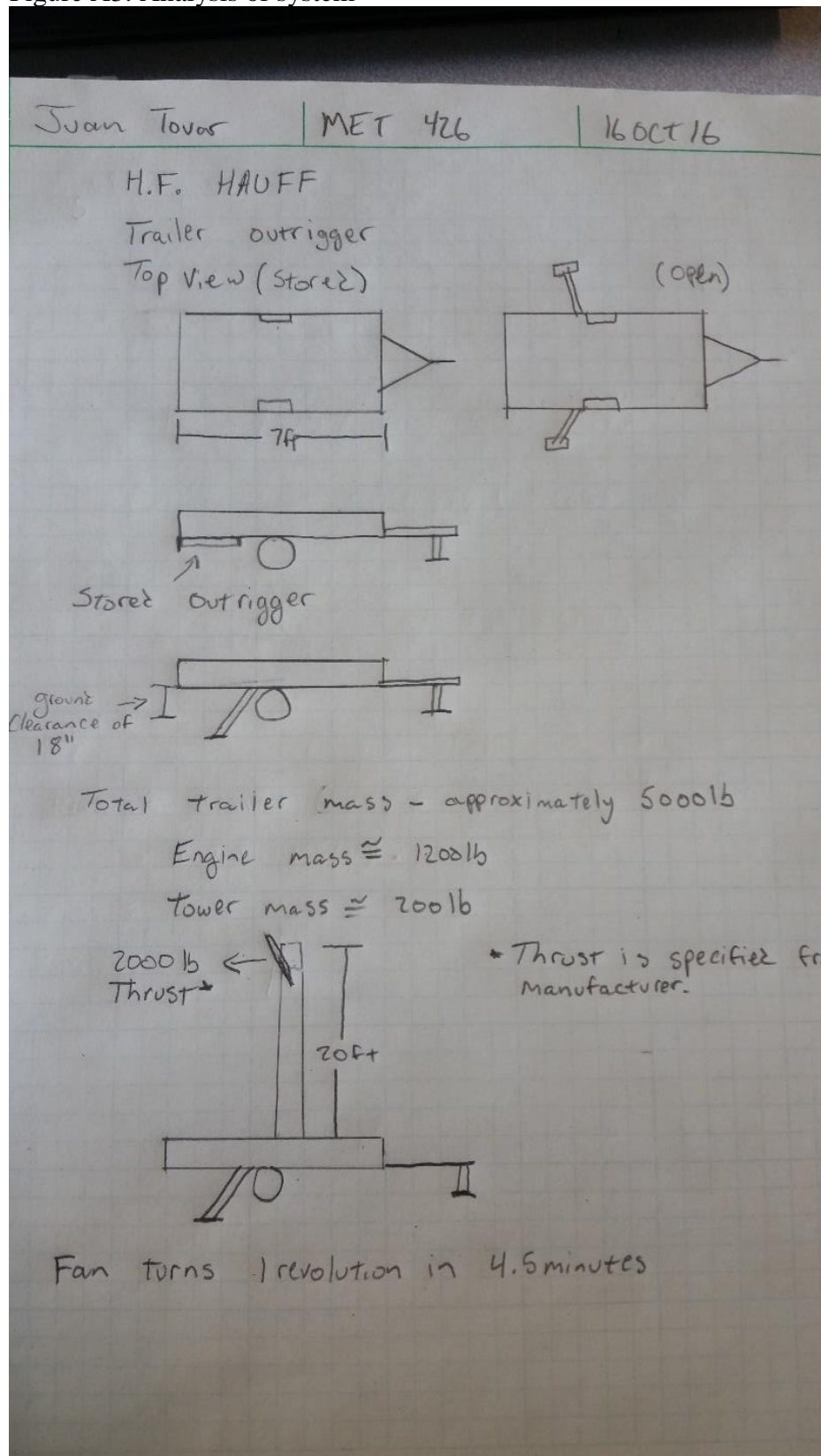


Figure A4: Minimum/Maximum extension

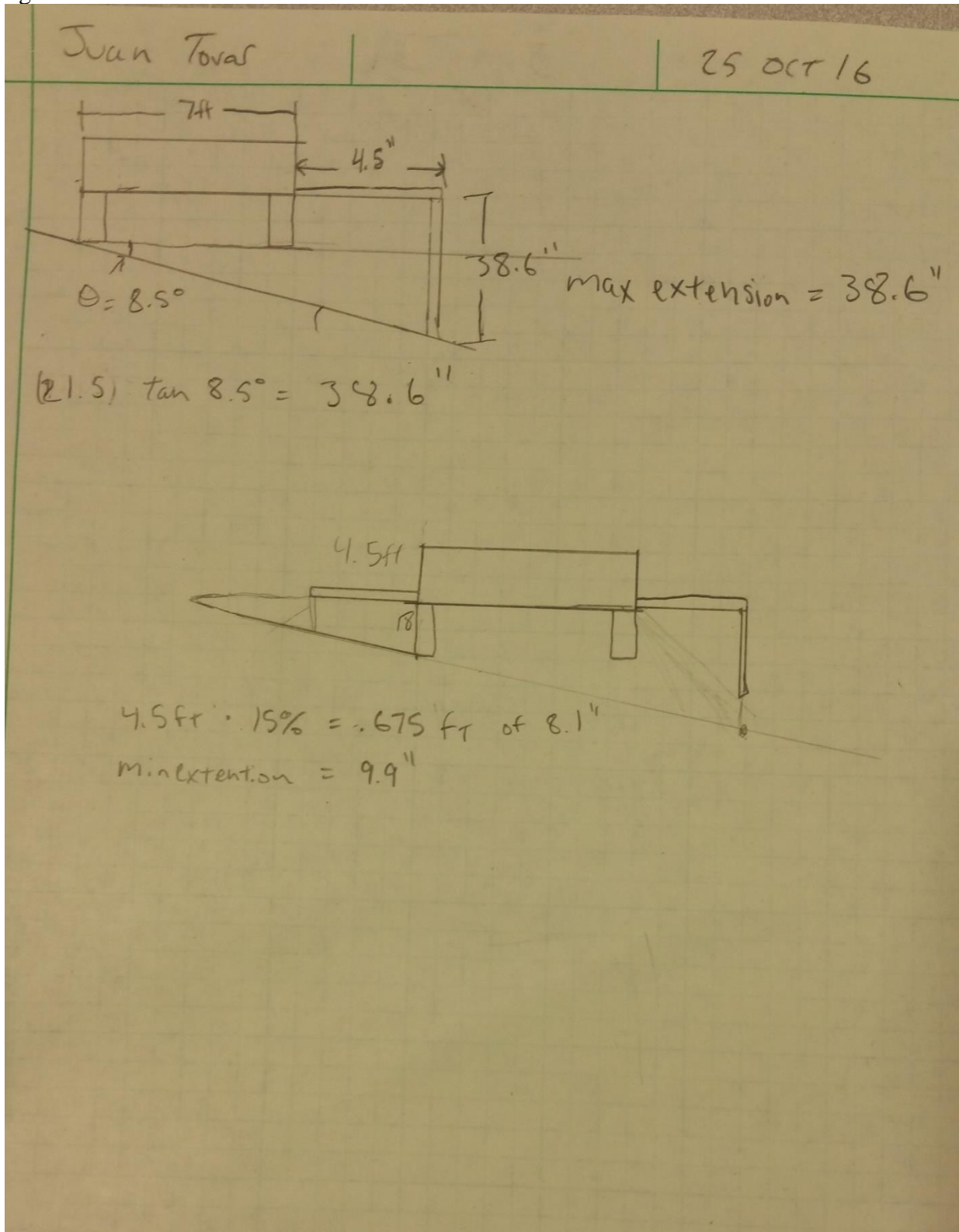


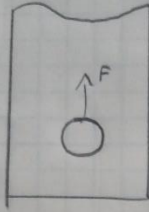
Figure A5: Stress Concentration in leg

Sean Toar | HAUFF OUTRIGGER

Given: $\frac{1}{4}$ " tubing with $\phi .5$ " hole

Find: Stress in hole

Soln



$F = 5000 \text{ lb}$
 $\phi = .5 \text{ in}$
 $T = .25 \text{ in}$
 $W = 2.5 \text{ in}$

$d/w = .5/2.5 = .2$ (Use figure 3-28, Mott)

$K_t = 5.1$

$\sigma_{nom} = \frac{F}{(W-\phi)T} = \frac{5000 \text{ lb}}{(2.5-.5) \cdot .25} = 10000 \text{ psi}$

