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Paper Airplane Building Machine: Paper Loading, Power Source, Machine Frame

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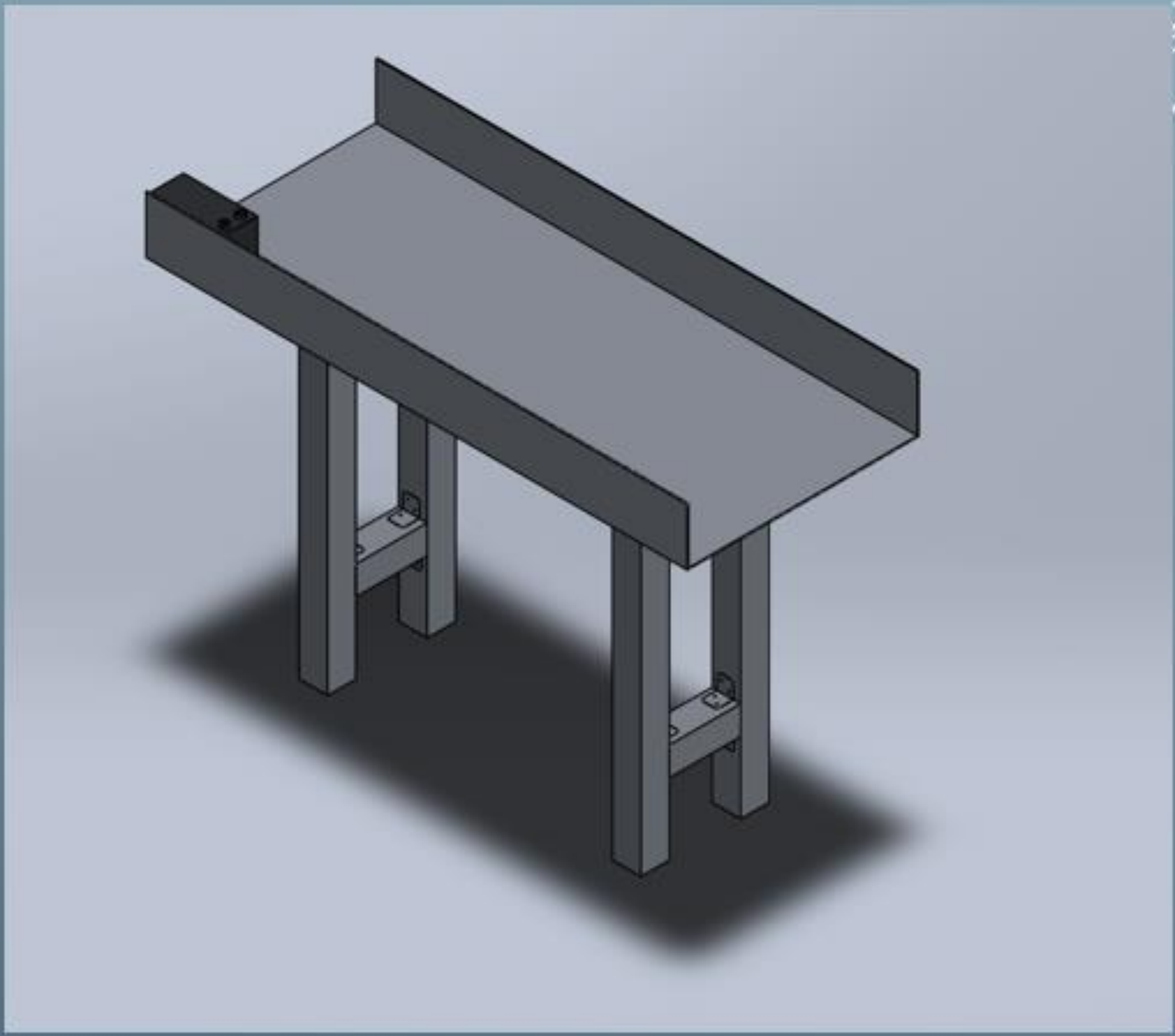

PAPER AIRPLANE BUILDING MACHINE

Subproject: Paper Loading, Power Source, and Machine Frame

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Project Partners:

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Abstract:

The project was motivated by an ASME 2016 design challenge. The challenge was to design and manufacture a device that would turn a single sheet of paper into a paper airplane and launch it. The project was divided into three portions. The proposal was biased on loading the paper into the machine, design and manufacture the machine frame and provide a reliable power source. A slow rpm motor was needed for the loading mechanism to prevent the paper from being damaged. To avoid any deflection in the frame, the total weight of the machine had to be considered. The shear and moment diagram was used to calculate the reaction forces, and to calculate the proper thickness of the material being used. Four motors were used for the paper loading and folding processes, in which each motor has fifteen RPM. Additionally, two linear actuators were used in the paper folding process. Moreover, the launching process required two motors each have fifteen thousand RPM. All of the motors that been mentioned require a twelve-volt battery. Both the launcher motors and the actuators were connected to a single battery. For the other motors, each two motors were connected to one battery. Each battery was connected to on-off switch. As a result, the process that the paper goes through, from loading to folding and finally launching, has been manually controlled.

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Introduction

Motivation:

This project was motivated by an ASME 2016 design challenge. The challenge is to design and manufacture a device that would turn a single sheet of paper into a paper airplane.

ASME Function Statement:

The function statement for this project is to build a machine that create three projectiles from standard sheet of paper and launch it, per ASME competition rules.

Subproject Function Statement:

Loading device, the purpose of this device is to deliver the paper into the machine to get it ready for the next step, which is forming the paper. Supply a power source to the entire system. Design the machine frame.

ASME Design Requirements:

- Build and test a prototype engineering system, which will be capable of fabricating three projectiles.
- Each projectile should be from a single sheet of 20-lb, A4 paper.
- Thrusting all the three projectiles to the maximum possible distance down the course within a five-minute (300 second) time limit.
- As the competition requirement, the system must be packed in a rectangular box.
- The height of the assembled system must be less than 30 inches (76.2 cm).
- The systems are required to have zero on-board emissions.
- The system must be designed such that the paper is manually loaded one sheet at a time, after the prior sheet has been launched.

Subproject Design Requirements:

1) Loading;
    - The paper loading should not exceed 3 seconds.
    - The loading device should be within the tolerance of the machine. The body frame width is (15 in) the loading device should not exceed this

number.

- The device should be capable of feeding the machine with size A4 paper.
- The device should be able to accept the paper manually one paper at a time.

2) Power Source;

- The power source should provide 10 Amps to the system.
- The power source width should be (10 cm) and it length should be (18 cm) also no more than (10 cm) in height.
- There should be a backup power source in case of failure of the primary source.
- The power source should have a main switch and an emergency switch.

3) Machine Frame;

- The width of the frame should be (10 in).
- The length of the machine frame assembly should be within (45 in).
- The frame should support at least (30lb).
- The frame should be easy to assemble.
- The frame must be flexible to adjust its height to (30 in).

ASME Success Criteria:

The scoring going to be based on the total distance traveled by the three projectiles, according to the ASME the scoring equation should be as below:

$$S = \frac{distance_1 + distance_2 + distance_3}{volume}$$

Equation 1-1

Where:

● Distancen$_n$ for n = 1, 2, 3 is the distance traveled by the three paper projectile.

● Volume is the total measured volume of your system based on the inside dimensions of the box in which it is initially packaged.

● Dimensions will be measured in meters, the units of S will be m-2.

Subproject Success Criteria:

1) For the paper loading, the paper should be delivered to the next stage within the time goal, which is 5 seconds without damaging it. According to the ASME competition rules, the machine must launch three projectiles only. In worst scenario if one of the three papers was damaged, the scoring will be based on the other two papers.

2) For the power source, the main source should be able to provide the power needed for each component in the machine, without using the backup source.

3) The frame must support the entire machine's weight including the power source and the motors used in the forming stage and the launcher without being bend.

Scope of effort:

The scope of effort of this project is to create a mechanism for launching projectiles compatible with frame integration and limitation.

Success of project:

To make this project successful, principles of aerodynamics need to be used. To use the principles and the assumptions in how each airplane design react to aerodynamics? Also, Air drag, which is the frictional force air exerts against the paper airplane, as well as the velocity ratio of the wheels that launch the airplane. All these principles need to be in mind. The success of the project is passed on the performance of the machine at the ASME competition.

Design and Analysis

Approach: Proposed Solution:

1) For the paper loading there are two possible designs. First design is using rollers to receive and deliver the paper to the forming stage. Second design is using a belt and a roller to transfer the paper. Both designs have advantages and disadvantages summarized in the table below.

Design No.	Advantage	Disadvantage
First Design “Rollers”	Cheaper, adjustable	More than two needed
Second Design “Belt”	Maintain the quality of the paper	Rollers are needed to help holding the paper.

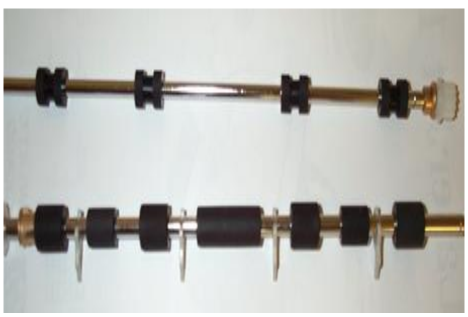


Figure 1: Paper delivery rollers.

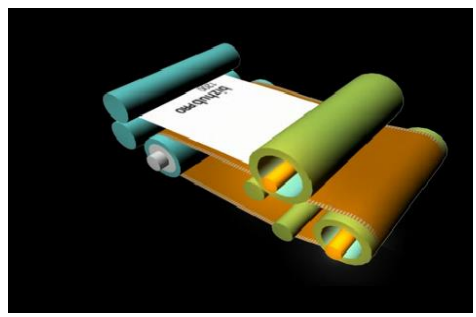


Figure 2: Paper delivery Belt.

2) For the power source many choices are available. Most likely rechargeable batteries are good choice in this project because they are more reliable than other batteries. Lead-Acid battery is optimal option since it has a small size and can deliver a constant voltage charge.

3) The big consideration in building the frame is what material should be best to use. Since there are no heavy weights will be put on the frame, 6061 T6 aluminum 0.09 in thick is ideal for the machine body. Also the frame should carry on its sides the motors of the forming mechanism as well as the launcher. In this consideration the frame should be adjustable and should have holes on it sides in order for the motors and

whatever material need to be fixed to the frame. “See Appendix B for the Drawings & Assemblies”.

Description:

1) The first design in the loading mechanism, which is using rollers, is best in this case because rollers have less weight and they require less spacing than the belts.

Figure 3: Paper loading used in printer.

The angular velocity can be measured by using “Equation 1-2”. The size of the paper is a major concern when calculating how many cycles should the roller rotates with respect to time. Since the goal was to deliver the paper to the forming in 3 sec and the radius of the roller is 12.7mm the rotational speed should not exceed 5 rad per second.

Circumference = $2 \pi r$	Equation 1-2

2) The power source should provide at least 10 Amp’s current for the whole system. Lead-Acid batteries are suitable in this machine, first because they have light weight about 2.5 kg, second because they are cheap and available in energy system (MET 411) lab. The model of the batteries that are going to be used is LC-R127R2PG see Appendix C for details. To decide how many batteries are going to be used the current needed in each motor should be calculated. To do so the method of calculation is given in Equations 1-3, 1-4. The torque, RPM and voltage of each motor used in the machine are given.

$P_{wr} = T \times \omega$	Equation 1-3
$I = V \div R$	Equation 1-4

3) The metal used in making the frame of the machine is 6061 aluminum 0.09 in thickness. This material is easy to cut and shape. For this project six to seven motors are going to be used for the loading, forming and launching processes. The weight of these motors including the material that they are going to need to support their process is around 1 to 2 Kg. The frame should carry this weight without being affected “See Fig 5 for shear moment diagram”.

Benchmark:

There are many printers out there that use rollers to deliver papers for the printing process. One of the models in the market is “HP LaserJet Pro MFP M127fn” which can print 21 papers per minute “See Figure 4”. This would take about five seconds to deliver the paper. Meanwhile, the time needed to deliver the paper in this machine is 4 seconds. The challenge is going to be minimizing the time to one second less than the model in figure 1 by using set of gears to increase the RPM.

Figure 4: Printer model HP LaserJet Pro MFP M127fn

Performance Predictions:

1. Loading mechanism: The angular velocity can be measured by using Circumference equation to get how many inches the roller will rotate per revoluation. Given the length of the paper, then the angular velocity can be calculated "*See Appendix (A) Figure 5 for calculation*".

2. Power source: the electrical circuit of the power source would be built in parallel so that the same number of volts travel throw the motors used. Referring to equation 1-3, 1-4 the current would be calculated.

3. Machine Frame: the frame design has been changed due manufacturing issue. The issue of the frame was the thickness of the aluminum sheet. It was too thick to be folded form the sides. The material has been changed and a new design has assigned for the machine frame. Here is a description of what the new design of the frame; a distributed load acting on the machine frame. The load include the U shape small frame placed on top of the original frame. The load also contain the weights of the motors and the rods used in the loading.

   Old design description;Three loads acting on the machine frame, first load at frame part 1, second load is on frame part 2 and third load is on frame part 3. . There will be three reaction forces equal to the sum of the three loads acting on the frame. The reaction forces are calculated and found to be 9.8 N at the beginning of the frame and 27.4N at the end of the frame. The maximum stress due to bending is then calculated and found to be 0.545 Kpa *"For calculation details see Appendix (A) Figure 6".*

Description of Analyses:

The consideration of the design is indicated by the size of the paper, since the machine performance is all about folding and shaping a paper airplane. The shape of the frame should be able to provide the space needed for all this process to happen. In other words, the width of the standard A4 paper is 11 inches and the frame width designed to be 8.5 inches. This would make a space for the loading and forming processes to perform easily. Also the length of the machine frame designed to be 38 inches, which would make a plenty of space for the three processes loading, forming and launching "*See Appendix B for frame parts & assembly*".

