Spring 5-27-2015

Seat Jack

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Seat Jack

By Justin Worden

September 2014 - June 2015

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Abstract

Many people around the world struggle with mobility. One of the biggest obstacles for who may struggle in this area is the simple task of moving from a sitting position to their feet. For some, this is the only thing that keeps them from walking around. Creating a portable device to help move a person from their chair to their feet would extremely aid the efforts of completing this simple task at any given moment. This report provides a proposed solution for this simple reoccurring task that countless people painfully struggle with every day. In order to make this device portable two main parameters were of concern, size and weight. Tests on the device's range of motion, support/rigidity, propulsion capacity, and difficulty of use are discussed. Assessment of the test results will provide evidence backing the proposed design of a device that will lower the difficulty of this task. This portable device will become a benchmark for alternative designs that will further improve possible aid to the user in need.

INTRODUCTION

This project is to create a device that will help my great grandmother get in and out of her chair easier. Spending time with my great grandmother always provides me with the biggest smile and happiness. Unfortunately, seeing her constantly have trouble getting up out of her chair gives me pain just watching her struggle. This pain has motivated me to come up with a solution to help her easily complete this task!

Function Statement

This device can provide support to a 273 lb. person while in the motion of moving from a sitting position to their feet.

Requirements

The Seat Jack shall meet these following requirements in order to function properly and complete the task at hand:

- This device should be able complete its full range of motion within thirty seconds
- Lift and support 273 lbs. maximum
- Portable (maximum size 1.5'wx1.5'hx6"t
- Able to fit on any chair with a seat of 18"x18" or larger
- Be in compliance of a safety factor of 5
- Weigh less than fifty pounds
- Provide support with a range of 30 degrees and 12 inches of lift

Success Criteria:

Based on academic learnings, analysis of stresses in each part of the seat jack can be conducted primarily using stress equations such as; $Max\ bending\ stress = \frac{Mc}{I}$, and $Max\ Tensile\ and\ Compression\ stress = \frac{P}{A}$. Using these two equations, proper dimensions and materials can be chosen for an appropriate design.

Scope:

This project includes a purchased jack to go along with fabricated seat and mounting parts for the assembly. The idea of this project is to keep things as light and compact as possible as well as minimizing cost while still providing aid to a person getting in and out of their chair. Processes such as welding, machining, and drilling are applied as well as some stress analysis of several parts of the seat jack to insure the device will not fail meeting a standard safety factor of five.

Benchmark:

Considering other previously made chairs that have seats that rise, Lazy boy or other brand recliners have had a similar idea for aiding people in and out of their chair. Professors' desks at Central Washington University also use similar type lifting components. The basis of the design will have a similar idea to these purchasable items on the market today.

DESIGN & ANALYSIS

For this project as a whole the design idea was to keep the device as portable as possible. Of course, weight is the biggest issue when trying to accommodate for a safe and sturdy device. Since this device uses purchased equipment for the drive motor and lift mechanism, the project breaks down into three main parts; The Seat, Jack housing, and Drive/lift equipment. Each of these parts are connected together with a section of 'hardware'. All of these parts are capable of supporting a 273 lb. person to a safety factor of five. According to Manufacture Humantics, a much heavier than ever before dummy shall be used in car crash tests based upon recent research showing that the average American's weight has dramatically increased in the past decade. For this project we will analyze using the same weight of 273 lbs.

In order to aid the description of the design of the Seat Jack, Figure A shows a basic layout of the Design.

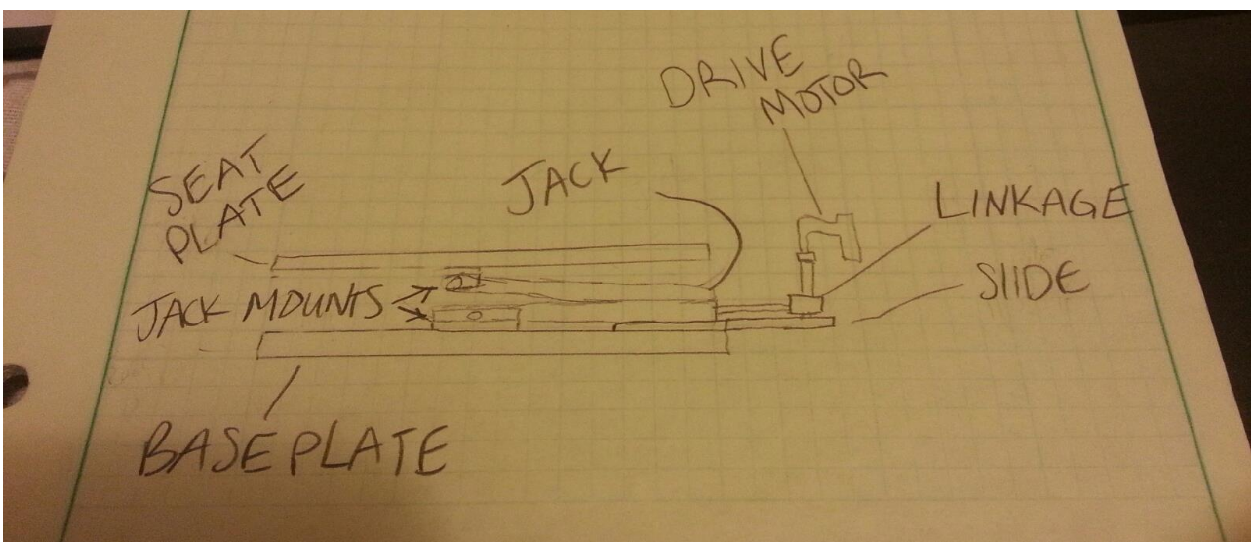


Figure A
Basic Layout of components

The Seat-

For dimensions of the seat, findings from public areas (primarily on the CWU campus) concluded that most standard chairs have a width of no more than 1.5' (from hip to hip) and a depth of no more than 2'(from knees to back). The largest found depth of 2' came to be fairly large and uncomfortable to sit in with free motion of legs. Based on these gatherings, the decision came to have the dimensions of the seat be: 1.5'x1.5' for area. The thickness of the seat plate is one half inch made out of 6061-T6 aluminum as opposed to the original plan of using 2014-0 Aluminum. (please note Appendix A Figure 2-4 for seat analysis)

The Base-

The base plate is a mirror image of the seat plate before being altered for accommodating for mounting devices to connect the base to the jack. This plate is also made of 6061-T6 aluminum. Unlike the seat, the base does not just support the 273 lb. person but also supports the weight of the jack, hand drill, and linkage of the drive. The base is also home for support of the linkage slide (eventually omitted from the design). This slide platform provides support for the mobile linkage components that connect the drive motor to drive shaft. Selection of this aluminum is based upon analysis of stress created from applied loads. (please note Appendix A Figure 2-2 for base analysis)

Jack Mounts-

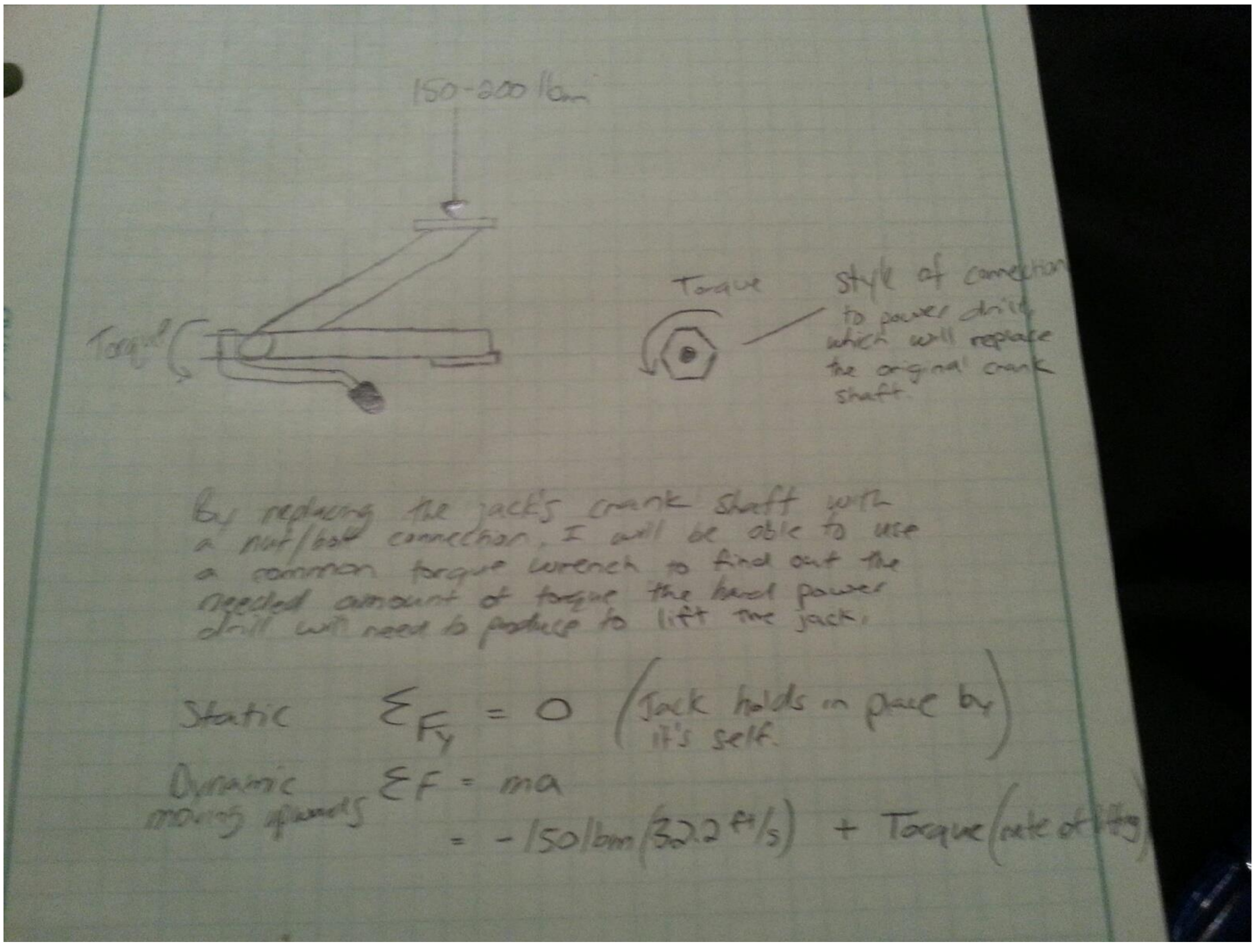
Mounting the Jack to the seat and base is key for providing the appropriate rigidity for support of a person. Intention of keeping these mounts simple, they are designed similar to basic angle iron you commonly see used for mounting numerous objects to a desired location. Between two angle iron resembling pieces the jack is connected and supported by an aluminum cross member. For purposes of welding these pieces of the mounts together, a common material of 6061-T6 will be used for all parts.

When purchasing these raw materials for the seat, base, linkage slide, and mounts it was appropriate to use the same material throughout the entire device. Using the same material for all, reduced price as for the originally desired 2014-0 aluminum is not as available as the 6061-T6. The 6061-T6 is not quite as light as the 2014-0 but the difference in this case is not large enough to outweigh the benefit of time and cost. Using the 6061-T6 still provides the needed support to accommodate for a 273 lb. person. Unfortunately, the price of the aluminum is higher compared to using steel but weight is a big factor in making the Seat Jack portable.

Drive and Linkage-

The Seat Jack is capable to be driven by almost any standard battery powered hand drill, in this case we will be using a Dewalt 18-Volt Cordless 1/2 in. (13mm) Compact Drill/Driver, that has enough torque to lift the 273 lb. person (Under the assumption noted in Figure 2-12 in Appendix A). In order for the hand drill to drive the jack, two straight bevel gears will need to be mounted at the end of the worm gear on the jack. These two gears will give a 90° corner which will make placement of the drill comfortable for the user to apply force. These bevel gears will have a one to one ratio of gear teeth and a pitch diameter of 12 to accommodate for size limits (Please note Figure 2-11 in Appendix A). A typical drive extension may be used for maximum comfort. Figure 1-1 describes the movement of the extending drive location.

Note: Unfortunately, due to cost issues during the manufacturing process the bevel gear shoulder joint was omitted from the design.



(Figure 1-1)- The handle on the left side of the jack sketch has been removed and replaced with a nut. This nut can then be turned by the drive motor to drive the worm, lifting the seat. While the nut is turned, the drive worm will extend horizontally in the left direction of the location shown in the model. The nut end will connect to the bevel gear corner joint which will receive applied torque from the hand drill.

When designing the linkage of the hand drill to the jack ideas to make it work became very troublesome. Originally the designer had the jack oriented just as it would be during intended use (lifting a ’96 Audi A4). Using this orientation of the jack seemed logical but actually caused problems in the linkage design. To provide the most support and rigidity possible, the mounts cause the base leg of the jack to stay stationary. This causes the drive rod to move. When using the jack for its intended use to lift a car, the movement of the base legs and drive rod are the opposite. The legs would both move (mirroring each other), while the drive rod would stay stationary.

Mounts causing change in movement produced a problem with the location of the drive torque input. As the user’s seat and body moved upward, the location of applying torque would dramatically dive down between the user’s legs. Comfort of use would drop dramatically making use difficult for the user. By simply flipping the jack over, the design strayed away from complicated elbow joints and uncomfortable application. The drive worm of the jack will now stay horizontal to the ground and only extend in one direction with the jack oriented correctly. In this position a simple 90° corner was ideal to make torque application more comfortable. Figure 1-2 shows what this corner joint will look like. Figure 1-3 shows the gears inside of the corner joint.

Note: Although the gears were not implemented on the prototype, the design idea is a great place to start for further improvements with following prototypes.

Figure 1-2

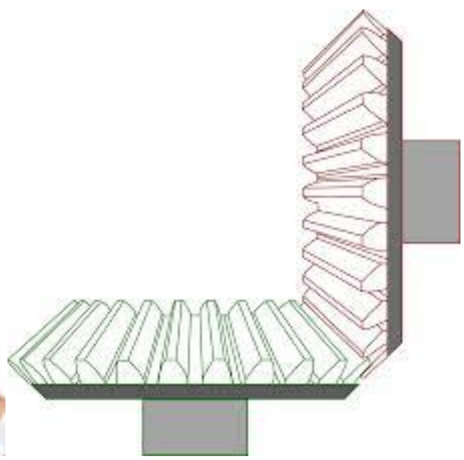
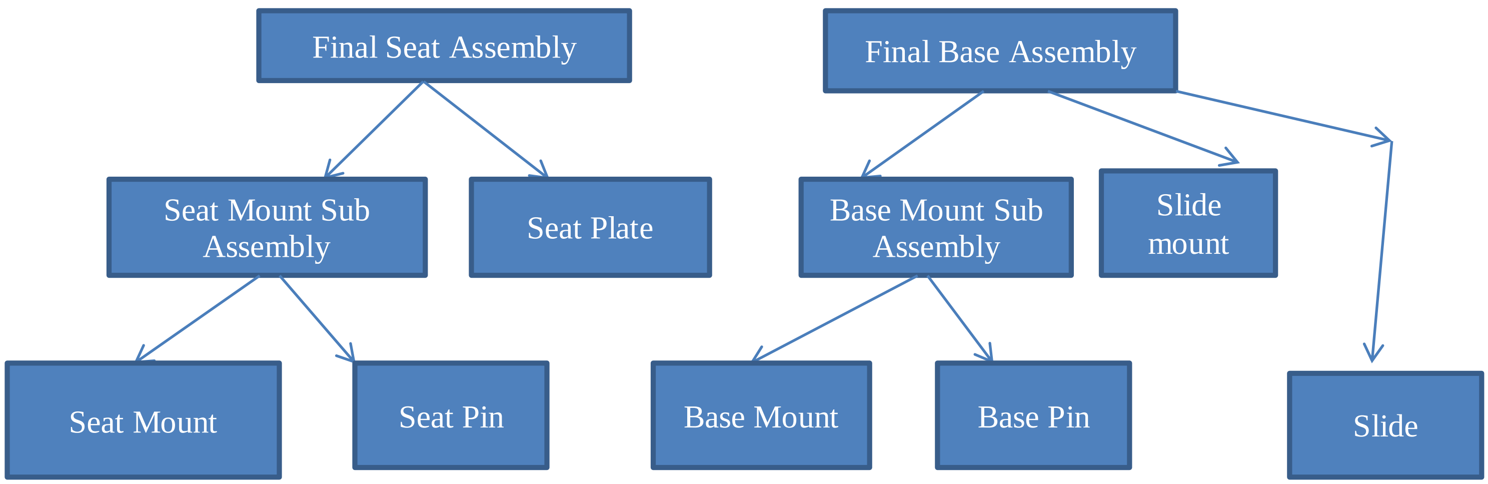


Figure 1-3

When analyzing the seat jack it was required to create some ridiculous scenarios that create conditions that will cause the device to break. In order to make sure that the jack will be supported enough horizontally and not tip over, the designer accounted for a scenario that was not impossible but most likely would never happen. By applying the weight of the person to the side of the seat (perpendicular to the support base and ground), several stress analyses at different locations could be calculated. But seriously who would sit on the side of the seat, making the half inch wide piece go right up their butt? Of course, analysis of the stresses created during intended use of the Seat Jack are accounted for.

Drawing Tree



METHODS & CONSTRUCTION

This project was inspired by a young engineering student wanting to help his grandmother in need. Using mostly simple already owned components, as well as purchased raw materials, and functioning parts; this project was designed, fabricated, and presented on Central Washington University's campus using the campus' shops and curriculum provided by the professors of the Mechanical Engineering and Technology and Industrial Engineering Technology departments.

This device is made up of four main parts; the seat, base, jack, and drive motor. All of these parts are connected and held within the devices housing area (between seat and base). The Jack has been purchased and slightly modified to connect to the drive motor. Other components that purchased include a hand drill, nuts, bolts, and raw 6061-T6 aluminum plates, rounds and extruded rectangles. The seat and supporting components will be fabricated in the fab shop located in the Hougue Technology Building on CWU's campus.

Device Operation:

The Seat Jack has a movement range from 10 degrees to 75 degrees, starting from parallel with the ground pivoting up on a hinge to being near perpendicular to the ground. The seat of the device will be powered by an electronic motor (hand drill), which is manually operated by a switch.