$\sigma_{max} = 5.1 \cdot 10000 \text{ psi} = 51,000 \text{ psi}$

Figure A6: stress on hole by pin

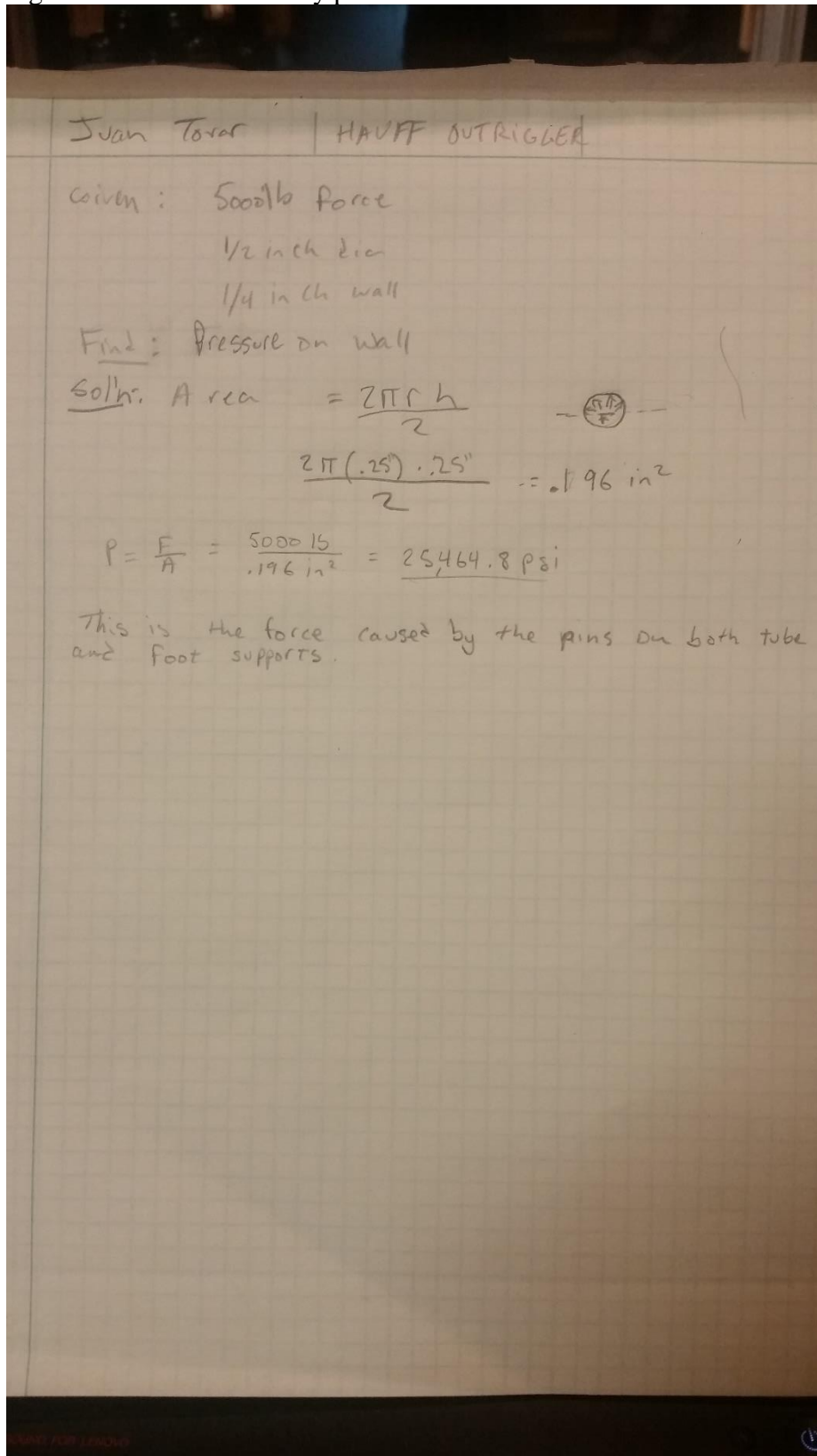


Figure A7: Cable analysis

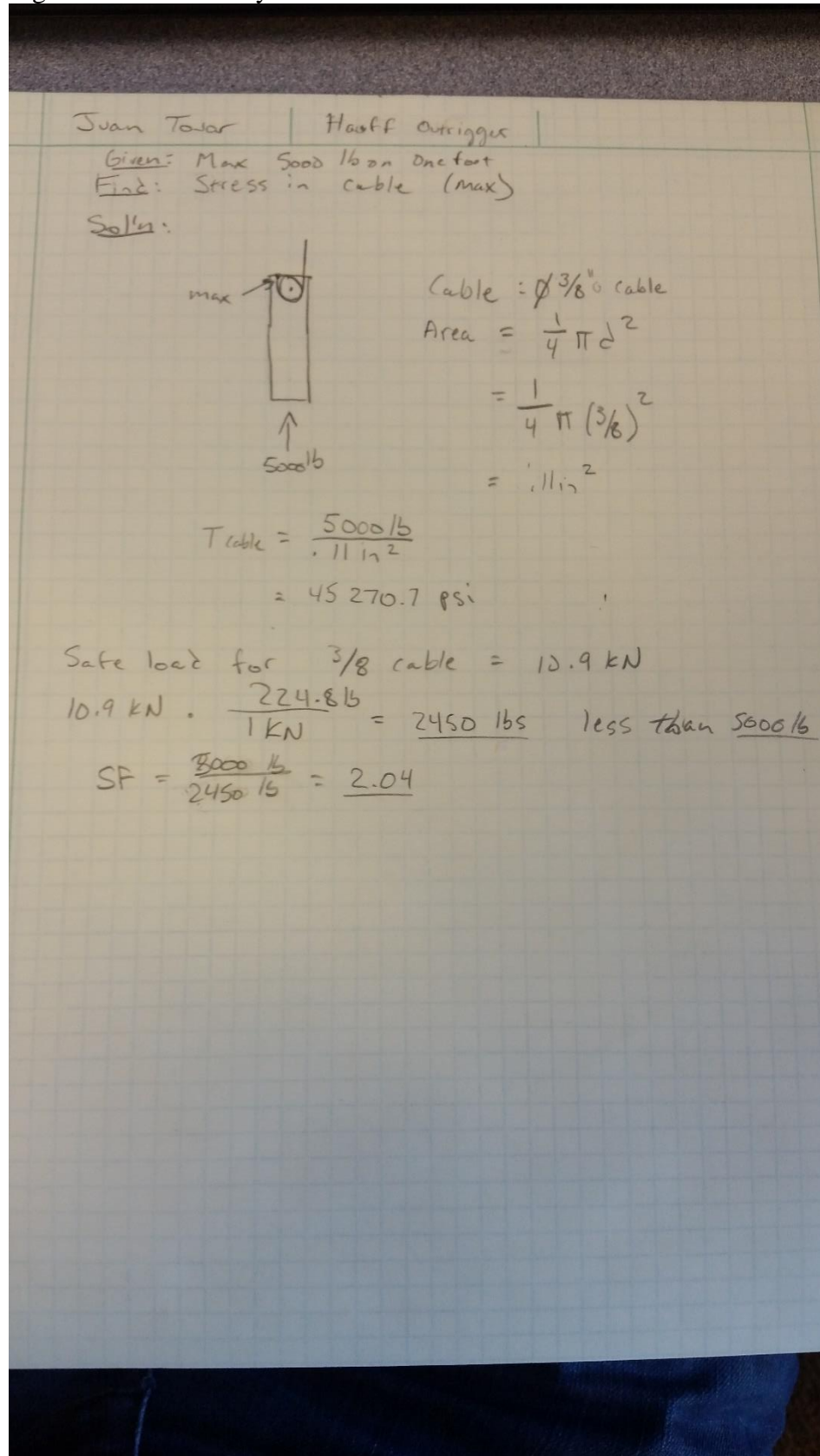


Figure A8: Force in each segment

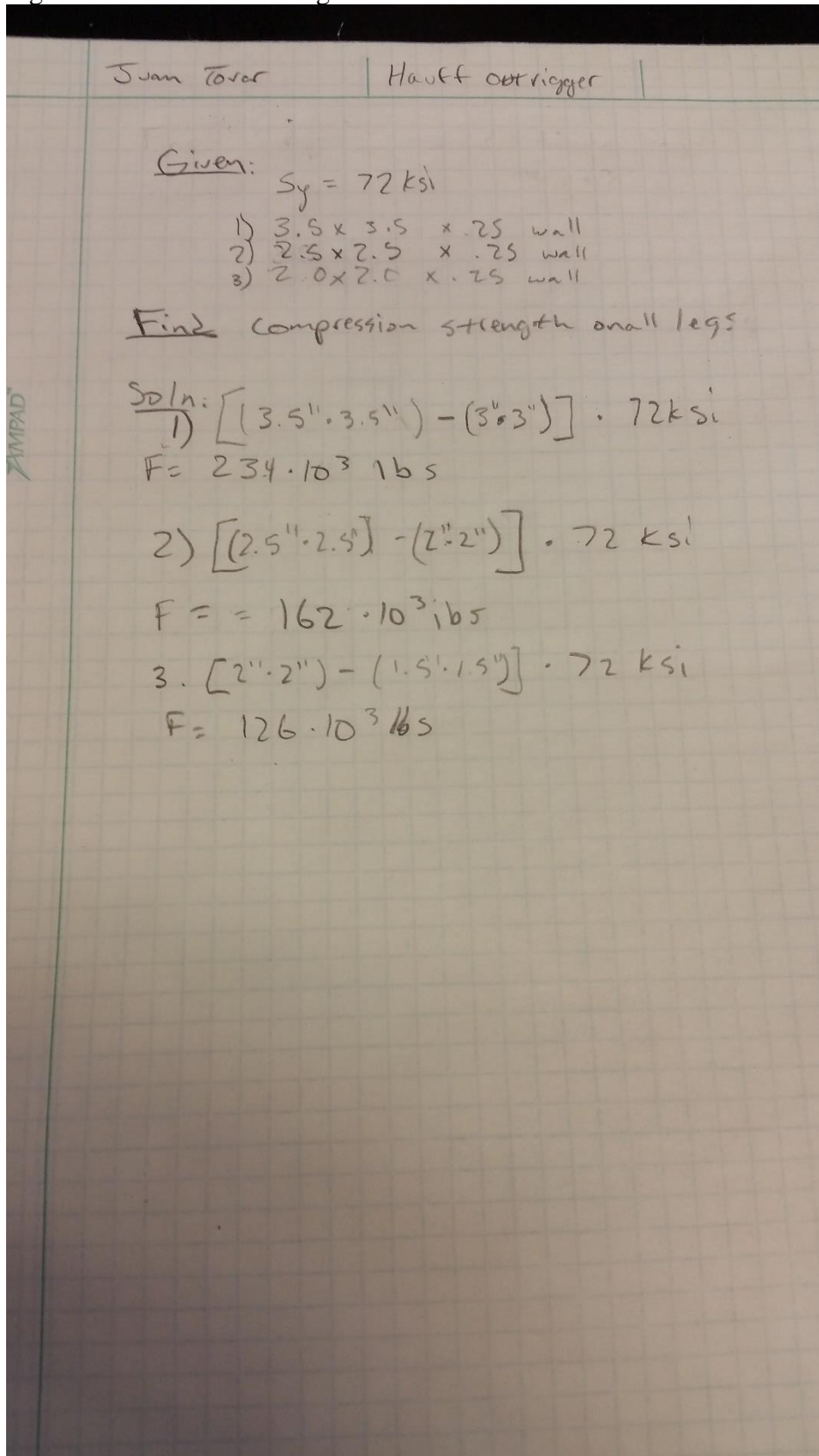


Figure A9: Column Buckling

Juan Tower	Hault Outrigger
<u>Given:</u> A513 Steel modulus of elasticity = $30 \cdot 10^6$ psi $S_y = 72$ ksi $A_{avg} = 2.25$ in ² $L_{max} = 39$ " $K = .65$ $r = .8$	
<u>Find:</u> allowable load	
<u>Soln:</u> $P_{cr} = \frac{\pi^2 EA r^2}{(KL)^2}$ $= \frac{\pi^2 (30 \cdot 10^6 \text{ psi}) (2.25 \text{ in}^2) (.8)^2}{(.65 \cdot 39")^2}$ $= 663,480$ lbs	
$P_a = P_{cr} / N$ $N = 3$	
$663,480 / 3 = \underline{221,160 \text{ lb}}$	

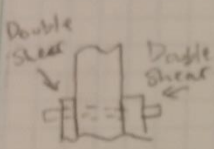
Figure A10: Foot Bolt stress

Span Tower | Huff Outrigger

Given: $1/2$ inch bolts
 $F_{max} = 5000$ lb
 $T = 1/4$ "

Find: Shear Stress
Bearing area stress

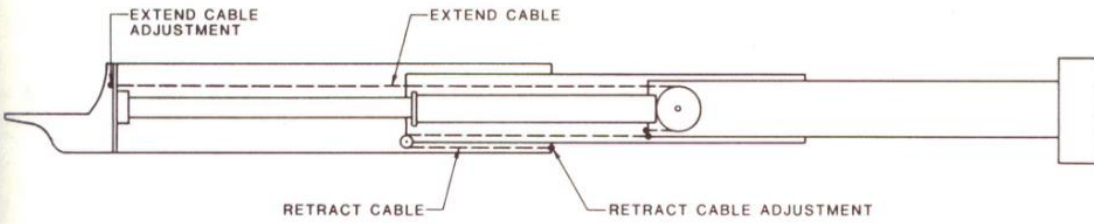
Sol'n: Shear Stress = $4F / (\pi d)^2$
 $= 4 \left(\frac{5000 \text{ lb}}{2} \right) / (\pi \cdot .5)^2$
 $= 12732$ Psi.