Analysis:

For the loading device two choices are available rollers and belt "*refer to figure 1, 2".*Rollers are going to be use in this project because they are cheap, easy to handle, flexible and they don't take much space. For the loading device two choices are available rollers and belts. Rollers are going to be use in this project because they are cheap, easy to handle, flexible and they don't take much space. The equations of *rotational motion* were used to calculate the time for the loading process:

$$\omega_f^2 = \omega_0^2 + 2\alpha\theta$$

$$\omega = \omega_0 + \alpha t$$

The calculated time found to be 56 seconds. *"See Appendix (A) Figure 5"*

For the thickness of the material used in designing the frame has to be considered. To calculate the proper thickness first the forces exerted on the frame had to be calculated by using *shear and moment diagram*. Also, assume that the frame had a contributed load of 8 lb/in. The formula of *bending stress* then is used to find the section modules. Finally, the *section modules equation* is used to find the thickness "*See Appendix (B) for Drawings*".

$$\sigma = \frac{M}{S}$$

$S = \frac{ht^2}{6}$

The thickness is found to be (0.106 in). *“See Appendix (A) Figure 6”*

Device Shape:

As discussed in the design requirement for the frame, the frame should be adjustable to fit in a box with a small volume. In other words the smaller the box the higher points will be earn in the ASME competition. In this manner the design of the frame is going to be made from a single piece of aluminum sheet 38”x 24”. The frame will have three sections. First section is the paper loading, second section is the forming section and the last section is the launching section.”*For final assembly drawing and tolerances see Appendix (B) figure 6, 7*”.

Panasonic Led acid batteries will be used as the power source. It will be connected as a parallel circuit in order to deliver a constant voltage for all the electric devices in the machine.

Weight	**2470 g**
Features	Maintenance-free
VDS certification	Yes
Manufacturer part No.	LC-R127R2PG
Voltage	12 V
Type	12 V 7.2 Ah
Rechargeable	Yes
Technology	AGM
T	65 mm
Height	94 mm
Width	151 mm
Capacity	7.2 Ah

Figure 5: Panasonic batteries used to supply power.

Device Assembly, Attachments

The frame is made from a 38”x 24” aluminum sheet with thickness of 0.09”. It is folded 4” from the sides. The folds are going to be 90º. Three aluminum square tubes 2”x 2” and 48” long each are going to be cut into two pieces. Also aluminum square tubes 1.5”x1.5” and 2” long are needed. The aluminum square tubes 1.5”x1.5” are going to be brazed on the bottom of the frame

The loading devices is going to be made of an aluminum rod has a diameter of 0.2”. It is connected to a 15 rpm motor. The rod has rubber tubes on it so that the paper move properly. The rod will be machined 11” long.

Methods and Construction

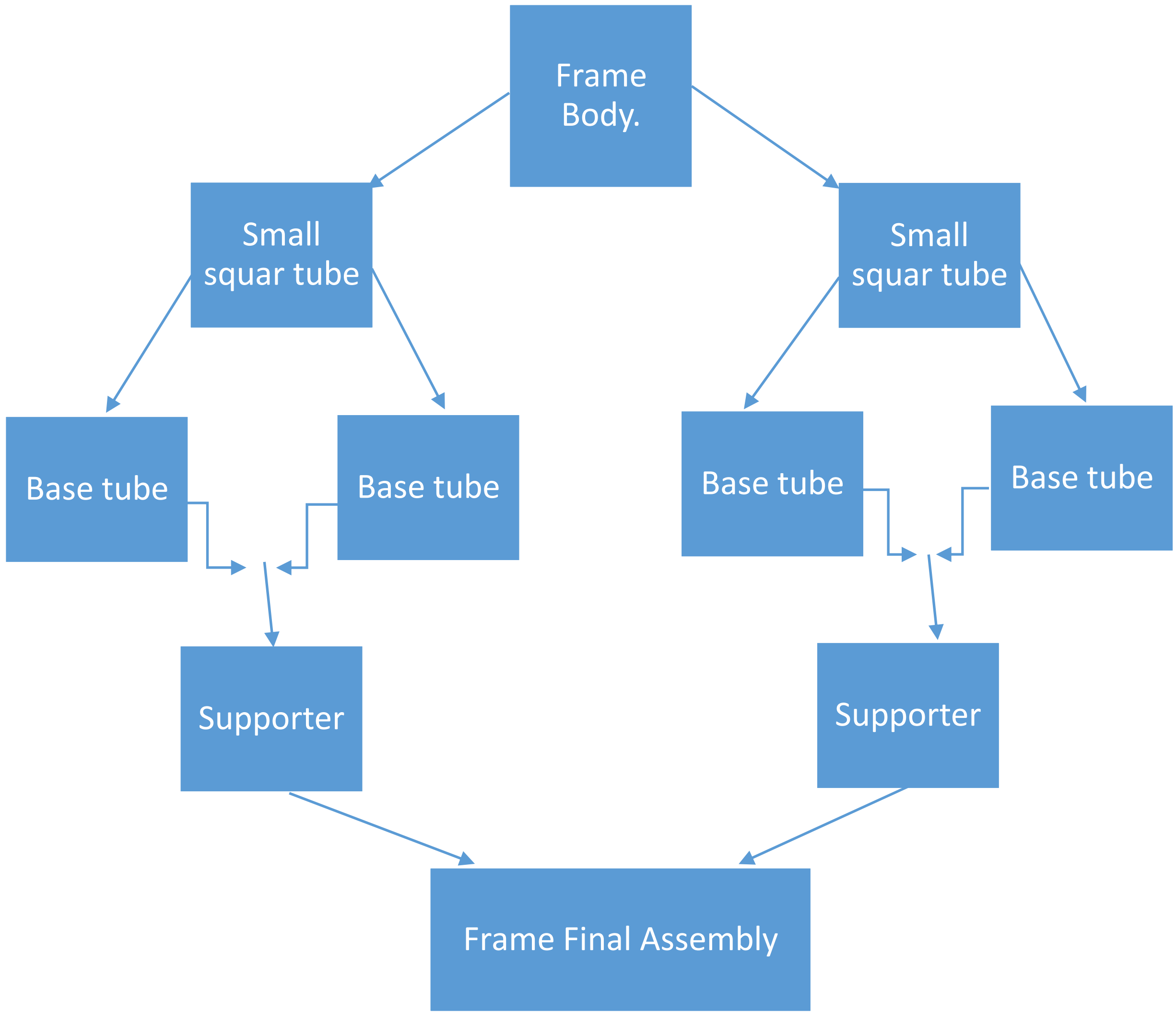
Construction:

The three parts of the frame are going to be manually folded by using the sheet folding machine founded in the welding lab at CWU. Frame body 1 & frame body 2 are exactly the same in shape, therefore they are going to be constructed the same. The final part however has a slight angle pointing to the launching side. The aluminum sheet will be cut to meet this angle and then it will be folded. The battery holder will be welded to the right side of frame body, making the left side of the frame empty to put the motors on. There will be five holders welded at the bottom of the frame. In these holders the aluminum squad tube will go to be used as stand to hold the frame.

Description:

This project intended to build and manufacture a machine that is capable of launching three projectiles. The projectiles are made from A4 paper and manually fed to the machine each one at a time. The machine will fold the paper into an airplane shape and then launch it per ASME requirements. The frame of this machine should be flexible to be folded in order to fit in one box. The design of this frame will be divided into three parts. First part is for the first process in the machine which is loading the paper. Second part is for the second process in the machine which is forming the A4 paper into an airplane shape. Final part is for launching the paper for the distance required. The frame will be made of 6061 T6 aluminum 1.6 mm thick. The first two parts, which are loading and forming, have the same design. The final part will have different design. For the first two parts, the aluminum sheet will be cut straight cuts from the sides by using the foot sheering machine found in welding Lab at CWU. The cuts will make the width of the sheet to be 305mm. Once the side cuts are made, the holes from the sides will be weld cut. Finally the frame will be folded from the sides using metal folding machine to give it the final shape "*See Appendix B for drawings*". Design part three, the aluminum sheet will be cut from the sides with an angle of 85°. Then the side cuts are made and lastly the sheet will be folded from the sides "*See Appendix B for drawing".* The three parts then are connected by using hinges to make the final assembly for the frame. The battery holder will be welded to the right side of the first part. Also the motors used in the machine are going to be connected to the right side of the machine to make it easier for the wiring.

Drawing Tree, Drawing ID's



Parts list and labels:

Part List	Part Label

Frame Body	F-1
Terminal Strip	TS
Roller Rod	RR
DC Motor	DC Motor
Holders	H-6
Frame legs	S-6
Aluminum Square Tube	AST

Manufacturing issues:

There was a major manufacturing issues. First, the aluminum sheets ordered were too thick to be folded. Second, there was 0.25” gap in between the square tubes. On other words the 2”x2” square tube had thickness of 0.125” and the outside dimensions of the small square tube was 1.25”x1.25. When placing the smaller tube in the larger tube a quarter inch gap will appear. This was adjusted by making threads to the larger tubes and putting eye hooks to hold the tow tubes together. For the material though smaller thickness was needed in order to make the 90 degree folds. 0.09” thick aluminum sheet bought to replace the old sheets. When assembling the frame together, the frame was not rigid. Two pieces of 2”x2” tubes were cut to be 5” long. Then they were put to connect the base tubes. Also L shaped hinges with screws and nuts were used to connect the base tubes with the supporters.

Due to problem in the process of the first design of the folding process, the motors were replaced slower motors with only 15 RPM. To prevent any damage to the paper while it goes throw the folding. The change of the motors affected the prediction numbers of the loading process. Instead of 3 seconds with 270 RPM motor the time dropped down to 56 seconds with a5 RPM motor.

Testing Method

<u>Introduction:</u>

There are two tests going to be used in this project. The first test is measure the time of the loading mechanism. The second test is the battery test where in the requirement the time that the machine must run is 5 min. the battery should be checked if it will manage to run for at least 5 min.

<u>Method/Approach:</u>

The first test method is to measure the DC motor final rpm for the paper loading process. The motor that is going to be used provides 220 rpm. The calculated angular velocity of the roller in the paper loading process found 7.3 radius per second. Converting the 7.3 radius per second to revolution per minute, the roller should rotate about 70 rpm which means a set of gears need to be designed to transport the 70 rpm to the roller. In this case the final rpm need to be measured to make sure the transported rpm is the one needed for the roller. A digital laser tachometer is going to be used to measure the rpm of the roller. The second test method is for the batteries used in the machine. The circuit is going to be made in a breadboard with all the resistors used. Then a fluke multimeter is going to be used to measure the current throughout the circuit to make sure that the resistors are appropriate.

<u>Test Procedure:</u>

<u>Loading Mechanism Test</u>

1- Inspect the loading rollers and make sure that the rubbers are touching each other to make sure that the rollers will drag the paper in.

2- Inspect and remove if there are any particles on the rubber of the roller or on the roller itself. This will make the paper go through the rollers smoothly.

3- Make sure that the paper loading motor is connected to 12-volt battery.

4- You should have 11” x 8.5” paper to complete this test.

5- Now run the motor by turning on switch (No. 1) the switches at the beginning of the paper path.

6- Wait 3 seconds so that the motor gets to its highest speed.

7- Put the paper on the paper path and push it towards the roller gently.

8- Start counting time as soon as the paper gets to the roller.

9- Turn the switch off along with the timer after about 40 seconds so that the folding process takes place while the paper still in the first roller.

10- After the folding process is completely done, turn the loading switch on again along with the timer.

11- Wait until the paper is completely out for the roller.

12- Stop the time counter and record the time.

Battery Testing

1- Charge the batteries.
2- Connect the batteries to the motors properly using wires.
3- Measure the volts by using a Multimeter while the motor switch is off. Then turn the switch on and after 60 seconds measure the volt. Recorded the values.
4- Measure the current by using a Multimeter while the motor switch is off. Then turn the switch on and after 60 seconds measure the current. Recorded the values.

Deliverables:

Once the test is being made and everything works as planned, the final subproject will be put together and it will be ready to use. In other cases of failure a solution should be planed a head to correct whatever need to be corrected. In case of the roller RPM was not the one needed after using the set of gears, different sizes of gears are going to be used to reach the 70 RPM needed for the roller. In case of failure in the power supply, a backup battery will be used to supply the power.

Budget/Schedule/Project Management

Proposed Budget:

Part Name	Part Description	Quantity	Part price	SKu	Supplier
Aluminum Sheet	5356 (38"x24") 0.09" Thickness	1	$50	S61.125T6.24.24	Western Metal
Aluminum square tube	6061 T6 ¾" x ¾" x 1/8" (10 foot long)	2	$20 each	61Q2.25T6511.48	Metals Depot.com
Panasonic Led acid batteries	12 Volts	5	$71 each	--------	MET Lab
Terminal Strip	Molex Barrier Terminal Blocks	3	$ 4 each		ACE "Ellensburg"
Roller	10" length	2	$ 1		Good Well
DC Motor	15 RPM	1	$ 16.29		Amazon
Aluminum Square tubes	6061 1.25" (A) x 0.125" (t) x 24"	4	$ 1 each	61Q1.14.125T6511.24	Metals Depot.com
Electric Wires	3 feet each	1	$15		Fred Meyer
Total Cost			$ 134.29		

Estimate total project cost:

The estimated cost that this project will need is around ($134.29). This price does not include the batteries that are supplied from CWU resources and the parts that are from the other suppliers.

Funding Sources:

Funding for this project will come from personal expenses and the scholarship sponsor, SACM Saudi Arabia Culture Mission.

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

Three parts are going to be supplied from Central Washington University, Engineering Technology Department. These parts are Panasonic lead acid 12 volts batteries, terminal strips and set of wires and DC motor. The aluminum sheets and aluminum square tube are going to be bought from a website for metal supplies called www.metalsdepot.com or cheaper metal supplier if found. The plastic gears and the roller are going to be taken from useless HP printer.

Schedule:

This project will be managed by following a particular schedule and time management assigned by the senior project course MET 495. This schedule is detailed in Appendix E with a Gantt chart explaining the deliverables in a specific time. The time is broken down to months starting from end of September 2015 to beginning of June 2016.

Project Management:

1. Human Resources:

   This project would not be completed without the help from the project partners Abdullah Alshahrani and Hassan Bujayli. They helped in brain storming, planning the project and then dividing the subproject. Likewise, Dr. Johnson, prof. Pringle and prof. Beardsley were a big help with answering questions regarding the proposal and the calculations. Also, the lab technicians Matt Burvee, Greg Lyman for their help.

2. Physical Resources:

   For the body parts all the cuts on the sides are going to be made by using the milling machine in the machine shop at CWU. Also the metal folding machine in the power lab is going to be used for folding the sides of the frames. Similarly, arc welding is going to be used to weld the battery holder to frame body 1. Another welding process is going to be used which is the press weld. This operation is going to be applied to the side holders and the hinges. The square tube is going to be cut for six long pieces and six small pieces. Both the small and the long pieces are going to be cut from one side to 45° by using miter saw. Afterward, the two pieces are going to be arc welded together.

3. Soft Resources:

All the drawing were made by using SolidWorks. Besides the documentation of this proposal were made by using Microsoft Office. MDESIGN Mott also were used to draw Mohr's circle.

4. Financial Resources:

   This project will be funded by SACM Saudi Arabia Culture Mission. Besides some of it will be funded from personal expenses.

