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Outrigger Project

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Out Rigger Project

By

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In Collaboration With:

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INTRODUCTION

Description

A windmill is connected to a platform. The platform itself doesn't have enough area or weight to counter the wind force on the windmill in order to keep it upright. Engineering could help solve this problem because a device is needed to be designed to help stabilize the platform.

Motivation

This project was motivated by a need for a device that would counter the wind force on a windmill and help stabilize a windmill to keep it upright.

Function Statement

The device will stabilize the platform.

Requirements

- The device will counter 24,250 lbft of wind force.
- The device will extend to a total width of 16 feet.
- The device will contract to a total width of 7 feet.
- The device must weigh no more than 800 lbs.
- The device costs no more than $2500 to manufacture including materials costs.

Success Criteria

The device stabilizes the platform. The device weighs less than 800 lbs. The device fits in the grape vineyard rows. The device costs less than $2500 total.

Scope of this Effort

The scope of this project will be the boom for the outriggers.

Benchmark

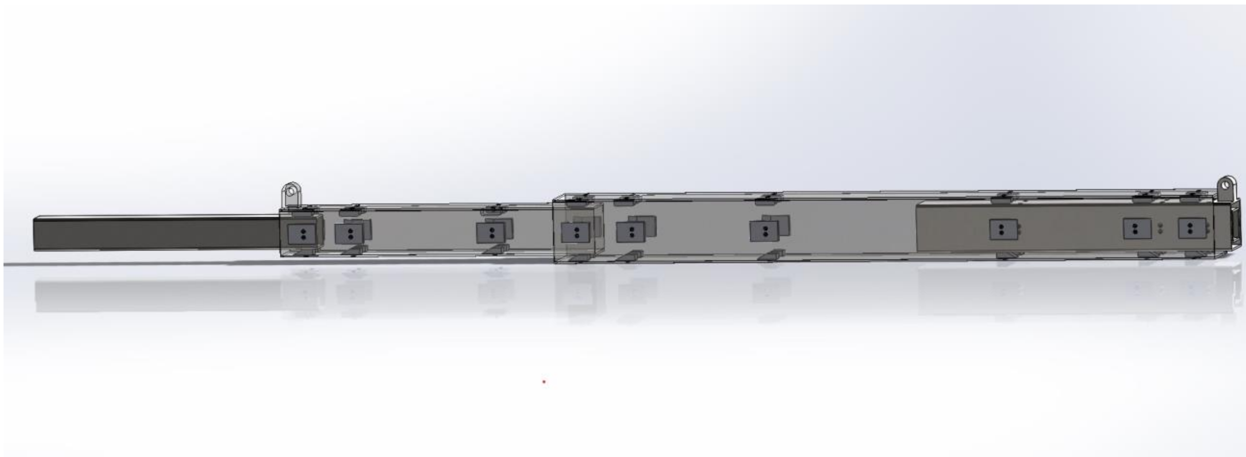
There are genie forklifts that are able to lift 5000+ pounds up to 50+ feet in the air. In order to be able to lift something that high and still be able to retract to an overall length of about 10-15 feet, genie utilized a device known as a mechanical multiplier. This project will utilize this device as a max of 7 feet is needed in order to be able to move the platform in between the orchard rows.

Success of this Project

Success of the project would be if the platform is stabilized, the device weighs less than 800 pounds and costs less than $2500 to manufacture including materials costs.

Design and Analysis

This design was conceived with the help of Neil Hauff and through some research on the Genie GTH844 and the grove crane's mechanical multiplier designs. The design will utilize hydraulics to push the middle boom outwards while using a chain and sprocket to push the smallest boom out at the same time the middle boom is being pushed out. The design will also consist of wear pads made of Delrin Acetal Resin.



One of the requirements was for the device to be able to extend to a total length of 16 ft. This was calculated by using a summation of moments about one of the edges, first neglecting the weight of the device (refer to appendix A-1). Since the device was calculated to weigh approximately 13.8% of the wind machine with the platform, a correction of the length of the boom was calculated (refer to appendix A-2). One of the other requirements was for the device to weigh less than 800 pounds. For this to be possible, material designation was necessary. First, the max stress was calculated using the flexure formula at each desired length. By finding the max stress certain lengths would see, material designation was possible (refer to appendix A-3 and A-4).

The device will be able to extend to the calculated total distance of 16 ft in approximately 45 seconds to stabilize the system and will weigh less than 800 lbs.

Methods and Construction

This project was conceived through Professor Pringle, Dr. J, and Dr. Choi. The design was suggested by Neil Hauff. This project was designed at CWU. Most of the parts can easily be found on the market without too much modification needed. Parts will be made and modified at CWU and at H.F. Hauff.

The device will be built in sections. First, wear pads will be bought. Next, holes will be drilled and counterbored into the 8x8 square tube. Once the holes are drilled, the wear pads will be screwed into that square tube. After that, the same process will be performed on the 6x6 square tube. A chain will be attached to the top of smallest boom and will be attached to the top of the largest boom. The 6x6 square tube will go inside of the 8x8 square tube. The 3.75x3.75 square bar will go inside of the 6x6 square tube. The chain will be guided using the wear pads and the sprockets. A hydraulic will attach to both side via the 6x6 square tubes.

The device should operate together as a system. The chain will pull the smallest boom out as the middle boom gets pushed out by the hydraulic. The legs will lower as the smallest boom extends further out.

This device will work automatically compared to the standard manual hand cranked device and will require less human strength to set up in the orchards.

This device will work up to 90% more automatically than the standard manual hand cranked device. It will require up to 95 % less human strength to set up in the orchards.

Neil didn't like the design too well as the wear pads were "too big", the device would be too heavy because of the 3.75x3.75 square bar, and not enough of the inner tubes were inside of the outer tubes. The initial design consisted of about 4 inches of the inner tube would be inside of the outer tube. The resolution to those problems was to first; instead of the 3.75x3.75 square bar, a 7x7 square tube would be used. This 7x7 tube would be used in place of the 6x6 tube and the 6x6 tube would be used in place of the 3.75x3.75 square bar. By doing this, it solved the weight issue and the wear pad issue. It decreases the total weight by about 100 pounds, and it decreased the wear pad thickness to approximately .45 inches. The initial thickness for the wear pads was about 1 inch. The next change was to get 42-inch-long tubes. The initial design consisted of 36-inch-long tubes as the initial plan was to get the tubes in standard sizes as to not have to cut them to size. This change will add an extra 6 inches of tube inside of the outer tubes, so instead of only 4 inches of inner tube inside the outer tube, it would be 10 inches.

There were some design changes in order to first make a scale model to prove the concept. The scale model will be approximately $1/4^{th}$ of the original model, except there was a change in one of the tube sizes. The main tube was originally 2x2. That tube was changed to a 3x2 for it to have space for the wire rope to feed through. In order to manufacture the parts that were needed for the scale model. Neil took it upon himself to have some of his workers cut out some parts with a CNC laser out of sheet metal as the tube sizes with the wall thicknesses that had been specified on the drawings weren't readily available. In cutting the sheet metal, some of the holes were also cut out with the laser. His workers then bent the sheet metal that had been cut out and welded them together. In welding the sheet metal parts together, some of the parts were oriented incorrectly and in return, some of the features were in the wrong place. This will be fixed by making the features in the correct locations. This will consist of only drilling a few holes where they were designed to be. There was a modification in the hole sizes, so all holes had to be drilled again to the new size. This change was made so the stubs on the wear pads could be made a little bigger and have higher strength. The wear pads were manufactured with the help of Professor Pringle and his skills setting up the 3d printer. Pins were made with some quarter inch round steel stock that was purchased at a local store. Pulleys are being considered of being made of the same round stock. Pins were made in a manual lathe. Pulleys will also be made in a manual lathe. Assembly will start once all the parts have been manufactured.

Testing Methods

Test Plan:

A tape measure will be used in order to test for the total length of the device fully extended. The tape measure will also be used to test for the total length of the device fully retracted. A commercial scale will be used to test for the total weight of the device. Receipts will be kept, and prices of materials will be recorded as backup incase a receipt is lost to be able to figure out the final cost of the project.

Since a scale model must be made to prove the concept before the actual device can be made, testing methods will remain the same. However, testing requirements will change to accommodate the size difference. The weight requirement for the scale model will be to weight less than 50 lbs. The overall length requirement will change to extend to a total width of 4 ft and contract to a total width of 2 feet. Due to the exponential difference in cost due to size difference, the scale model will cost no more than $120 to complete. There will be no counter the wind thrust requirement as this scale model will be made only to prove the concept of a hydraulic pushing out a tube and a chain (wire rope in the scale model) pushing out another tube.

For the first test, the overall contract length was measured for the scale model. The requirement for this is for the device to contract to a max of 2 feet or 24 inches. After doing multiple measurements from different points of the device. An average of 25.5 inches was achieved, which is 1.5 inches over the requirement. For this test, the scale model did not pass. For the second test, weight was measured using a scale. The weight requirement is for the device to weight no more than 50 lbs. Multiple similar measurements were taken. The average of these measurements was 10.8 pounds, which is 39.2 pounds under the 50-pound weight requirement. The third test was like the first, except this time the device was measured from end to end with the device fully extended. The requirement for this test is to extend to a minimum of 4 feet or 48 inches. The device was able to achieve a total length of 52 inches, which is 4 inches over the minimum required. For the final test, the requirement was for the device to cost no more than $120. By looking at an excel spreadsheet where the prices of everything that went into the device was kept. The final price for the device was $108.72, which was $11.23 under the requirement. The device met all but 1 requirement. To meet that requirement, about .8 inches of the main tube would have to be cut. Even then, the device will meet all of the other requirements.