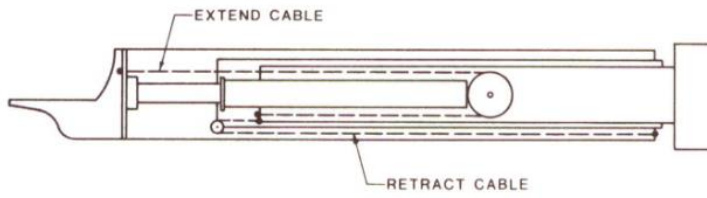
Bearing area Stress = $F / (Tl)$
 $= 2500 \text{ lb} / (.25 \cdot .5) \text{ in}^2$
 $= 20000$ Psi

Figure B1

BOOM ILLUSTRATIONS



BOOM EXTENDED



BOOM RETRACTED

Figure B2: Assembly Exploded

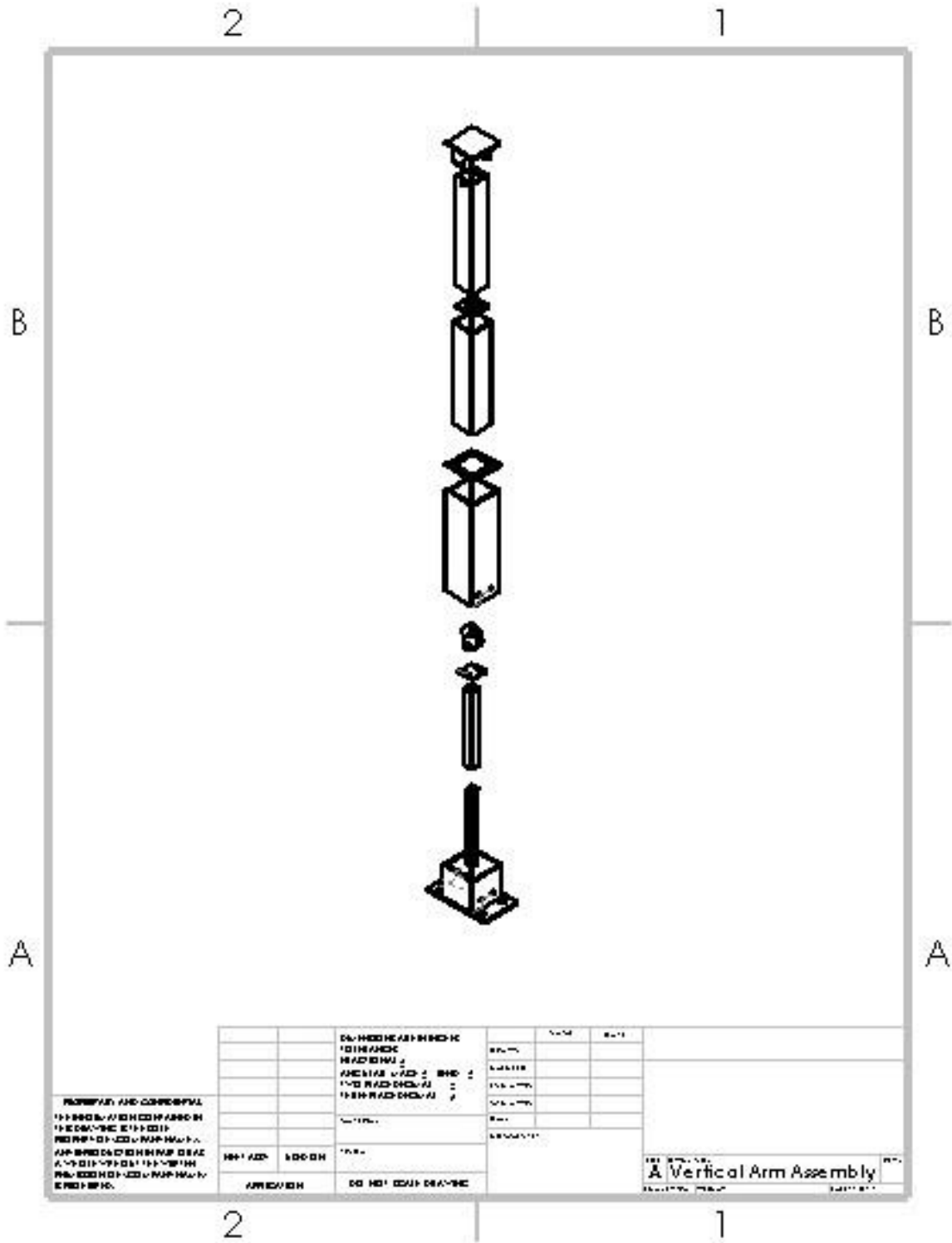


Figure B3: Assembly Closed

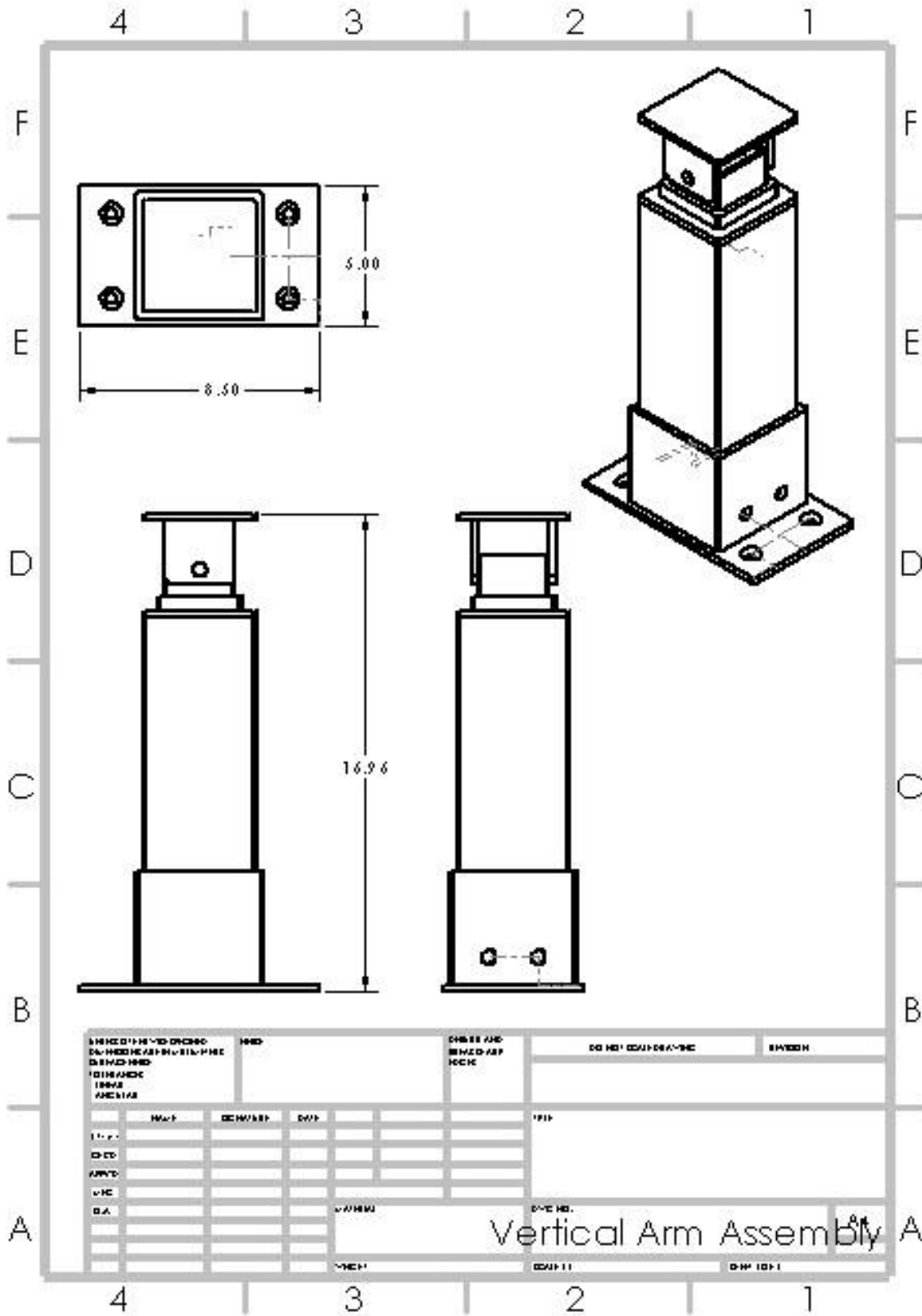


Figure B4: Extended Arm (not full extension)