Benchmark Comparison:

This device resembles the functionality of some seats on recliners out on the market today produced by Lazy Boy and other furniture companies. Unlike these recliners, the Seat Jack is much smaller and requires support from another chair or bench. The jack, seat, mounting brackets, and drive motor weigh considerably less than compared seat lifts on the market today. As well as the prior qualities, the Seat Jack is also portable.

Predicted performance of device:

The Seat Jack will accomplish the movement of getting in and out of a seat much easier with its 8-12 inch lift with a 30° angle of help. Operation of the device is easy enough for any person to use. Goals for time will be reached and assumed to succeed past the time requirement of thirty seconds. The Seat Jack will accomplish all of these requirements while being portable. Unfortunately, I believe the Seat Jack will not be as easy to move around as first anticipated due to its final weight. The idea of the device being ideal for practical pick up and take with you tasks but will still meet the requirement of being portable for location changes.

Risk Analysis:

There are three main risks that need to be accounted for; time, cost, and the ability of parts being manufactured. As for manufacturing the parts, several hours will be spend in machining the dimensions of each part as well as dealing with the welding process of connecting parts. The proposed amount of time for design, analysis, construction, and testing of the device is around 8-9 months or approximately the length of three academic quarters at CWU. The price of the parts may become more of a risk than anticipating due to the requirement of weight to support. To keep the Seat Jack as light as possible, some juggling between material selections may occur. Accounting for the available budget may place a cap on how light the device can actually be.

TESTING METHOD

In order to complete the requirements of this project the engineer must take the necessary tests to make sure those requirements are capable of happening. Required tests such as; finding out how much torque the pinion must provide to the worm gear to lift 100-273 lbs.; weighing the device to make sure the Seat Jack weighs less than 50 lbs; and measurements of size to ensure that the fully collapsed Seat Jack is smaller than 1.5’x1.5’x6”.

Test Plan:

-In order to test for the amount of torque needed to be provided by the drive motor, plans of having a volunteer sit on the Seat Jack, while the designer uses a common torque wrench to find how much torque is needed to lift them up. If one person cannot be found person heavy enough to simulate the weight requirement of 273 lbs. then weight will need to be added by having the volunteer hold an object that will add enough weight to meet this requirement.

-Time requirements can be tested for by simply using a stop watch to time how long the Seat Jack takes to move from fully collapsed to fully extension.

-Testing for required size can be accomplished by using a typical ruler or measuring tape to ensure that the Seat Jack is adequately small enough to be portable. The designer will then carry the Seat Jack around to evaluate the difficulty of transport as well as making sure it will fit on each and every seat possible.

- Testing for weight requirements the designer will place the device on any scale appropriate to measure the weight of the device.

Testing Procedures and Results

Test 1- Torque supply needed to lift a given weight.

Materials:

1. One fifty pound weight.
2. A person weighing around 100 lbs.
3. A person weighing around 150 lbs.
4. A person weighing around 200 lbs.
5. A person weighing around 250 lbs.
6. One torque wrench with needle gauge.
7. Seat Jack

Procedure:

1. Place the fifty pound weight on the seat of the Seat Jack.
2. Connect the torque wrench to the drive nut on the drive worm.
3. Lift the fifty pound weight.
4. Record amount of torque needed to start lifting.
5. Record amount of torque needed to continue lifting while already moving.
6. Repeat steps 1-5 with remaining weights.(record the actual weight of specimen)

Torque needed	100 lbs	150 lbs	200lbs	250lbs	300lbs
To start lift	Did not read	5 ft·lbs	6.66 ft·lbs	8.33ft·lbs	10ft·lbs
To cont. lifting	Did not read	5 ft·lbs	6.66ft·lbs	8.33ft·lbs	10ft·lbs

NOTE: Results were not exact, little changes on the scale of the torque wrench were hard to distinguish.

Test 2: Time of full cycle of movement.

Materials:

1. Seat Jack
2. Stop watch
3. Hand drill drive motor

Procedure:

1. Connect drive motor to input nut.
2. Lift seat up all the way and then back down to starting position.
3. Record time it takes to complete this cycle.
4. Repeat Steps 2-3 two more times and calculate average.

Trial #	Time Needed	Average
1	23.5 sec	25.9 sec
2	27.8 sec	
3	26.4 sec	

Test 3: Size requirement.

Materials:

1. Seat Jack
2. Measuring tape

Procedure:

1. Measure the length width and height of the seat jack and record the values.

Height: 5 6/8th inches.
Width: 18 inches.
Length: 18 inches.

Test 4: Angle and height of lift provided requirement.

Materials:

1. One smart phone with a level by degree ap. (or protractor)
2. Seat Jack
3. Measuring tape

Procedure:

1. Lift seat to full extension and record the angle of lift provided.
2. Conclude if it meets the 30 degree minimum standard.
3. While seat is fully extended measure and record the height of which the highest point of the seat reaches.

Angle of Lift: 70-75 degrees.
Height of lift: 8.5 in.

Test Five: Weight requirement

Materials:
1. Seat Jack
2. Scale that can weigh down to tenths of a pound.

Procedure:
1. Place Seat Jack on scale.
2. Record weight.

Total Weight: 48.3 lbs

BUDGET/SCHEDULE/PROJECT MANAGEMENT

Budget:

The budget of this project was fairly manageable as for most of the screws and nuts were purchased at a low cost. As for the manufactured items, all of the manufacturing processes have been performed by the designer with no need to pay someone else for labor. A couple parts were indeed a bit expensive, especially the thicker slabs of Aluminum needed for the base and seat as well as the 90^{o} corner joint. Unfortunately, the corner joint was out of the budget range available. The designer should always be aware that the price projected for the items needed, will be lower than actual price as estimations of costs are not exact. An approximate total cost for the project will be set at $289.76 out of pocket. (Please note Appendix D)

Schedule/Project Management

Including all steps from design to final prototype, a total estimated project time has been set at 362.8 hours. An approximate schedule for this project is as follows:

Fall Quarter:

- Project Decision
- Design and Analysis
- Predictions of performance
- Selection of Materials

Winter quarter:

- Building device
- Material purchases
- Parts fabrication
- Complete device assembly

Spring Quarter:

- Testing
- Documentation of device capabilities
- Manufacturing Feasibility

Important dates:

- Jan 12 – proposal review
- Jan 31 - Completed proposal
- Feb 5 – Critical Design Review
- March 12 - Completed Prototype
- March 26 – Function Analysis
- May 25 – Testing Completion
- June – Final Project Presentation
  (Please note Appendix E for detailed gant chart and description of time spent on project)

DISCUSSION

Stress analysis has been provided in regards to material selection. A choice of one material for all has been made, with 6061-T6 aluminum for all parts. Design of the Seat Jack's parts includes drawings of; the seat part/assembly, base mounts/ assembly, and fasteners combined. Machining, welding, and drilling processes have been laid out into detailed steps in the schedule and completed with record of time.

Attaining all parts came with ease for the most part. Purchasing all goods worked out in the long run with only one set back according to the schedule. When ordering the raw aluminum, shipping ended up taking much longer than predicted which set back the manufacturing process by two and a half weeks. Part of the hold up on starting the manufacturing processes was also due to the confusion on the transaction for the bevel gear box. The payment was sent in to complete the order to have the gear box shipped to the assembly sector, but was ultimately only one tenth of the asking price for the gear box. Subsequently, the confusion between $150.00 and $1500.00 lead to the omission of the gear box entirely from the design. $1500.00 landed well out of the affordable budget, which came straight from the designers pocket. This made the machining processes time limit to a minimum leaving little spare time for errors.

Thankfully all components were completed by the first deadline, which was for having a working device. Having these processes rushed did cause tolerances to widen slightly, but ultimately were up to predicted standard. A few machining flaws can be noticed on some of the extruded rectangles which make up the mounting brackets. For example, at one point during milling the shape of these angles, the work piece had been dislodged from the holding vise leaving it with minimal, slightly noticeable, end mill teeth marks.

Changes such as; size of mounting holes on both seat and base plates, deciding to tack together the mounting pins to angles (instead of fully welding). Some other small changes have been made to make the assembly and manufacturing processes come together more smoothly which will minimize time and cost overall during building of the device.

After conclusion of the prototype being complete, torque testing confirmed that the drive motor only needed to produce approximately 10 ft·lbs of torque to lift 300lbs with the “Seat Jack”. This 10 ft·lbs of torque can easily lift the weight of the chosen dummy at 273lbs.

Mode of Failure

All parts meet a safety factor of 5 which is typical for any supporting object of a human. Even during the highest mode of failure analyzed in Figure 2-3, the supporting pin of the Jack to the base, failure will not occur. With all the weight positioned on this one pin, (the way the jack stands this will not happen) it would take five times the force created from our statistically size determined dummy. That pin alone is built to withstand 6,519 psi so the likeliness that the weight of a human being will destruct that pin is very low.

CONCLUSION

Seat Jack goes with you, where ever you go! The completed prototype acts as a benchmark for further improvements with portable seat lifting devices. Several processing skills have been demonstrated to manufacture the first prototype of its kind. Using these skills to go along with the equipment provided by the Central Washington University’s Mechanical Engineering Technology and Industrial Engineering Technology departments, the Seat Jack prototype has been designed, manufactured, and tested to provide these attributes; Becoming one of the first portable seat lifting devices, Weighing in under 50 lbs, Providing lift to up to a 300 lb person, demonstrating a lift range of up to 8.5 inches, attaining a maximum angle between 70° and 75°, and having a cycle time under 30 seconds, all while costing less than $300.00 to produce. There is a great area for improvement in all the categories these attributes fall under. Given the funding of a large company and its recourses, minimizing weight and size while maximizing lifting capacity can be attained. Doing just that will produce a very valuable device this world has yet to see.

ACKNOWLEDGEMENTS

Acknowledgements to both the MET and IET programs at CWU to provide me with the knowledge of material as well as the shop equipment needed to design, analyze, and manufacture this project. A great thanks to my three main professors at the university; Professor Charles Pringle, Dr. Craig Johnson, and Professor Rodger Beardsley.

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APPENDIX A – Analyses

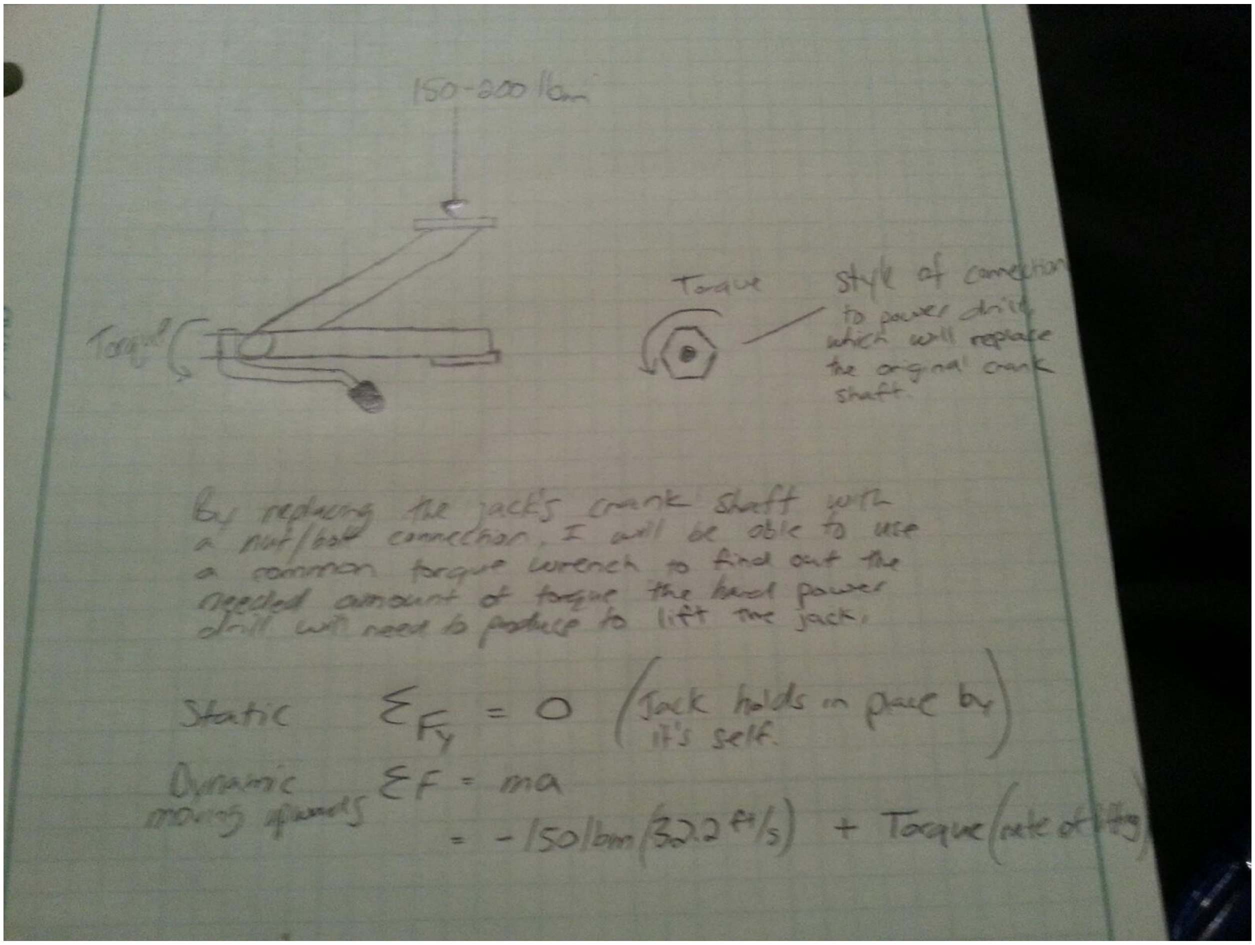

150-200 lbm
Torque
Torque
style of connection to power drill which will replace the original crank shaft.
By replacing the jack's crank shaft with a nut/bolt connection, I will be able to use a common torque wrench to find out the needed amount of torque the hand power drill will need to produce to lift the jack.
Static ΣFy = 0 (Jack holds in place by it's self.)
Dynamic moving upwards ΣF = ma
= -150 lbm(32.2 ft/s) + Torque(rate of lifting)

Figure 2-1

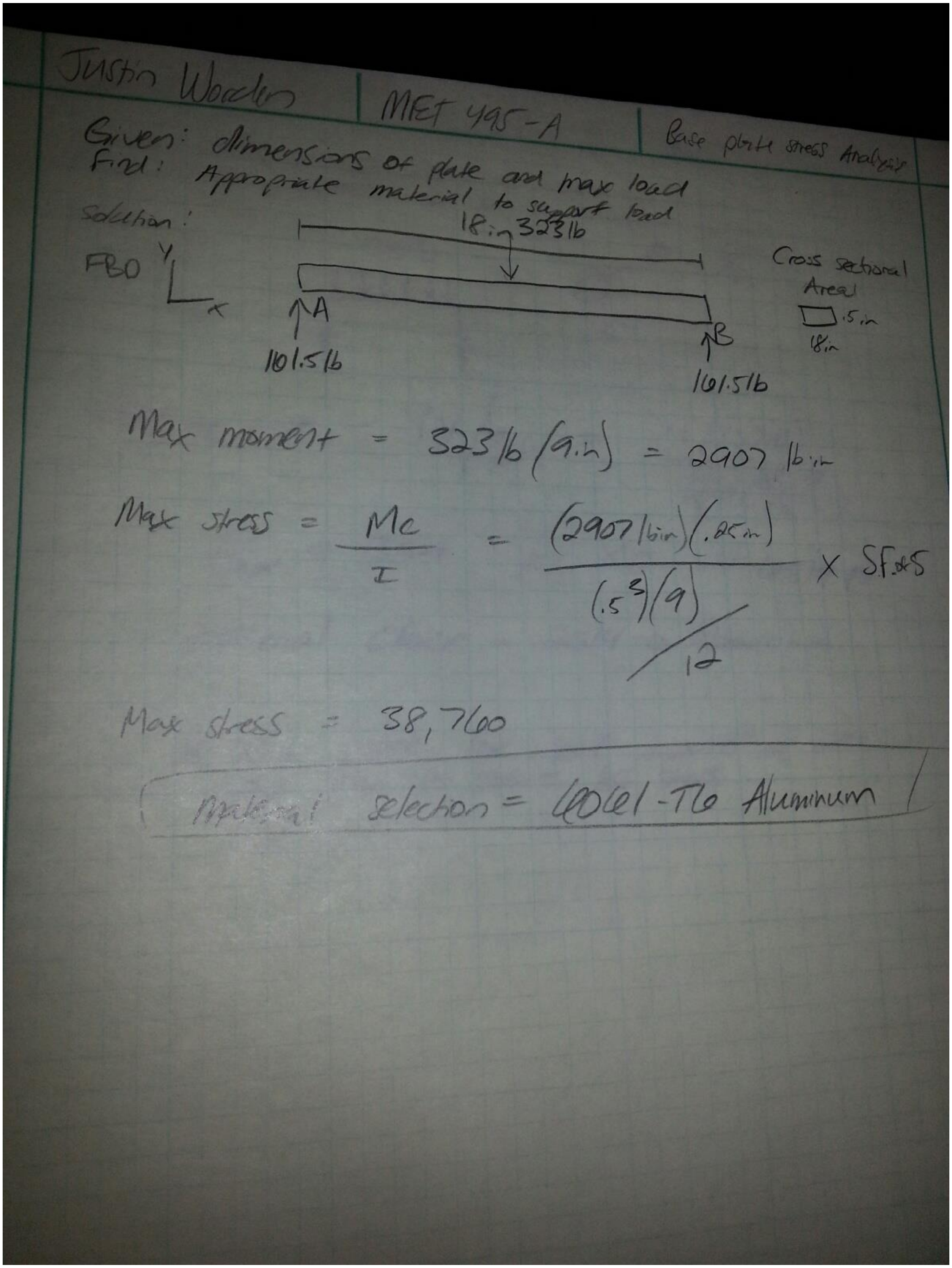

Justin Woeckler
MET 495-A
Base plate stress Analysis
Given: dimensions of plate and max load
Find: Appropriate material to support load
Solution:
FBD
18 in
323 lb
A
B
161.5 lb
161.5 lb
Cross sectional Area
.5 in
18 in
Max moment = 323 lb (9 in) = 2907 lb·in
Max stress = Mc / I
Max stress = 38,760
selection = 6061-T6 Aluminum