Budget/Schedule/Project Management

This project is susceptible to a few primary risks: cost, schedule, and transportation.

Cost and Budget:

A parts list is provided in Appendix C. The parts list provides the parts identification, description, sources and cost as shown in Appendix D.

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

Some of the parts will require welding as well as machining.

Labor cost will not be included in the budget but will correlate to the time shown in the schedule. Rates for welding are estimated at $80 an hour and machine shop rates are estimated at $70 an hour.

The total cost of this project is estimated to be $2500. This includes materials cost, welding cost and machine work costs.

The budget for the actual device hasn't been touched because a proof of concept scale model had to be built first. The scale model will be built in order to prove that the actual device will work without the high cost. It can be estimated that the scale model will cost between $60 and $80 depending on the materials that are chosen for it. As of right now, $38 have been used on the scale model. This only includes the cost of the tubes. It is estimated that an extra $6 will be used for 3d printed wear pads and hydraulic mounts, an extra $15 for drilling the holes and machining the features that need to be machined in the tube, and about $15 for wire rope and pulleys. Once the scale model is finished and has proven the concept, the actual device will be ready to be built and the actual budget will be in use. If the sponsor wants to do so.

Schedule:

The scheduling issue has to do with whether the materials will come in on time. It will also have to do with the availability of the machine shop and whether a place to weld some of the parts can be found. This project will be completed by the last week of the second quarter.

Milestone:

The materials will be here by the end of the first week of the second quarter at latest. The 8x8 square tube will be drilled, counterbored, and have wear pads installed by the end of the second week of the quarter. The same process will occur on the 6x6 square tube as well as welding some sprocket mounts and the hydraulic mount and will be completed by the end of the fourth week. The device should be completed by the eleventh week of the quarter.

TRANSPORTATION:

The transportation issue has to do with not being able to make trips to Yakima and back to Ellensburg due to not having enough money to do a weekly fuel refill or to buy a weekly commuting pass.

The scheduling issues that have happened so far were; having to design and make a scale model which resulted in pushing the original device manufacturing process back quite a bit if not aside, having to re-drill some holes due to some features being in the wrong location and also due to wanting a thicker stub on the wear pads and hydraulic mounts. A small scheduling issue that occurred was that the wear pads and hydraulic mount took longer to 3d print than expected. There was also an issue with the diameter of the stubs on all parts as it was varying quite a bit and had to be sanded down which took at least 2 days. This resulted in a delay of assembling all the parts together and finish up the scale model.

Discussion

This project has evolved from the primary design due to lack of knowledge. The initial design consisted of a 4x4 square tube assigned as the biggest of the tubes followed by a 3x3 square tube and a 2x2 square tube. These tubes are not big enough to incorporate the use of wear pads and wouldn’t be able to handle the max stress that the device would be seeing. The initial design also consisted of slots that needed to be machined out of the square tubes which would require hours of machine shop time which in turn would raise the total cost of the project. The initial design also did not use a chain and sprocket to pull the smallest boom out to the desired extended length. The initial length was calculated to 5.4 ft per side for a total length of 17.8 ft. The optimized length was calculated to be 4.5 ft per side for a total length of 16 ft.

There were a few issues that arose prior to the manufacturing process. These issues involved; Neil not liking certain parts of the design, therefore, delaying the manufacturing process until they were fixed, having to design a scale model in order to prove the concept before getting the thumbs up for the original size device, and lack of local resources, which meant having to fabricate some of the tubes themselves. The parts that Neil didn’t like, were improved upon and he was satisfied with the improvements of the device. Neil took it upon himself and his workers to get the tubes fabricated. During the fabricating process, some of the parts that the tubes were made of were orientated incorrectly, resulting in certain features being in the wrong location. In order to correct this, the features had to be machined again, but this time, in the right place. Another issue that was had was that the stubs on the wear pads and the hydraulic mount for the scale model were too small and needed more material so they wouldn’t break off too easily. This issue was resolve by drilling bigger holes in the tubes and changing the design of the wear pads and hydraulic mount to have bigger stubs.

A new issue arose regarding the wear pads. The pegs on the wear pads that are supposed to go into the holes that were drilled into the tubes were breaking off. The solution to this issue will be to use super glue. About two thirds of the wear pads that were requested from professor

Pringle, no longer have pegs. It was decided to have the bottom of the wear pads sanded down as to make an even surface so the super glue could make maximum contact with the wear pad and tube. Even the wear pads that still have the pegs will be super glued into place for added strength. Another issue had to do with the wire rope and how it would be mounted in the tubes. After consulting for a few minutes with Dr. Johnson, a solution to this problem was found. To resolve this problem, a hole would be drilled on either side of the largest tube. The wire rope will be fed from the inside to the outside through the hole. On the outside of the tube, the wire strands will be pulled apart, twisted together and soldered so it won't be able to fit through the hole.

Testing was done on the one fourth scale device. The requirement for minimum extended length is 48 inches for the one fourth scale model. The device passed by having a minimum extended length of 51 inches. The requirement for the max retracted length is 24 inches. The device failed with a max retracted length of 25.5 inches. The requirement for the weight of the device was to weight no more than 50 pounds. The device passed with a weight of 10.0 pounds exactly. The cost requirement for the device was to be no more than 120 dollars. The device passed by costing 102 dollars. The only issue with testing was looking for the receipts and finding similar parts online for parts that weren't personally purchased in order to get the price. There were no other issues with testing.

There was only one issue with testing until a test that wasn't on the test plan was done. This test was to find the max weight that the device could support. Before the test could begin, a few modifications were done to the device, adding aluminum blocks between the legs and middle tubes. This had to be done due to the parts being over machined in the manufacturing process. In order to do this test, a subject weighting approximately 164 pounds stood on the device. The subject was able to stand on the device for about 5 seconds before the wear pads gave out.

Conclusion

A design for the device required to help stabilize a wind machine with a mobile platform has been conceived. Parts for this project have been specified and budgeted (refer to Appendix C and Appendix D). With this information, the device is ready to be manufactured.

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

1. Having substantive engineering merit in calculating max stress, max deflection, chain size and chain sprocket design.
2. Weight and cost within the parameters of the resources.

Acknowledgements

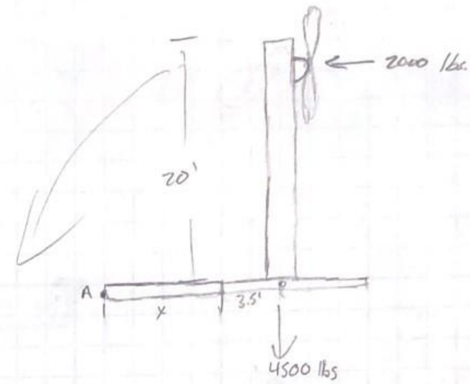
H.F. Hauff Sponsored this project.

Neil Hauff, Professor Pringle, Dr. Johnson, and Dr. Choi mentored the principal engineer in the design and calculations. Tyler Hoffman helped finalize the design.

Appendix A

A-1: Length of Boom

Given: F = 2000 lbs of thrust
Height = 20'

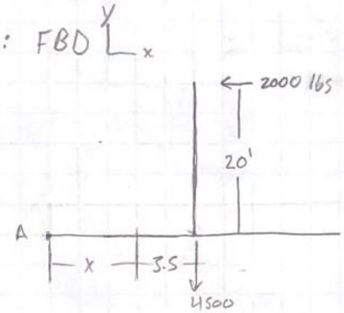


Find: Length of Boom

Assume: Total weight = 4500 lbs, neglect total weight of Boom

Method: 1) FBD 2) Moments about A
3) Solve for X

Solve: FBD



Moment about A

$$\Sigma M_a = -4500 \text{ lbs} (x + 3.5') + 2000 \text{ lbs} (20') = 0$$

$$= -4500x - 15{,}750 \text{ lb·ft} + 40{,}000 \text{ lb ft} = 0$$

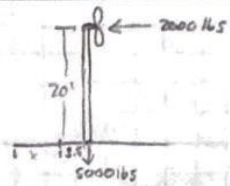
$$= \frac{4500x}{4500} = \frac{24{,}250 \text{ lb ft}}{4500 \text{ lb}} \longrightarrow \underline{x = 5.4 \text{ ft}}$$

A-2: Correction on Length of Boom

Correction on Length of Boom

1/1

Given: F = 2000 lbs of thrust
Height = 20'



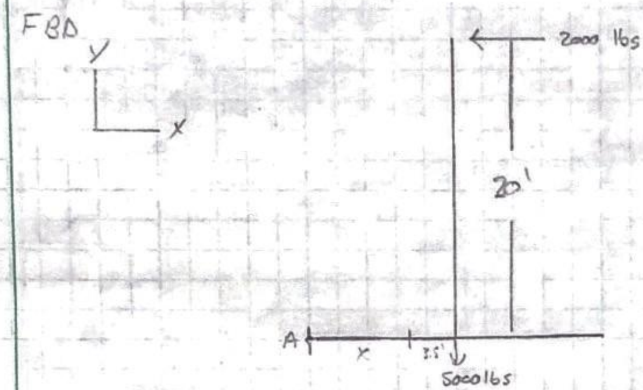
Find: Length of Boom

Assume: weight of Boom = 500 lbs
Weight of Wind machine + Platform = 4500 lbs

Methods: 1) FBD
2) ΣM_A
3) Solve for x

Solve:

FBD



ΣM_A

$$\Sigma M_A = 2000\ lbs\ 20\ ft - 5000\ lbs\ (x + 3.5\ ft) = 0$$
$$= 40000\ ft\ lbs - 17{,}500\ ft\ lbs - 5000x\ lbs = 0$$
$$= \frac{22500\ ft\ lbs}{5000\ lbs} = \frac{5000x\ lbs}{5000\ lbs}$$
$$\boxed{4.5\ ft = x}$$