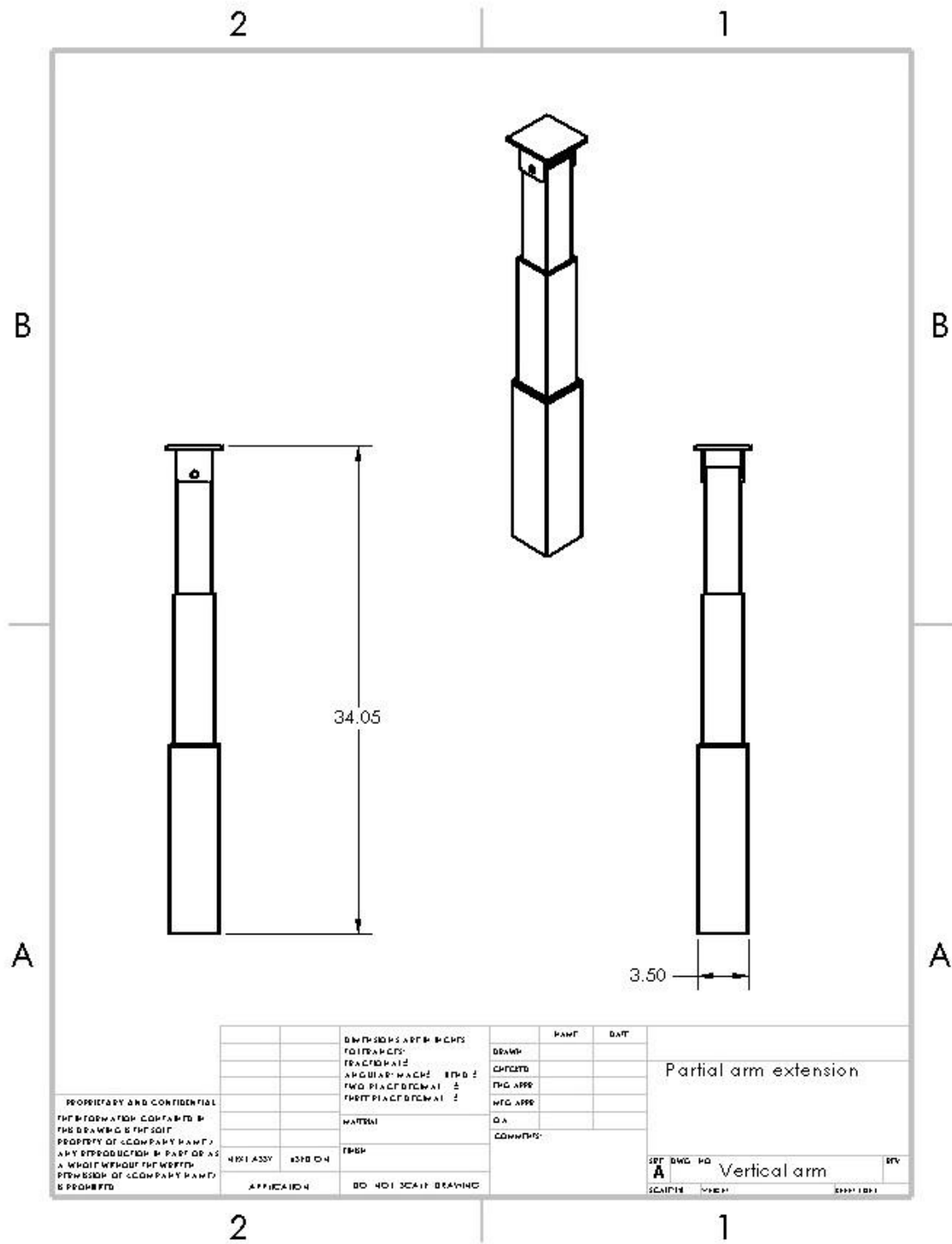


Figure B5: Inner Tubing on leg

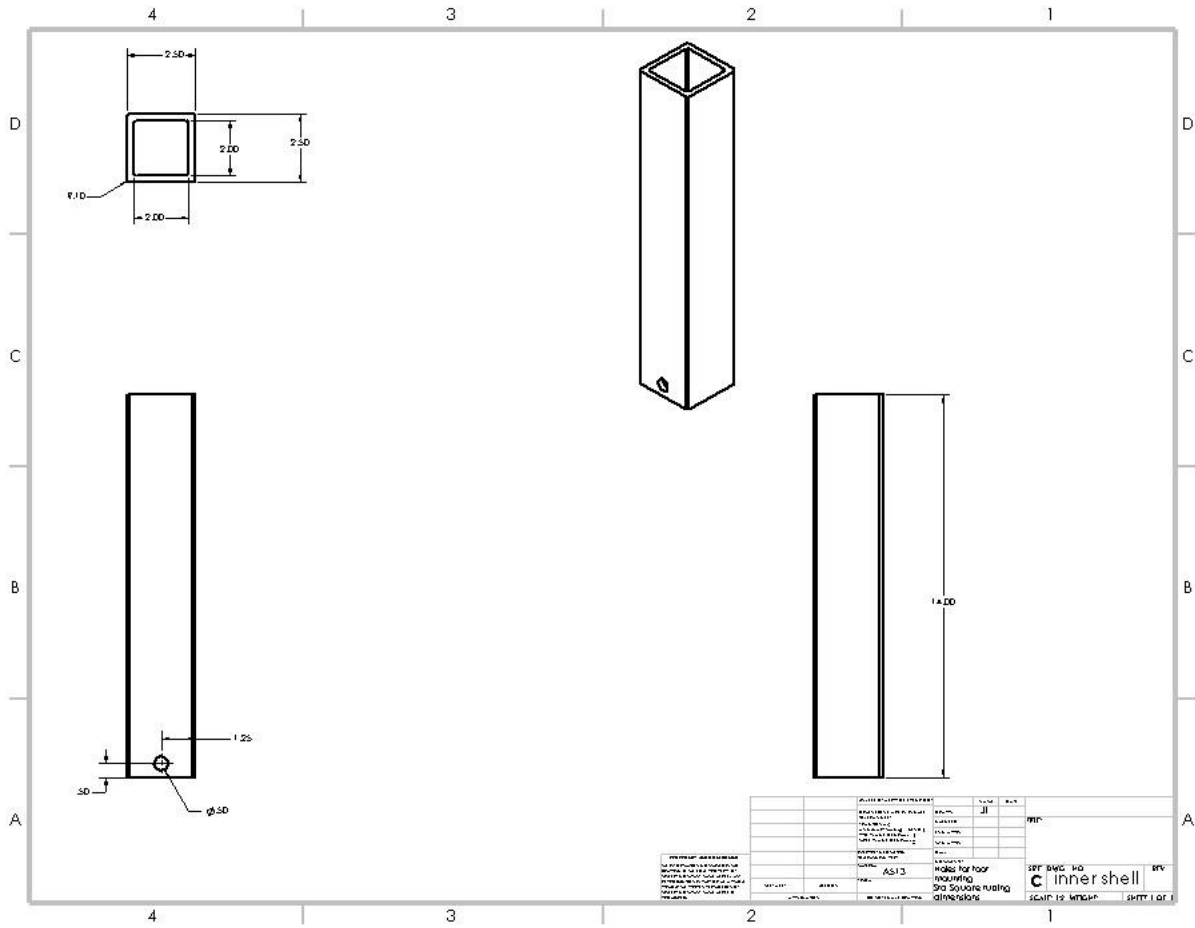


Figure B6: Foot

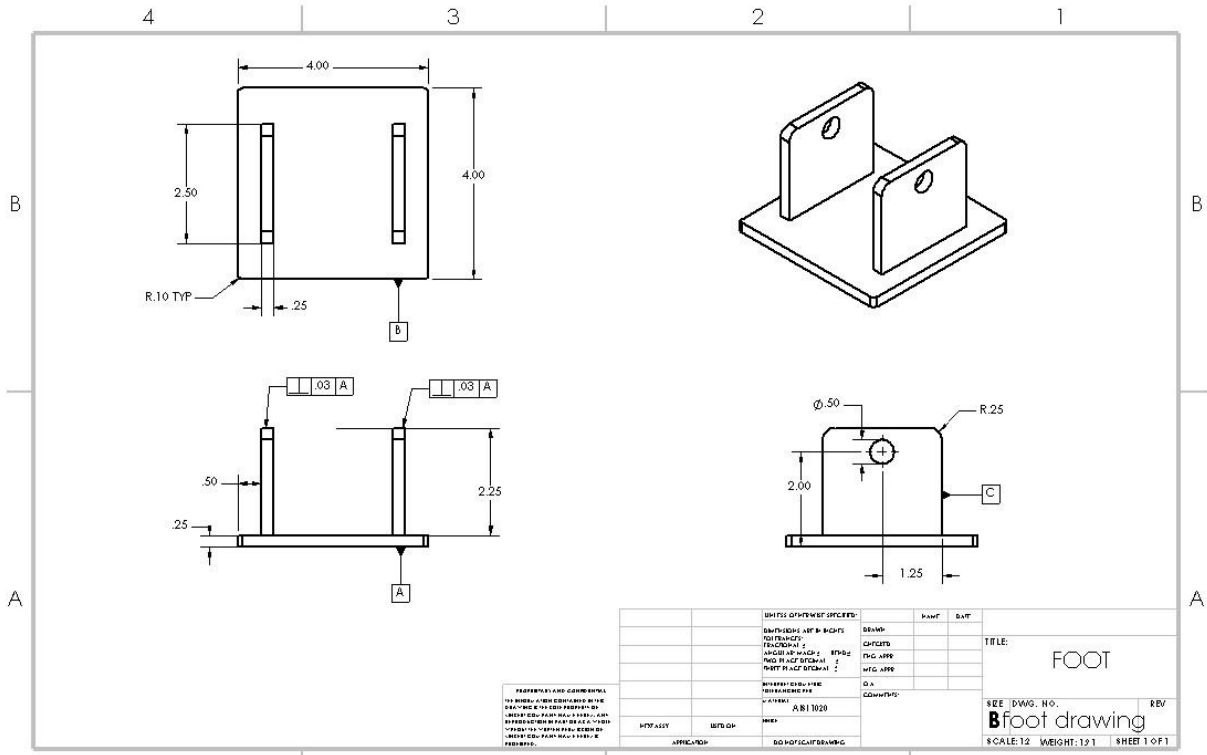


Figure B7: Mounting plate

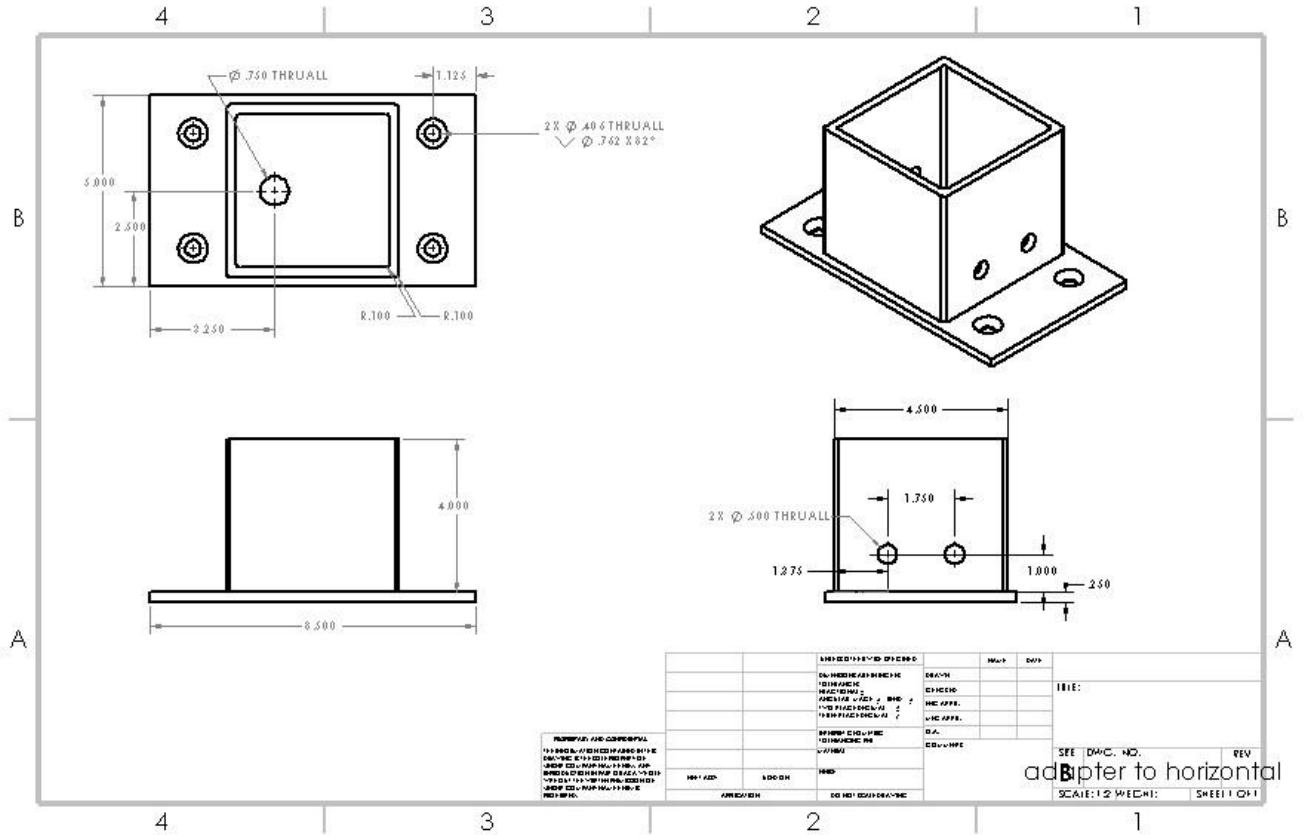