Figure 2-2

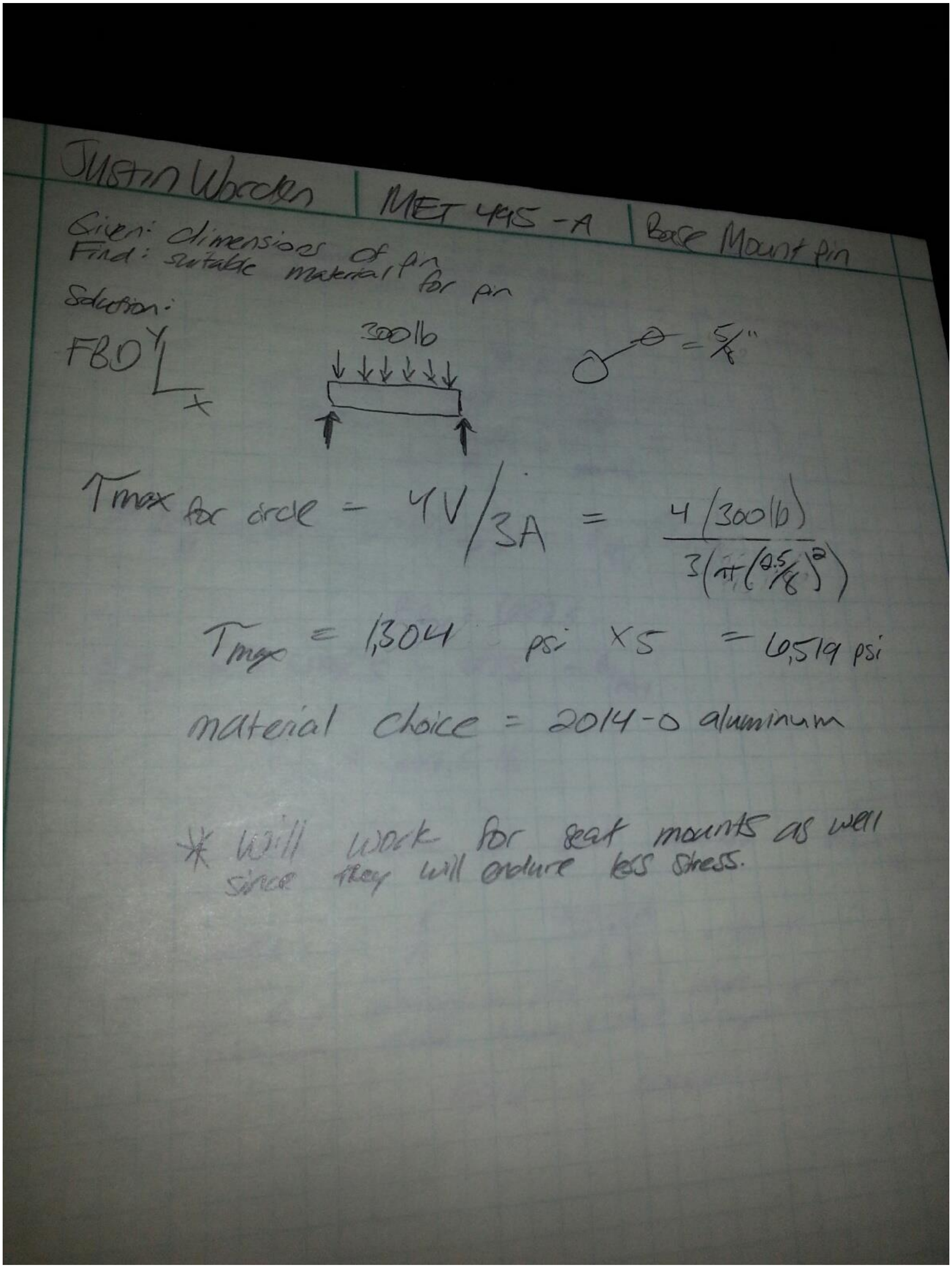
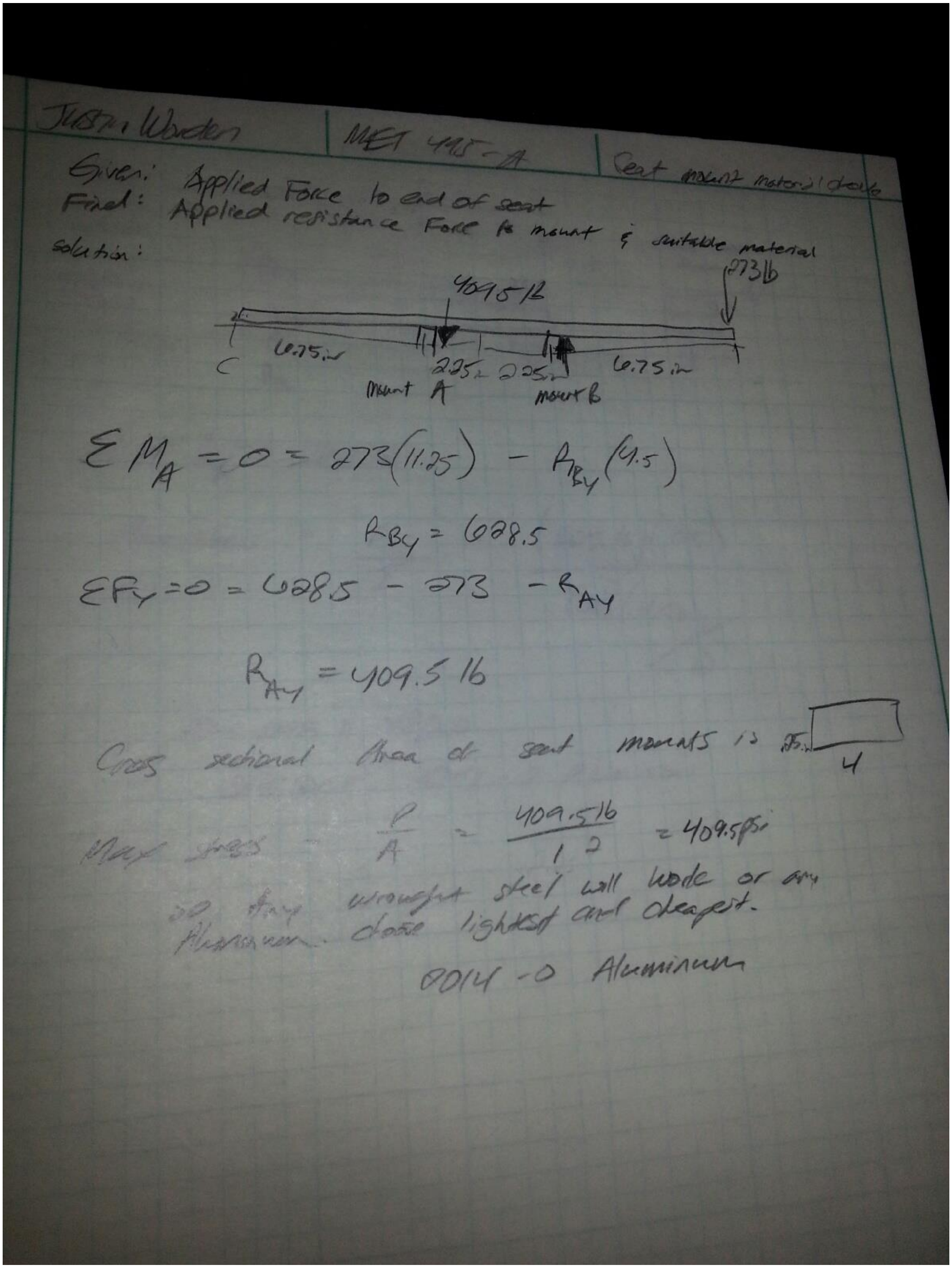

Justin Worden
MET 495 - A
Base Mount pin
Given: dimensions of pin
Find: suitable material for pin
Solution:
FBD
300 lb
τ_{max} for circle = 4V/3A = 4(300 lb) / 3(π(0.5/8)²)
τ_{max} = 1,304 psi × 5 = 6,519 psi
material choice = 2014-0 aluminum
* Will work for seat mounts as well since they will endure less stress.

Figure 2-3



Justin Warden | MET 495-A | Seat mount material choice

Given: Applied Force to end of seat

Find: Applied resistance Force to mount & suitable material

solution:

$$\Sigma M_A = 0 = 273(11.25) - R_{By}(4.5)$$

$$R_{By} = 628.5$$

$$\Sigma F_y = 0 = 628.5 - 273 - R_{Ay}$$

$$R_{Ay} = 409.5 \text{ lb}$$

Cross sectional Area at seat mounts is .25 in × 4

Max stress $= \frac{P}{A} = \frac{409.5 \text{ lb}}{1 \text{ in}^2} = 409.5$ psi

So any wrought steel will work or any Aluminum. chose lightest and cheapest.

2014-O Aluminum

Figure 2-4

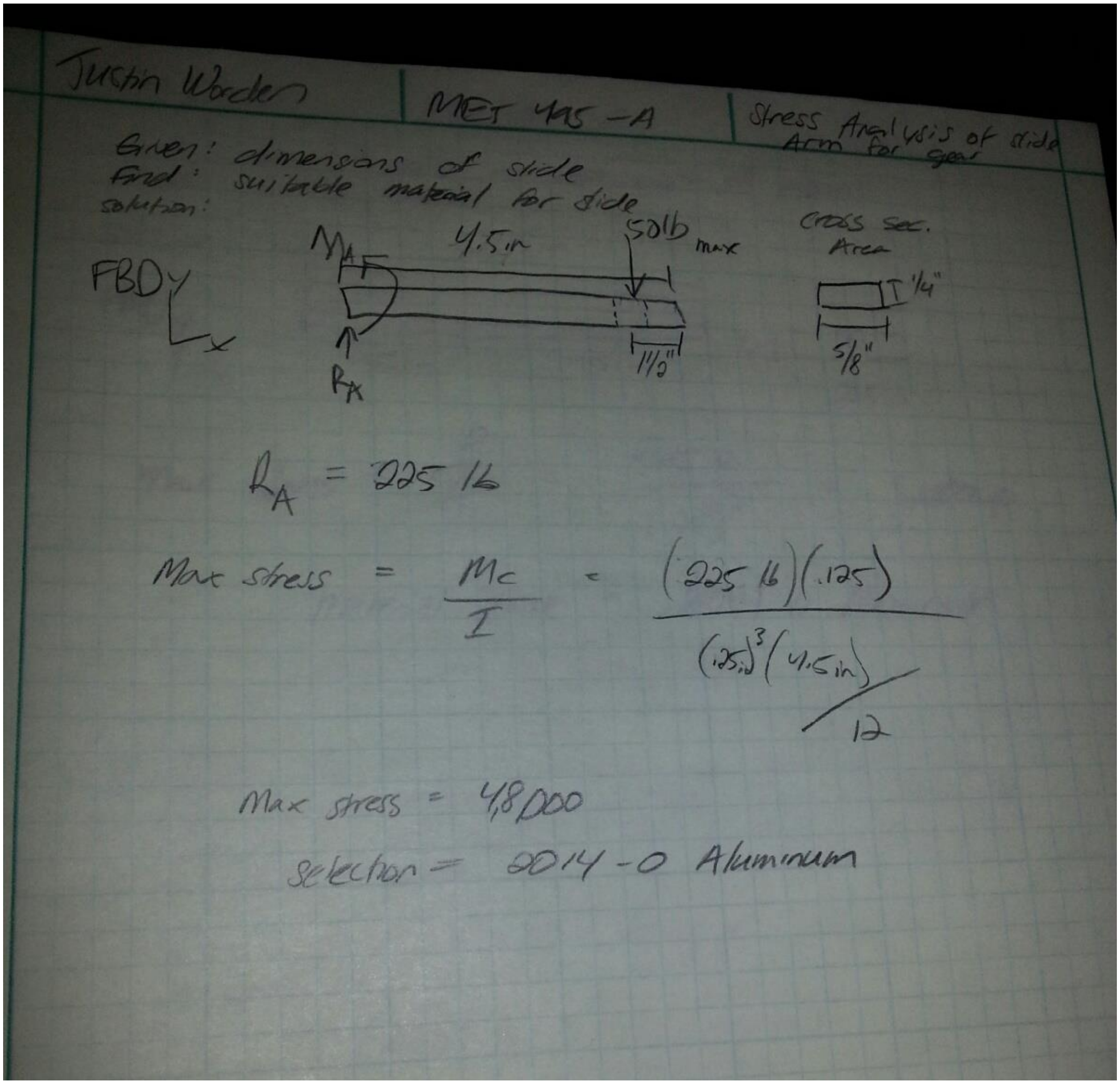

Justin Worden
MET 495 -A
Stress Analysis of slide Arm for gear
Given: dimensions of slide
Find: suitable material for slide
solution:
FBD
MA
4.5 in
50 lb max
RA
1 1/2"
cross sec. Area
1/4"
5/8"
RA = 225 lb
Max stress = Mc / I = (225 lb)(.125) / ((.25 in)^3 (4.5 in) / 12)
Max stress = 48,000
selection = 2014-0 Aluminum

Figure 2-5

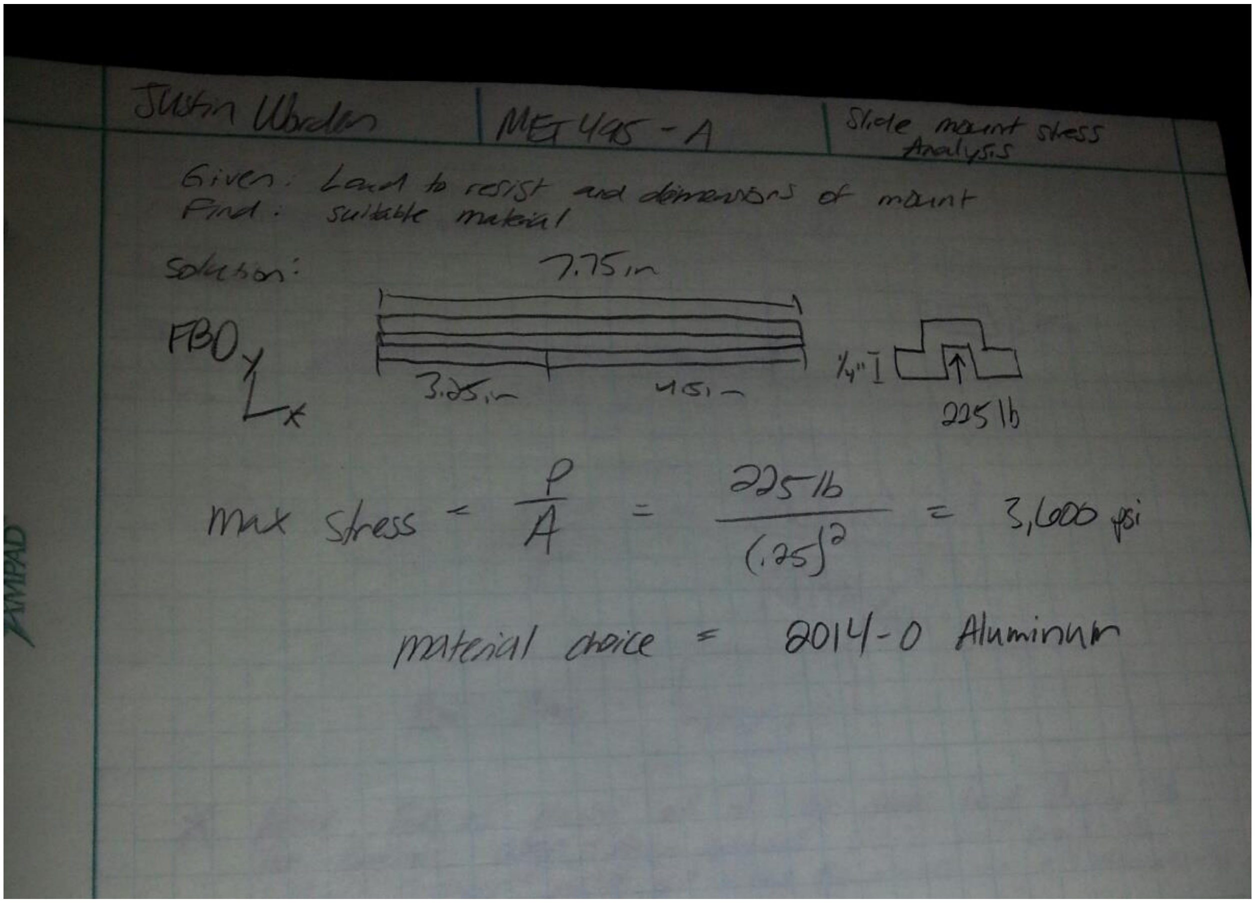

Justin Worden
MET 495 - A
Slide mount stress Analysis
Given: Load to resist and dimensions of mount
Find: suitable material
solution:
7.75 in
FBD
y
x
3.25 in
4.5 in
1/4"
225 lb
max stress = P/A = 225 lb/(.25)^2 = 3,600 psi
material choice = 2014-0 Aluminum