A-3: Max Stress, Material Designation

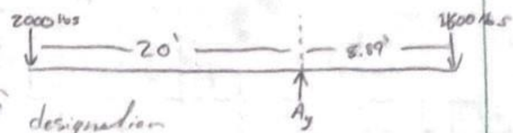
Max Stress | Material | Designation 1/2

Given: Picture shown

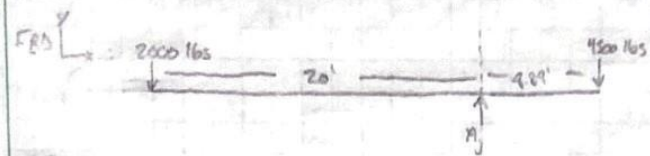
Find: Max stress, Material

Assume: Wind thrust in y direction

Method: 1) FBD, 2) Add forces in y direction 3) V/m 4) Flexure 5) material designation



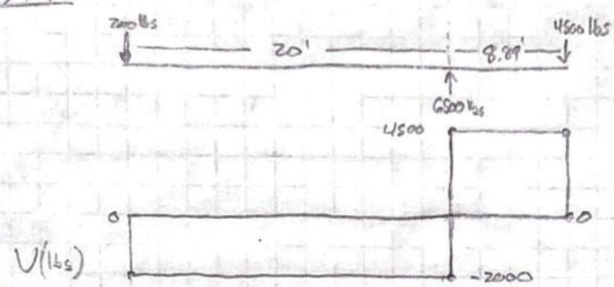
Solve:

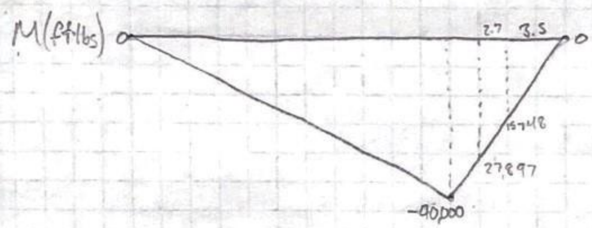


Add forces in y direction

$$\Sigma F_y = 0 = -2000\,lbs - 4500\,lbs + A_y \rightarrow A_y = 6500\ lbs$$

V/M





Flexure

$$\sigma = \frac{MC}{I}$$

$I = 70.7\,in^4$ from table 1514 pg 823

$$M = 15{,}748\ ft\,lbs\left(\frac{12\,in}{1\,ft}\right) = 188{,}976\ in\,lbs$$

$$\sigma = \frac{188{,}976\,in\,lbs\,(4\,in)}{70.7\,in^4} = 10{,}691.7\,psi = \boxed{10{,}700\ psi}$$ @ 3.5 from center of platform

2/2

$\underline{I = 28.6}$ from table 15-14 page 823

$M = 27{,}897\ ft\cdot lbs \left(\frac{12\ in}{1\ ft}\right) = \underline{334{,}764\ in\ lbs}$

$\sigma = \frac{334{,}764\ in\ lbs\ (3\ in)}{29.84\ in^4} = 33654\ psi = $ **33,700 psi @ 5.2' from center of platform**

$I = \frac{4^4}{12} = \underline{21.33\ in^4}$

$M = 40000\ ft\ lbs \left(\frac{12\ in}{1\ ft}\right) = 480000\ in\ lbs$

$\sigma = \frac{480000\ in\ lbs\ (2\ in)}{21.33} = 45{,}007.03\ psi = $ **45,000 psi @ 8.9 ft from center of platform**

Material designation

HSS 8×8 = Aluminum 6061 T6

HSS 6×6 = low Carbon steel

4×4 = low Carbon steel

A-4: Correction on Max Stress, Material Designation

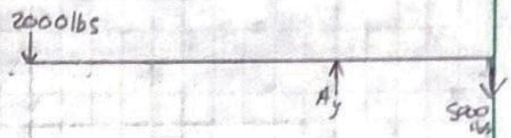
Correction on | Max Stress | Material Designation | 1/2

Given: Picture Shown

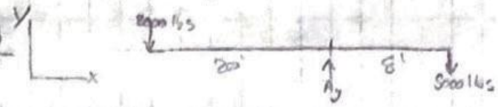
Find: Max Stress, Material

Assume: Wind thrust in y-direction
Material Homogenous

Methods: 1) FBD 2) ΣF_y
3) V/M 4) Flexure
5) Material designation



Solve: FBD



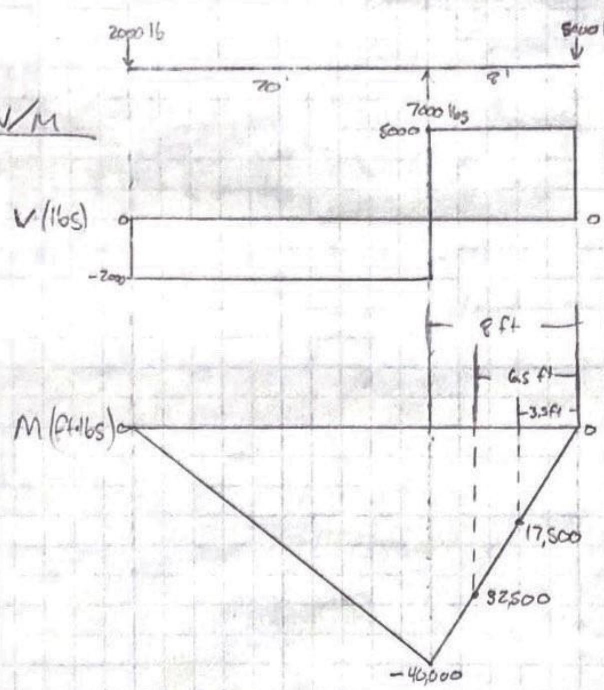
ΣF_y

$\Sigma F_y = -2000 \text{ lbs} - 5000 \text{ lbs} + A_y = 0$

$= -7000 \text{ lbs} + A_y = 0$

$= \boxed{7000 \text{ lbs} = A_y}$

V/M



Flexure

$\sigma = \frac{MC}{I}$

$I = 70.7 \text{ in}^4$ from table 15-14 A, B23

$M = 17{,}500 \text{ ft lbs} \cdot \frac{12 \text{ in}}{1 \text{ ft}} = 210{,}000$

$\sigma = 210{,}000 \ldots$

$I = 28.6$ from table 15-14 pg 823

$M = 32500 \text{ ft·lbs} \left(\frac{12 \text{ in}}{1 \text{ ft}}\right) = 390000 \text{ in lbs}$

$\sigma = \frac{390000 \text{ in lbs} (3 \text{ in})}{28.6 \text{ in}^4} = 40{,}909.01 \text{ psi} =$ **41 ksi @ 6.5 ft from center of platform**

$I = \frac{3.75^4}{12} = 16.48 \text{ in}^4$

$M = 40{,}000 \text{ ft·lbs} \left(\frac{12 \text{ in}}{1 \text{ ft}}\right) = 480{,}000 \text{ ft·lbs}$

$\sigma = \frac{480000 \text{ in lbs} (1.875 \text{ in})}{16.48 \text{ in}^4} =$ **54,613.33 = 54.62 ksi @ 8 ft from center of platform**

<u>Material Designation</u>

HSS 8×8×1/4 = Aluminum 6061 T6

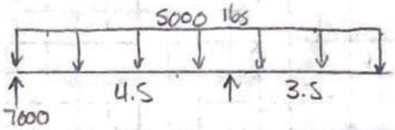
HSS 6×6×1/4 = Low Carbon Steel

= Low Carbon Steel

A-5: Max Deflection

Beam Deflection 1/1

Given: Picture shown



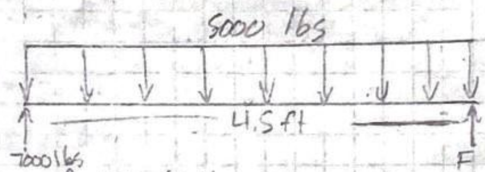
Find: Max Deflection

Assume: Uniform Load on Beam
$I = 28.6\ in^4$

Method: 1) FBD 2) Modulus of Elasticity for materials
3) Max Beam Deflection

Solve:

FBD



Modulus of Elasticity

1018 CD = 29 Msi

Max Beam Deflection

$E = 29\ Msi$ $I = 28.6\ in^4$ $\omega = 5000\ lbs$ $L = 4.5\ ft$ $W = 22500\ lbs$

Using Formula d from table A14-1 in Mott

$$Y_{max} = \frac{-5\omega L^4}{384EI} = \frac{-5(5000)(4.5)^4\left(\frac{12\ in}{1\ ft}\right)}{384(29\times10^6)\,28.6} = \boxed{-.67\ inches}$$

A-6: Hydraulic Power Needed To Push/Pull Moving sections

Hydraulic Power | Need to Push | Booms out

Given:

Find: Required hydraulic Power needed to push Booms out

Assume: Wear pads have dirt, Friction coefficient for Low carbon steel on dirt = .49, weight of section to move = 350 lbs
Cylinder Bore diameter = 2.54in, Piston Rod diameter = 1.57in
$N = 2$

Method: 1) Frictional Force 2) Push/Pull Force 3) Safety Factor

Solve:

Frictional Force

$$F = \mu_k N$$
$$= .49\,(350\text{ lbs})$$
$$= 171.5\text{ lbs}\ (2\text{ sections}) = 343\text{ lbs}$$