Figure B8: Middle Tube

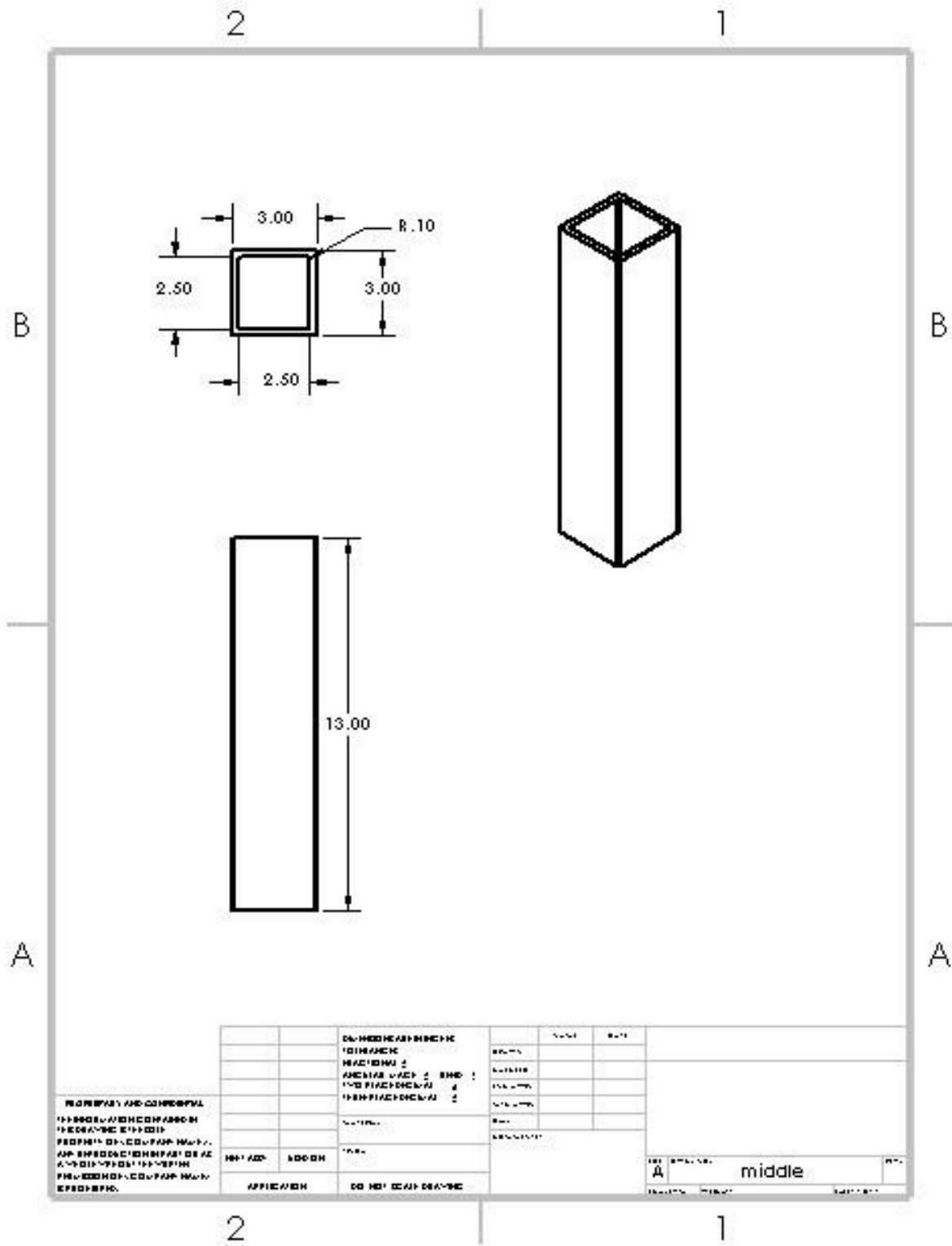


Figure B9: Outside Shell

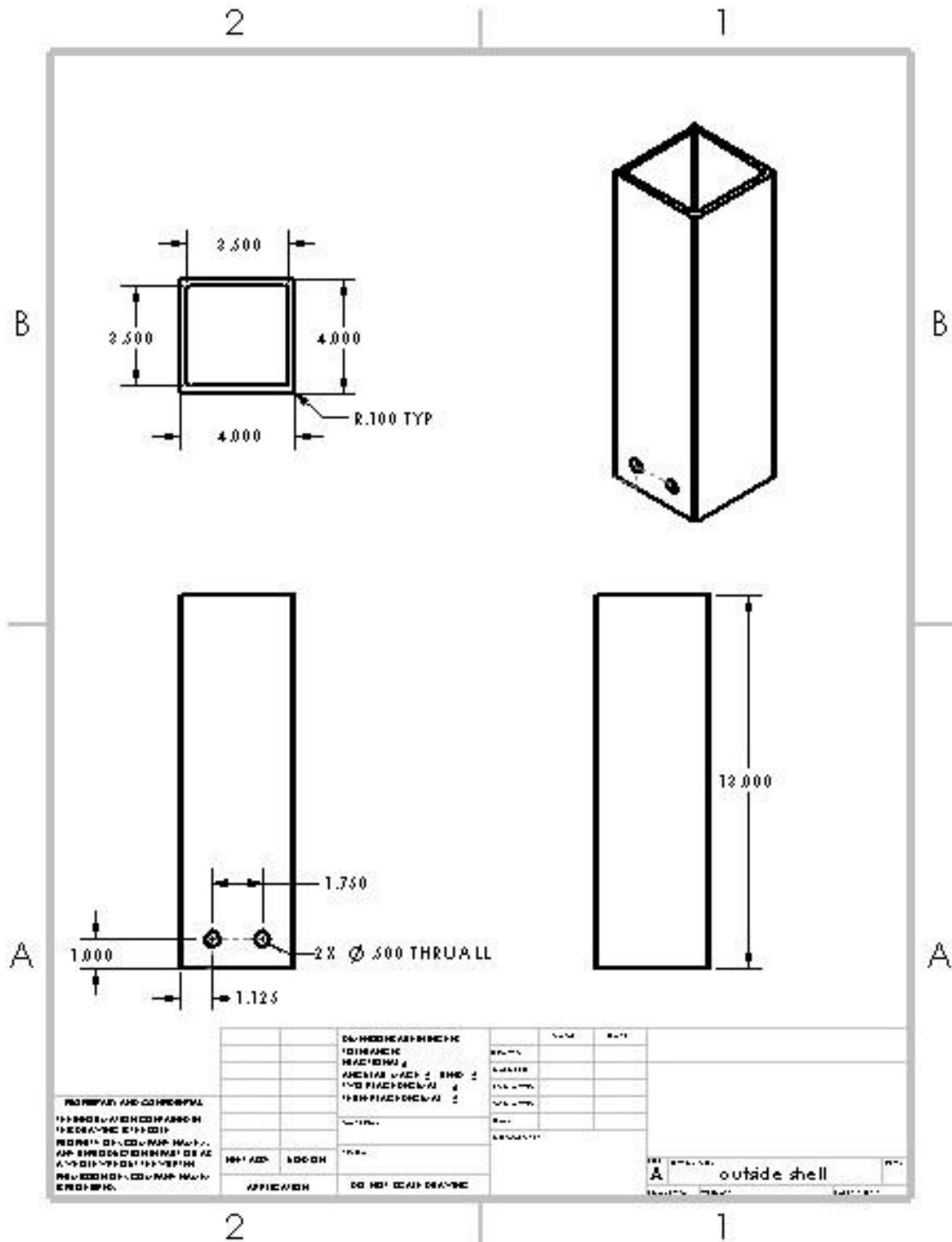


Figure B10: Reducer

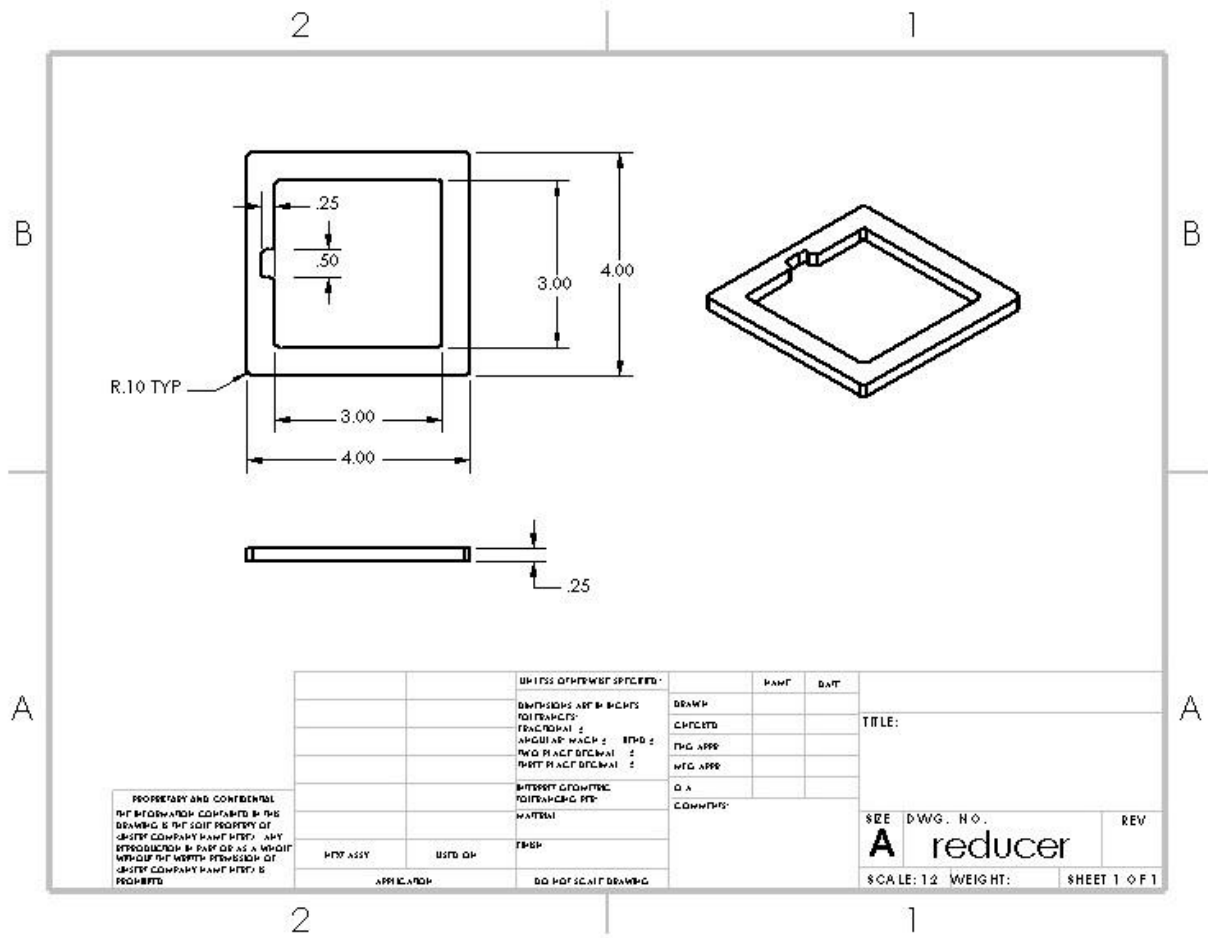