Figure 2-6

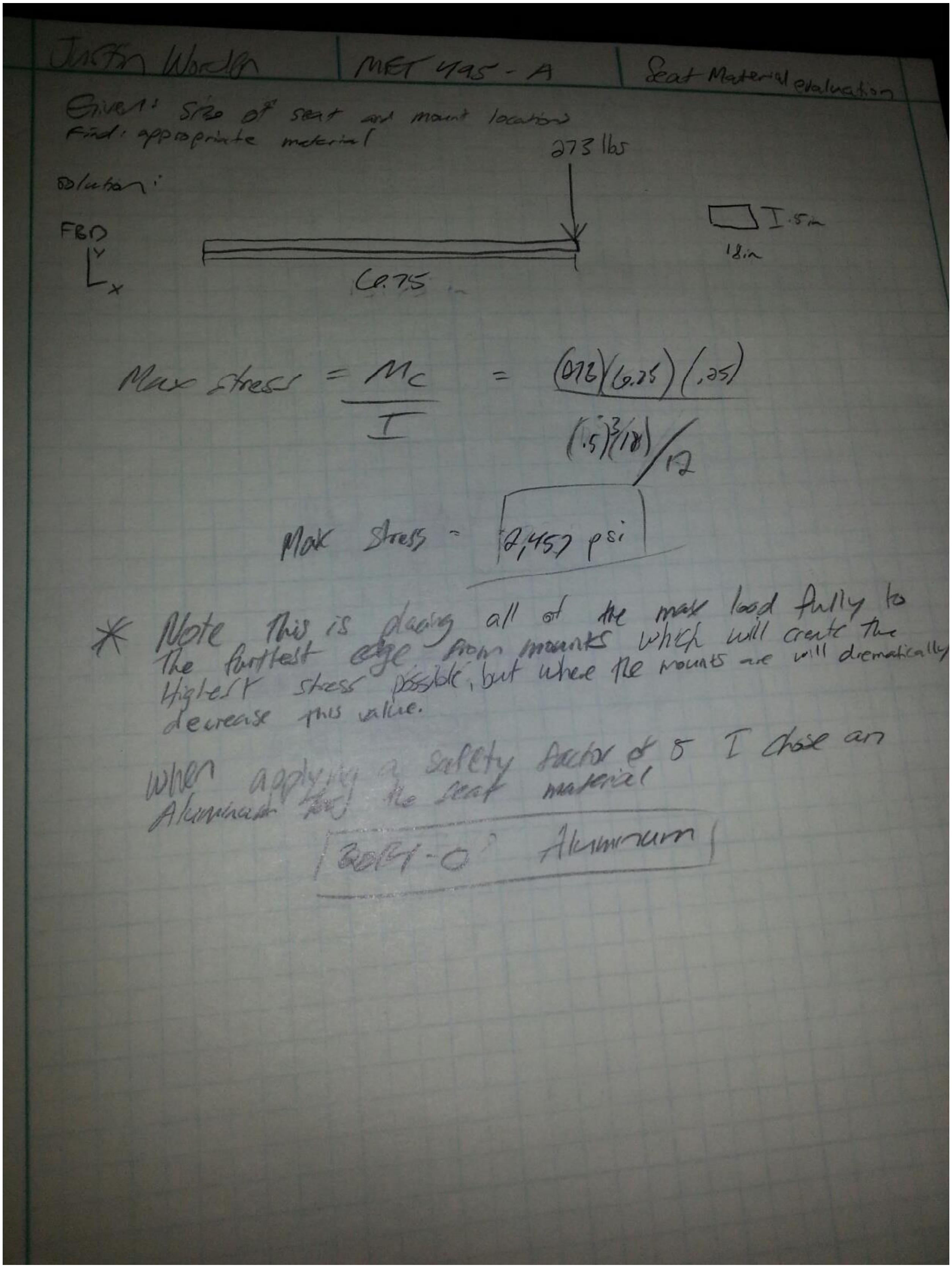

MET 495 - A
Seat Material evaluation
Given: Size of seat and mount locations
Find: appropriate material
273 lbs
Solution:
FBD
y
x
.5in
18in
6.75
Max Stress = Mc / I
Max Stress = 2,457 psi
* Note this is placing all of the max load fully to the furthest edge from mounts which will create the highest stress possible, but where the mounts are will dramatically decrease this value.
When applying a safety factor of 5 I chose an Aluminum for the seat material
Aluminum

Figure 2-7

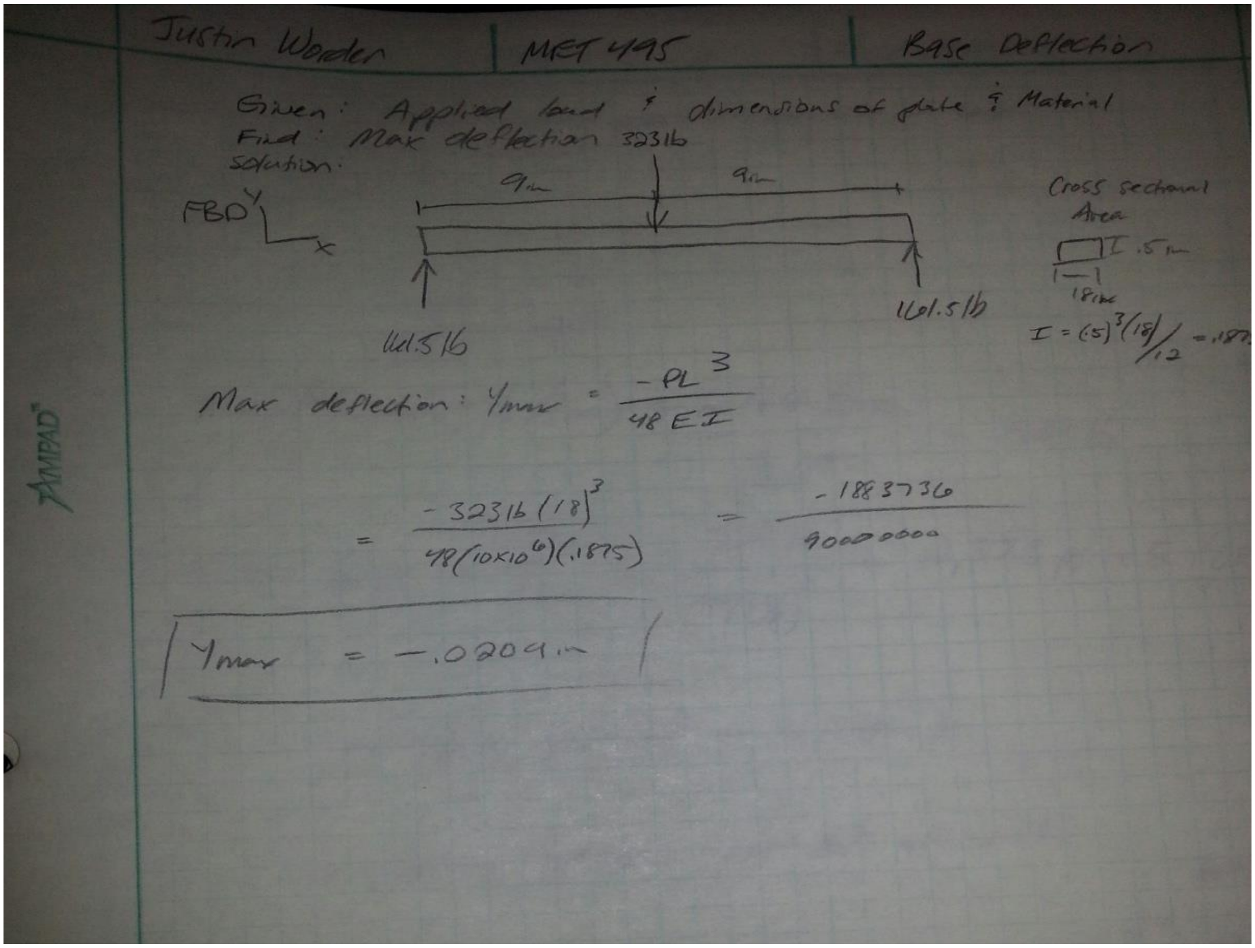

Justin Worden
MET 495
Base Deflection
Given: Applied load & dimensions of plate & Material
Find: Max deflection 323lb
Solution:
FBD
9in
9in
Cross sectional Area
.5in
18in
161.5lb
161.5lb
I = (.5)^3(18)/12 = .1875
Max deflection: Ymax = -PL^3 / 48EI
= -323lb (18)^3 / 48(10x10^6)(.1875) = -1883736 / 90000000
Ymax = -.0209in

Figure 2-8

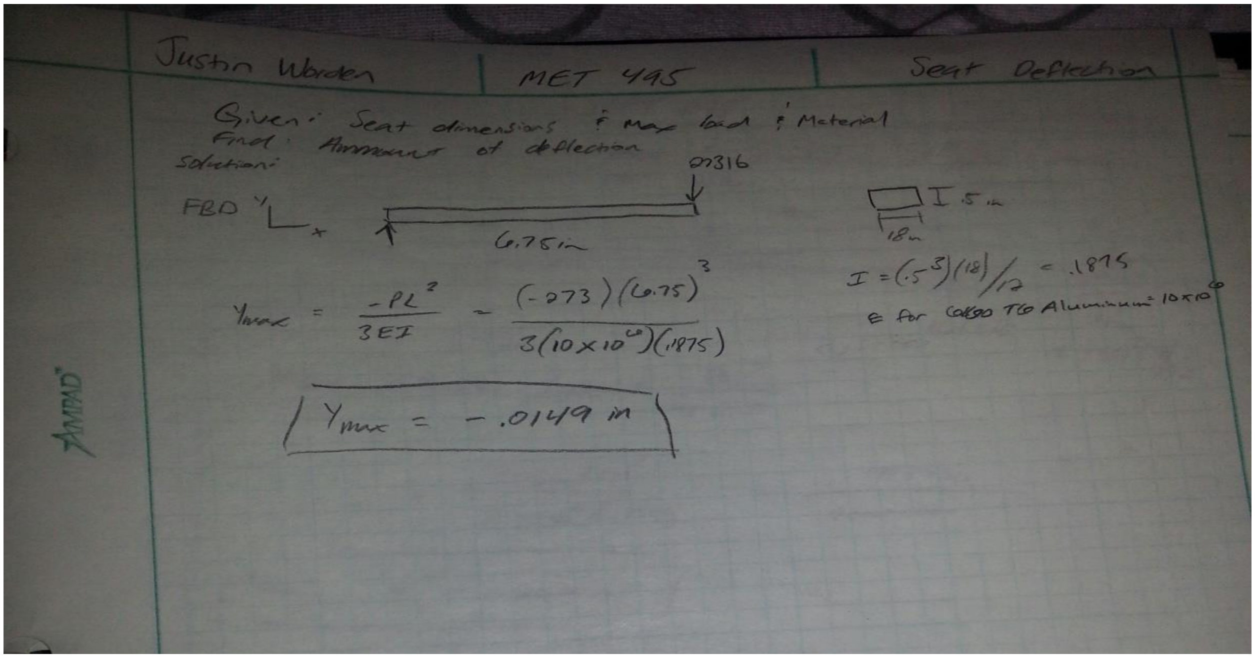


Figure 2-9

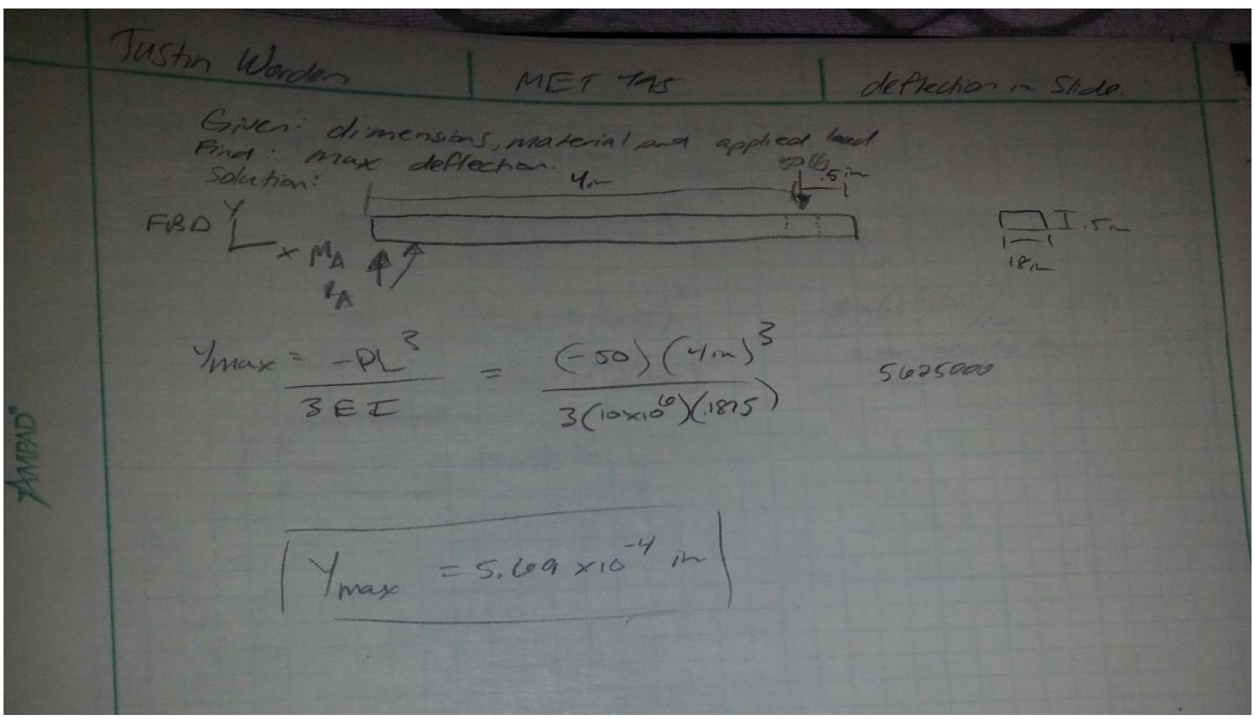


Figure 2-10

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		*APPLICATION:*			*Load with moderate shock driven by an electric motor.*										
2					*Example Problems 10-5 and 10-6*	*Both gear straddle mounted*							Bevel Gear Corner for Seat Jack		
3					***Factors in Design Analysis:***										
4	P =	2.5	hp		Load distribution factor, K_m:	From Table 10-3									
5	n_P =	500	rpm			Quality class of mounting:									
6	P_d =	12				General	High								
7	N_P =	32			Both gears straddle mounted:	1.44	1.20								
8	n_G =	500	rpm		One gear straddle mounted:	1.58	1.32								
9		32.0			Neither gear straddle mounted:	1.80	1.50								
10	N_G =	32			*Enter K_m =*	1.44									
11					Overload Factor: K_o =	1.50	Table 9-5								
12	n_G =	500.0	rpm		Size Factor: K_s =	1.00	Table 9-6: Use 1.00 if P_d >= 5								
13	m_G =	1.00			Estimated s_{at} =	36000	psi	***Iterate with new s_{at}***							
14	D_P =	2.667	in		Modulus of elasticity, E (pinion/gear) =	3.0E+07	psi	3.0E+07	psi	For C_v and K_v					
15	D_G =	2.667	in		Dynamic Factor: C_v and K_v =	0.816	Computed: Equation 10-15			u =	0.925				
16	γ =	45.00	degrees		***NOTE: If Cv is less than:***	0.515	***Use higher quality number***			K_z =	75.8				
17	Γ =	45.00	degrees		Service Factor: SF =	1.00	Use 1.00 if no unusual conditions								
18	A_o =	1.8856	in		Reliability Factor: K_R =	1.00	Table 9-8	Use 1.00 for R = .99		*For R =*	K_R				
19					*Enter: Design Life:*	1000	hours	See Table 9-7		0.9	0.85				
20	v_t =	349	ft/min		Pinion - Number of load cycles: N_P =	3.0E+07	Guidelines: Y_N, Z_N			0.99	1.00				
21	W_t =	236	lb		Gear - Number of load cycles: N_G =	3.0E+07	10^7 cycles	$>10^7$	$<10^7$	0.999	1.25				
22	***ut Data:***				Bending Stress Cycle Factor: Y_{NP} =	1.00	1.00	1.00	Fig. 9-22	0.9999	1.50				
23	Nom	Max	Max		Bending Stress Cycle Factor: Y_{NG} =	1.00	1.00	1.00	Fig. 9-22						
24	0.566	0.629	0.833		Pitting Stress Cycle Factor: Z_{NP} =	1.00	1.00	0.98	Fig. 9-24						
25	F =	1.000	in		Pitting Stress Cycle Factor: Z_{NG} =	1.00	1.00	0.98	Fig. 9-24	Through Hardened					
26	Cp = 2300		Table 9-9		***Stress Analysis: Bending***					Grade 1 Steel					
27	Q_v = 6		Table 9-2		Pinion: Required s_{at} =	32,660	psi	See Fig. 9-10 or		HB	257	Fig. 9-10			
28					Gear: Required s_{at} =	38,921	psi	Table 9-3 or 9-4		HB	338	Fig. 9-10			
29					***Stress Analysis: Pitting***										
30	J_P = 0.230		Fig. 10-13		Pinion: Required s_{ac} =	80,513	psi	See Fig. 9-11 or		HB	160	Fig. 9-11			
31	J_G = 0.193		Fig. 10-13		Gear: Required s_{ac} =	80,513	psi	Table 9-3 or 9-4		HB	160	Fig. 9-11			
32	I = 0.077		Fig. 10-14		***Specify materials, alloy and heat treatment, for most severe requirement.***										
33					***One possible material specification:***										
34					Pinion: HB 213 required: AISI 1040 WQT 1100; HB = 235										
35					Pinion: HB 213 required: AISI 1040 WQT 1100; HB = 235										
36															