Push Force

$$\text{Push Force} = \frac{\text{Psi}\,\pi\, d^2}{4}$$ where $\text{Psi} = \text{lb}/\text{in}^2$ & d = Cylinder bore diameter

$$\text{Psi} = \frac{\text{Push Force}\,(4)}{\pi\, d^2} \rightarrow \text{Psi} = \frac{343\text{ lbs}\,(4)}{\pi\,(2.54\text{ in})^2} = \underline{67.7\text{ psi}}$$

Pull Force

$$\text{Pull Force} = \frac{\text{Psi}\,(\pi)\,(d^2 - r_d^2)}{4}$$ where r_d = Piston rod diameter

$$\text{Psi} = \frac{\text{Pull Force}\,(4)}{\pi\,(d^2 - r_d^2)} \rightarrow \text{Psi} = \frac{343\text{ lbs}\,(4)}{\pi\,(2.54\text{ in}^2 - 1.57\text{ in}^2)} = \underline{104.54\text{ Psi}}$$

Safety Factor

Hydraulic Pressure = Psi N → Hydraulic Pressure = 109.54(2)

→ **Hydraulic Pressure = 220 psi required to Push and pull moving Sections of the Device**

A-7:

A-8:

A-9:

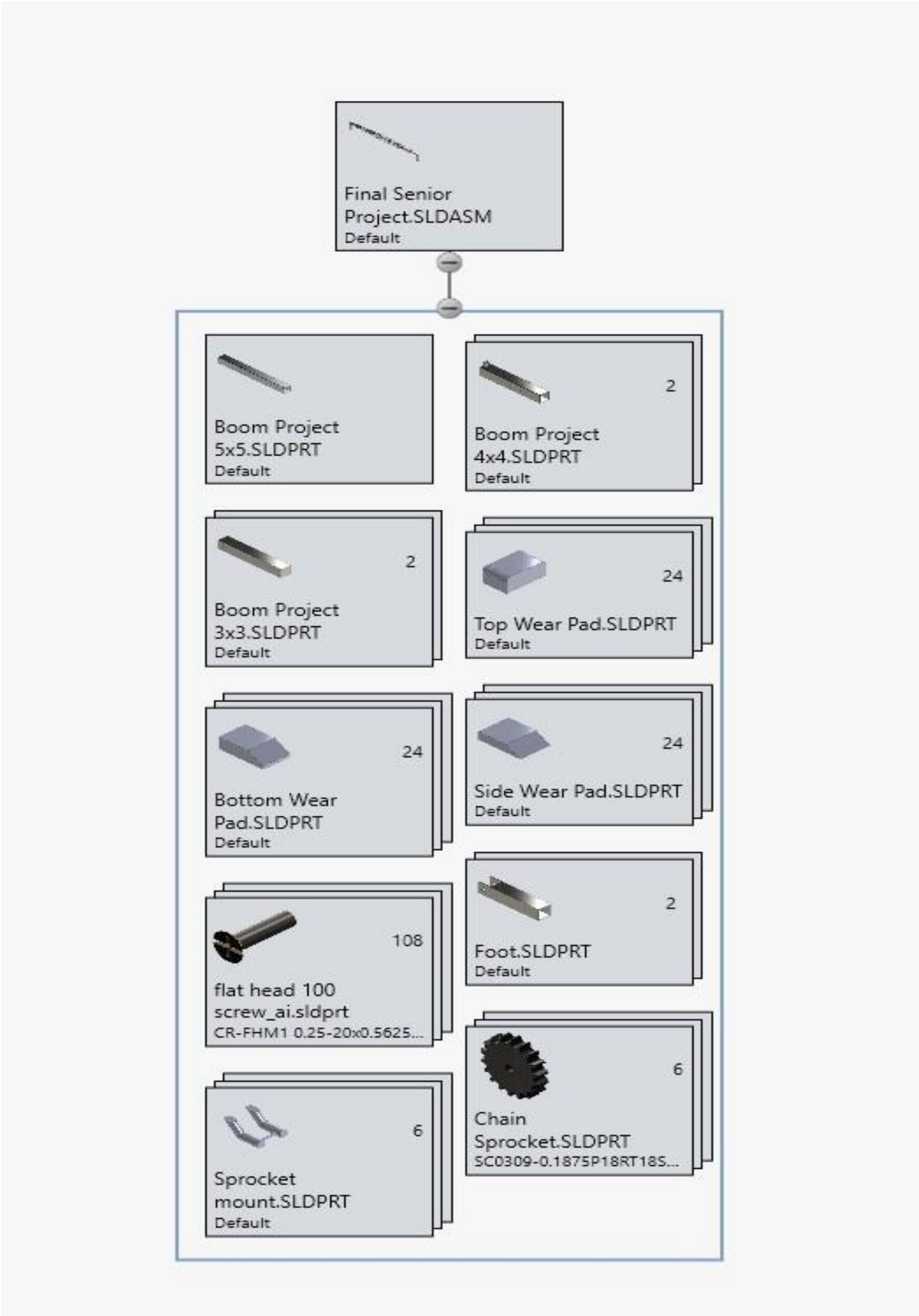
A-10:

A-11:

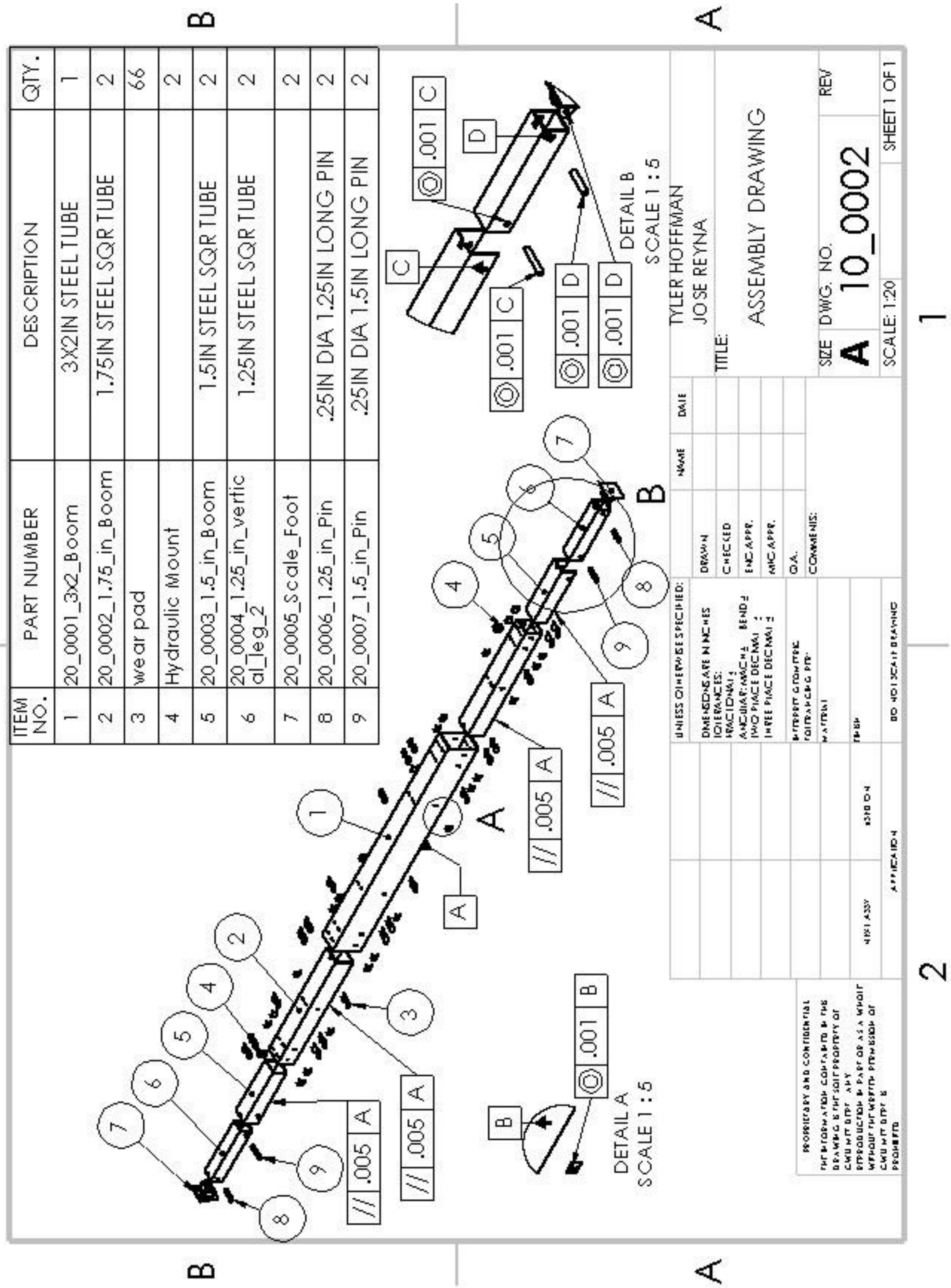
A-12:

Appendix B

B-1: 10-0001

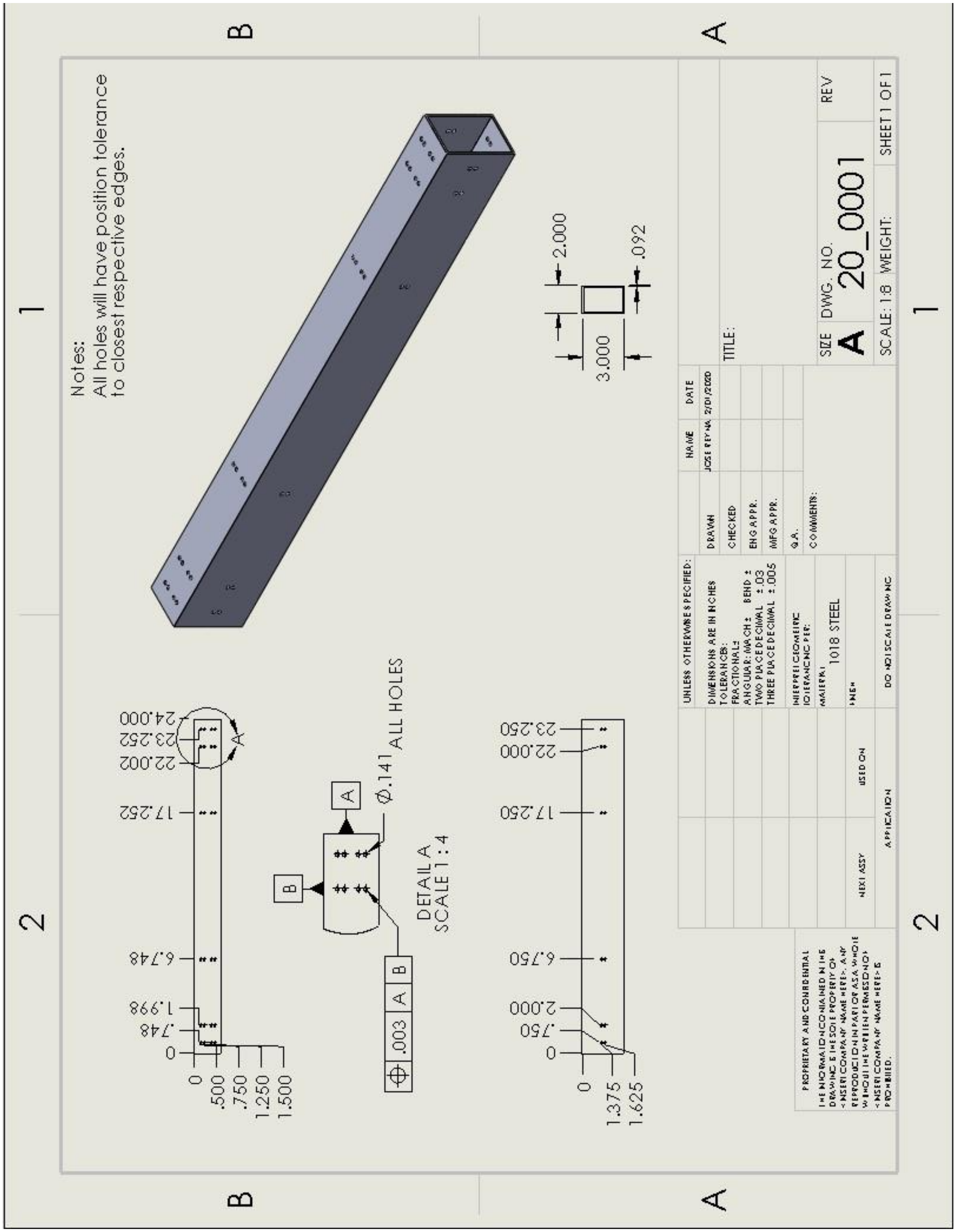


B-2: 10-0002

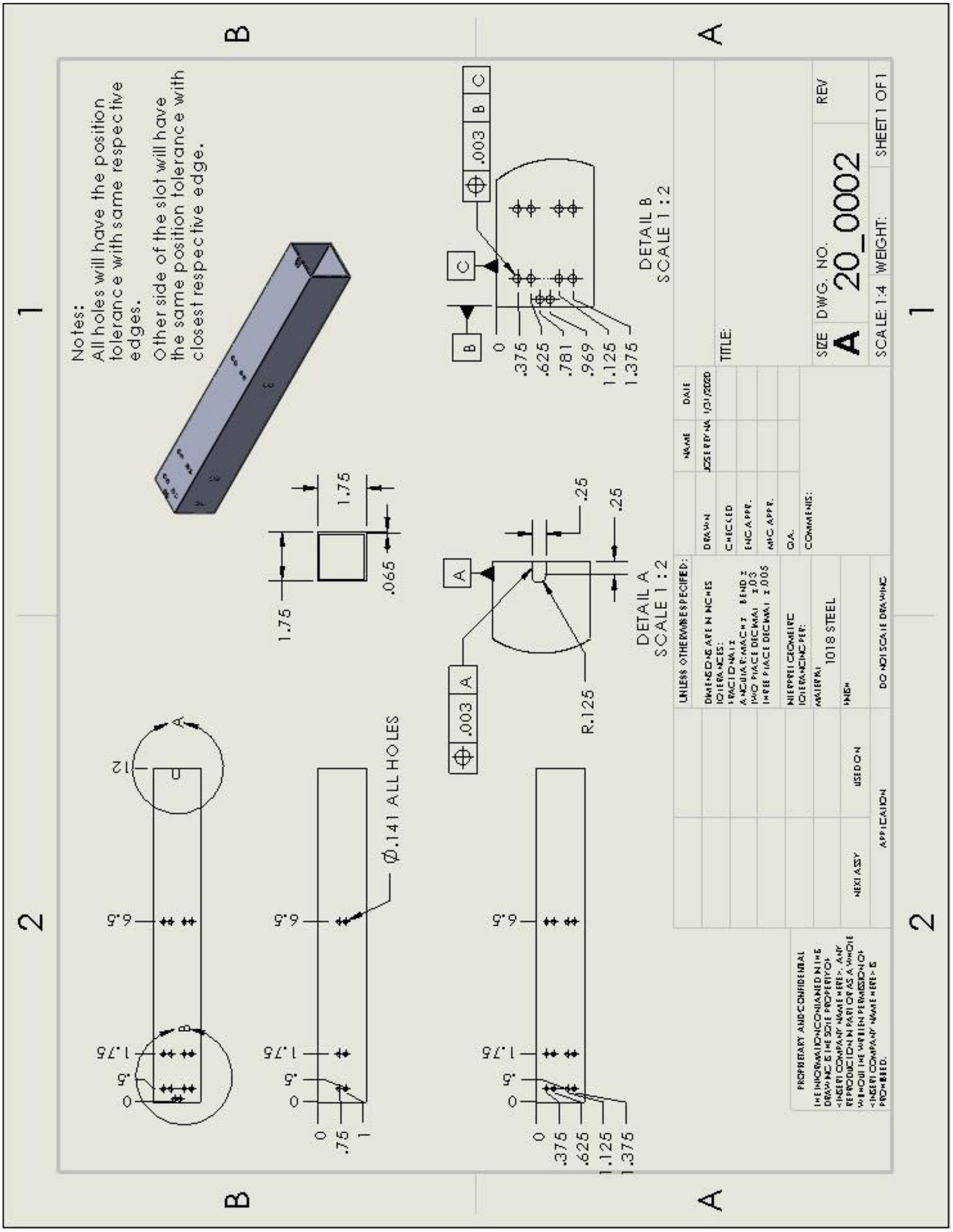


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	20_0001_3x2_Boom	3X2IN STEEL TUBE	1
2	20_0002_1.75_in_Boom	1.75IN STEEL SQR TUBE	2
3	wear pad		66
4	Hydraulic Mount		2
5	20_0003_1.5_in_Boom	1.5IN STEEL SQR TUBE	2
6	20_0004_1.25_in_vertical_leg_2	1.25IN STEEL SQR TUBE	2
7	20_0005_Scale_Foot		2
8	20_0006_1.25_in_Pin	.25IN DIA 1.25IN LONG PIN	2
9	20_0007_1.5_in_Pin	.25IN DIA 1.5IN LONG PIN	2