Figure B11: Inner shell Cable stop

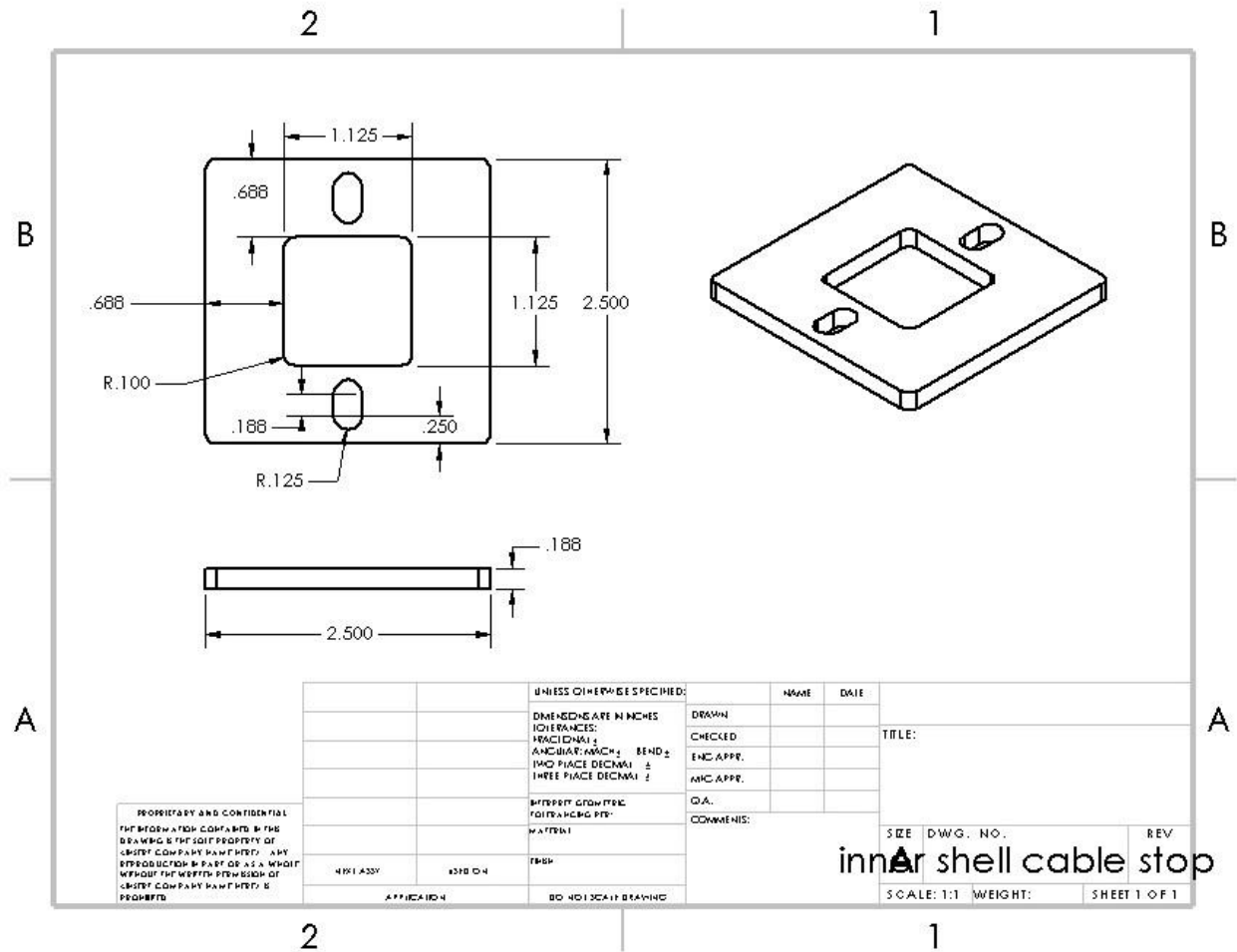


Figure B12: Piston Rod

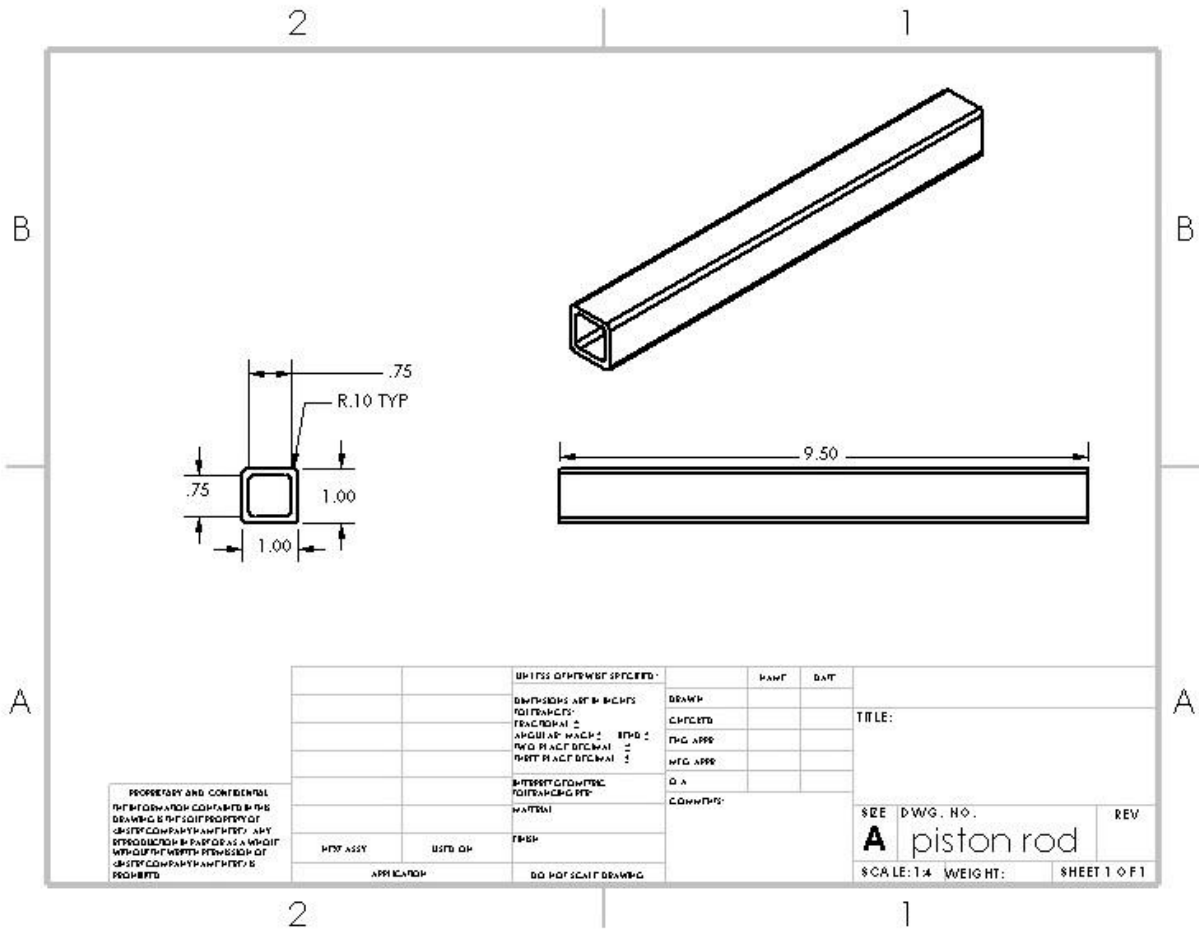


Figure B13: Piston Rod

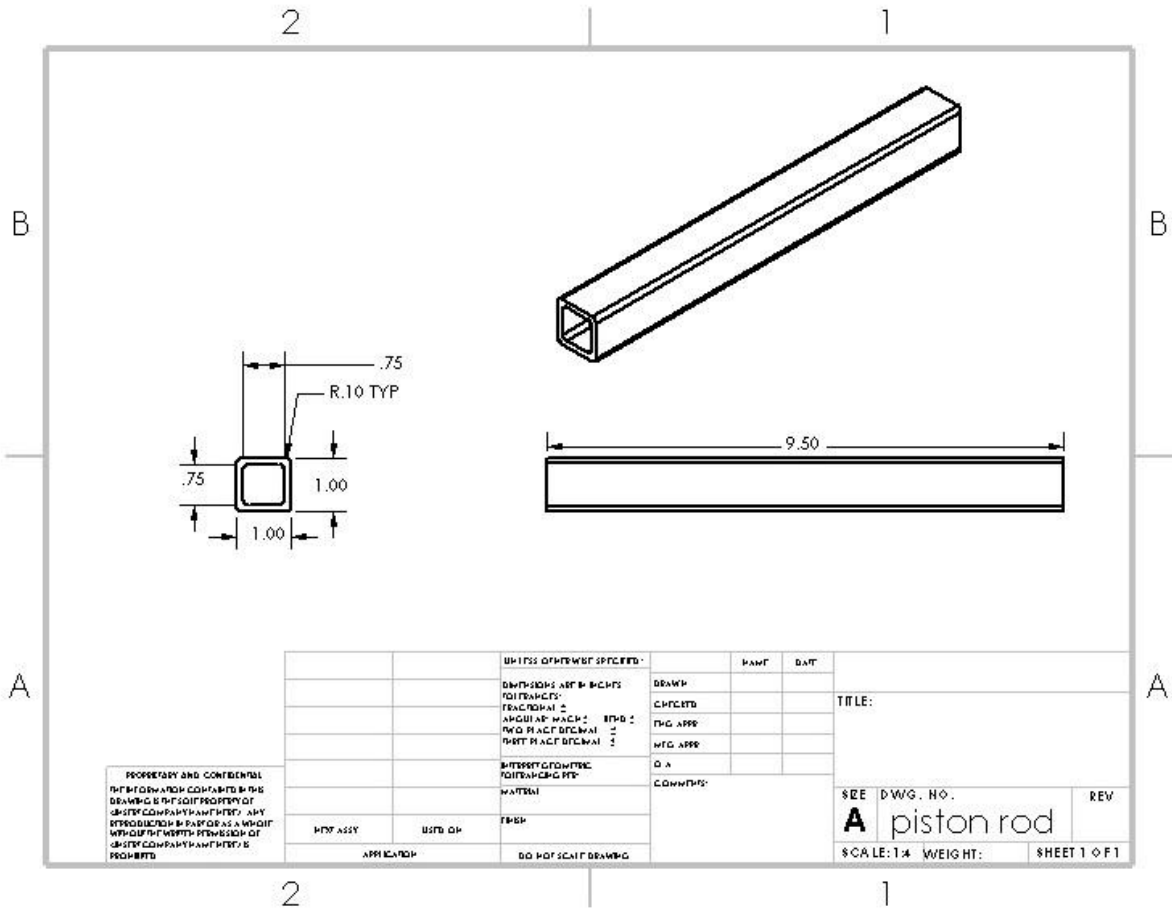


Figure B14: Pulley Mount