Discussion

The overall project is divided into three subprojects. One is the paper loading, frame design and power supply. Second is forming the paper received into an airplane shape and deliver it to the final stage, which is launching the paper airplane. In the first subproject, the motor used in paper loading part which runs 220 RPM has to be justified to meet the speed needed which is 70 RPM for the roller to deliver the paper. Calculations have been made to design a set of gears to minimize the motor speed. Four gears have been assigned to make this happen which are two gears with 24 teeth and two gears with 12 teeth.

The power supply part, two lead acid batteries are going to be used to deliver the volts and current needed for the motors used in this machine. A parallel circuit has been made to make the voltage constant in each station. Sets of resistors are going to be used in each station to deliver the right current to each motor.

For the machine frame part, the frame designed so that it is one piece to make it easier when setting up the machine for the competition.

Conclusion

This project is committed to build a machine that makes an airplane from a standard A4 paper. It is divided into three subprojects. First subproject is the paper loading, frame design and power supply. Second subproject is forming the paper received into an airplane shape. Third subproject is launching the paper airplane to a specified distance. In the first subproject, the RPM of the motor used in the paper loading needed to be minimized to be able to deliver the speed required to the roller. The batteries used to supply the power for the whole machine is going to be lead acid batteries. These batteries are being chosen because they are rechargeable and reliable in this matter. The frame of the machine is made of a sheet of aluminum folded 90˚form its sides.

Acknowledgements

I am really grateful because our group members managed to complete our airplane building machine project within the time given by the senior project course MET 495 at CWU. This project cannot be completed without the effort and co-operation from the group members, Abdullah Alshahrani and Hassan Bujayli. I also sincerely thank my professors in the Mechanical Engineering Department, Dr. Craig Johnson, Prof. Charles Pringle and prof. Roger Beardsley for the guidance and encouragements in making this project.

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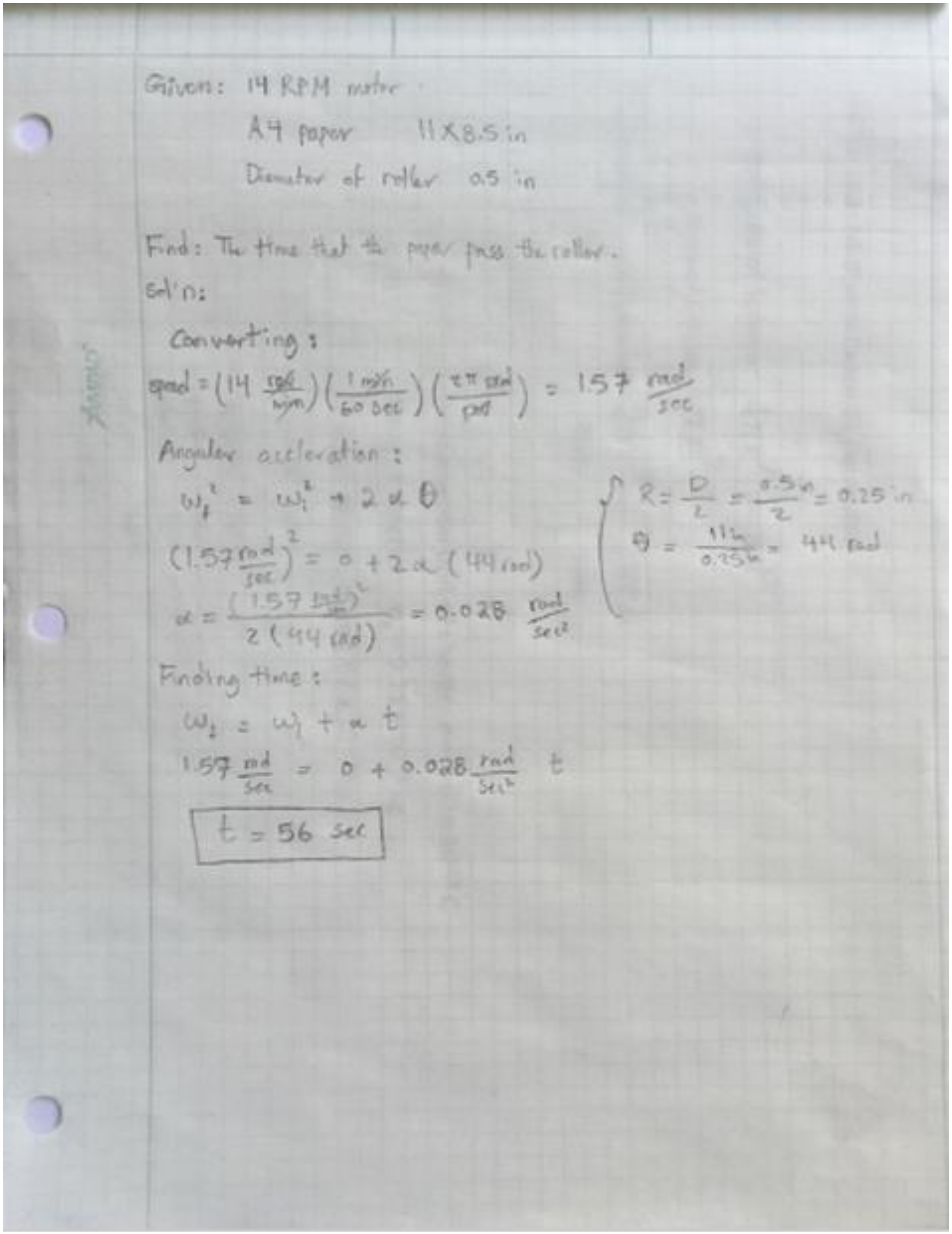
http://www.farnell.com/datasheets/1674772.pdf

Time of loading process:



Given: 14 RPM motor

A4 paper 11X8.5 in

Diameter of roller 0.5 in

Find: The time that the paper pass the roller.

Sol'n:

Converting:

$$\text{speed} = \left(14\ \frac{\text{rev}}{\text{min}}\right)\left(\frac{1\ \text{min}}{60\ \text{sec}}\right)\left(\frac{2\pi\ \text{rad}}{\text{rev}}\right) = 1.57\ \frac{\text{rad}}{\text{sec}}$$

Angular acceleration:

$$\omega_f^2 = \omega_i^2 + 2\alpha\theta$$

$$\left(1.57\ \frac{\text{rad}}{\text{sec}}\right)^2 = 0 + 2\alpha\,(44\ \text{rad})$$

$$\alpha = \frac{\left(1.57\ \frac{\text{rad}}{\text{sec}}\right)^2}{2\,(44\ \text{rad})} = 0.028\ \frac{\text{rad}}{\text{sec}^2}$$

$$R = \frac{D}{2} = \frac{0.5\ \text{in}}{2} = 0.25\ \text{in}$$

$$\theta = \frac{11\ \text{in}}{0.25\ \text{in}} = 44\ \text{rad}$$

Finding time:

$$\omega_f = \omega_i + \alpha t$$

$$1.57\ \frac{\text{rad}}{\text{sec}} = 0 + 0.028\ \frac{\text{rad}}{\text{sec}^2}\ t$$

$$t = 56\ \text{sec}$$

Figure 5: loading mechanism time calculation.

Thickness of frame:

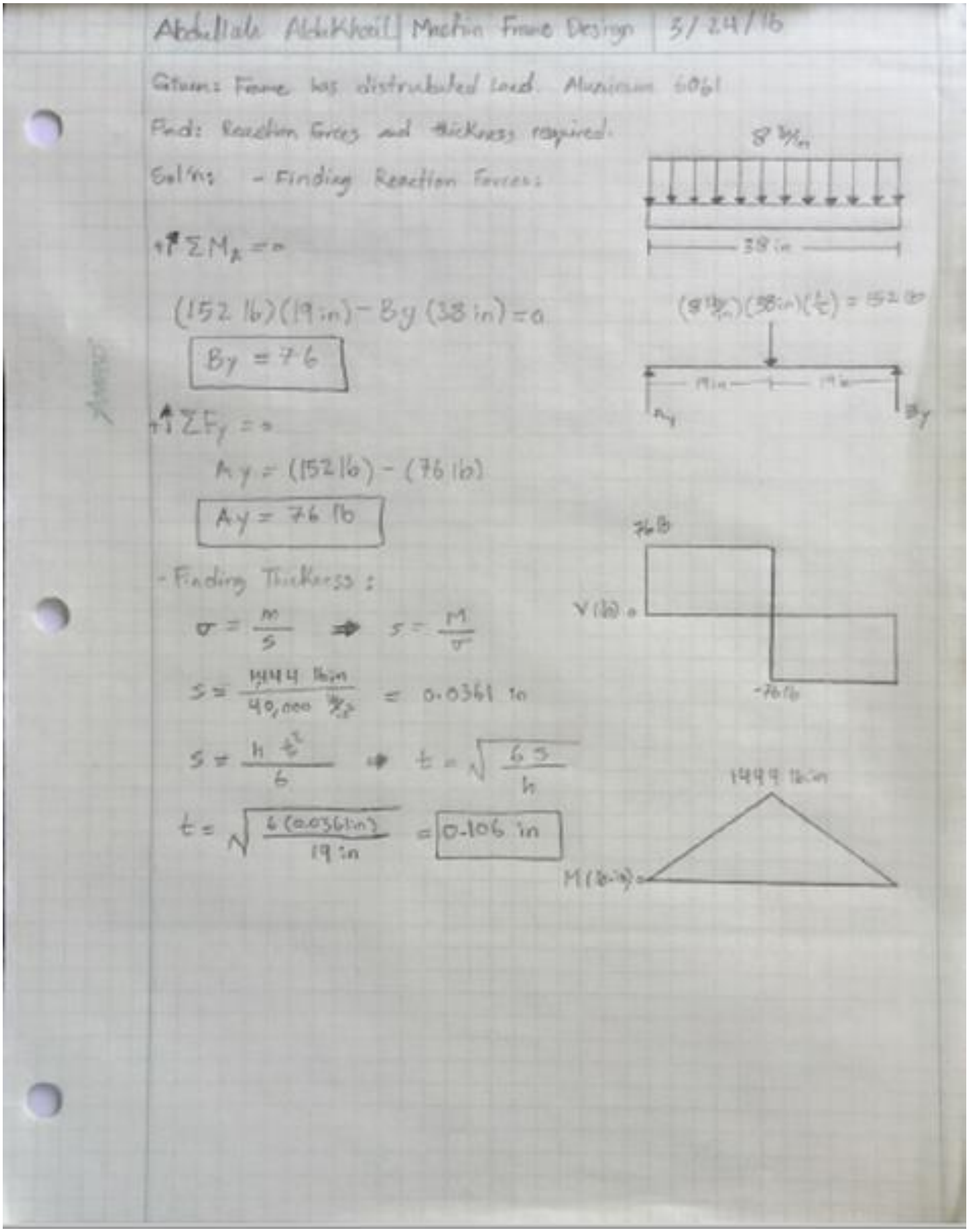


Figure 6: Thickness of frame calculation.

Reaction Forces, Thickness required Calculations for Frame:

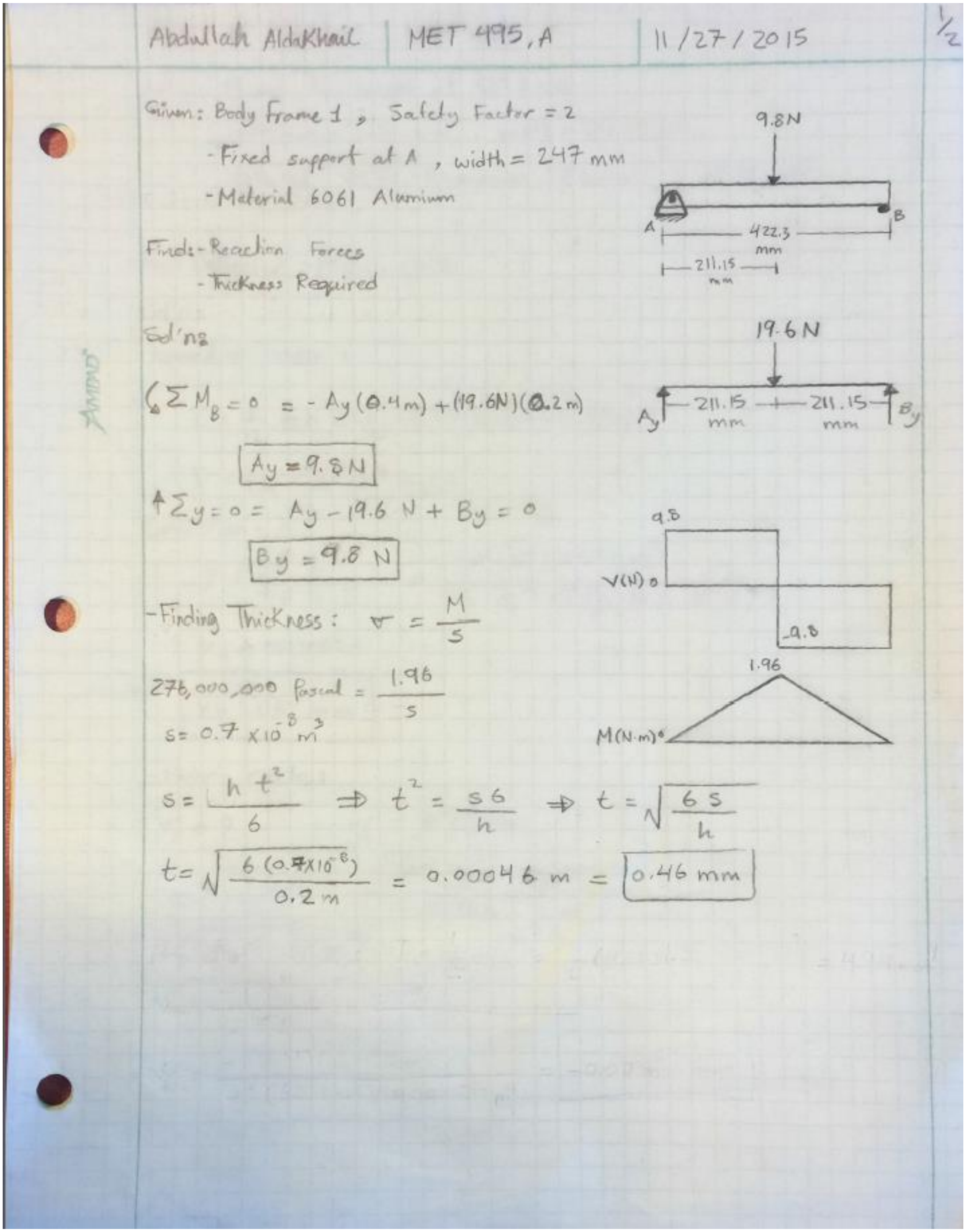
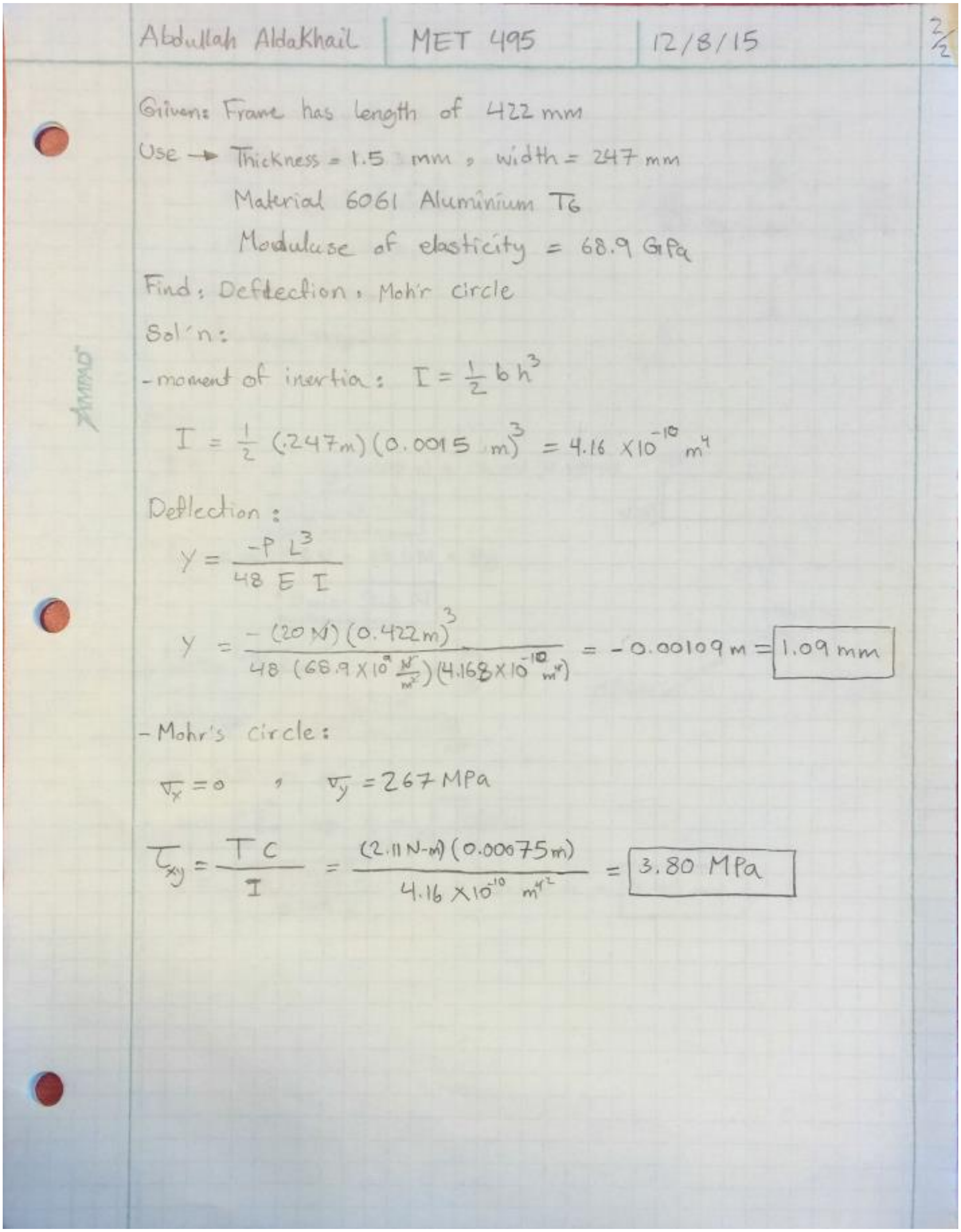


Figure 7: Shear & Moment diagram of the machine frame part 1.

Deflection Calculation for Frame:



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Given: Frame has length of 422 mm

Use → Thickness = 1.5 mm , width = 247 mm

Material 6061 Aluminium T6

Moduluse of elasticity = 68.9 GPa

Find: Deflection , Mohr circle

Sol'n:

- moment of inertia: $I = \frac{1}{2} b h^3$

$$I = \frac{1}{2} (.247m)(0.0015\ m)^3 = 4.16 \times 10^{-10}\ m^4$$

Deflection:

$$y = \frac{-P L^3}{48 E I}$$

$$y = \frac{-(20 N)(0.422m)^3}{48 (68.9 \times 10^9 \frac{N}{m^2})(4.168 \times 10^{-10} m^4)} = -0.00109 m = \boxed{1.09 mm}$$

- Mohr's circle:

$\sigma_x = 0$, $\sigma_y = 267$ MPa

$$\tau_{xy} = \frac{T c}{I} = \frac{(2.11 N\text{-}m)(0.00075m)}{4.16 \times 10^{-10}\ m^{4}} = \boxed{3.80 MPa}$$

Mohr's Circle for FB1:

Tedata

Program : MDESIGN Module version: 13.0	User : Date : 09.12.2015	Customer: Proj. Nr:

Combined Stresses and Mohr's Circle

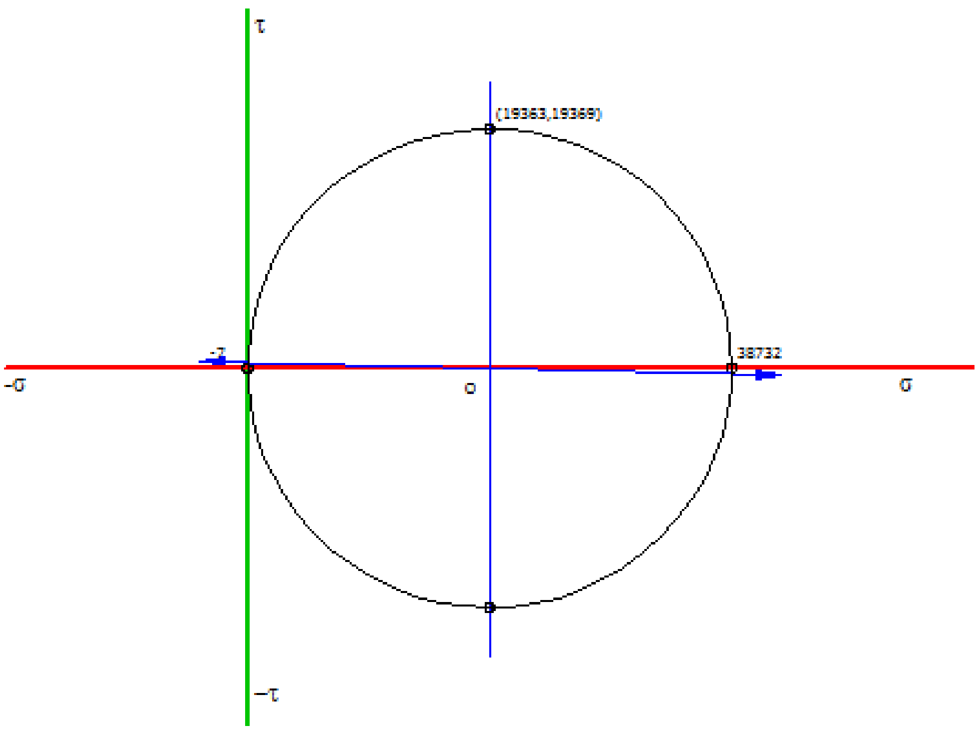
Input data:

Combined Stresses and Mohr's Circle

Normal stress acting along x-axis	σx = 0	psi
Normal stress acting along y-axis	σy = 267	MPa
Shear stress	τxy = 3.53	MPa

Results:

Maximum principal stress	$\sigma 1$ =	38731.844	psi
Minimum principal stress	$\sigma 2$ =	-6.768	psi
Maximum shear stress	τmax=	19369.306	psi
Average normal stress	σavg=	19362.538	psi
Principal planes	$\phi\sigma$ =	-0.757	°
Angle of maximum shear stress	$\phi\tau$ =	45.757	°

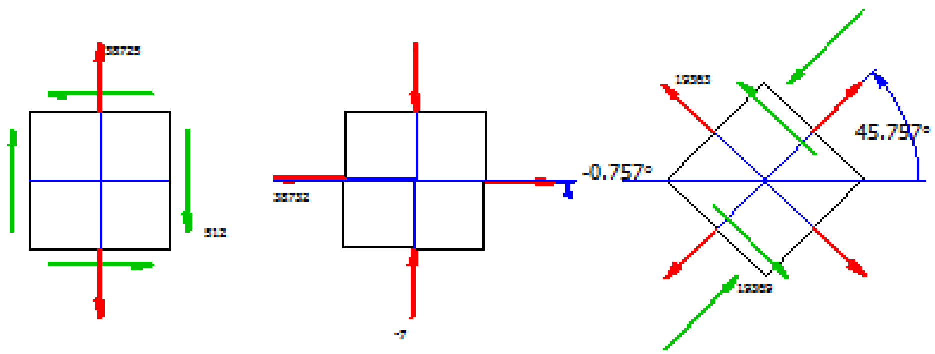


Principle Stress for FB1:

Tedata		
Program : MDESIGN Module version: 13.0	User : Date : 09.12.2015	Customer: Proj. Nr:

Combined Stresses and Mohr's Circle

Relationships among original stress element, principal stress element, and maximum shear element for a given loading



Original stress element | Principal stress element | Maximum shear stress element

Reaction Forces, Thickness required Calculations for FB2:

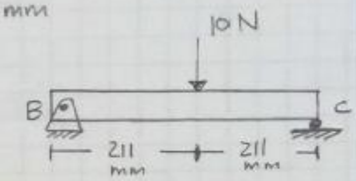
Abdullah Aldakhail | MET 495 | 12/8/2015 | 1/2

Given: - Frame body 2, safety factor 2

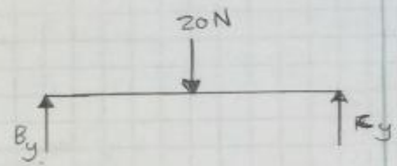
- Fixed at B, has width of 247 mm
- Material 6061 Aluminium

Find: - Reaction Forces

- Thickness required



Sol'n:



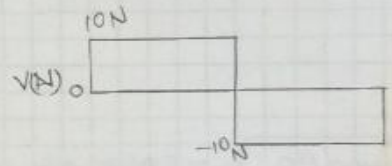
$\circlearrowleft \Sigma M_c = 0 = -B_y(0.422\ m) + (20\ N)(0.211\ m)$

$\boxed{B_y = 10\ N}$

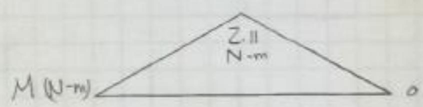
$+\uparrow \Sigma y = 0 = 10 - 20 + C_y$

$\boxed{C_y = 10\ N}$

- Finding Thickness: $\sigma = \frac{M}{S}$



$S = \frac{M}{\sigma} = \frac{2.11\ N\text{-}m}{276{,}000{,}000\ \frac{N}{m^2}}$



$S = 0.8 \times 10^{-8}\ m^3$

- Section modulus for rectangle:

$S = \frac{B H^2}{6} \Rightarrow H = \sqrt{\frac{6S}{B}}$

$H = \sqrt{\frac{6(0.8 \times 10^{-8}\ m^3)}{0.247\ m}} = 0.00043\ m = \boxed{0.43\ mm}$

Deflection Calculation for FB2:

Abdullah Aldakhail | MET 495 | 11/27/2015 — 2/2

Given: Frame has length of 4223 mm

Thickness = 1.5 mm , width = 247.65 mm

Material 6061 Aluminum Elasticity = 68.9 GPa

Find: Deflection , Mohr's circle

Sol'n:

moment of inertia :

$$I = \frac{1}{12} b h^3 = \frac{1}{12} (0.247 m)(0.0015 m)^3$$

$$I = 4.16 \times 10^{-10} \ m^4$$

Deflection :

$$y = \frac{-P L^3}{48 E I} = \frac{-(19.6 N)(0.422 m)^3}{48 (68.9 \times 10^9 \frac{N}{m^2})(4.16 \times 10^{-10} m^4)}$$

$$y = 0.00106 \ m$$

$$\boxed{y = 1.06 \ mm}$$

- Mohr's circle :

$\sigma_x = 0$, $\sigma_y = 267$ MPa

$$\tau_{xy} = \frac{T c}{I} = \frac{(1.96 N \cdot m)(0.00075 m)}{4.16 \times 10^{-10} m^4}$$

$$\boxed{\tau_{xy} = 3.53 \ MPa}$$

Mohr's Circle for FB2:

Tedata

Program : MDESIGN	User :	Customer:
Module version: 13.0	Date : 09.12.2015	Proj. Nr:

Combined Stresses and Mohr's Circle

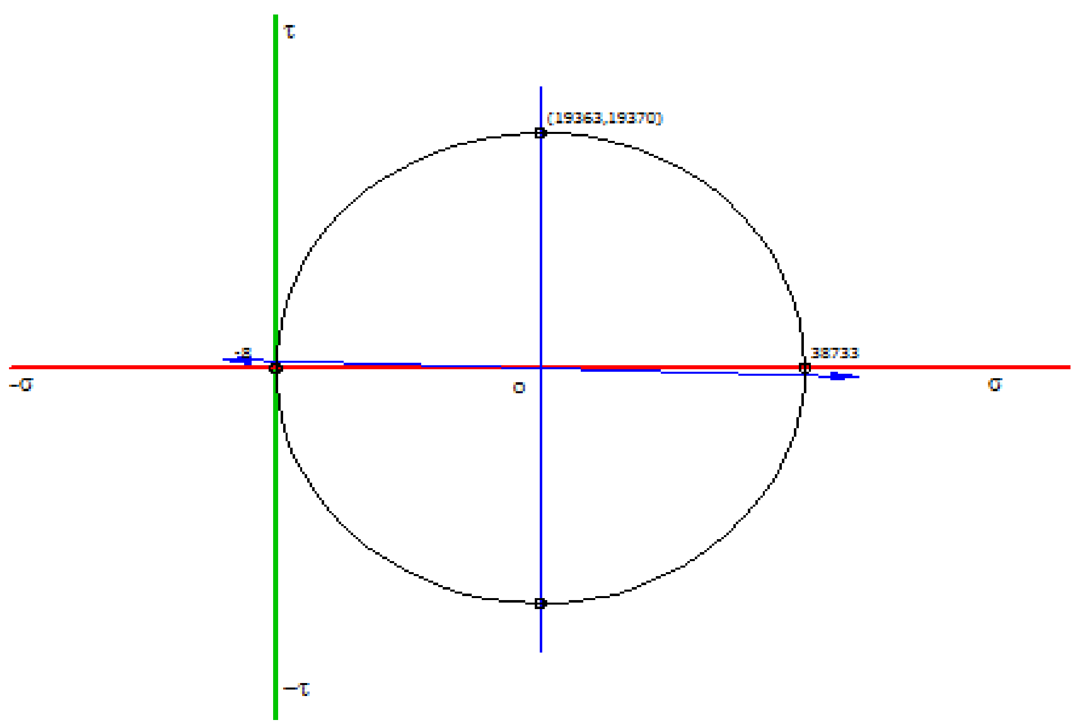
Input data:

Combined Stresses and Mohr's Circle

Normal stress acting along x-axis	σx =	0	psi
Normal stress acting along y-axis	σy =	267	MPa
Shear stress	τxy =	3.8	MPa

Results:

Maximum principal stress	$\sigma 1$ =	38732.918	psi
Minimum principal stress	$\sigma 2$ =	-7.842	psi
Maximum shear stress	τmax =	19370.380	psi
Average normal stress	σavg =	19362.538	psi
Principal planes	$\phi\sigma$ =	-0.815	°
Angle of maximum shear stress	$\phi\tau$ =	45.815	°



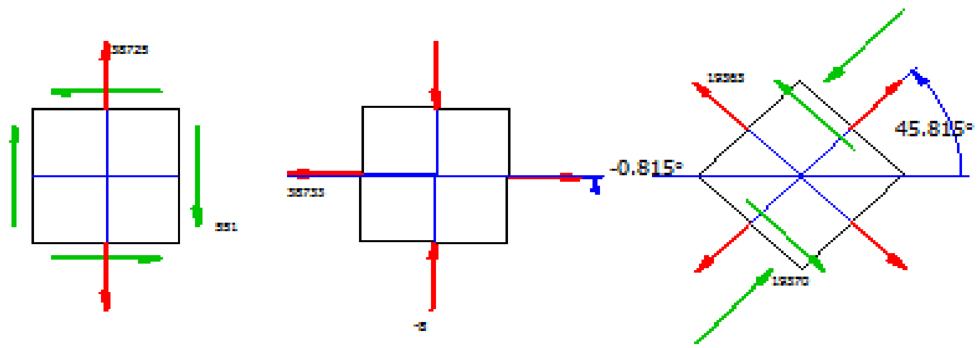
Principle Stress for FB2:

Tedata

Program : MDESIGN Module version: 13.0	User : Date : 09.12.2015	Customer: Proj. Nr:

Combined Stresses and Mohr's Circle

Relationships among original stress element, principal stress element, and maximum shear element for a given loading



Original stress element

Principal stress element

Maximum shear stress element

Reaction Forces, Thinness required Calculations for FB3:

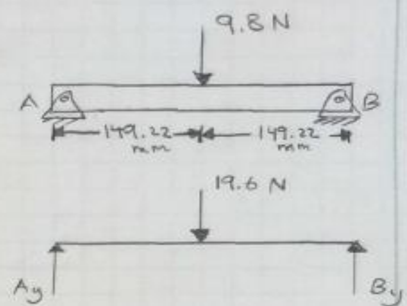
Abdullah AldaKhail | MET 495 | 11/27/2015 | 1/2

Given: Frame body part 3

Safety factor = 2

Fixed support at A, B

Material aluminum 6061



Find: Reaction Forces

Thickness required

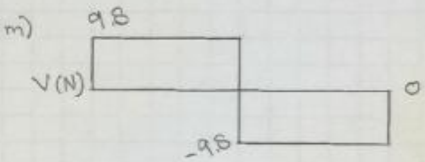
Sol'n:

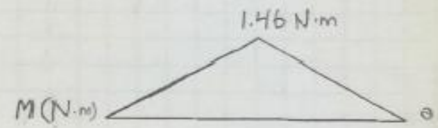
$\circlearrowleft \Sigma M_B = 0 = -A_y(0.298\ m) + 19.6N(0.149m)$

$\boxed{A_y = 9.8\ N}$

$\uparrow \Sigma y = 0 = 9.8N - 19.6N + B_y$

$\boxed{B_y = 9.8\ N}$





+ Finding Thickness: $\sigma = \frac{M}{S}$

$S = \frac{M}{\sigma} = \frac{1.46\ N.m}{276{,}000{,}000\ \frac{N}{m^2}}$

$S = 0.5 \times 10^{-8}\ m$

$S = \frac{h t^2}{6} \Rightarrow t = \sqrt{\frac{6S}{h}}$

$t = \sqrt{\frac{6(0.5\times10^{-8} m)}{0.149\ m}} = 0.00045\ m = \boxed{0.45\ mm}$

Deflection Calculation for FB3:

Abdullah Aldakhail | MET 495 | 11/27/2015 | 2/2

Given: From part 3 has length 298.22 mm

Thickness = 1.5 mm , width = 195 mm

material 6061 aluminum

Modaluce of elasticity = 68.9 GPa

Find: Deflection , Draw mohr's circle

Sol'n:

moment of inirtia: $I = \frac{1}{12} bh^3$

$I = \frac{1}{12} (0.195\ m)(0.0015\ m)^3 = 5.48 \times 10^{-11}\ m^4$

Deflection:

$y = \frac{-P L^3}{48 E I}$

$y = \frac{-(19.8 N)(0.298 m)^3}{48 (68.9 \times 10^9 \frac{N}{m^2})(5.48 \times 10^{-11} m^4)}$

$Y = 0.0029\ m = \boxed{2.89\ mm}$

- Moh'r circle:

$\sigma_x = 0$, $\sigma_y = 276$ MPa

$\tau_{xy} = \frac{Tc}{I} = \frac{(1.96 N \cdot m)(0.00075 m)}{5.48 \times 10^{-11}\ m^4} = \boxed{26.8\ MPa}$

Mohr's Circle for FB3:

Tedata

Program : MDESIGN	User :	Customer:
Module version: 13.0	Date : 09.12.2015	Proj. Nr:

Combined Stresses and Mohr's Circle

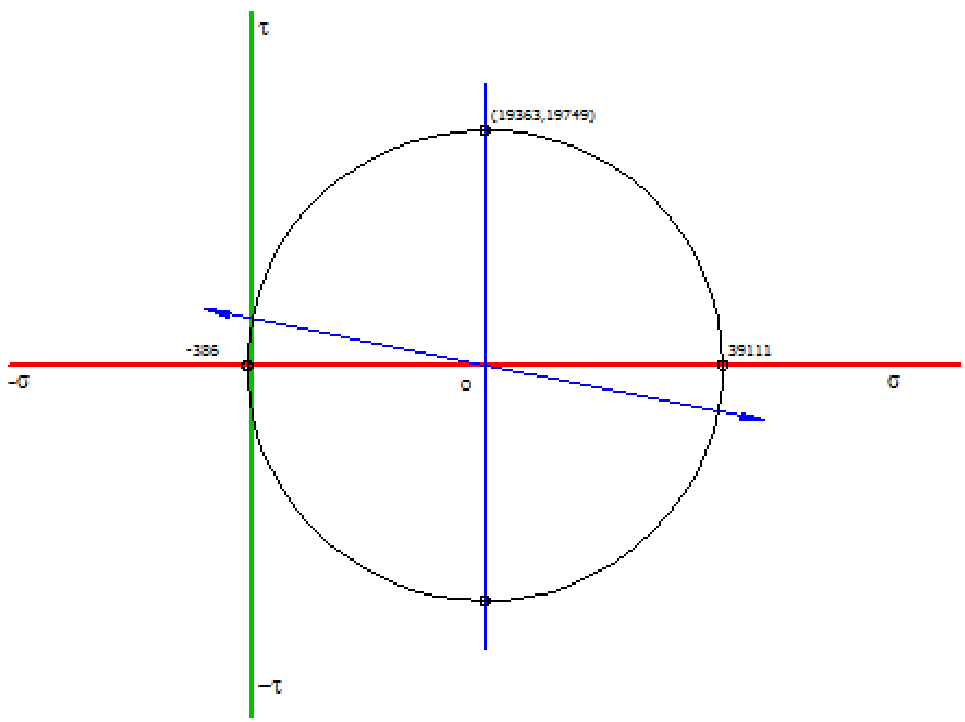
Input data:

Combined Stresses and Mohr's Circle

Normal stress acting along x-axis	σx = 0	MPa
Normal stress acting along y-axis	σy = 267	MPa
Shear stress	τxy = 26.8	MPa

Results:

Maximum principal stress	σ1 =	39111.379	psi
Minimum principal stress	σ2 =	-386.303	psi
Maximum shear stress	τmax=	19748.841	psi
Average normal stress	σavg=	19362.538	psi
Principal planes	ϕσ =	-5.676	°
Angle of maximum shear stress	ϕτ =	50.676	°

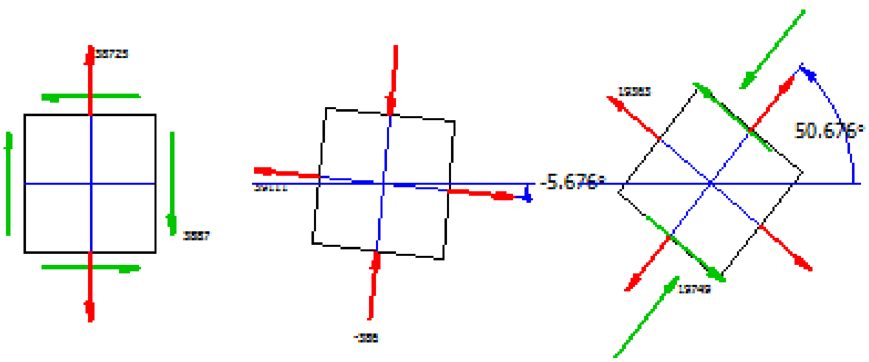


Principle Stress for FB3:

Tedata		
Program : MDESIGN Module version: 13.0	User : Date : 09.12.2015	Customer: Proj. Nr:

Combined Stresses and Mohr's Circle

Relationships among original stress element, principal stress element, and maximum shear element for a given loading

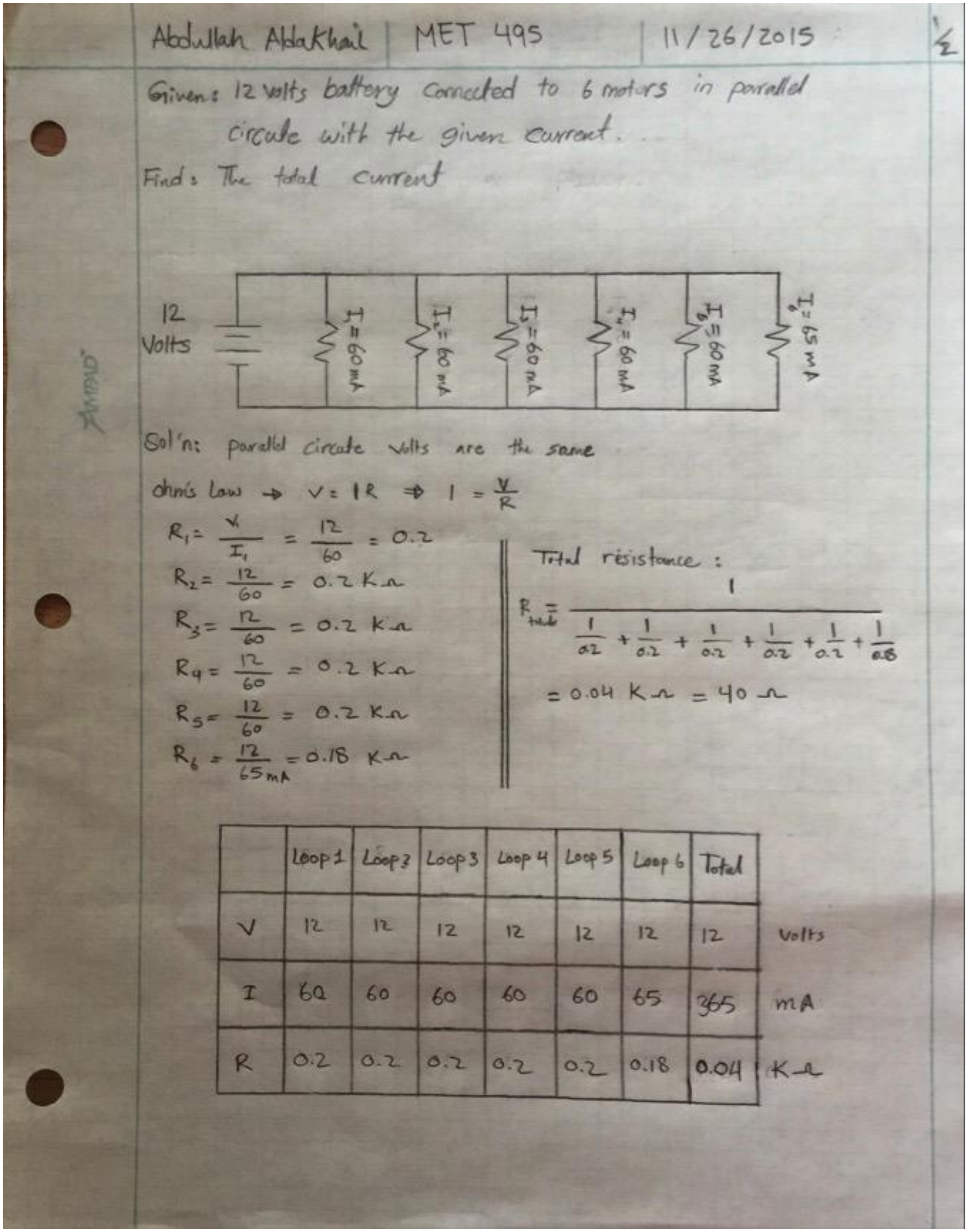


Original stress element

Principal stress element

Maximum shear stress element

Resistor required calculations:


Abdullah Aldakhail | MET 495 | 11/26/2015 | 1/2

Given: 12 volts battery connected to 6 motors in parallel circute with the given current.