B-3: 20-0001

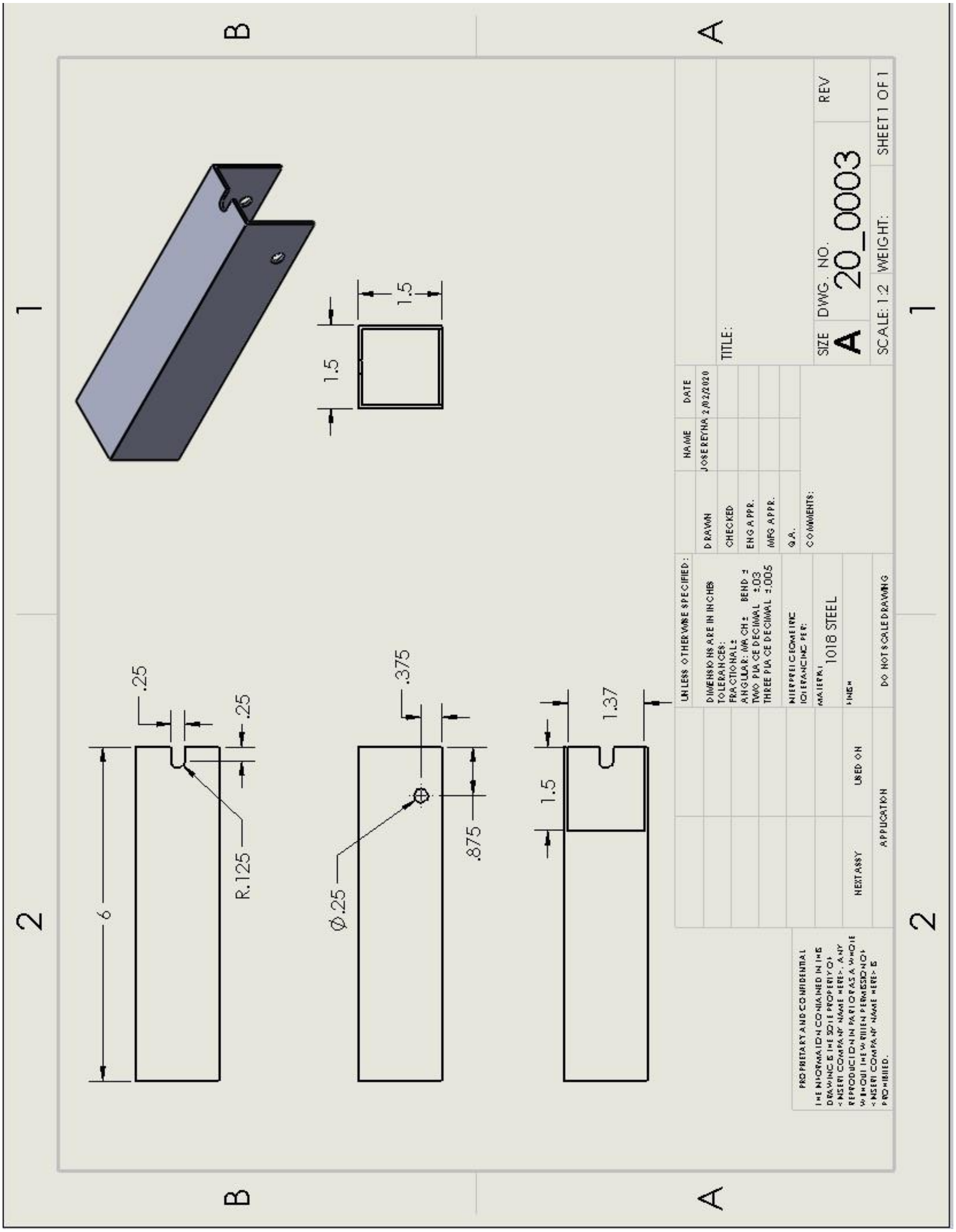

Notes:
All holes will have position tolerance
to closest respective edges.
2.000
.092
3.000
Ø.141 ALL HOLES
.003 A B
DETAIL A
SCALE 1 : 4
0
.748
1.998
6.748
17.252
22.002
23.252
24.000
.500
.750
1.250
1.500
.750
2.000
6.750
17.250
22.000
23.250
1.375
1.625
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
1018 STEEL
DO NOT SCALE DRAWING
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
TITLE:
SIZE
A
DWG. NO.
20_0001
REV
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL

B-4: 20-0002



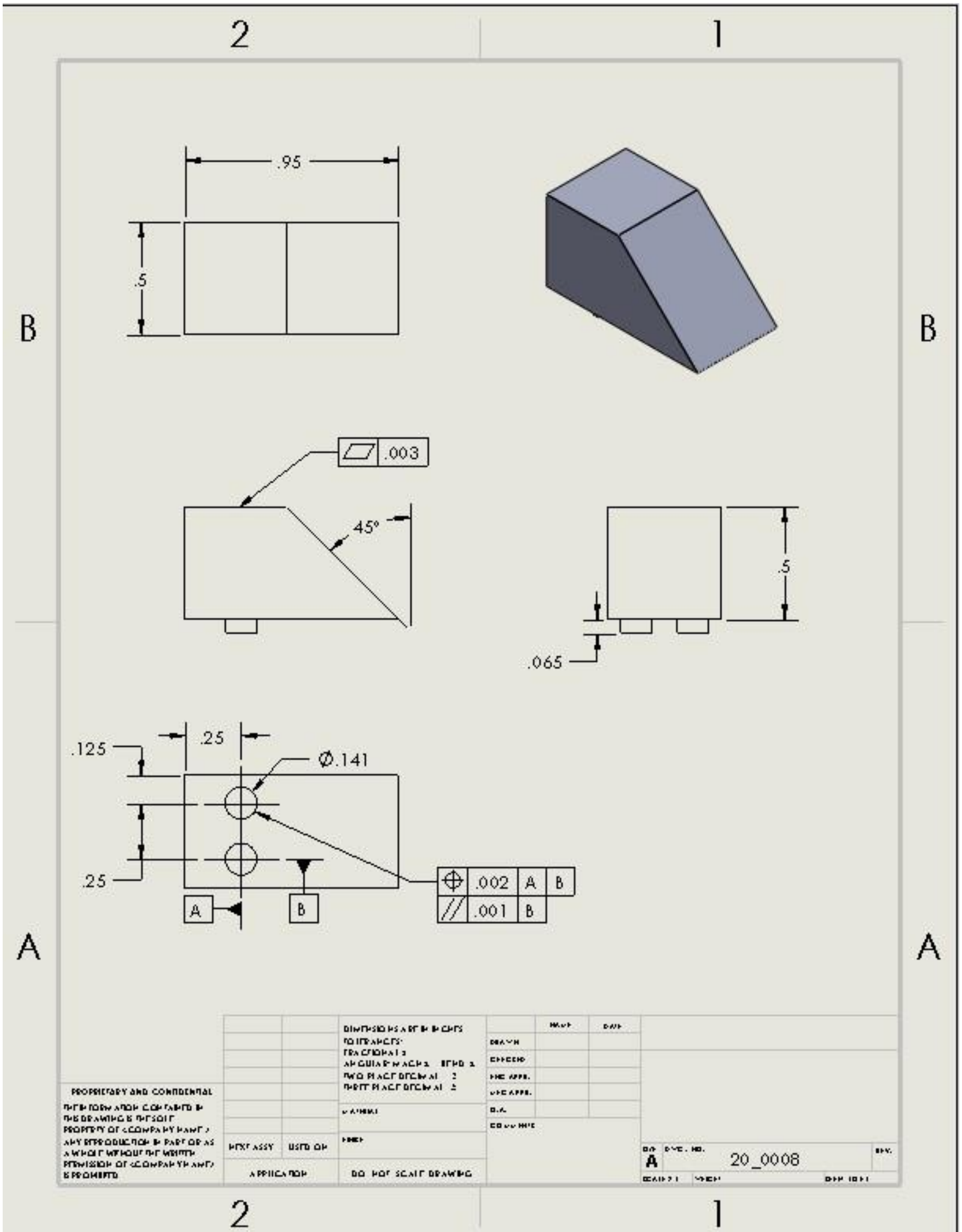
Notes:
All holes will have the position tolerance with same respective edges.
Other side of the slot will have the same position tolerance with closest respective edge.
Ø.141 ALL HOLES
R.125
DETAIL A
SCALE 1 : 2
DETAIL B
SCALE 1 : 2
1018 STEEL
DWG. NO.
20_0002
SIZE
A
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
REV
TITLE:

B-5: 20-0003



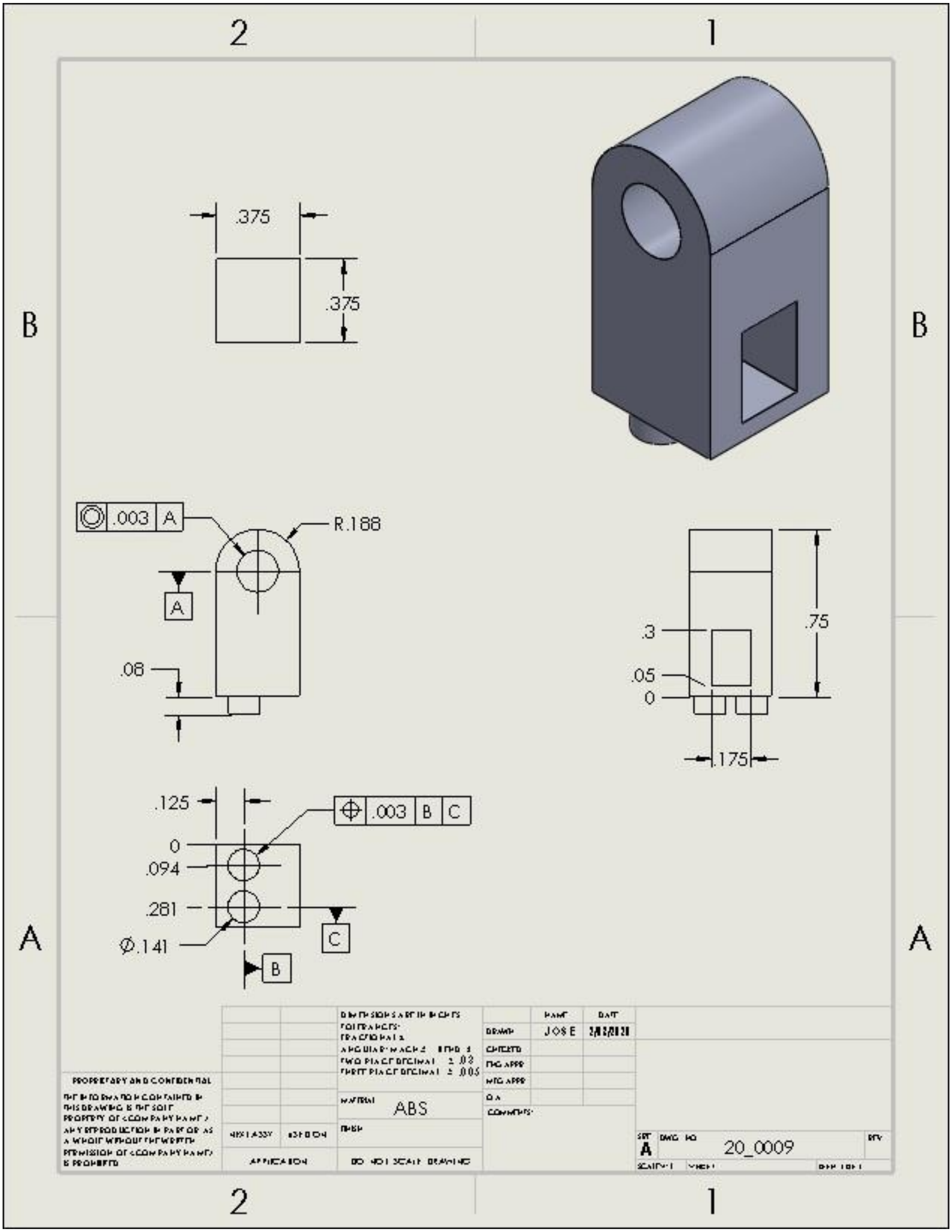
DWG. NO.
20_0003
SIZE
A
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
TITLE:
1018 STEEL
DRAWN
JOSE REYNA
2/02/2020
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
6
R.125
.25
.25
Ø.25
.375
.875
1.5
1.37
1.5
1.5