Figure 2-11

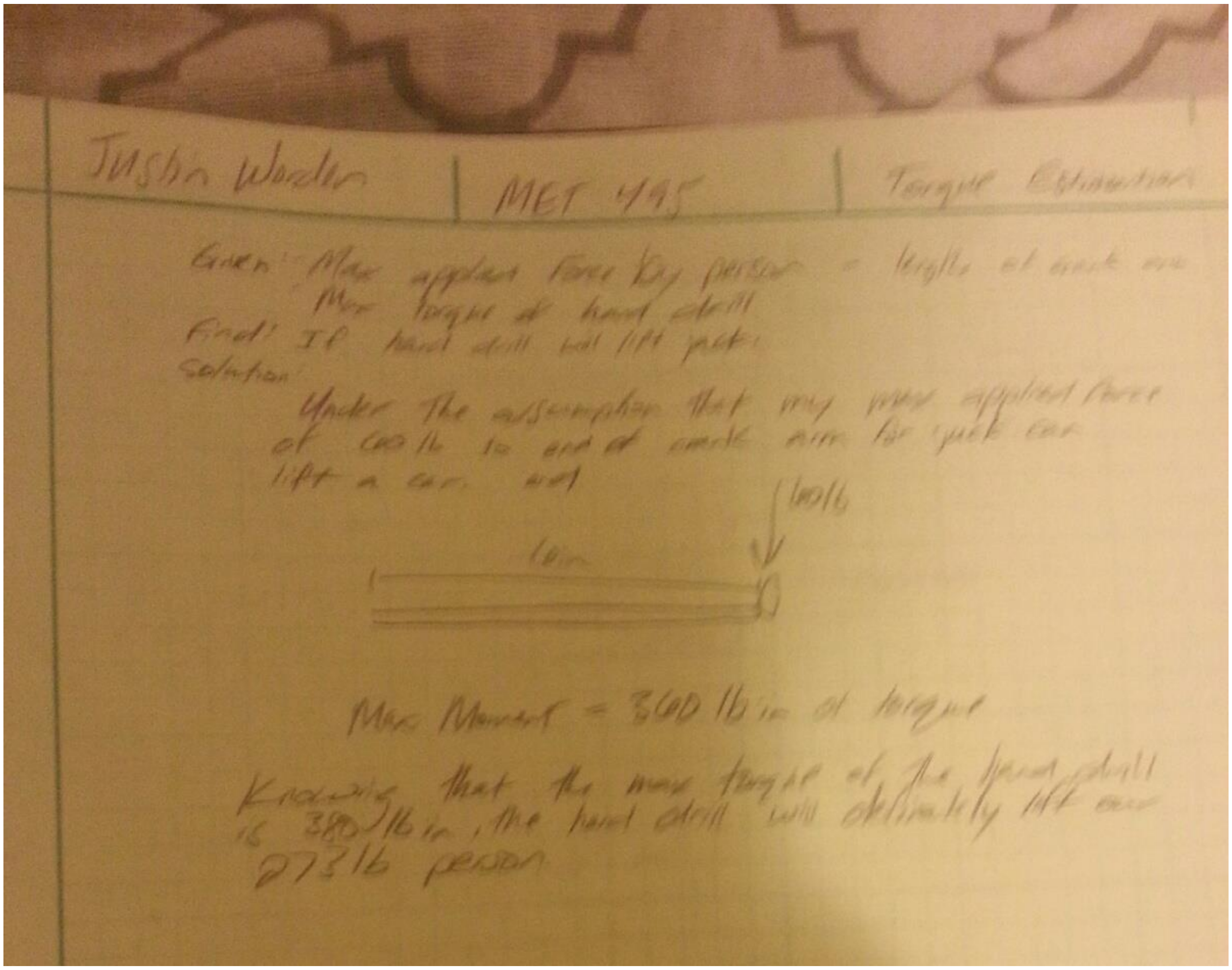


Figure 2-12

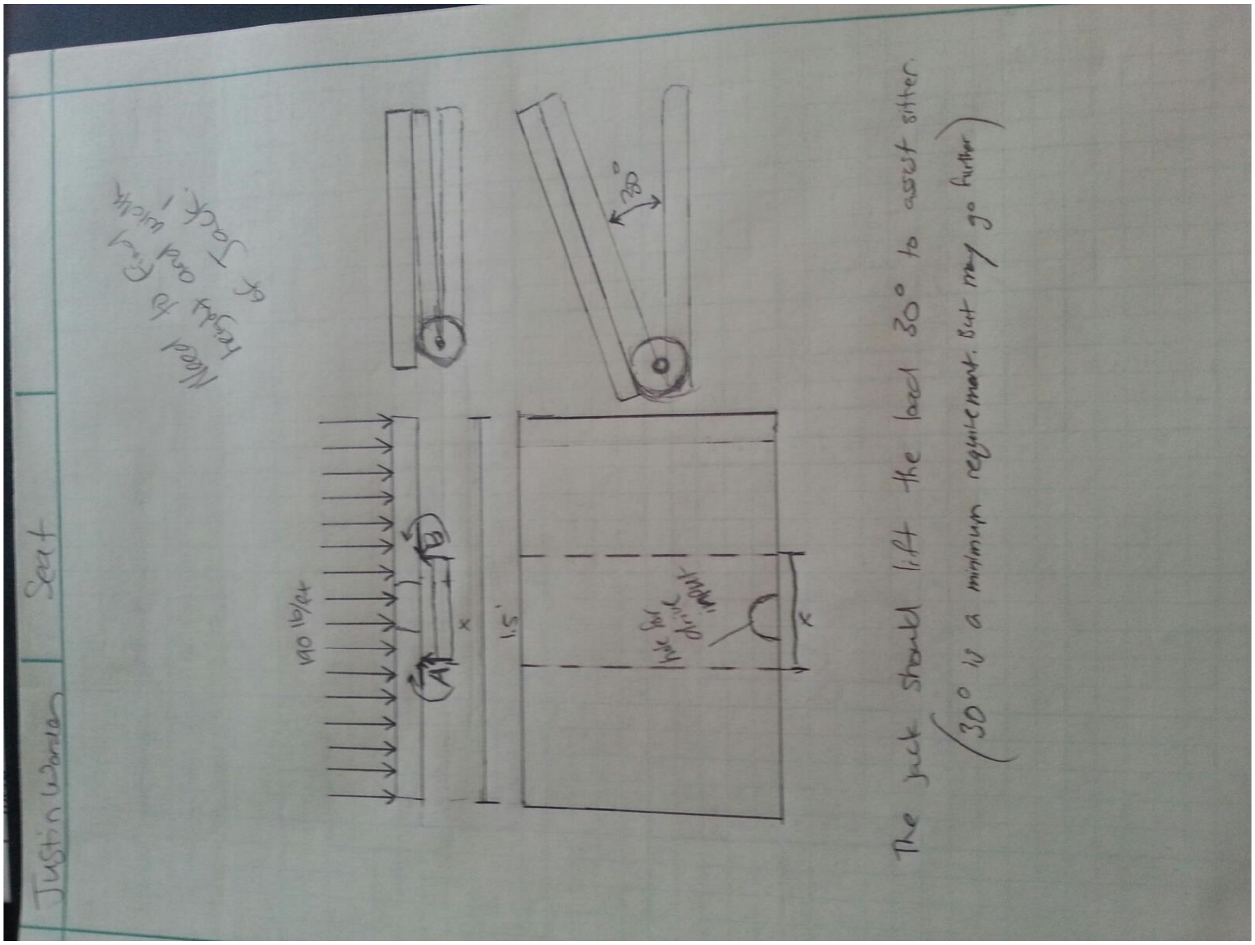

Justin Warden
Seat
190 lb/ft
A
B
x
1.5'
30°
The jack should lift the load 30° to assist sitter.
(30° is a minimum requirement. But may go further)