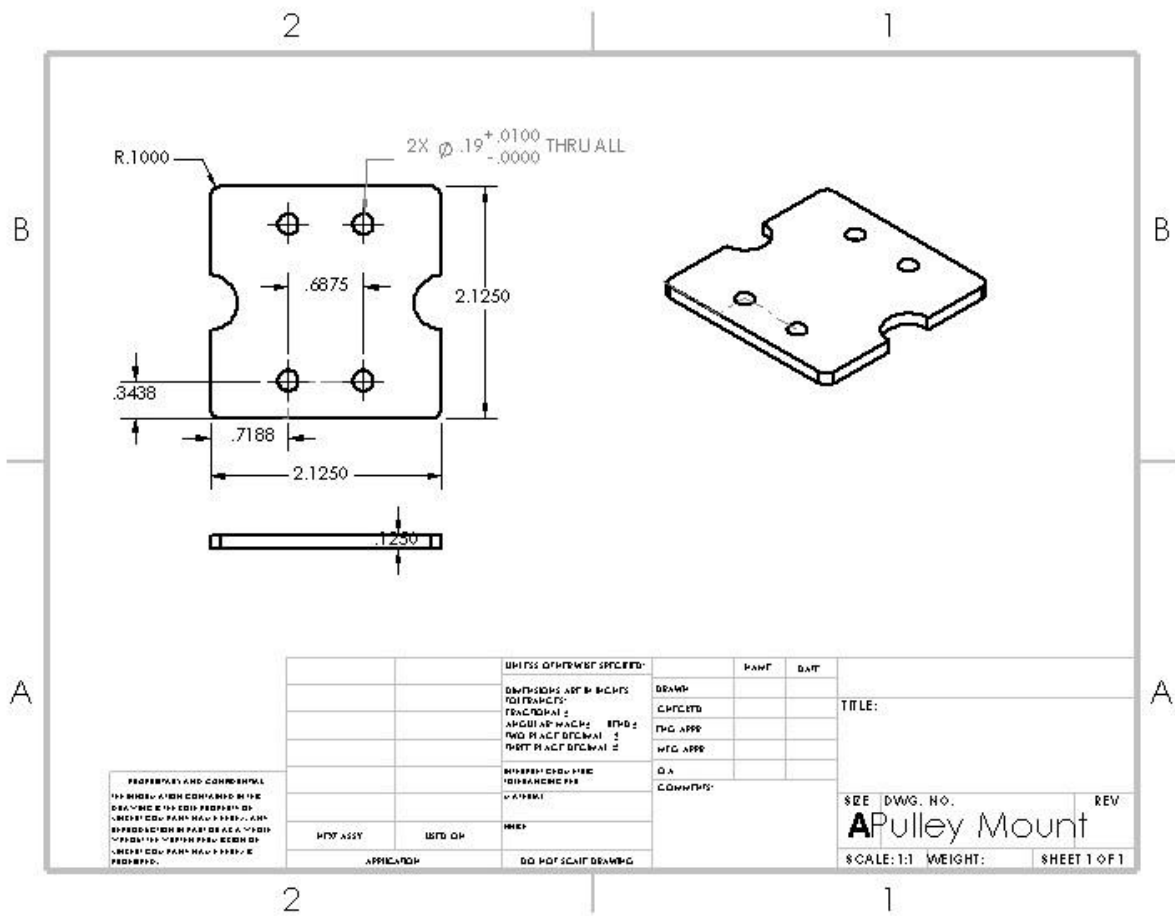
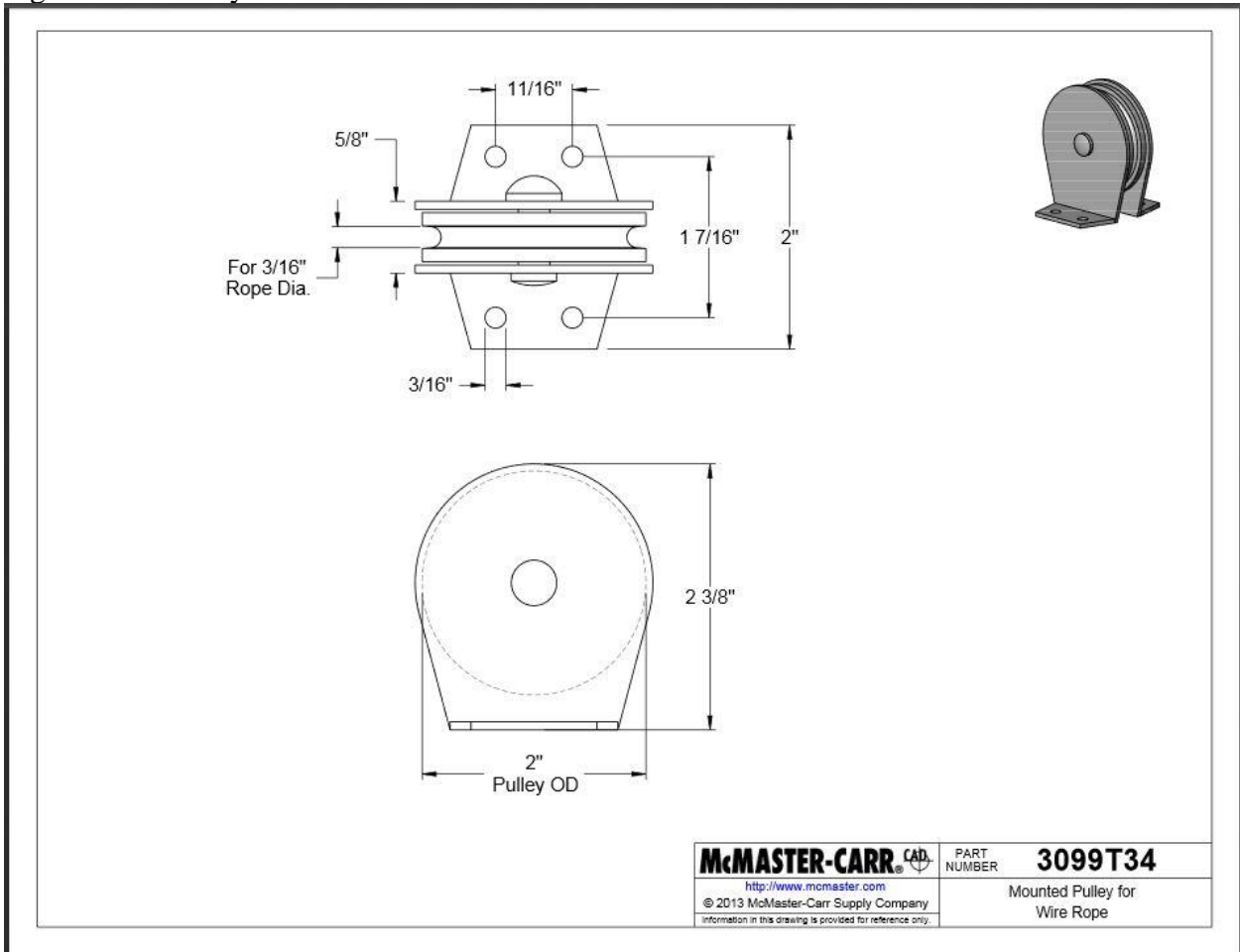


Figure B15: Pulley



Appendix C:
Parts list

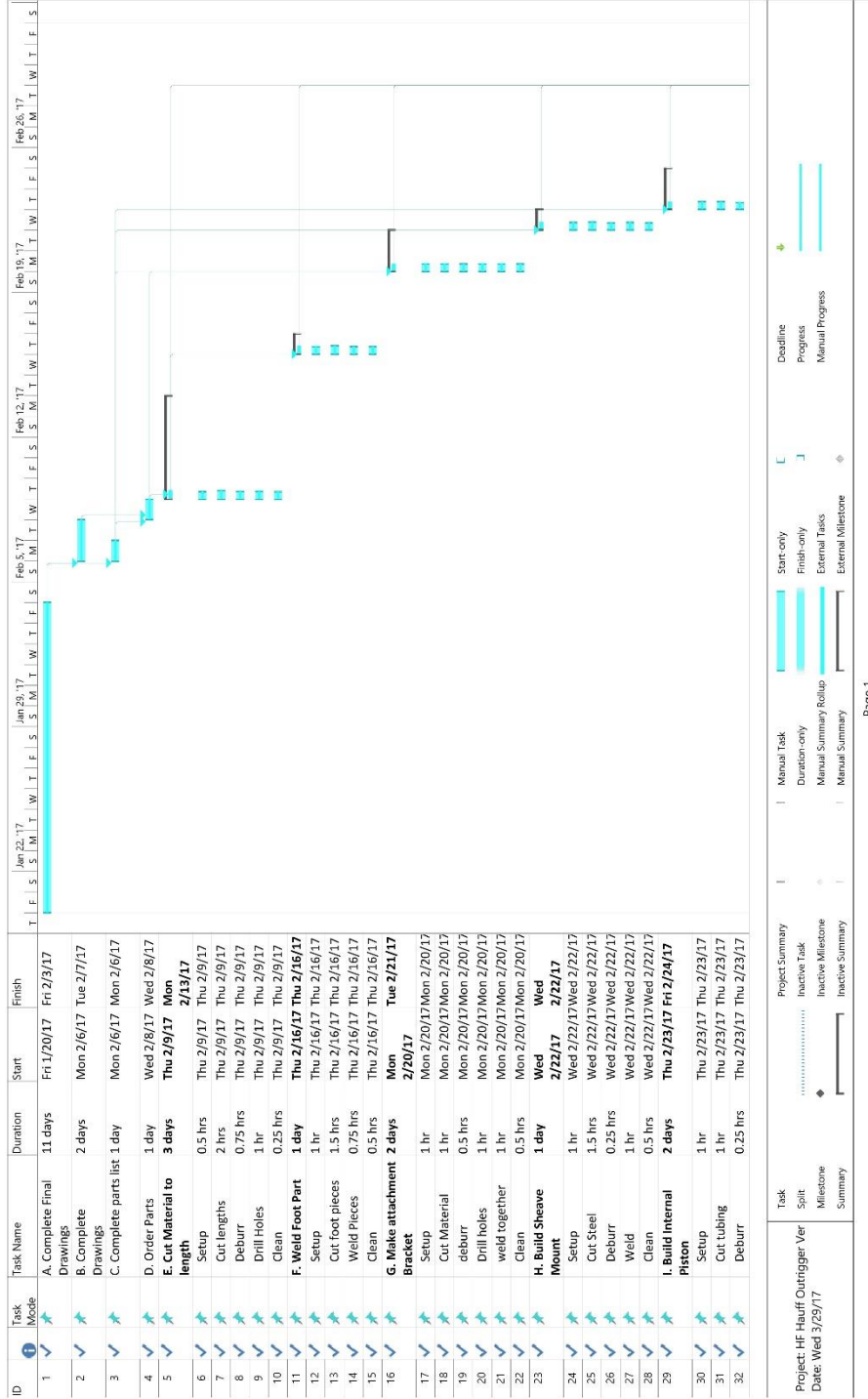
Source: MetalsDepot.com (steel), McMaster-Carr (pulleys nuts, and bolts)