B-6: 20-0008



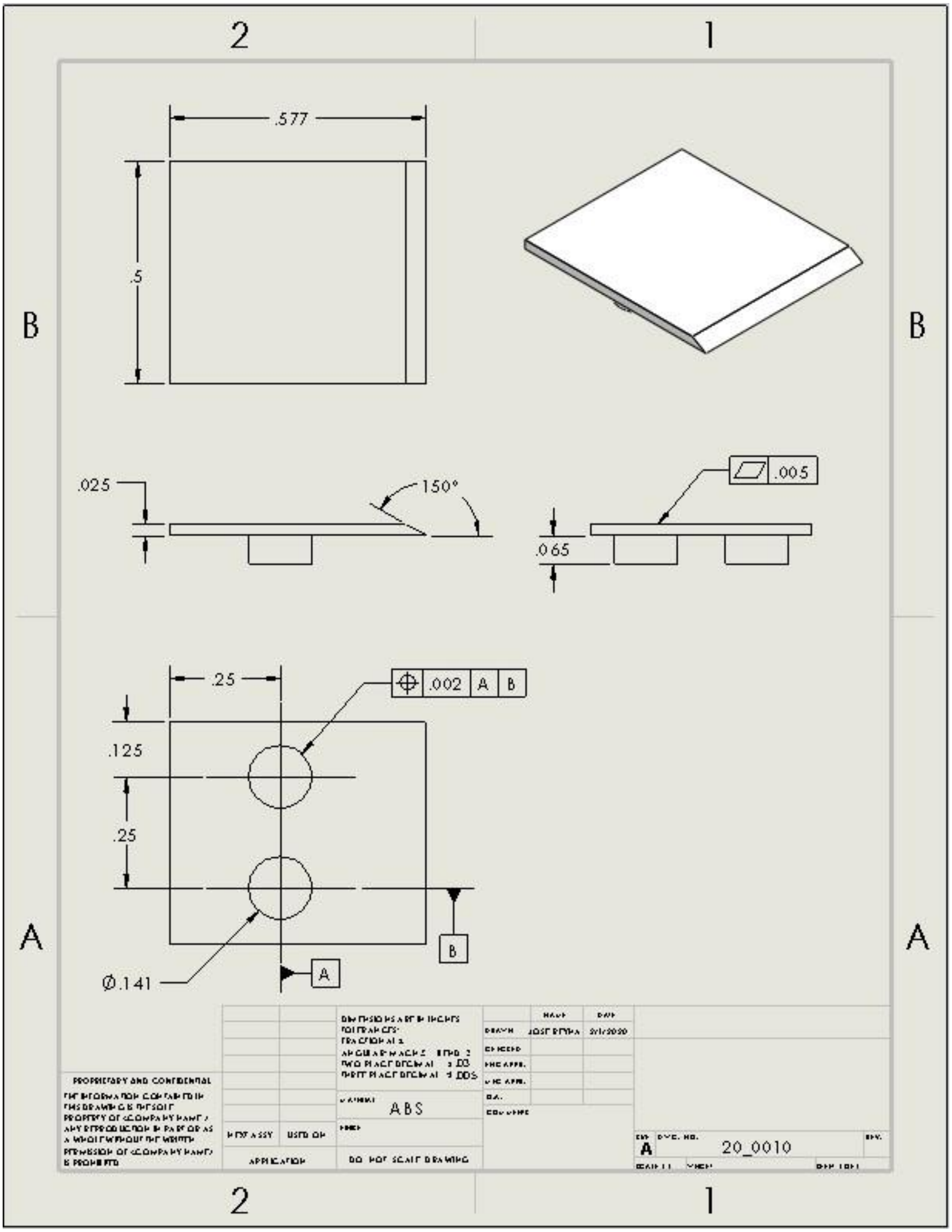
.95
.5
.003
45°
.5
.065
.125
.25
Ø.141
.25
A
B
.002 A B
.001 B
PROPRIETARY AND CONFIDENTIAL
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
A
20_0008

B-7: 20-0009



2
1
B
A
.375
.375
.003
A
R.188
.08
.3
.75
.05
0
.175
.125
.003
B
C
0
.094
.281
⌀.141
C
B
PROPRIETARY AND CONFIDENTIAL
DRAWN
JOSE
MATERIAL
ABS
DO NOT SCALE DRAWING
A
20_0009

B-8: 20-0010


.577
.5
.025
150°
.005
.065
.25
.002 A B
.125
.25
B
A
Ø.141
ABS
20_0010
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
APPLICATION
USED ON
NEXT ASSY

Appendix C

Appendix D

<u>Budget</u>

Item	Number of Items							
HSS 6x6x1/4	1							
HSS 4x4x1/4	2							
HSS 3x3x1/4	2							
Hydraulic	1							
Wear Pads	36							
Chain/Wire Rope								

Appendix E

PROJECT TITLE: H.F. Hauff Outrigger Project
Principal Investigator: Jose Reyna

		Duration												
TASK:	Description	Est.	Actual	%Comp	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
ID		(hrs)	(hrs)				X X	X X						
1	Proposal*													
1a	Outline	0.5	0.13			X			X					
1b	Intro	5	2.5			X			X					
1c	Methods	1	0.5			X			X					
1d	Analysis	3	0.5						X					
1e	Discussion	1	0											
1f	Parts and Budget	1	0.5											
1g	Drawings	3	2											
1h	Schedule	2	0.33											
1i	Summary & Appx	4	1											
	subtotal:	20.5	7.46											
2	Analyses													
2a	Length of Boom	0.25	0.17											
2b		99	99											
2c		99	99											
2d		99	99											
2e		99	99											
	subtotal:	396.3	396											
3	Documentation													
3a	Part 1 leg drawing	99	99											

3b	Part 2 arm drawing	99	99											
3c	Subassembly torso	99	99											
3d	Part 3 head drawing	99	99											
3e	Part 4-foot drawing	99	99											
3f	Subassembly Trunk	99	99											
3g	Part 5 toe drawing	99	99											
3h	Part 6 hand drawing	99	99											
3i	Subassembly side	99	99											
3j	Device robot drawing	99	99											
3k	Kinematic Check	99	99											
3l	ANSIY14.5 Comply	99	99											
3m	Make Object Files	99	99											
	subtotal:	1287	1287											
4	<u>Proposal Mods</u>													
4a	Project Robot Schedule	99	99											
4b	Project Robot Part Inv.	99	99											
4c	Crit Des Review*	99	99											
	subtotal:	297	297											
7	<u>Part Construction</u>													
7a	Buy Part leg	99	99											
7b	Make Part arm	99	99											
7c	Make Part head	99	99											
7d	Buy Part foot	99	99											
7e	Make Part toe	99	99											
7f	Make Part hand	99	99											
7g	Take Part Pictures	99	99											
7h	Update Website	99	99											
7i	Manufacture Plan*	99	99											
	subtotal:	891	891											
9	<u>Device Construct</u>													
9a	Assemble Sub LL	99	99											
9b	Assemble Sub RR	99	99											

9c	Assemble Sub FF	99	99											
9d	Assemble Robot	99	99											
9e	Take Dev Pictures	99	99											
9f	Update Website	99	99											
	subtotal:	594	594											
10	<u>Device Evaluation</u>													
10a	List Parameters	99	99											
10b	Design Test&Scope	99	99											
10c	Obtain resources	99	99											
10d	Make test sheets	99	99											
10e	Plan analyses	99	99											
10f	Instrument Robot	99	99											
10g	Test Plan*	99	99											
10h	Perform Evaluation	99	99											
10i	Take Testing Pics	99	99											
10h	Update Website	99	99											
	subtotal:	990	990											
11	<u>495 Deliverables</u>													
11a	Get Report Guide	99	99											
11b	Make Rep Outline	99	99											
11c	Write Report	99	99											
11d	Make Slide Outline	99	99											
11e	Create Presentation	99	99											
11f	Make CD Deliv. List	99	99											
11e	Write 495 CD parts	99	99	◇										
11f	Update Website	99	99											
11g	Project CD*	99	99				◇							
	subtotal:	891	891	◇										
	Total Est. Hours=	5367	5353											

Labor $	100	####												
Note:	Deliverables*													
	Draft Proposal													
	Analyses Mod													
	Document Mods													
	Final Proposal													
	Part Construction													
	Device Construct													
	Device Evaluation													
	495 Deliverables													

Appendix F

Appendix G

Appendix H

Appendix I

Appendix J

JOB HAZARD ANALYSIS
{Lifting Heavy Objects}

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Back brace, steel toed shoes
Reference Materials as appropriate:	ehs.berkeley.edu/

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
☐	☐	☐	☐	☒	☐	☐
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
	Lifting heavy object. Saving yourself from injury is more important than avoiding damage to what you're lifting.	Back injury, Foot injury from dropping heavy object	Bend knees to lessen pressure on the lower back. Use legs as the source of power to lift object. Solicit the help of others or employ tools if object is too heavy to be lifted by one person
	Transporting heavy object.	Back injury, Slipping on wet or slick floor	Evaluate condition of floor along path from origin to destination. Do not move heavy loads until floor is dry., See above for more information.
	Setting heavy object down.	Foot injury from dropping heavy object, Back injury	Do not drop object. See above for more information.