Figure 1-4

Figure 1-5 Actual picture of jack

APPENDIX B – Sketches, Assembly drawings, Sub-assembly drawings, Part drawings

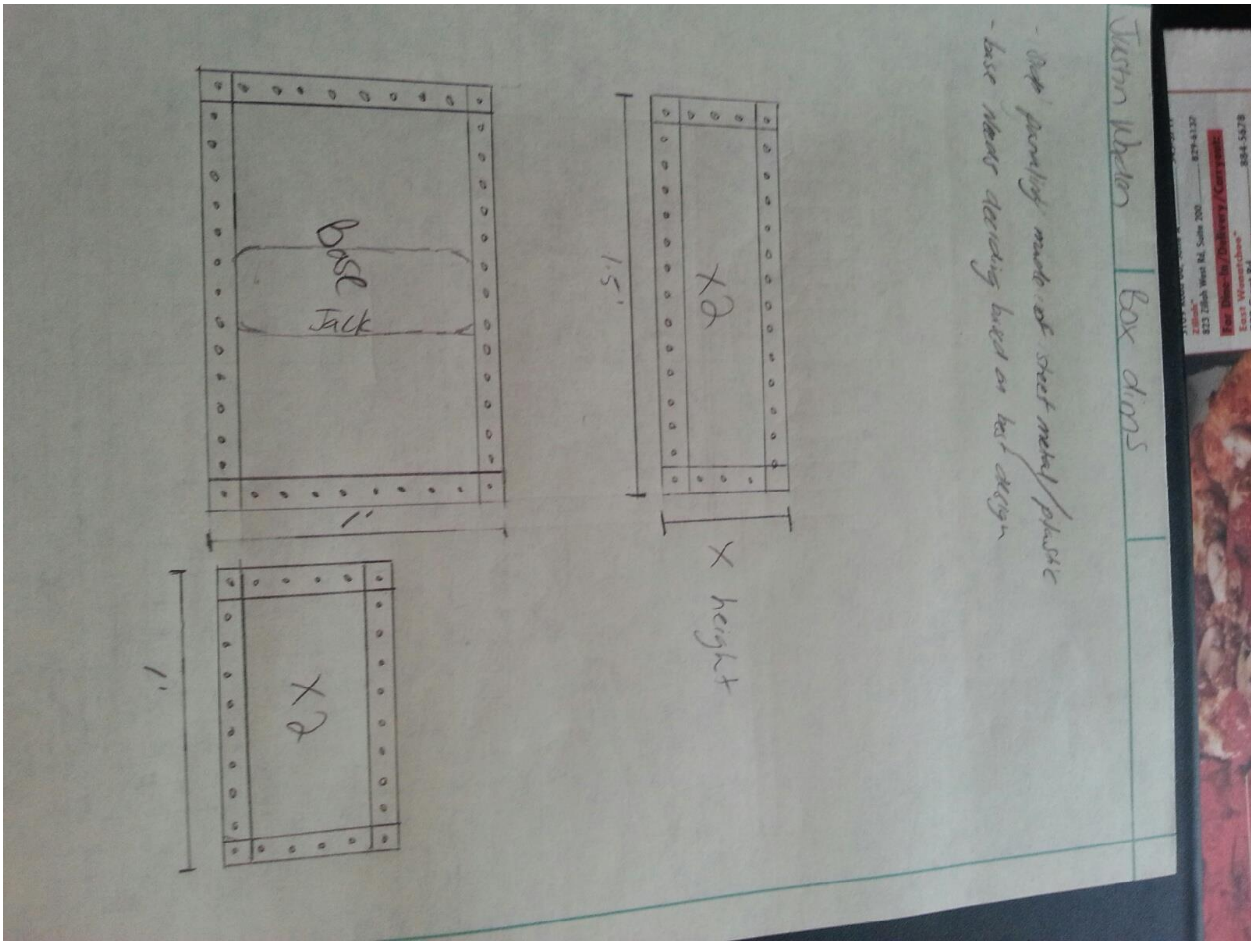


Figure 3-1

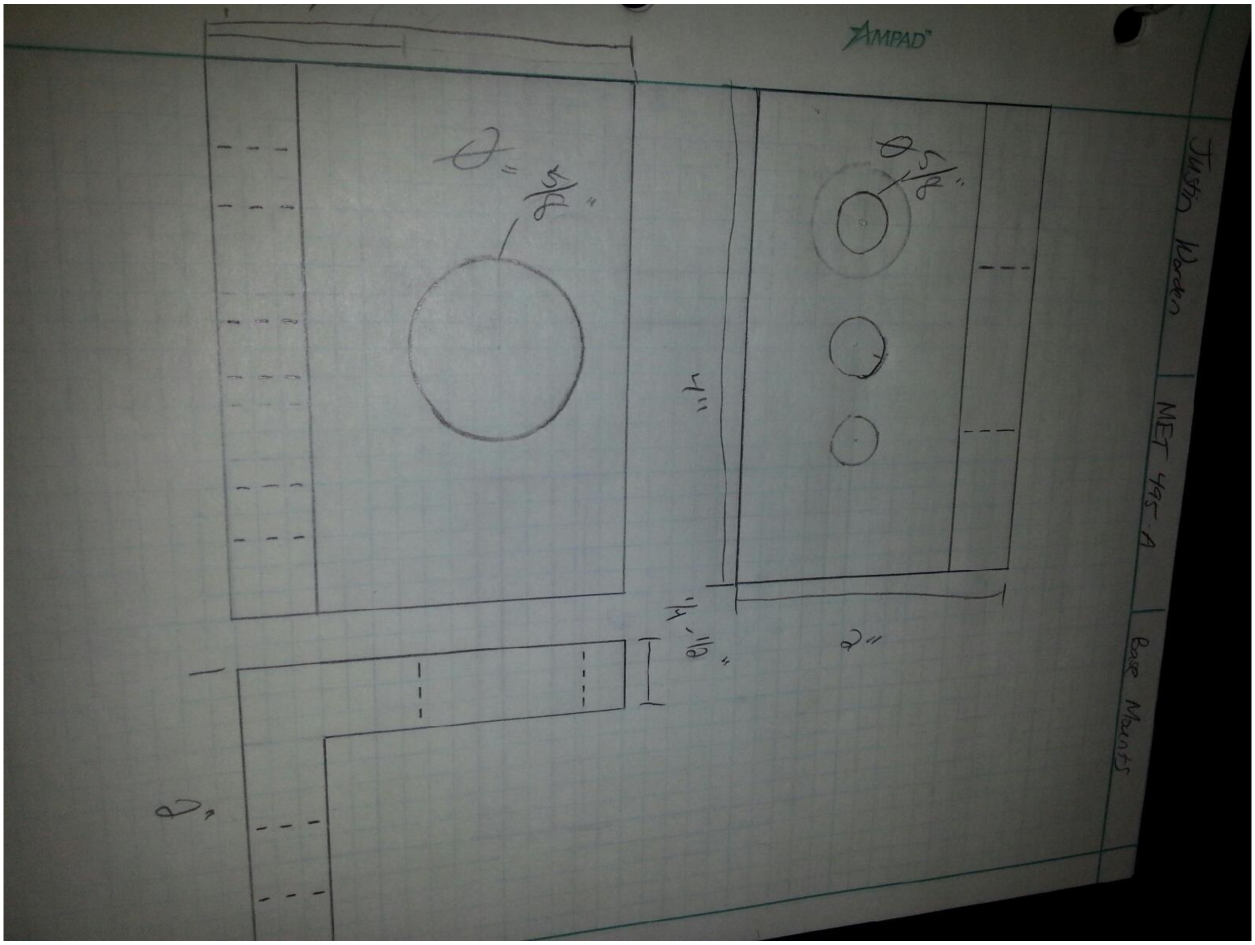


Figure 3-2

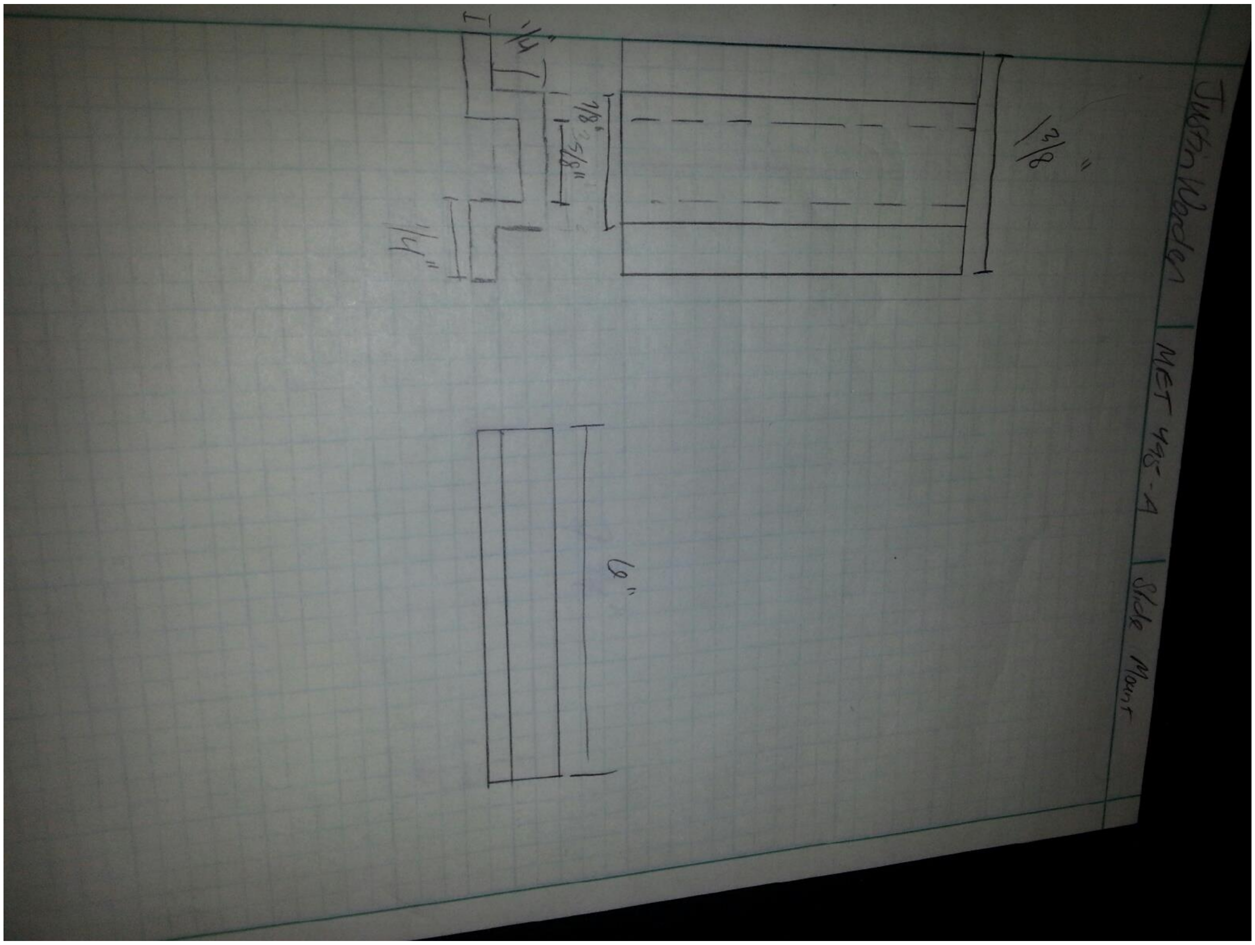


Figure 3-3

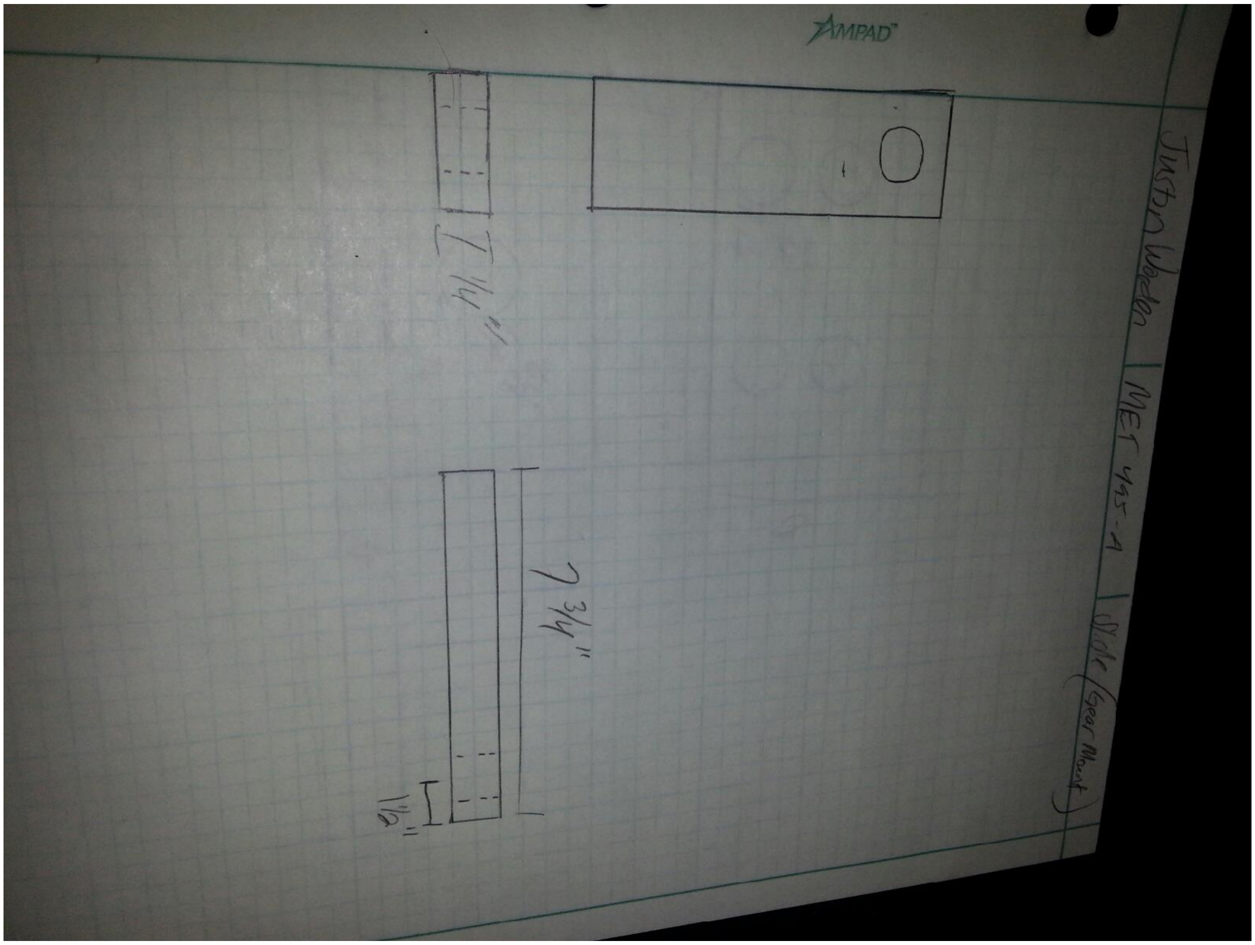


Figure3-4

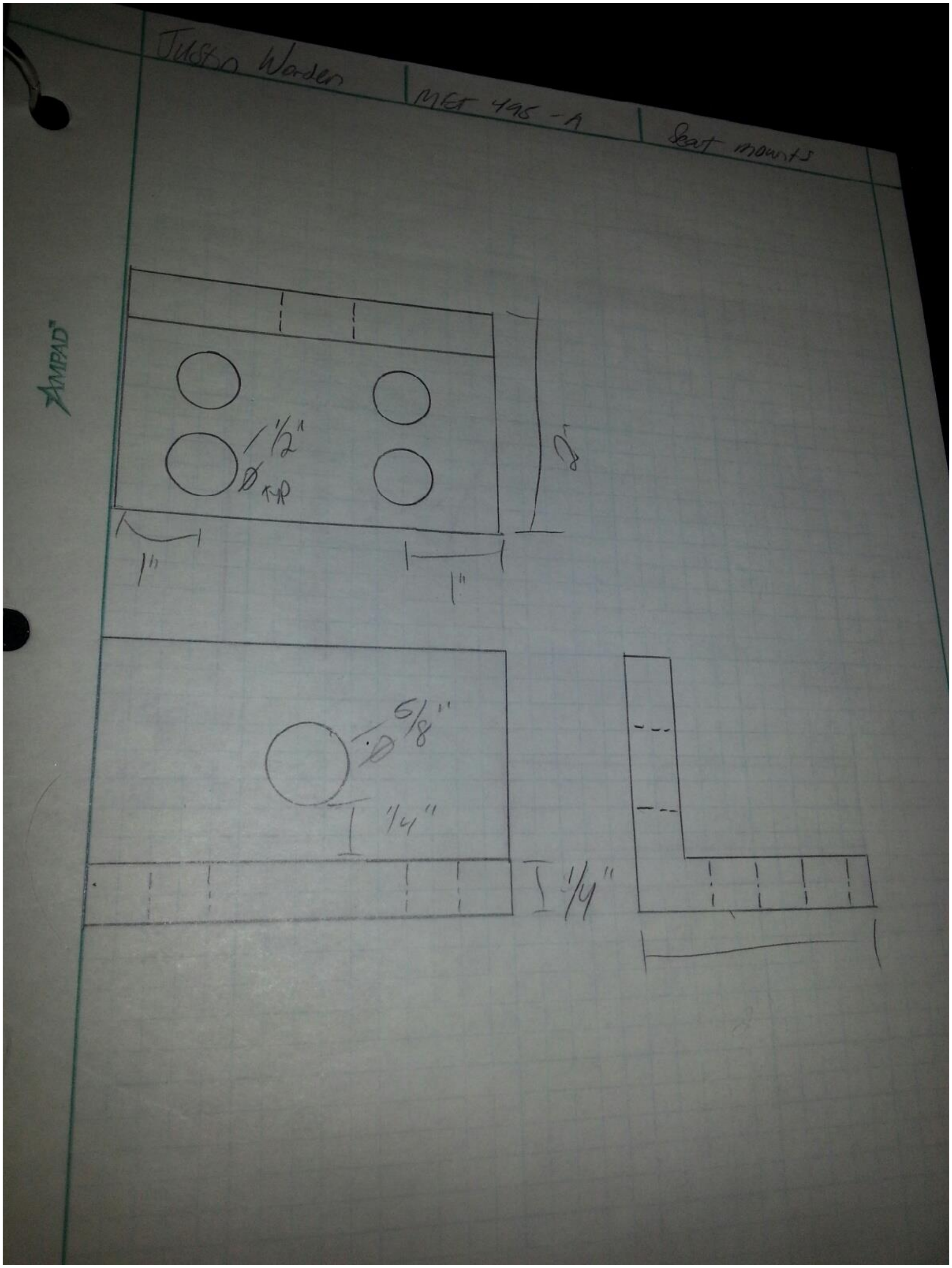


Figure 3-5

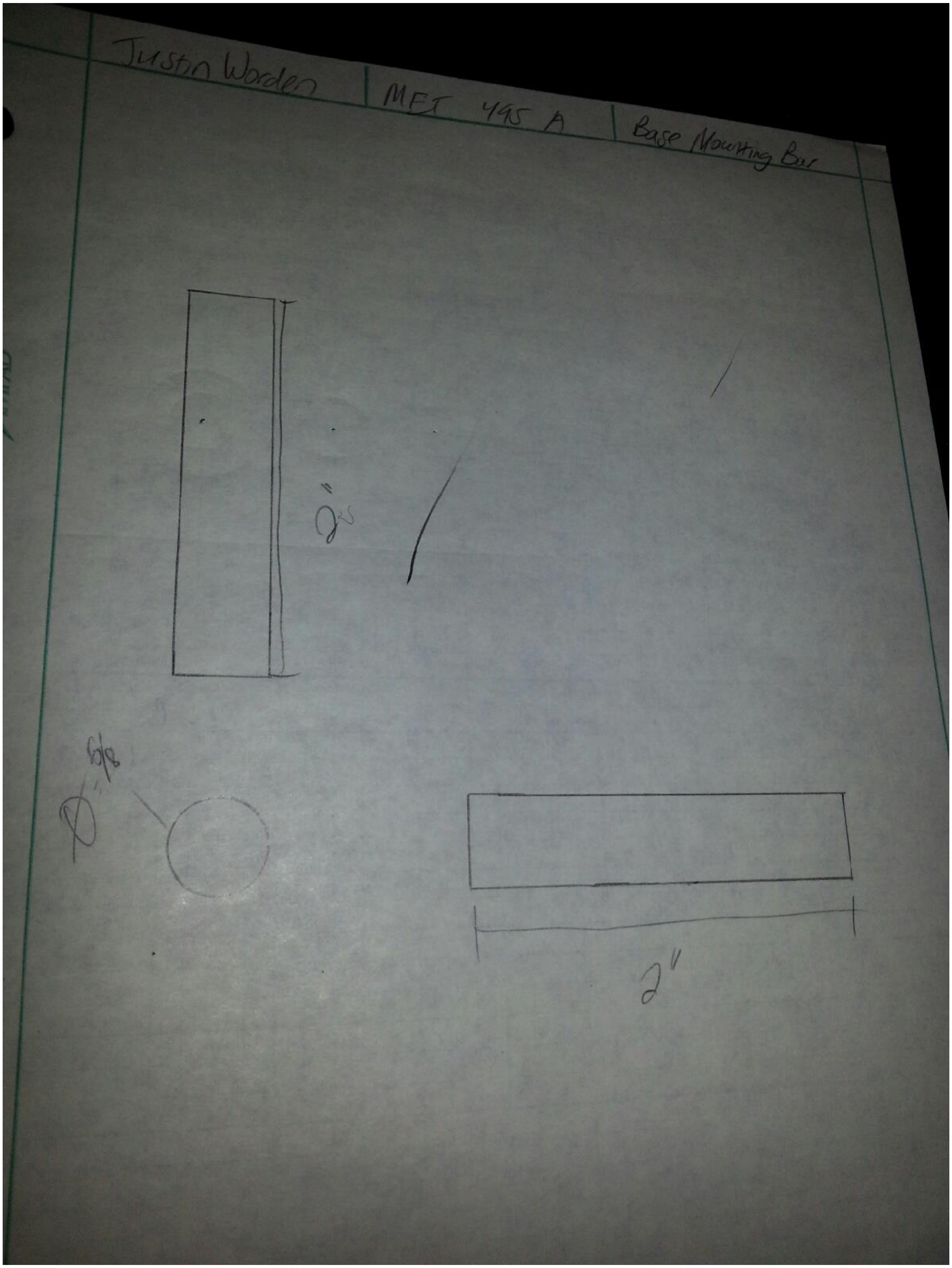


Figure 3-6

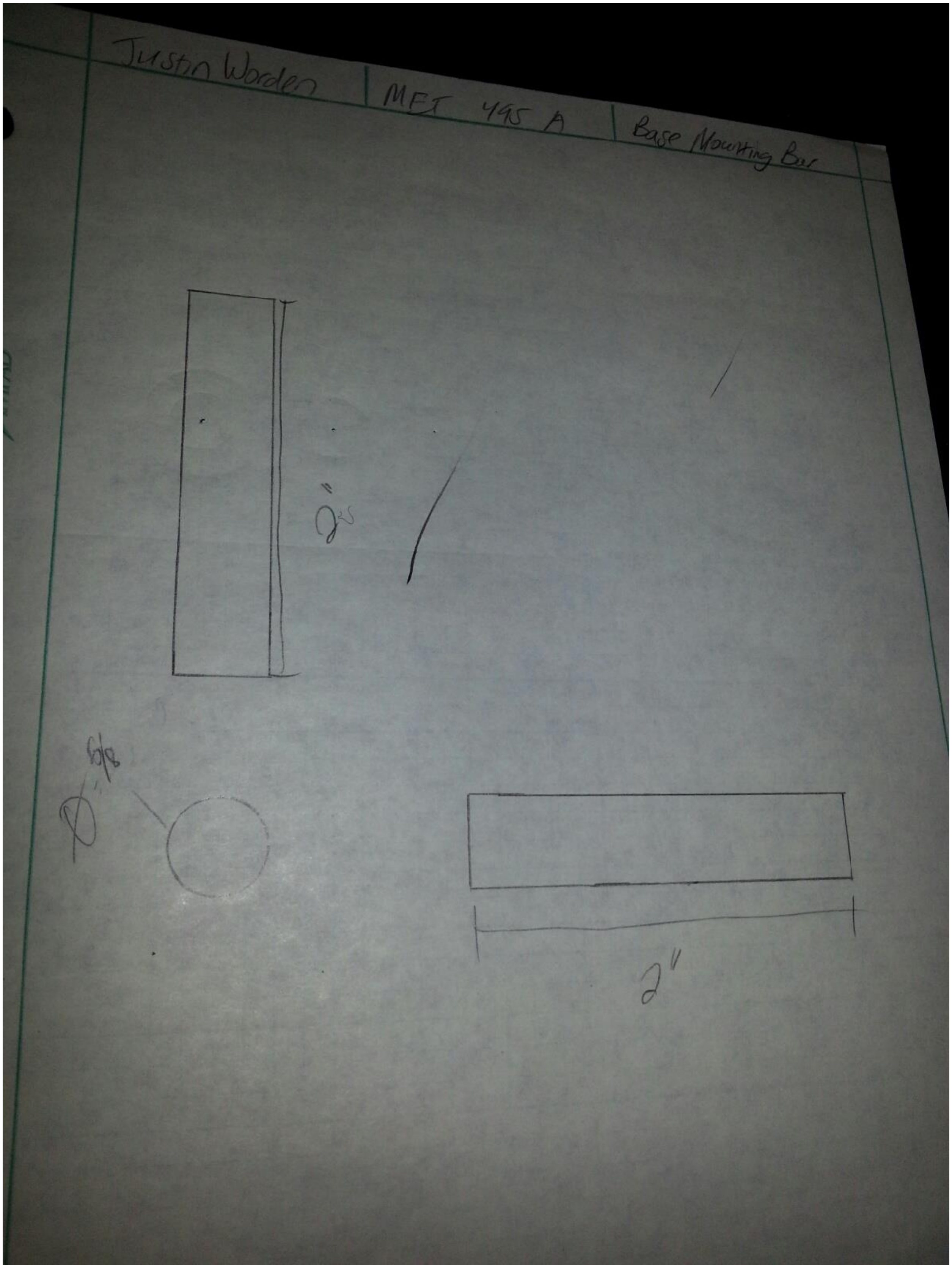


Figure 3-7

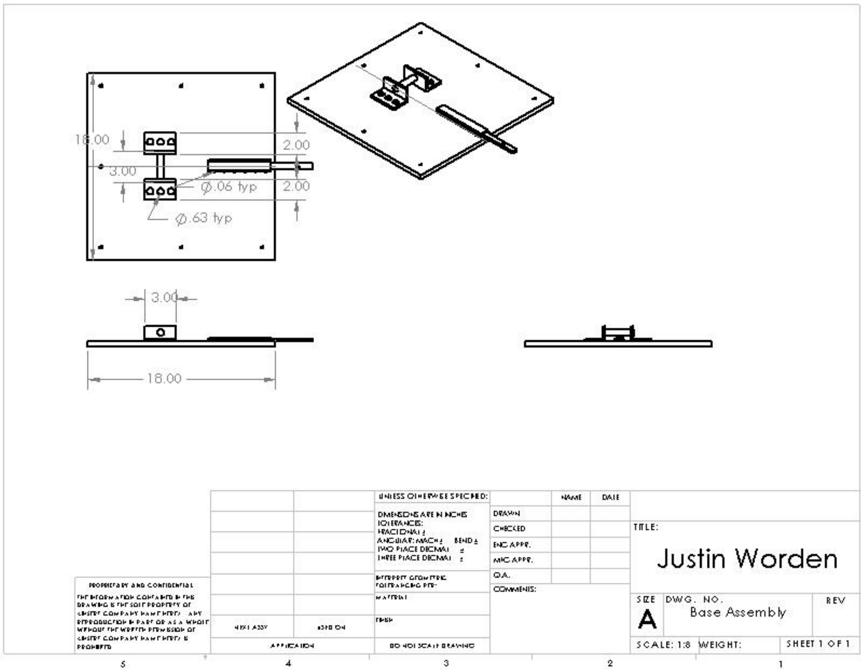


Figure 4-1

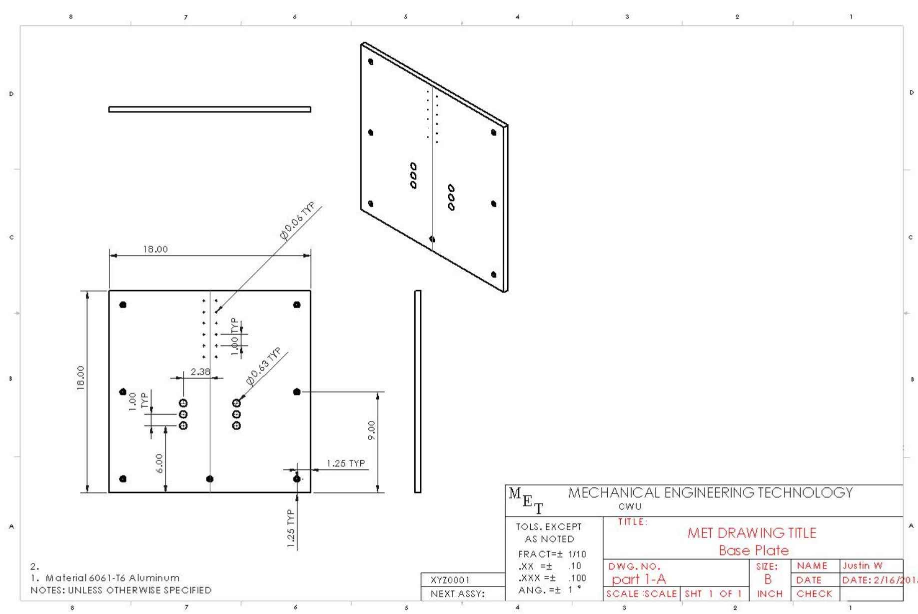


Figure 4-2

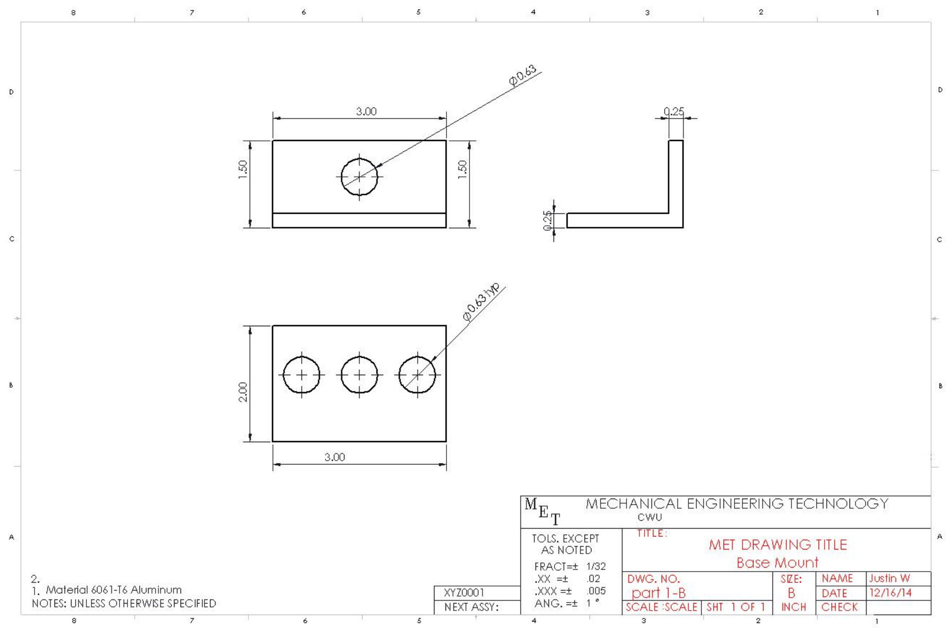


Figure 4-3

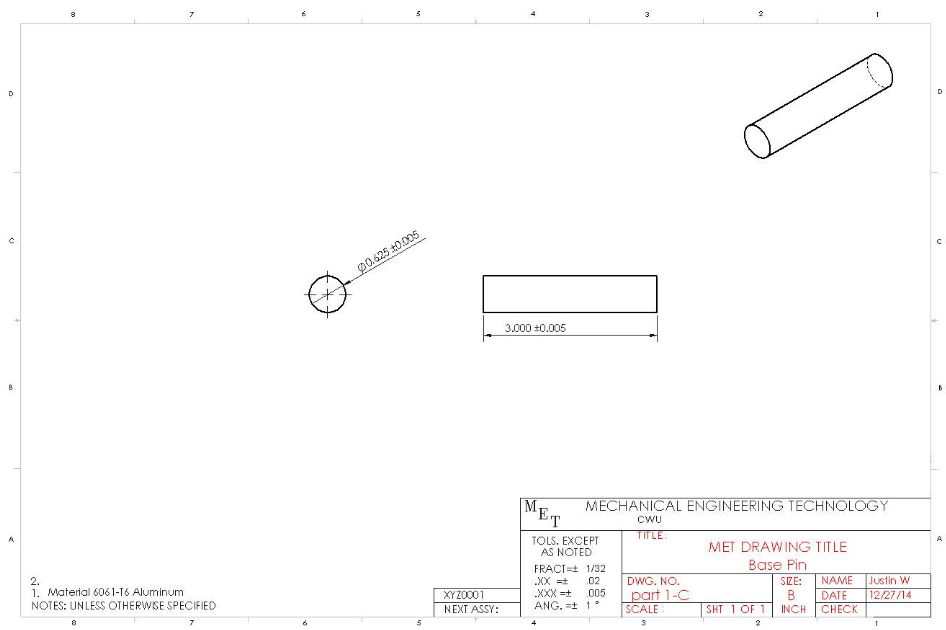


Figure 4-4 This is the one that is of ANSI 14.5 Requirements

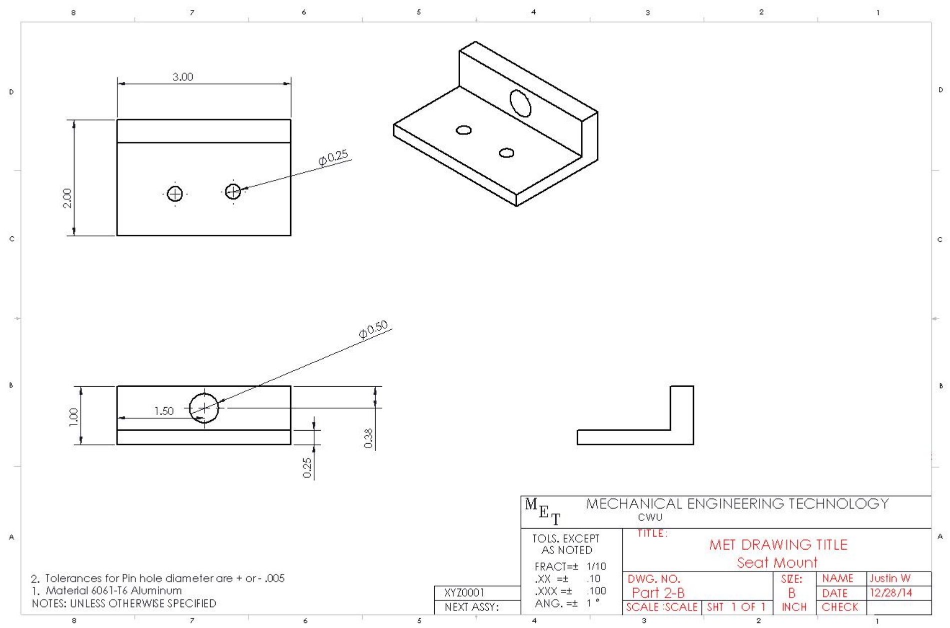


Figure 4-5

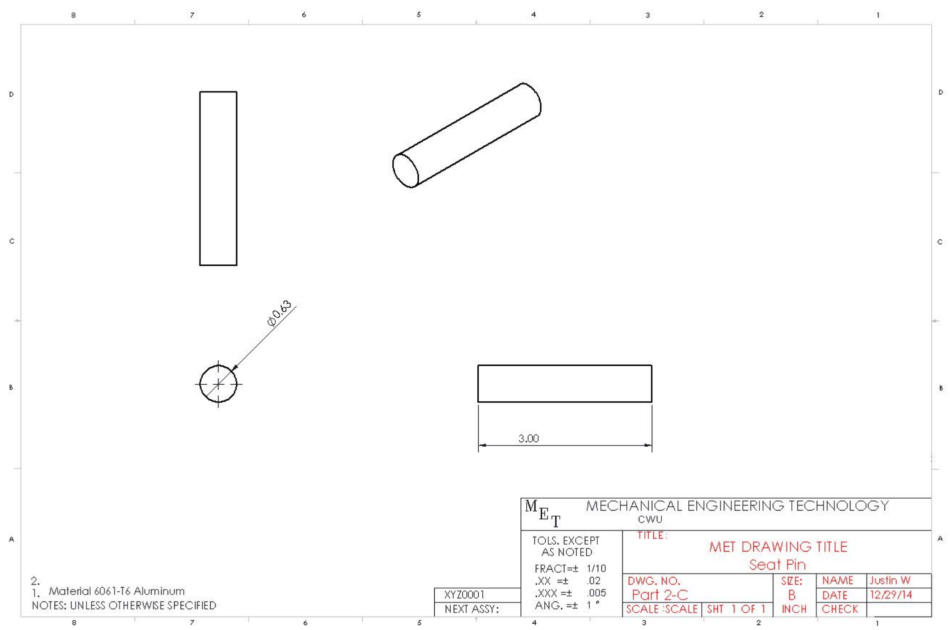


Figure 4-6

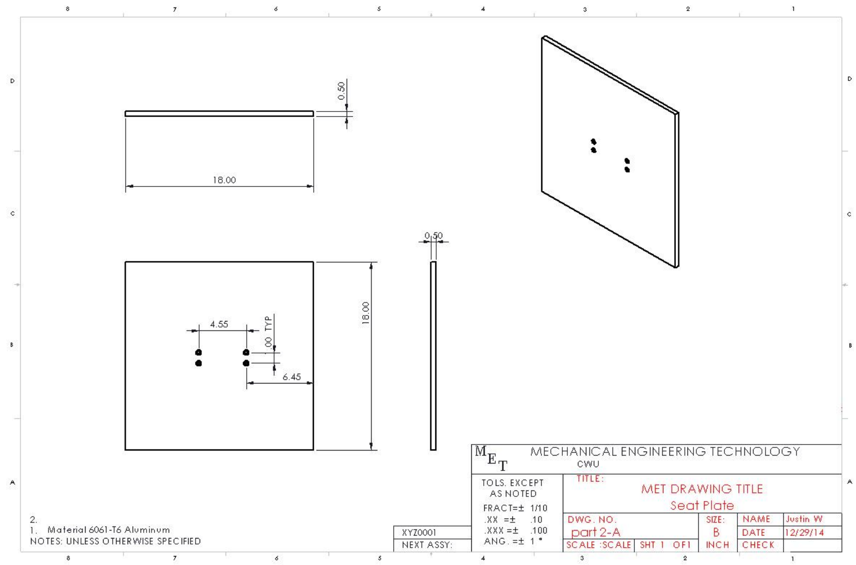


Figure 4-7

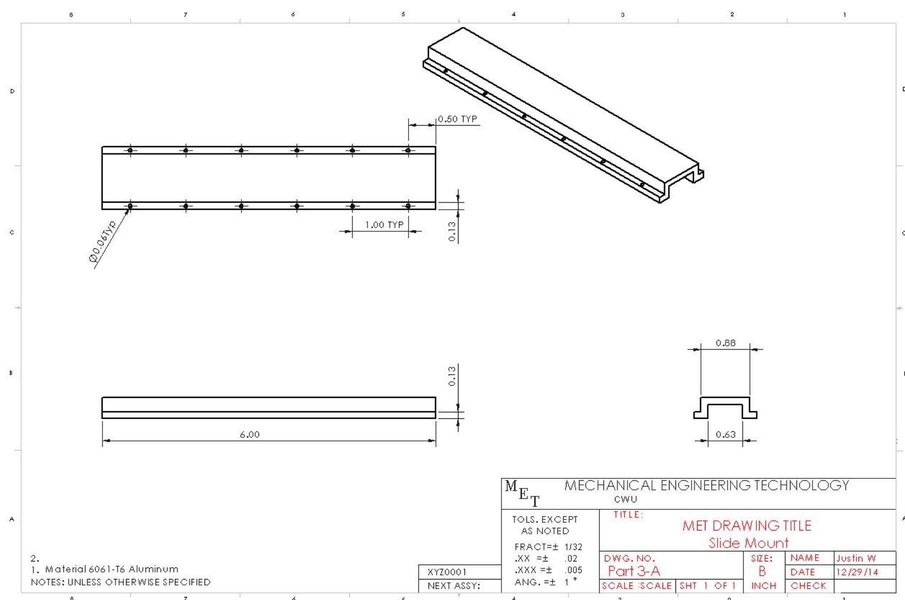


Figure 4-8

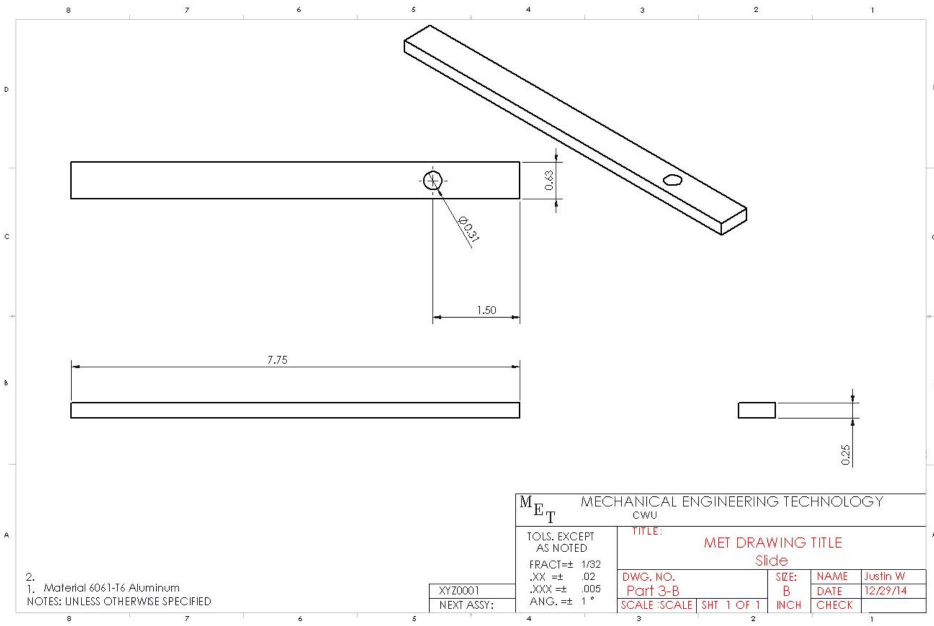


Figure 4-9

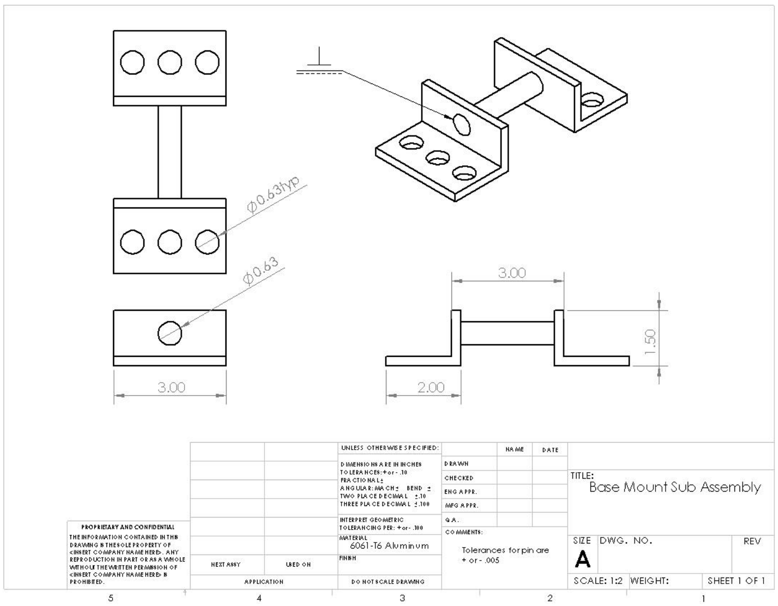


Figure 4-10

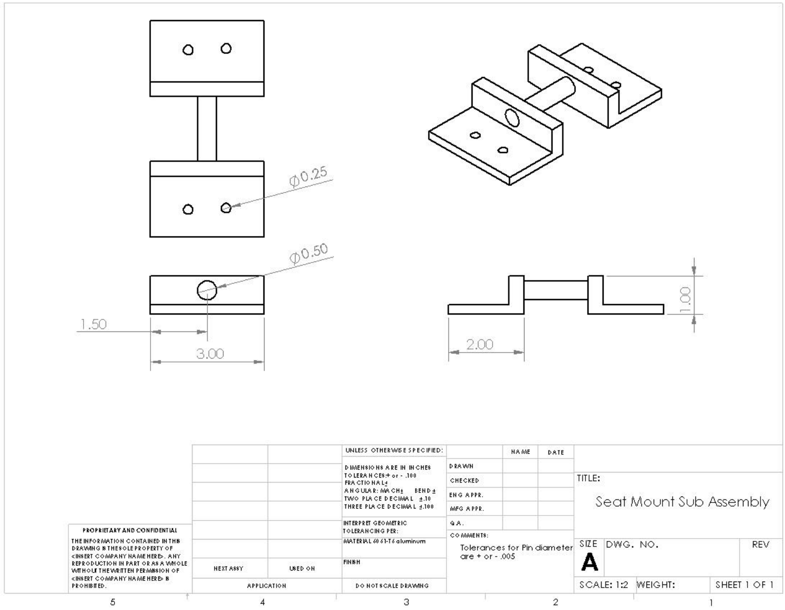

⌀0.25
⌀0.50
1.50
3.00
2.00
1.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:+ or - .100
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±.10
THREE PLACE DECIMAL ±.100