Product Type	Dimensions	Price
A-500 Square tubing	2.5"x2.5"x.250" 6 ft.	\$103.02
	3"x3"x.250" 6 ft.	\$123.92
	4"x4"x.250" 6 ft.	\$173.84
	4.5"x4.5"x.250" 2 ft.	\$84.80
A-513 Square tubing	1"x1"x.125" 4 ft.	\$13.96
A-36 Steel Plate	4'x2'x.25"	\$122.48
Pulley	2" diameter for 3/16" wire (4 pcs.)	\$28.08
Bolts	8 count 1/2"-13 6" length partial thread Gd. 5	\$22.42
	4 count 1/2"-13 4" length partial thread Gd. 5	\$8.62
Nuts	25 count 1/2"-13 Flange nuts Gd. 5	\$7.73

Appendix D: Budget

Product Type	Dimensions	Price
A-500 Square tubing	2.5"x2.5"x.250" 6 ft.	\$103.02
	3"x3"x.250" 6 ft.	\$123.92
	4"x4"x.250" 6 ft.	\$173.84
	4.5"x4.5"x.250" 2 ft.	\$84.80
A-513 Square tubing	1"x1"x.125" 4 ft.	\$13.96
A-36 Steel Plate	4'x2'x.25"	\$122.48
Pulley	2" diameter for 3/16" wire (4 pcs.)	\$28.08
Bolts	8 count 1/2"-13 6" length partial thread Gd. 5	\$22.42
	4 count 1/2"-13 4" length partial thread Gd. 5	\$8.62
Nuts	25 count 1/2"-13 Flange nuts Gd. 5	\$7.73
Total		\$688.87

Appendix E: Schedule



ID	Task Mode	Task Name	Duration	Start	Finish	Jan 22, '17	Jan 29, '17	Feb 5, '17	Feb 12, '17	Feb 19, '17	Feb 26, '17	
						S	M	T	W	T	F	S
33	✓	Weld Sheave mount	1 hr	Thu 2/23/17	Thu 2/23/17							
34	✓	Clean	0.5 hrs	Thu 2/23/17	Thu 2/23/17							
35	✓	J. Assemble All Parts	3 days	Wed 3/1/17	Fri 3/3/17							
36	✓	Assembly	5 hrs	Wed 3/1/17	Wed 3/1/17							

Project: HF-Halff Outtrigger Ver
Date: Wed 3/29/17

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

Appendix F: Supporting Documents

Figure F1: Benchmark



Appendix G: Testing

H.F. Hauff Outrigger: Vertical Arm

By Juan Tovar

Function Test

Introduction:

The design of the vertical arm is constructed out of PVC. The actual device for real world application will be constructed out of steel. The PVC model can still be used to demonstrate the functionality of the device. The device has one internal pulley which may or may not have a mechanical advantage. Once the calculations located in the appendix are completed, it is proven that there is no mechanical advantage for the system. This test will gather data on the force put into the device and the force that is exerted. There should be a 1:1 ratio between force in and force out.

The test is to be conducted on April 10th. The schedule in appendix A4 outlines the timeline.

Method:

The testing method is for numerical data. The resources for this test are 2 different types of scales. One scale is a standard countertop digital scale and the second is a tension scale which has a hook used to attach to the device. The countertop scale will be placed vertically so that when the vertical arm extends, it puts a force against it. The tension scale will be attached to the cable. The test will be conducted 4 times.

Test Procedure:

The test will be conducted without the horizontal component. The test will be done horizontally on a counter or bench. The scale will need a backstop in order to rest the scale against it so it may read the force. There will be a pull scale on the cable as well. The cable will be pulled until the bottom of the vertical arm applies pressure to the scale. Both readings of the scales will be recorded. The test will be repeated 4 times.

In order to ensure that the data is accurate, a calibrated weight will be used to check the accuracy of the two scales. This will verify that the test is gathering data that can be used.

The test will occur in the Fluke Lab on Monday April tenth.

Resources:

Vertical arm

1 countertop digital scale

1 digital tension scale

1 5-kilogram calibration weight

1 3-kilogram calibration weight

Procedure:

1. Place scale on counter
2. Press tare and verify scale reads "0 g"
3. Place 5 kg weight on scale
4. Record reading
5. Repeat steps 2-4 three times to ensure precision
6. Hang tension scale
7. Press tare and ensure scale reads "0 lbs"

8. Hang 3 kilogram (6.6 lbs) weight on scale
9. Record reading
10. Repeat steps 7-9 three times to ensure precision
11. Place counter top scale vertically against wall on counter
12. Press tare and ensure scale reads "0 lbs"
13. Place vertical arm on counter horizontally
14. Attach tension scale to cable from the vertical arm
15. Press tare and ensure scale reads "0 lbs"
16. Pull cable with tension scale until vertical arm puts pressure on countertop scale
17. Record reading off of both scales
18. Reset vertical arm to compact position
19. Repeat steps 12-18 four times

Safety:

Wear safety glasses in the case of failure of the vertical arm. Potential of flying plastic debris.

Deliverables:

The test will yield two sets of data. They will be labeled Force in and Force out. The data can be used to determine the percentage of force which is lost in the system.

From the calculations of the mechanical advantage of the pulley system in the device, it was determined that there should be a 1:1 ratio between the force in and the force out.

The test will be successful if a full collection of data is gathered and the device functions properly to yield accurate readings. The accuracy of the scales will also determine the success of the test.

Conclusion:

The test was repeated 2 times. The first test was done with a different scale to measure the force out. A standard spring scale with a dial was first used. However, the results shown in appendix A2 demonstrates that there was a significant amount of loss in the system. The results discrepancies were attributed to two causes, accuracy of the spring scale, and the leftover epoxy on the surface of the device from manufacturing.

In order to yield more accurate data, the two causes were to be minimized. The scale was replaced with a digital scale, and both of the counters were tested for accuracy and precision. The device was also disassembled and each part was cleaned of excess epoxy and material to ensure proper function.

After the two causes of inaccurate results were mediated, the test was performed again and yielded data which was closer to calculated results.

Appendix:
A1: Calculated Values

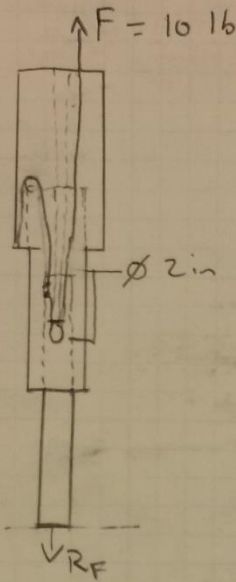
Juan Tovar

MET 495C

4-10-17

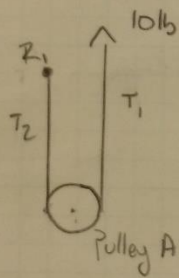
1/1

Given:

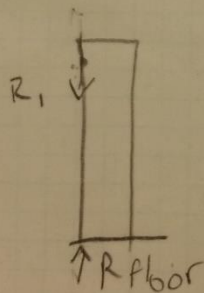


Find: Reaction

Soln:



$\sum F_y = 0$
 $T_1 = 10 \text{ lb}$
 $T_1 = T_2 = 10 \text{ lb}$
 $R_{\text{pulley}} = 20 \text{ lb}$
 $R_1 = T_2 = 10 \text{ lb}$



$R_1 = R_{\text{floor}} = 10 \text{ lb}$

$R_F = 10 \text{ lb}$

No mechanical advantage.

Trial	Tension on cable (lbs)	Force on Foot (lbs)	% Loss
1	10.026	516 1202	42.6
2	10.461	616 302	37.5
3	10.25	615	41.4

A3: Test 2

Juan Torar		MET 495C	4-24-17	1/1
	Force in (lb)	Force Out (lb)	% loss	
1	6.55	6.20	5.3%	
2	9.2	7.54	18%	
3	9.35	8.23	12%	
4	7.95	6.82	14%	

avg = 12.3% loss

A4: Gantt Chart

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	6 PM	Mon Apr 17 12 AM	6 AM	12
1	★	Gather Testing Supplies	15 mins	Mon 4/17/17	Mon 4/17/17					
2	★	Calibrate Scales	20 mins	Mon 4/17/17	Mon 4/17/17	1				
3	★?	Test tension scale	10 mins							
4	★?	Test pressure scale	10 mins							
5	★	Set Up Testing Area	10 mins	Mon 4/17/17	Mon 4/17/17	2FS+3 mins				
6	★?	Place scale vertical	3 mins							
7	★?	Attach tension scale	3 mins							
8	★?	set up Vertical arm	6 mins							
9	★	Perform test	15 mins	Mon 4/17/17	Mon 4/17/17	5				
10	★	Clean up test station	10 mins	Mon 4/17/17	Mon 4/17/17	9				

A5: Calibration Pictures





Appendix J: Resume

Juan Tovar

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Education **Central Washington University** | Ellensburg, Washington | 2013 – Current

- Bachelor of Science in Mechanical Engineering Technology (BSME)
- Cumulative GPA: 3.9/4.0
- Anticipated date of graduation: Spring 2017
- Relevant coursework: Statics, Dynamics, Engineering Analysis, Mechanics of Materials, Fluid Mechanics, Dynamics of Machinery, Measurement and Instrumentation, Industrial Processes, Elements of Material Engineering, Machine Design, Mechanical Vibrations, Thermal Systems Laboratory, and Heat and Mass Transfer

Memberships **CWU Cycling Team** | Ellensburg, Washington | 2013 – Current

- President
- Cyclist on team
- Participate in five or more competitions per year throughout the northwest and northern California
- Participate in five or more volunteer events per year

Employment **REI** | Seattle, Washington | 2011 – 2014

Safeway | Leavenworth, Washington | 2010 – 2011

2010 – 2011 **Mission Ridge Ski and Snowboard Resort** | Wenatchee, Washington |

Skills **Competencies and Software**

- Knowledgeable of various materials (e.g., aluminum, carbon and steel) and manufacturing processes
- Proficient in use of the following tools: Lathes, vertical mills, horizontal mills, angle grinders, plasma cutters, oxy-acetylene torches, arc welders, grinders, shears, drill press, and chop saws
- Native English speaker fluent in Spanish (reading, writing, and conversation)
- Excels at working independently as well as part of a team
- Strong background in customer service
- Proficient in Microsoft Excel, Microsoft PowerPoint, and Microsoft Word
- Competent in AutoCAD, SolidWorks by Dassault Systems (Similar to Catia)