JOB HAZARD ANALYSIS
{12" Band Saw}

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Proper operation of band saw, Safety glasses or face shield
Reference Materials as appropriate:	ehs.berkeley.edu/

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
☐	☐	☒	☐	☐	☐	☐

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
	Check condition of blade.	Cutting fingers and hands	Avoid contact with blade teeth.
	Align materials flat on table	Pinching fingers or hands	Keep fingers and hands away from pinch points.
	Adjust guard to no more than _ inch above top of material.	Pinching fingers or hands	Avoid pinch points between guard and housing and between guard and material.
	Start blower and saw.	Cutting fingers and hands, Injuries from flying sawdust	Keep fingers and hands away from blade. Use push bar for smaller materials., Wear safety glasses or face shield

JOB HAZARD ANALYSIS
{Drill Press}

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Operation of the drill press, First aid, Gloves, Eye protection
Reference Materials as appropriate:	ehs.berkeley.edu/

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
☒	☐	☒	☐	☐	☐	☐
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
	Load the vise.	Foot injury if the vise falls, Finger pinching while sliding the vise	Secure the vise on the table with T-pins., Don't let your fingers get under the vise unless you are lifting it from the table. Keep your eyes on the task.
	Lock the table in place.	Back strain	Don't lean over the table to twist the lock handle.
	Load the bit.	Hand injury from the bit	Wear gloves. Don't hold on the end of the bit

	Start the drill	None foreseen	
	Feed the drill with the feed	Injury caused by breaking the bit, Eye or skin damage from cutting oil, Hand injury from the exposed pulley near the feed handle	Feed with the appropriate pressure. Use the appropriate bit for the type of metal. Wear eye protection, Use the lowest RPM. Wear eye protection. Wear a long sleeved shirt., Make sure a pulley guard is in place. Don't push the feed handle toward the pulley.
	Unload the vise.	Foot injury if the vise falls, Finger pinching while sliding the vise	Leave the vise secure on the table with T-pins until it is unloaded., Don't let your fingers get under the vise unless you're lifting it from the table., Keep your eyes on the task.
	Clean the table.	Eye injury from metal debris	Wear eye protection. Do not use compressed air

JOB HAZARD ANALYSIS
{3D Printer}

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Read and understand SDS on Stratasys P400SC Sodium Hydroxide Read and understand how to operate the Fendall Porta Stream II Emergency Eyewash Station Read and understand operation manual for proper and safe use of dissolve tank., Heavy Duty Neoprene Gloves (gauntlet style), Safety Glasses, Full FaceSplash Shield, Liquid resistant lab coat
Reference Materials as appropriate:	ehs.berkeley.edu/

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
☒	☐	☒	☐	☐	☐	☒
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
	Assess work area; is it clear of obstructions and slip/trip hazards?	Slip, Trip or Fall	Remove any obstructions or trip hazards. Maintain a dry floor
	Assess path to emergency eye wash station; is the path clear and free of obstructions?	Not immediately able to access emergency eyewash station if needed	Remove any obstructions and maintain clear pathway
	Select and don personal protective equipment	Exposure of corrosive solution to eyes or skin	Use of PPE is required and mandatory
	Select items/parts needing dissolve support removed and place in appropriate	Loss of parts within solution tank	Use appropriate basket

	soak basket		
	Slowly raise lid of solution tank and allow condensate to drain back into the solution tank	Possible corrosive solution spilled outside of solution tank.	Place lid in secondary containment container
	Slowly lower soak basket into solution tank making sure not to splash solution	Exposure of corrosive solution to eyes or skin	Work in a slow and deliberate manner
	Make sure basket is submerged and sitting level on the bottom of tank	Possible corrosive solution from being splashed on operator	Work in a slow and deliberate manner
	Replace solution tank lid	Possible accidental exposure of corrosive solution	No not operate without lid in place
	Set timer on solution tank control	Solution tank not dissolving support material properly	Verify timer is set and operating
	Do not allow observers within splash area during time while parts are put into or being removed from dissolve tank	Possible exposure of corrosive solution to eyes or skin.	Maintain a three foot perimeter anytime the tank lid is removed
	Maintain tank water levels within the manufacturers specifications	Possible exposure of corrosive solution to eyes or skin	Don personal protective equipment, remove solution tank lid, and replace/remove water as necessary.
	Draining solution from tanks as necessary	Possible corrosive solution spilled outside ofsolution tank or exposure of corrosive solution to eyes or skin	Don personal protective equipment, remove drain plug from tank, attach hose to drain, and drain liquid into designated 5 gallon containers. Constantly monitor disposal container, DO NOT overfill (more than 4 gallons)
	Mixing and adding new solution to tanks	Possible corrosive solution spilled outside ofsolution tank or exposure of corrosive solution to eyes or skin.	Don personal protective equipment SPECIAL NOTE: ALWAYS! ADD concentrate (P400-SC) to water, NEVER add water to concentrate!

JOB HAZARD ANALYSIS
USING HAND-OPERATED POWER TOOLS

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Gloves, Eye Protection, and Mask When Necessary Operation of the Tool
Reference Materials as appropriate:	UC Berkeley JHA; 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
☒	☐	☒	☐	☒	☐	☒
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. Check condition of the blade, if applicable.	Lacerations.	Avoid contact with blade teeth. Be sure the tool is unplugged.
	2. Check that the guard is in working condition and in the proper position, if applicable.	Lacerations.	Avoid contact with blade teeth. Be sure the tool is unplugged.
	3. Plug in power tool.	Injuries from starting tool when in the "on" position.	Ensure tool is in the "off" position before plugging in.
		Potential electrocution from cord in poor condition.	Inspect condition of cord before plugging in. If cord is in poor condition, do not use the tool until the cord has been repaired.
	4. Operating power tool.	Lacerations and other injuries.	Always wear safety goggles.

			Evaluate surroundings before turning on power tool and be aware of others. Make sure that cutting will not come into contact with any utilities. Don’t wear loose clothing. Make sure the blade or bit is not binding as it goes into the work. If blade or bit is binding, cease operation of the tool and evaluate reasons for binding. Ensure that material being operated on is secured.
	5. Unplugging power tool.	Lacerations.	Ensure tool is in the “off” position before unplugging.
	6. Changing blade/bit/other tool parts.	Lacerations.	Ensure tool is unplugged before changing any part of the tool.

JOB HAZARD ANALYSIS
OPERATING A MILLING MACHINE

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Safety Glasses, Ear Plugs Milling Machine Operations
Reference Materials as appropriate:	UC Berkeley JHA; 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
☐	☐	☒	☐	☐	☒	☐

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
	Milling text blocks	Injury to hands from milling blades	Never disconnect safety shields from milling blades.
		Hearing damage from noise of machine operation	Wear hearing protection, such as ear plugs, if operating machine for periods extending more than 10 minutes.
		Possible eye injury from wire stitches thrown out by milling blade	Wear safety glasses during operation.
		Crushing finger hazard from book clamp	Do not hold book at spine when activating book clamp. Hold book at the face.

JOB HAZARD ANALYSIS
USING HAND TOOLS

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	None foreseen
Reference Materials as appropriate:	UC Berkeley JHA; 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
☐	☐	☐	☐	☐	☐	☐
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. Check condition of blade, if applicable.	Lacerations	Avoid contact with blade or teeth of a tool.
	2. Using hand tool.	Lacerations, pinching or impact and other injuries	Assess surrounding environment and be aware of others. Check to see that replaceable parts such as blades are secured. Be aware of what may happen if the tool slips or is misdirected. Use caution when using tool.

	3. Transporting hand tool.	Injuries to self and others	Ensure that the blade is not exposed when transporting. Do not throw the tool. Assess surrounding environment and be aware of others.

JOB HAZARD ANALYSIS
USING AN ARC WELDER

Prepared by: Jose Reyna	Reviewed by: Approved by:

Location of Task:	H.F Hauff Machine Shop, Hogue Technology Building, CWU
Required Equipment / Training for Task:	Welding hood, Welding jacket and apron, Gloves, Safety glasses, work shoes Operation of arc welder, Operation of a fire extinguisher, Location and use of the fire alarm
Reference Materials as appropriate:	UC Berkeley JHA; 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
☒	☐	☒	☒	☒	☐	☒
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. Close off welding area.	Flashing	Close welding curtain to shield outsiders from flashing.
	2. Prepare for arc welding.	Inhalation of fumes	Turn on exhaust fan and timer.
		Flashing	Wear welding hood.
		Sparks	Wear welding jacket, apron, gloves, work shoes.
		Slag splatter	Wear welding jacket, apron, gloves, work shoes.
	3. Turn on power and unwrap wire.	Tripping	Take care to keep wire untangled and free from under feet.
	4. Insert arc welding rod in handle.	Pinch to fingers	Keep fingers away from pinch points.
	5. Strike arc.	Flashing, sparks, slag	Wear welding hood, welding

		splatter	jacket, apron, gloves, work shoes.
	6. Allow material to cool on workbench.	Burn to hands or fingers	Wear glove. Chalk mark welded area “Hot”
	7. Remove remainder of arc welding rod (if any) from handle, set aside on workbench to cool.	Burn to hands or fingers	Chalk mark welded area “Hot”
	8. Wrap wire.	Tripping	Take care to keep wire untangled and free from under feet.
	9. Use chipping hammer to remove excess slag.	Eye damage by flying debris from hammer strikes	Wear safety glasses.
		Injuring fingers with hammer	Use caution to avoid striking fingers or hands with hammer.