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL 6061-T6 aluminum
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Tolerances for Pin diameter are + or - .005
TITLE:
Seat Mount Sub Assembly
SIZE
A
DWG. NO.
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
5
4
3
2
1

Figure 4-11

APPENDIX C – Parts List and Costs

Part Ident	Part Description	Source	Cost	Disposition
Aluminum 6061 T6 Aluminum 6061 T6	(1) 1'x2'x.5" Plate (1) ½" Round Bar	Metals Depot	$142.00 $2.76	TBD
Fasteners	(6) ¼" tapered Screws (4) 5/8" Bolts (12) 1/16" Screws (1) 5/16" Bolt (4) 5/8" nuts (6) ¼" nuts (1) 5/16" nut	Local Hardware	$25.00	TBD
Motor	1 Hand Drill Dewalt 18-Volt Cordless 1/2 in. (13mm) Compact Drill/Driver	Lowes	$120.00	TBD
Linkage	1 90 degree Bevel Gear Corner by Nosen	Nosen International	TBD	
		Cost Total:	$289.76	

APPENDIX D – Budget

Part Ident	Part Description	Source	Cost	Disposition
Aluminum 6061 T6 Aluminum 6061 T6	(2) 18"x18"x.5" Plate (1) ½"x 1' Round Bar (2) 2"x12"x1.5" Extruded rectagle	Online Metals	$142.00 $2.76 $10.15	acquired
Fasteners	(6) ¼" tapered Screws (4) 5/8" Bolts (12) 1/16" Screws (1) 5/16" Bolt (4) 5/8" nuts	Local Hardware	$25.00	acquired

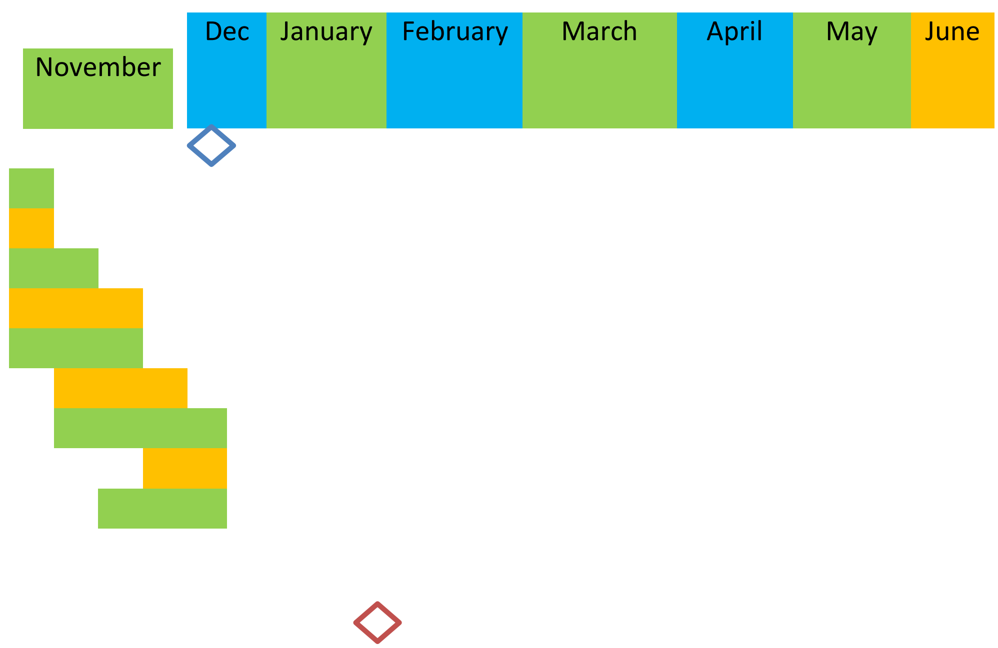
	(6) ¼” nuts (1) 5/16” nut			
Motor	1 Hand Drill	Lowes	$120.00	Ended up being donated
		Cost Total:	$299.91	
Labor Cost		Total Labor Costs:	0$	