Find: The total current

Sol'n: parallel circute volts are the same

ohm's Law → $V = IR$ ⇒ $I = \frac{V}{R}$

$R_1 = \frac{V_1}{I_1} = \frac{12}{60} = 0.2$

$R_2 = \frac{12}{60} = 0.2\ K\Omega$

$R_3 = \frac{12}{60} = 0.2\ K\Omega$

$R_4 = \frac{12}{60} = 0.2\ K\Omega$

$R_5 = \frac{12}{60} = 0.2\ K\Omega$

$R_6 = \frac{12}{65\,mA} = 0.18\ K\Omega$

Total resistance:

$$R_{total} = \frac{1}{\frac{1}{0.2}+\frac{1}{0.2}+\frac{1}{0.2}+\frac{1}{0.2}+\frac{1}{0.2}+\frac{1}{0.18}}$$

$= 0.04\ K\Omega = 40\ \Omega$

	Loop 1	Loop 2	Loop 3	Loop 4	Loop 5	Loop 6	Total	
V	12	12	12	12	12	12	12	Volts
I	60	60	60	60	60	65	365	mA
R	0.2	0.2	0.2	0.2	0.2	0.18	0.04	KΩ

Figure 8: Resistor calculations.

Calculating power needed:

Abdullah Aldakhail | MET 495 | 11/26/2015 | 2/2

Given: 6 motors with given torque and RPM

Find: Power needed

Sol'n:

motor 1, 2, 3, 4, 5 are NXT 170 RPM, 20 N.cm torque

$$T = (50\,N \cdot cm)\left(\frac{1\,m}{100\,cm}\right) = 0.5\,N.m$$

$$\omega = \left(170\,\frac{rev}{min}\right)\left(\frac{min}{60\,sec}\right)\left(\frac{2\pi\,rad}{rev}\right) = 17.8\,\frac{rad}{sec}$$

$$Power = T \cdot \omega$$

$$= (0.5\,N.m)\left(17.8\,\frac{rad}{sec}\right) = \boxed{8.9\ watt}$$

motor 6 is PF 405 RPM, 11 N.cm tourque

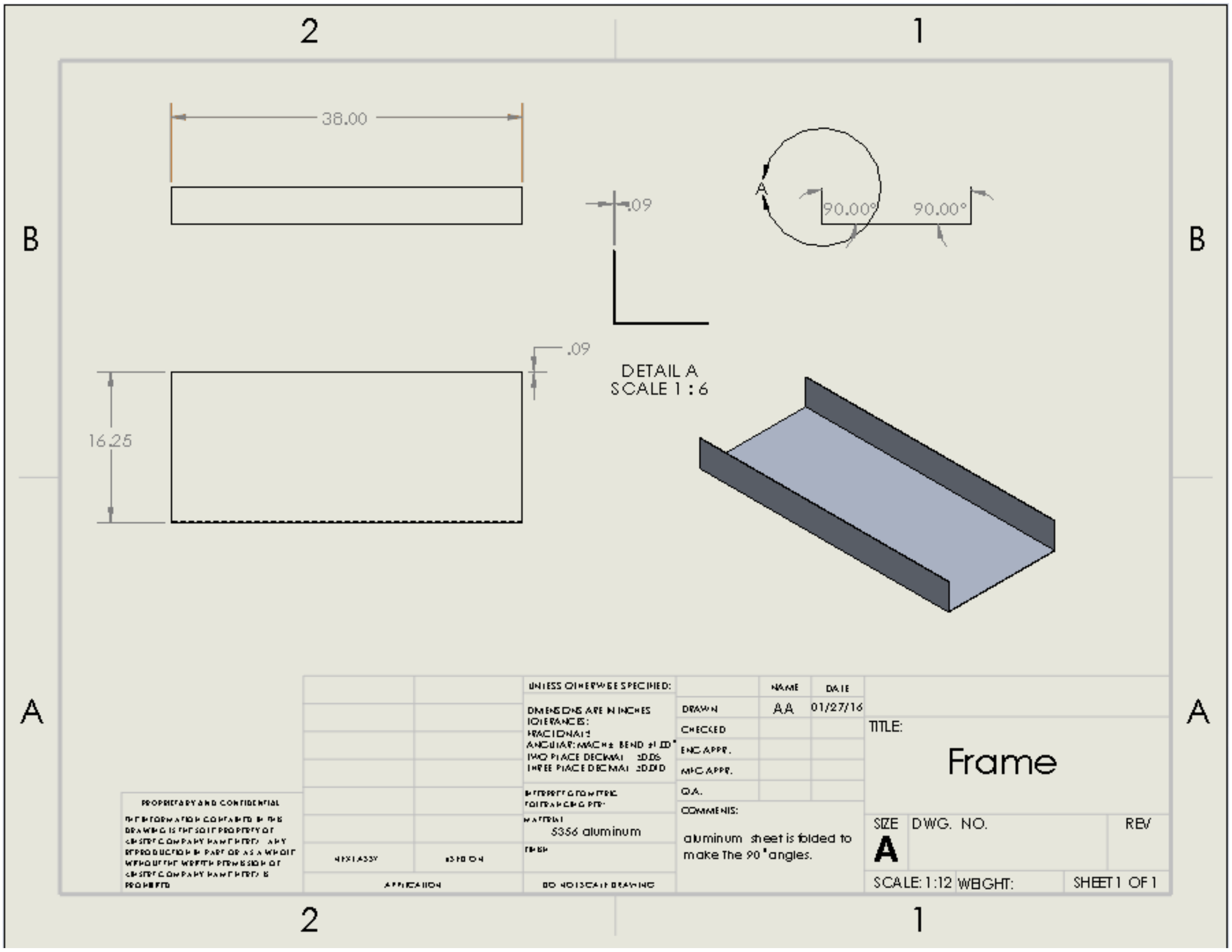
$$T = (11\,N \cdot cm)\left(\frac{1\,m}{100\,cm}\right) = 0.11\,N \cdot m$$

$$W = (405\,RPM)\left(\frac{min}{60\,sec}\right)\left(\frac{2\pi\,rad}{rev}\right) = 42.4\,\frac{rad}{sec}$$

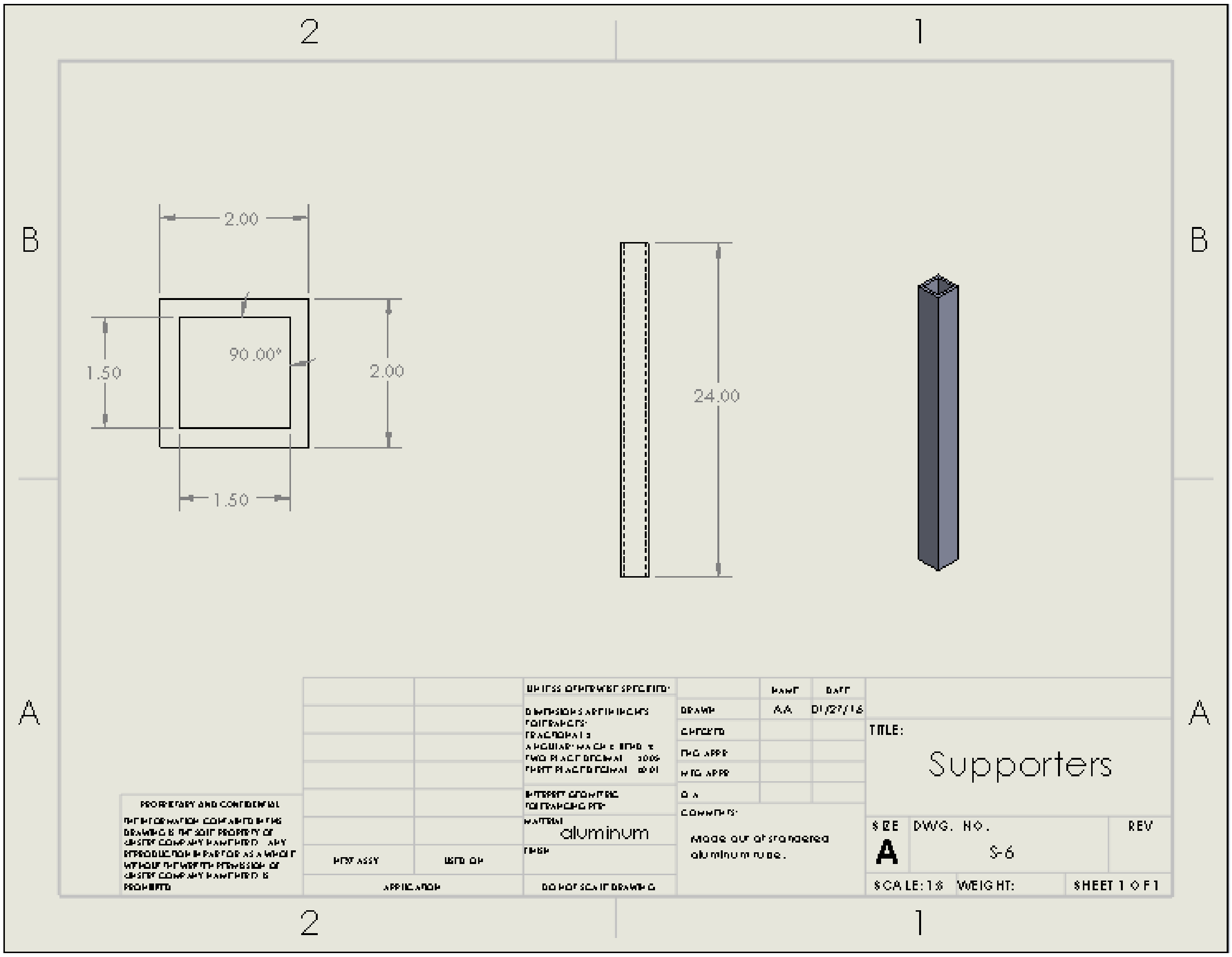
$$Power = T \cdot \omega = (0.11\,N\text{-}m)\left(42.4\,\frac{rad}{sec}\right) = \boxed{4.67\ watt}$$

Appendix B – Drawings Sketches, Assembly drawings, Sub-assembly drawings, Part drawings

Frame Part 1:

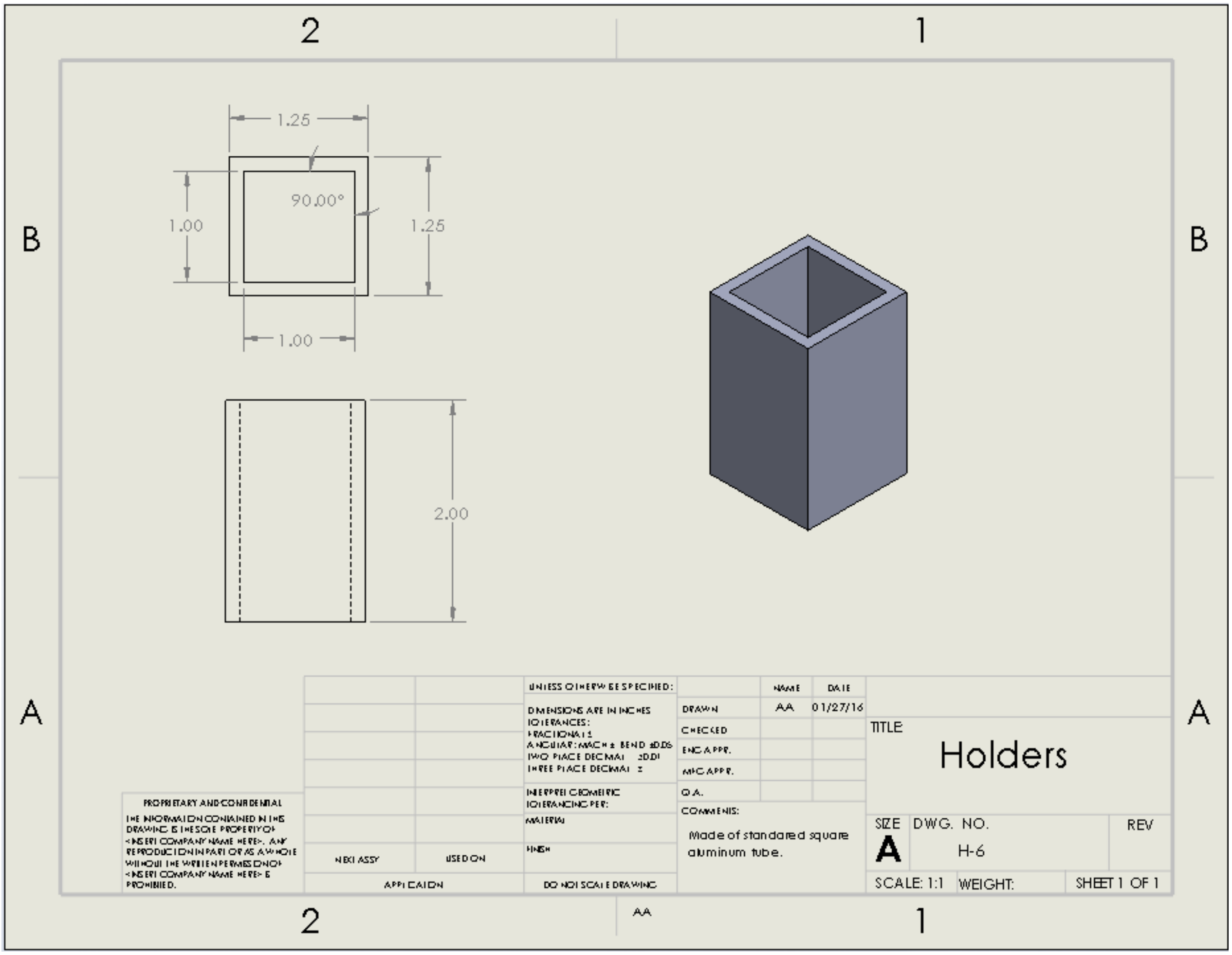


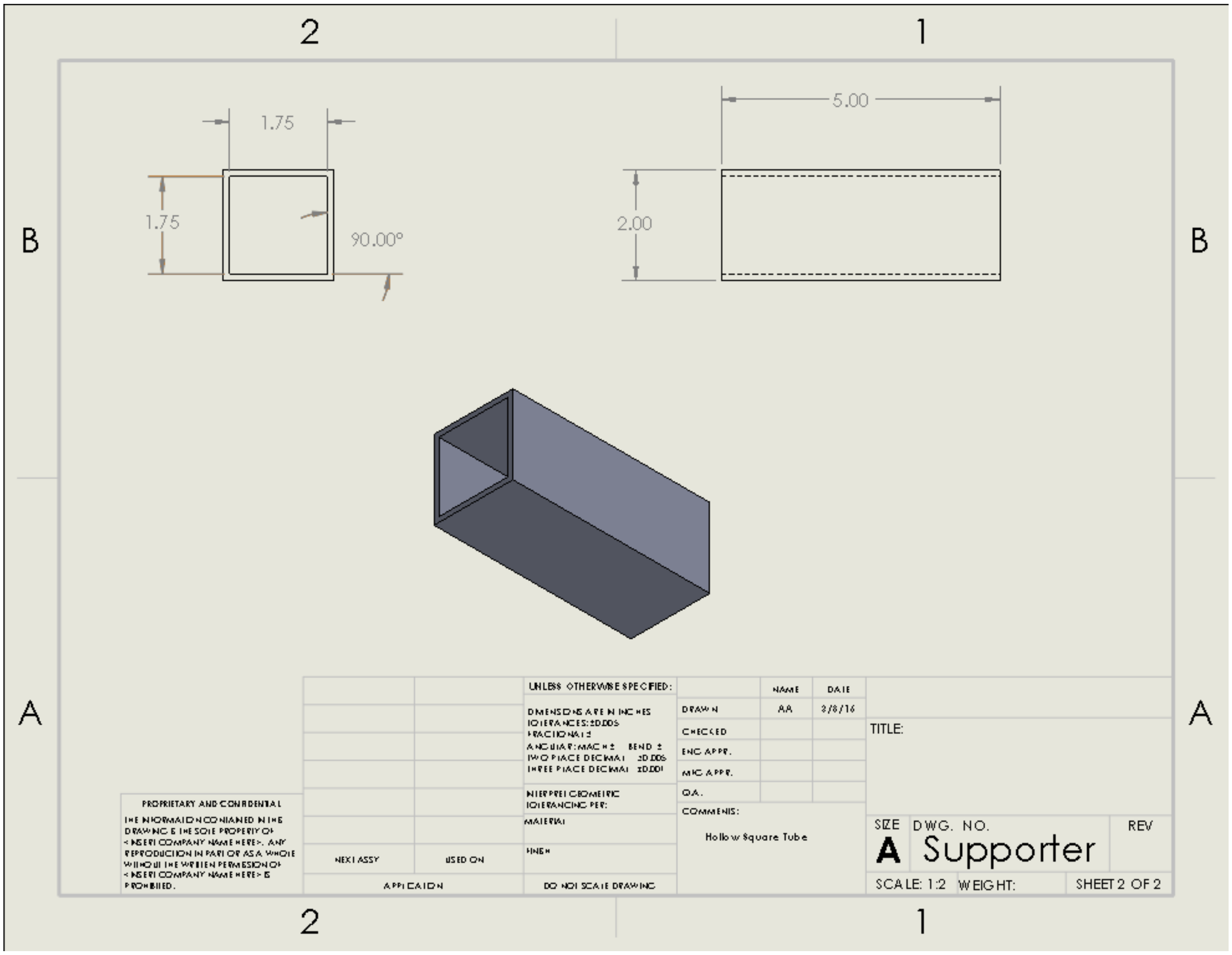
Stand Tube:

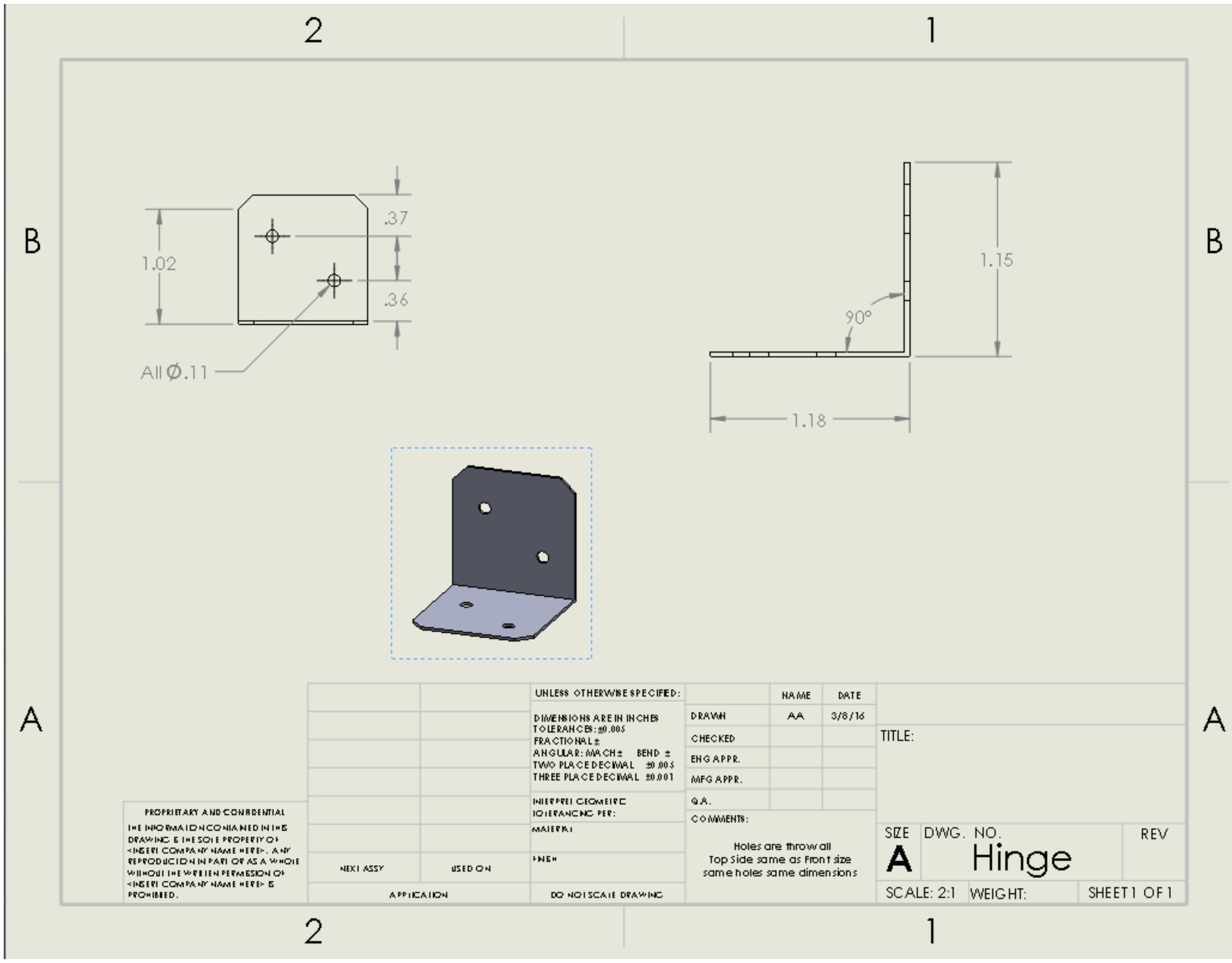


2.00
90.00°
1.50
2.00
1.50
24.00
TITLE:
Supporters
MATERIAL
aluminum
COMMENTS:
Made out of standard aluminum tube.
DRAWN
AA
01/27/16
SIZE
A
DWG. NO.
S-6
REV
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1

Holder:


1.25
90.00°
1.00
1.25
1.00
2.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
DRAWN
AA
01/27/16
TITLE
Holders
Made of standard square aluminum tube.
SIZE
A
DWG. NO.
H-6
REV
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL


1.75
1.75
90.00°
5.00
2.00
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
AA
TITLE:
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Hollow Square Tube
PROPRIETARY AND CONFIDENTIAL
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
SIZE
DWG. NO.
REV
A
Supporter
SCALE: 1:2
WEIGHT:
SHEET 2 OF 2



New design Assembly:

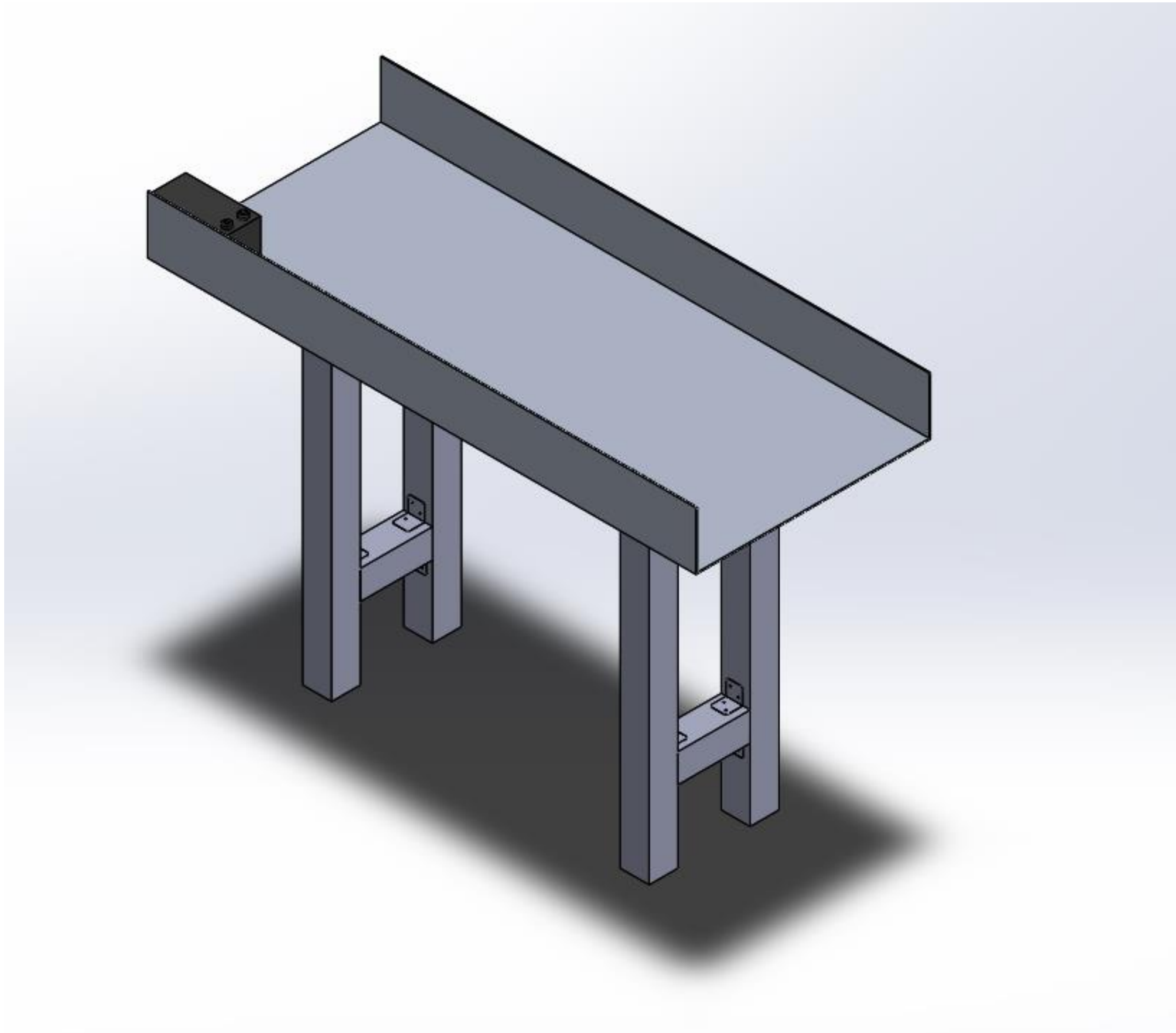
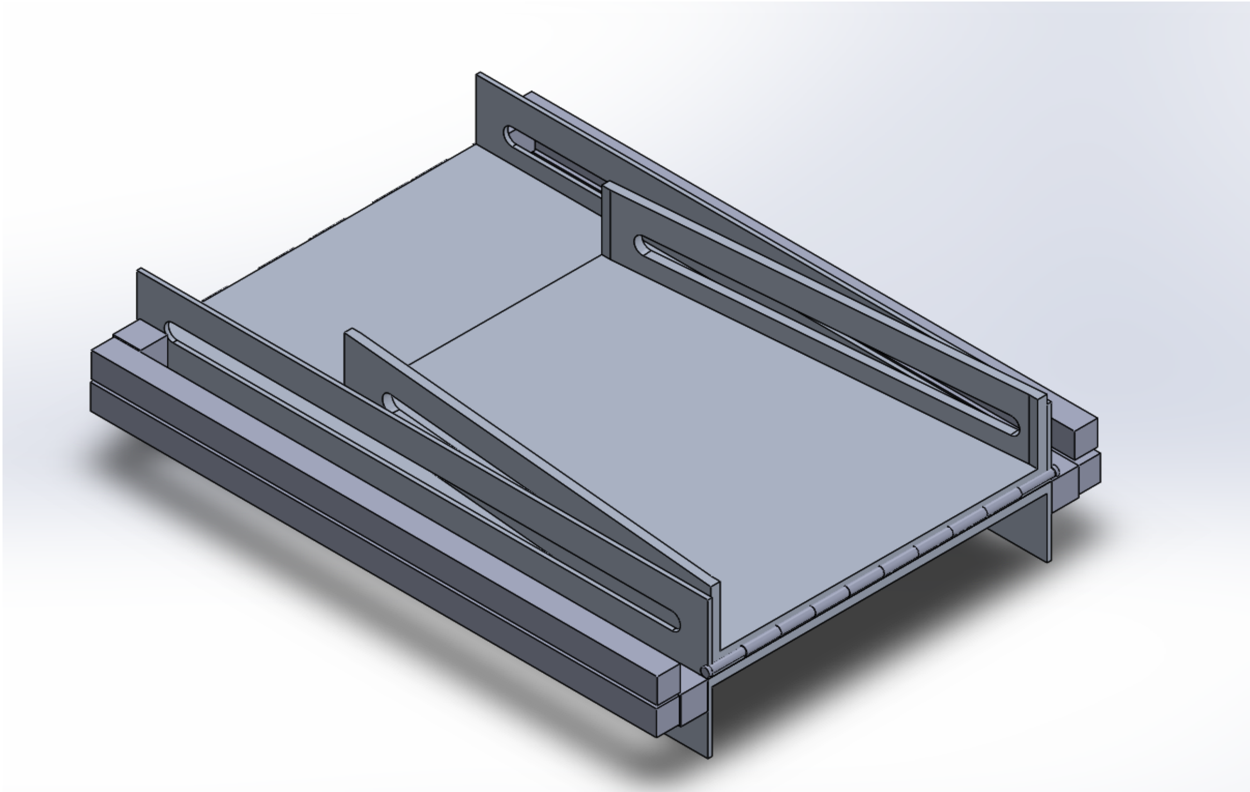
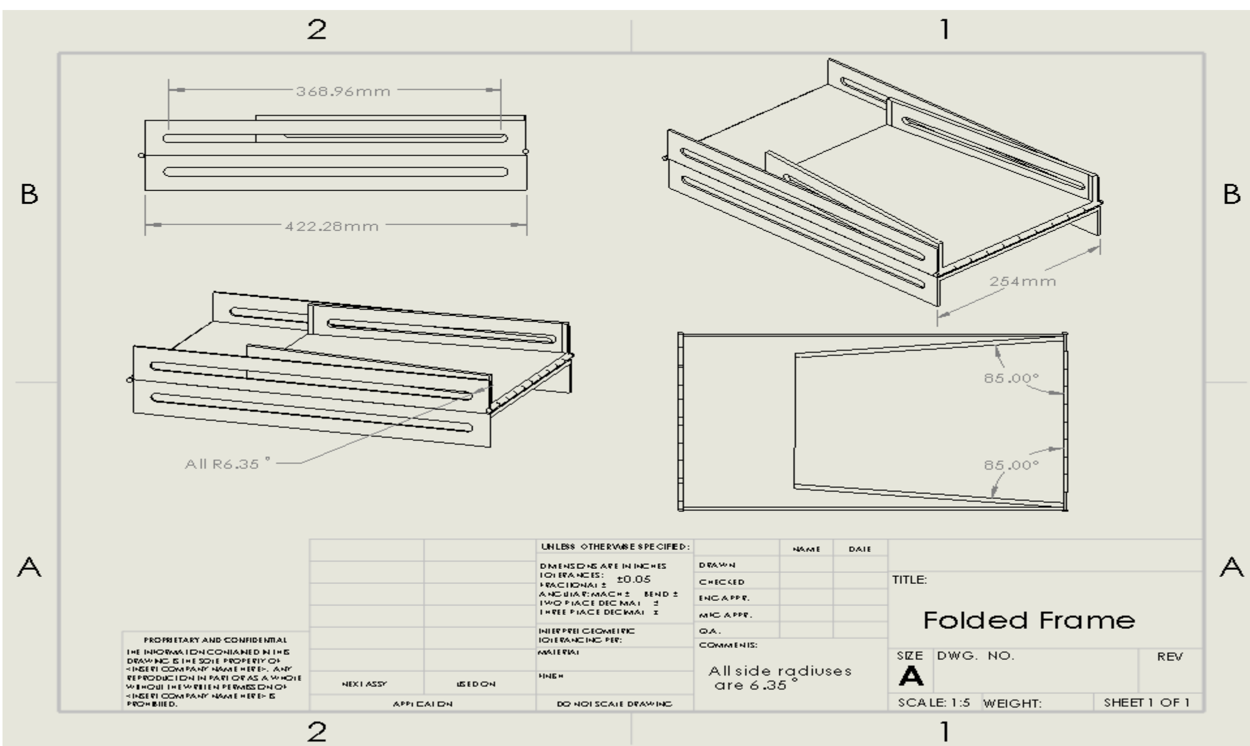