APPENDIX E – Schedule

SCHEDULE FOR SENIOR PROJECT:								
					March 17-20 Finals		Note: June 4 Presentation	
PROJECT TITLE:_______		Seat Jack					Note: June 9-12 Finals	
ENG. TECH.:____________________								
TASK: ID	Description	Duratioin (hours)	January	February	March	April	May	June
1	Proposal**	94		9-Mar				
1a	Outline	7	11-Jan					
1b	Intro	6	11-Jan					
1c	Methods	6	11-Jan					
1d	Analysis	15	19-Jan					
1e	Discussion	5	24-Jan					
1f	Parts and Budget	3	19-Jan					
1g	Drawings	15		9-Mar				
1h	Schedule	8	9-Mar					
1i	Summary & Appx	6		9-Mar				
2	Manuf Plan**	23			18-Mar			
3	Device Construct	60				15-Apr		
4	Test Plan**	1				16-Apr		
5	Device Evaluated	10					12-May	
6	Project Report**	20						8-Jun
	Total Hours Est:	184						
	Deliverables:**							

Senior Project Schedule
PROJECT TITLE: Seat Jack
Principal Investigator: Justin Worden

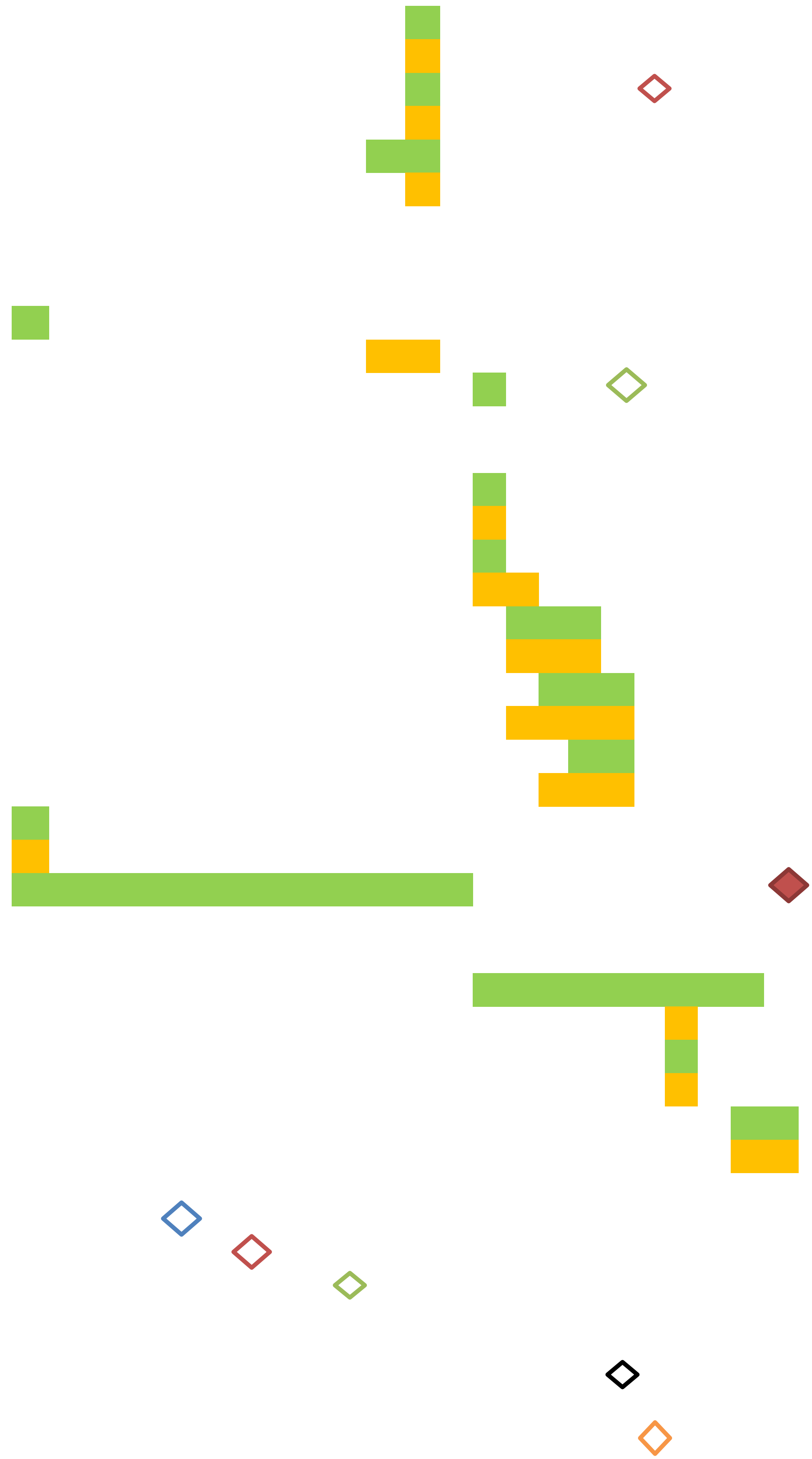
TASK ID:	Description	Est. (hrs)	Actual (hrs)
1	**<u>Proposal</u>**		
a.	Outline	7	1.8
b.	Intro	6	2
c.	Methods	6	5.3
d.	Analysis	15	18.4
e.	Discussion	5	5.6
f.	Parts and Budget	3	5.5
g.	Drawings	15	35.5
h.	Schedule	8	12.4
i.	Summary	6	10.2
	Subtotal:	71	96.7



2		**Analysis**		
	a.	Material Specs	1	1
	b.	Solidworks dwgs	15	35.5
	c.	Drawing Tree	4	2.5
	d.	Seat Stress Strain	10	12.6
	e.	Base Stress Strain	10	14.5
	f.	Bolts/screws	3	2.5
		Subtotal:	43	68.6
3		**Documentation**		
a.		Seat Drawing	2	10.2
	b.	Base plate drwg.	2	5.3
	c.	Base Assembly	3	2.8
	d.	Seat assembly	1	1.3
	e.	Seat pin Drawing	2	1.2
	f.	Base pin Drawing	2	1.2
	g.	Slide Drawing	2	1.5
	h.	Slide mount Drwg.	1	7.6
	i.	Bolt/ Screw drwg.	1	4.4
		Subtotal:	16	35.5
4		**Proposal Mods**		
a.		Prod. Assembly	1	1
	b.	Construction	1	1
	c.	CDR	1	1
		subtotal:	3	3
5		**Part Construction**		
a.		CNC milling	20	14
	b.	Drilling	6.8	5
	c.	Welding	2	.5
	d.	Threading	2.1	0
	e.	Layout dims	2.9	2
	f.	Measuring	.2	1
	g.	Milling	5.9	14 don't add
	h.	Purchasing.	5	6
	i.	Mounting	3	1.5
	j.	Test Welds	2	.2
		Subtotal:	50	30.2

6 **Testing Schedule**

a.	List Parameters	12	.4
b.	Cycle Spec.	4	.5
c.	Relations. Eval.	4	.5
d.	Clean Up	2	.5
e.	Pictures	1	.2
f.	Update Website	3	1
	Subtotal:	26	3.1
7	**Weight test**		
a.	List Parameters	2	1
b.	Test and Scope	2	1
c.	Obtain Resource	4	.6
d.	Make Test Sheets		1
e.	Plan Analyses	1	.1
f.	Check Dimensions	2	.3
g.	Compact size rec	2	.2
h.	Lift test	2	.5
i.	Easy test	2	.5
j.	Pictures	2	0
k.	Report Analysis	1	1
l.	Update Website	2	2
	Subtotal:	23	8.2
11	**495 Deliverables**		
a.	Get Report Guide	1	1
b.	Report Outline	1	3
c.	Write Report	40	50
d.	Slide Outline	3	2
e.	Video Outline	4	3
f.	Create Present.	2	3
g.	Finalize Video	4	2
h.	Update Website	5	6
	Subtotal:	60	70
	Grand Total:	362.8	315.3



Note: **Deliverables***

Draft Proposal

Analyses Mod

Document Mods

Final Proposal

Part Construction


Testing
Schedule
Heating
Evaluation
495
Deliverables

Progress Schedule				
PROJECT TITLE: Seat Jack				
Designer/Project Manager:				
		Duration		Complete
TASK:	Description	Est.	Actual	
ID		(hrs)	(hrs)	
1	Proposal*			
1a	Outline	7	1.8	
1b	Intro	6	2	
1c	Methods	6	5.3	
1d	Analysis	15	18.4	
1e	Discussion	5	5.6	
1f	Parts and Budget	3	5.5	
1g	Drawings	15	35.5	
1h	Schedule	8	12.4	
1i	Summary & Appx	6	10.2	
	subtotal:	71	96.7	
2	Analyses			
2a	Stress Anal=> All Parts	15	18.4	
	subtotal:	15	18.4	
3	Documentation			
3b	Seat Drawing	2	10.2	
3c	Base Plate drawing	2	5.3	
3d	Base Assembly drawing	3	2.8	
3e	Seat Assembly drawing	1	1.3	
3f	Seat Pin drawing	2	1.2	
3g	Base Pin drawing	2	1.2	
	Slide drawing	2	1.5	
3i	Slide Mount drawing	1	7.6	
	Bolt Drawings	1	1.8	
	Screw Drawings	1	2.6	

	Sub total = 16	Sub total = 35.5hrs

7	Part Construction			
7a	Make Part 1- A	10	4.2	
	- Rough Cut	3.2	2.6	
	- CNC mill down to dim	3.3	.7	
	- Mark out Hole pos	.5	.5	
	- Drill Holes	1.5	.2	
	- Thread Holes	1.5	.2	
7b	Make Part 2 -A	5	3.8	
	- Rough cut	2	2.5	
Set up vice in CNC mill	- CNC mill Down to Dim	1.2	.6	
Set Work origin	- Mark Hole locations	.5	.3	
Write Program	- Drill Holes	.6	.2	
	- Thread Holes	.6	.2	
7c	Make Part 3-A	8	5.5	
Set up vice in CNC mill	- Rough Cut	2.2	2.5	
Set Work origin	- CNC mill Down to dim	2.3	.4	
Write Program	- Mark Hole Locations	1	.6	
	- Drill holes	1.4	.7	
	- Measure hole Diam	.1	.1	
	- Bore to appropriate fit	1	1.22	
7d	Make Part 3-B	8		
Center part on Lathe	- Rough cut on Lathe	2.2	2	
	- Cut to dim tolerances	1	1	
	- Cut holes on Jack	1.3	1	
	- Bore holes on jack to fit	1.4	1	

	- Weld A and B together	2	.5	
	- Measure Shrinkage	.1	.1	
7e	Make Part 5-A	8		
Set up vice in CNC mill	- Rough cut to full size Bar	2.2	2	
Set Work origin	- CNC mill edge cuts	2.1	2	
Write Program	- CNC mill slide pathway	2.3	1.8	
	- Mark Hole locations	.4	.6	
	- Drill Holes on Drill Press	1	1.5	
7f	Make Part 5-B	5		
	- Rough cut	2.2	2.2	
Set up vice in CNC mill	- CNC Mill down to Dim	1.3	1.5	
Set Work Origin	- Mark hole Locations	.5	.7	
Write Program	- Drill Holes on Drill Press	1	.8	
	Make Part 6-A/B	6		
	- Purchase Gears	5	8	
	- Mount on Shaft (bolt)	1	1	
	subtotal:	50	30.2	
9	Device Construct			
9a	Assemble Sub Head	2	.1	
9b	Assemble Sub Main Body	3	.5	
9c	Assemble Full Assembly	3	1	
9d	Take Dev. Pictures	1	.5	
9e	Update Website	2	1	
	subtotal:	11	3.1	
10	Device Evaluation			
10a	List Parameters	2	2	
10b	Design Test&Scope	2	2	
10c	Obtain resources	4	2	
10d	Make test sheets	2	.5	
10e	Plan analyses	2	.5	
10f	Instrument Wrench	2	.5	
10g	Test Plan*	2	.2	
10h	Perform Evaluation	2	.3	
10i	Take Testing Pics	1	.3	
10h	Update Website	2	3	

	subtotal:	49	11.3	
11	495 Deliverables			
11a	Get Report Guide	1	1	
11b	Make Rep Outline	1	3	
11c	Write Report	40	50	
11d	Make Slide Outline	3	2	
11e	Create Presentation	4	3	
11f	Update Website	11	11	
	subtotal:	60	70	
	Total Est. Hours=	362.8	315.3	

APPENDIX F – Expertise and Resources

Knowledge was gained from curriculum provided through the MET and IET programs. The CWU facilities were also offered for use, which included computer labs as well as machine and fabrication shops. Thanks Dr. Craig Johnson as well as Professor Charles Pringle for all the help that they have provided over the course of this project.

APPENDIX G – Evaluation sheet (Testing)

Time of Cycle	Range of Cycle	Final Weight	Required Torque Max
25.9 sec	8.5 in	48.3	~10ft·lbs

APPENDIX H – Testing Report

Test 1- Torque supply needed to lift a given weight.

Materials:

8. One fifty pound weight.
9. A person weighing around 100 lbs.
10. A person weighing around 150 lbs.
11. A person weighing around 200 lbs.
12. A person weighing around 250 lbs.
13. One torque wrench with needle gauge.
14. Seat Jack

Procedure:

7. Place the fifty pound weight on the seat of the Seat Jack.
8. Connect the torque wrench to the drive nut on the drive worm.
9. Lift the fifty pound weight.
10. Record amount of torque needed to start lifting.
11. Record amount of torque needed to continue lifting while already moving.
12. Repeat steps 1-5 with remaining weights.(record the actual weight of specimen)

Torque needed	100 lbs	150 lbs	200lbs	250lbs	300lbs
To start lift	Did not read	5 ft·lbs	6.66 ft·lbs	8.33ft·lbs	10ft·lbs
To cont. lifting	Did not read	5 ft·lbs	6.66ft·lbs	8.33ft·lbs	10ft·lbs

NOTE: Results were not exact, little changes on the scale of the torque wrench were hard to distinguish.

Test 2: Time of full cycle of movement.

Materials:

4. Seat Jack
5. Stop watch
6. Hand drill drive motor

Procedure:

5. Connect drive motor to input nut.
6. Lift seat up all the way and then back down to starting position.
7. Record time it takes to complete this cycle.
8. Repeat Steps 2-3 two more times and calculate average.

Trial #	Time Needed	Average
1	23.5 sec	25.9 sec
2	27.8 sec	
3	26.4 sec	

Test 3: Size requirement.

Materials:

3. Seat Jack
4. Measuring tape

Procedure:

2. Measure the length width and height of the seat jack and record the values.

Height: 5 6/8th inches.
Width: 18 inches.
Length: 18 inches.

Test 4: Angle and height of lift provided requirement.

Materials:

4. One smart phone with a level by degree ap. (or protractor)
5. Seat Jack
6. Measuring tape

Procedure:

4. Lift seat to full extension and record the angle of lift provided.
5. Conclude if it meets the 30 degree minimum standard.
6. While seat is fully extended measure and record the height of which the highest point of the seat reaches.

Angle of Lift: 70-75 degrees.
Height of lift: 8.5 in.

Test Five: Weight requirement

Materials:

3. Seat Jack
4. Scale that can weigh down to tenths of a pound.

Procedure:
3. Place Seat Jack on scale.
4. Record weight.

Total Weight: 48.3 lbs

APPENDIX I – Testing Data

Test 1- Torque supply needed to lift a given weight.

Torque needed	100 lbs	150 lbs	200lbs	250lbs	300lbs
To start lift	Did not read	5 ft·lbs	6.66 ft·lbs	8.33ft·lbs	10ft·lbs
To cont. lifting	Did not read	5 ft·lbs	6.66ft·lbs	8.33ft·lbs	10ft·lbs

Test 2: Time of full cycle of movement.

Trial #	Time Needed	Average
1	23.5 sec	25.9 sec
2	27.8 sec	
3	26.4 sec	

Test 3: Size requirement.

Height: 5 6/8th inches.
Width: 18 inches.
Length: 18 inches.

Test 4: Angle and height of lift provided requirement.

Angle of Lift: 70-75 degrees.
Height of lift: 8.5 in.

Test Five: Weight requirement

Total Weight: 48.3 lbs

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APPENDIX J – Resume

Justin Worden

2513 N Colombia St
Phone: 253 229 1151
E-mail: wordenj@cwu.edu

Objectives

Obtain a part time or full time job where I can utilize my experience and skills to become a company asset.

Education

High School Diploma (June 2010)

- Multiple semester honor roll student
- Team Captain on Varsity soccer team

Central Washington University (2010-2015

- Currently Attending (Senior Standing)
- Pursuing a Bachelor's degree majoring in Mechanical Engineering and Technology.

Experience

Sales Associate (2009-2010)

Zumiez (**SOUTH HILL MALL**, 3500 **SOUTH MERIDIAN** #340, **PUYALLUP**, **WA** 98373)

Floor Sales Associate – Apply aggressive and Suggestive selling techniques, Provide a comfortable and relaxing shopping environment for customers, Work register, Stock Supplies and provide inventory reports.

Branch Manager (May 2011 – September 2011)

Student Edge Painting (#100 - 2018 156th Ave NE
Bellevue, WA 98007)

Manager – Place bids on houses to be painted, Manage crew of painters, Supply all Materials to crew, Encourage crew members to produce their best work, Manage pay roll, Deal with customer service.

Tow Truck Driver (May 2012 - Present)

Superior Auto Recovery (2539 N Hayden Island Dr, Portland, OR 97217)

Driver – Repossess Vehicles, Tow/ dolly vehicles and park them in yard, Handle client's personal property, Write up condition reports on cars, Deliver repossessed vehicles to auction.

Skills

- Hard Worker - Good Customer to Employee relationship
- Good team player - Very Personable