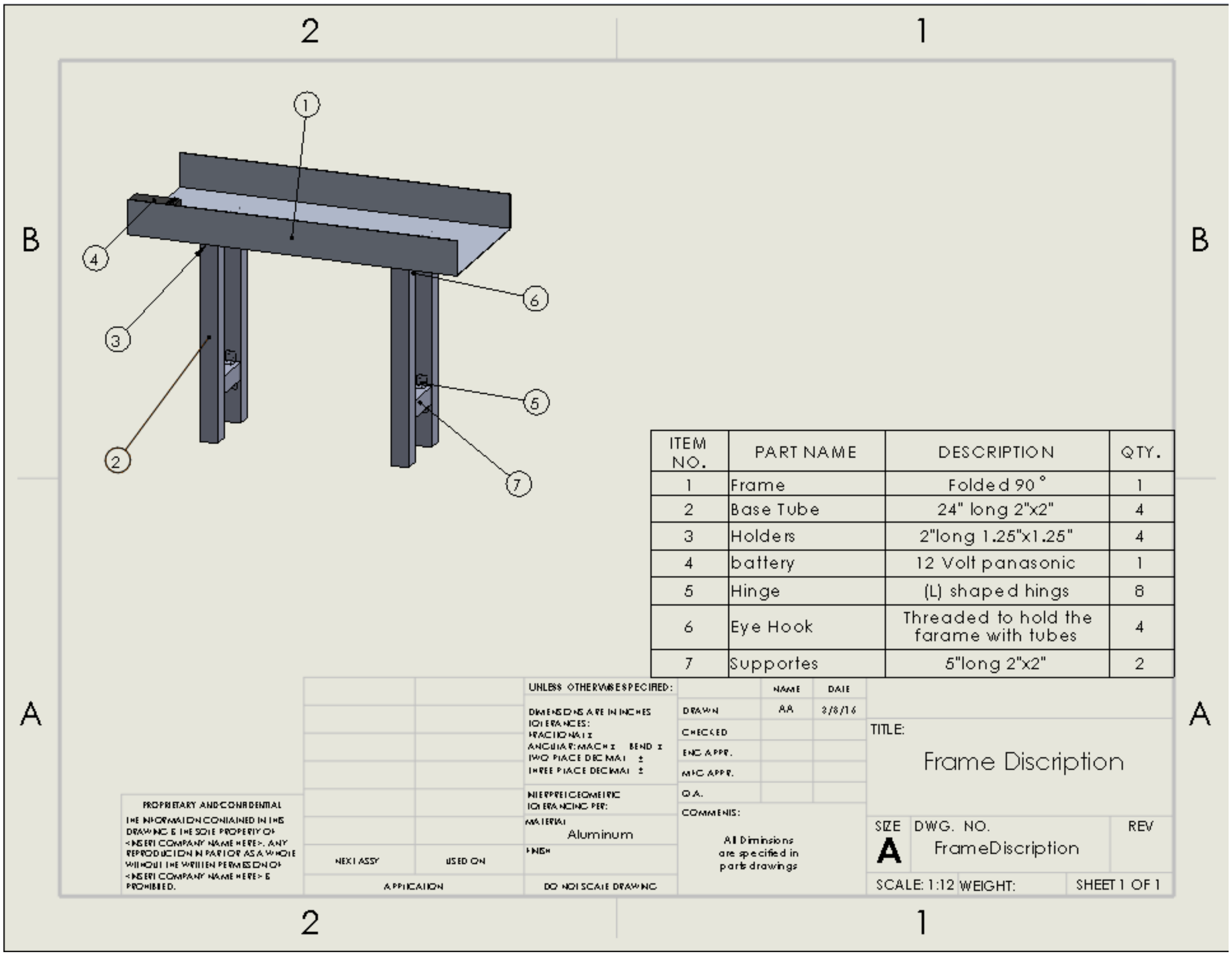
Figure 6: Machine frame assembly

First Frame Design:





Appendix C – Parts List (use real brands and IDs)



ITEM NO.	PART NAME	DESCRIPTION	QTY.
1	Frame	Folded 90 °	1
2	Base Tube	24" long 2"x2"	4
3	Holders	2"long 1.25"x1.25"	4
4	battery	12 Volt panasonic	1
5	Hinge	(L) shaped hings	8
6	Eye Hook	Threaded to hold the farame with tubes	4
7	Supportes	5"long 2"x2"	2

Weight	2470 g
Features	Maintenance-free
DS certification	Yes
lanufacturer part No.	LC-R127R2PG
oltage	12 V
ype	12 V 7.2 Ah
echargeable	Yes
echnology	AGM
	65 mm
leight	94 mm
Vidth	151 mm
apacity	7.2 Ah

❖ Panasonic Lead Acid batteries:

Appendix D – Schedule

				Senior Project Schedule
				Project Title: Paper Airplane Building Machine
				Subproject Title: Paper Loading, Machine Frame Designing and Power Supply.

Investigator: Abdullah Aldakhail

Task ID:	Description	Est. (hrs.)	Actual Time	Sep/29/2015	Oct/05/2015	Oct/19/2015	Nov/02/2015	Nov/16/2015	Dec/01/2015	Dec/09/2015	Jan/11/2016	Jan/18 to 22	Feb/ 15 to 21	Feb/ 22 to 27	March/ 1 to 9	March/09/2016
1	**Proposal**															
1.a	Outline	4	6													
1.b	Introduction	7	8													
1.c	Methods	8	10													
1.d	Analysis	17	17													
1.e	Discussion	6	7													
1.f	Parts and Budget	8	7													
1.g	Drawing parts and assembly	20	20													
1.h	Schedule	10	15													
1.i	Summery and Appendix	12	12													
	Total Proposal Time:	**92**	102													
2	**Collect Materials & Parts Needed**															
2.a	Order Aluminum Sheet	.15	1													
2.b	Order Aluminum Square tube	.15	.30													
2.c	Order Battery Holder	.15	.30													
2.d	Buy Terminal Strips	.30	.50													
2.e	Buy wires	.30	.50													
2.f	Order DC Motor	.15	.30													
2.g	Get Batteries from Prof. Beardsley	.15	.20													
2.h	Order Aluminum Rod for Hinges	.15	.30													
2.i	Get The paper Roller	.15	.15													
2.j	Gather all parts	.45	1.0													
2.k	Get laser tachometer from Prof. Beardsley	.15	.40													
2.l	Get fluke Multimeter from Prof. Beardsley	.15	.20													
2.m	Get Caliper	.15	.25													
	Total Gathering Material	**4.20**	5.2													
3	**Construct**															

3.a	Cut the Sides of Frame Body 1	.30										X				
3.b	Use CNC to Cut the Side Holes	3.0										X				
3.c	Fold The sides to Make Final Shape	.15										X				
3.d	Cut the Sides of Frame Body 2	.30										X				
3.e	Use CNC to Cut the Side Holes	1.0										X				
3.f	Fold The sides to Make Final Shape	.15														
3.g	Cut the Sides of Frame Body 3	.45										X				
3.h	Use CNC to Cut the Side Holes	1.0										X				
3.i	Fold The sides to Make Final Shape	.15														
3.j	Cut The Aluminum Tube to 2”	.30														
3.k	Weld The Tube To make 90° Edge	1.0														
3.l	Weld the Battery Holder To F B 1	.20										X				
3.m	Weld Square Holders to All Bodies	.15														
3.n	Assemble roller to motor & Gears	1.30														
3.o	Assemble all parts together	.30														
3.p	Build Parallel Circuit in testing board	.30														
3.q	Fold the frame to 90 degrees	2.0	3.0													
3.r	Cut 4 (2x2) pieces square tubes 24” long	2.0	1.5													
3.s	Cut 4 (1.25x1.25) pieces square tubes 2” long	3.0	1.5													
3.t	Cut 2 pieces of (2x2) tube 5” long	1.5	2.0													
3.u	Drill 4 holes in 2”x2” tube	4.0	6.0													
3.v	Braze (1.25”x1.25”) tube under frame body	6.0	14.3													
3.w	Connect the (2x2) long and short ones by screws	5.0	6.3													
3.x	Make thread in(2x2) tubes for eye hooks to hold the frame	3.0	2.0													
	Total Construction:	**26.30**	37													
4	**Test**															
4.a	Measure Resistance & Current	.30														
4.b	Measure Roller RPM	.30														
4.c	Put Load on Frame & measure deflection	.30														
	Total Testing	1.30														
	Total Time Consumed:	**106.5**														

Milestone	◆ **Proposal Completed**	

	(X) Indicate the steps that been modified ubon the new frame design.	

Appendix E - Expertise and Resources

Most of the subproject is going to be made in the welding shop. CNC might be used for cutting the holes operation, definitely need help with the operation as well as some guidance in the welding processes from the Lab Technician. Likewise some processes will be made in the machining shop for example the milling machine might be used to cut some material. Advice and guidance from the Electrical engineering staff such as Christopher Hobbs Lecturer or Greg Lyman.

Appendix F –Testing Data (a form to record your test data)

Current & Resistance Testing

Step 1:

+ Build Parallel Circuit with 6 Loops,

+ Each loop will have the assigned resister.

+ Measure the Resistance & Current in each loop.

Roller RPM Testing

Step 1:

+ Run the Motor and measure its Initial RPM….

Initi

Step

+ Connect the motor to the shaft and the gears….

+ Run the motor and measure the roller RPM

Fina

Loop 1	Loop 2	Loop 3
Resistance _______	Resistance _______	Resistance _______
Current ________	Current ________	Current ________

Loop 4	Loop 5	Loop 6
Resistance _______	Resistance _______	Resistance _______
Current ________	Current ________	Current ________

______________ mm.	______________ mm.	______________ mm.

Appendix G – Testing Report

Test Design Guide

Introduction:

In this portion of the project, there are two testing has been made. The first test is the loading mechanism. Basically, the test is to record the time that the paper takes to go in and out the loading rollers. Then compare it with the calculated values. The second test is to measure the volt and the current in the batteries twice, one with load and other without load. This test was assigned to check the time that the battery will last before its discharges. One of the design requirements is that the machine needs to work for at least 5 minutes.

- **Requirements:**

  For the first test the requirements are: A4 paper, Timer, the battery should be connected to the motor.
  For the second test the requirements are: Multimeter, the battery should be full charged.

  - **Parameter of interest:**

    1- The first test is the time of the loading process.
    2- The second test was based on the battery lose per unit time.

  - **Predicted performance:**

    1- For the first test there are other factors involve which can vary form the calculated values such as friction between the rollers and the movements of the rubber on the rollers.

    2- For the second test, the performance should be good since the motors only consume 0.08 Amp with load according to the manufacture.

  - **Data acquisition:**

    All the data were gathered in the home shop where the machine was manufactured.

  - **Schedule:**

    The first test was scheduled on March/22/2016
    The second test was scheduled on April/ 25/2016

Method/Approach: (describe in detail)

- **Resources:** (hard/soft/external, people, costs),

  1- The resources for the first test: A4 paper, Timer, Hassan helped with the timing, there was no actual cost for this test other than the cost of the machine to complete the test.

  2- The resources for the first test: Multimeter, two measuring wires red and black, 12 volt battery, timer, Abdullah Alsahrani and Hassan helped to complete the testing.

- **Data capture/doc/processing,**

  1- Loading Time Test:

Paper Loading Testing	
Trail No.	Time sec
Trail 1	55
Trail 2	54
Trail 3	56
Trail 4	55
Average	55

  2- Battery Test:

Loading mechanism Battery						
Trail No.	Volte without Load	Volte with load	Current without load	Current with load	Time Sec	Battery Lose %
Trail 1	12.19	12.12	9.45	8.96	60	0.1%
Trail 2	12.18	12.11	9.42	8.95	60	0.1%
Trail 3	12.16	12.09	9.41	8.93	60	0.1%
Average	12.18	12.11	9.43	8.95	60	0.1%

❖ Total loss in 5 minutes is about 0.5% pass

Launcher Battery						
Trail No.	Volte without Load	Volte with load	Current without load	Current with load	Time Sec	Battery Lose %
Trail 1	12.40	9.90	10.22	8.41	60	2.5%
Trail 2	12.00	9.50	10.10	8.38	60	2.5%
Trail 3	11.95	9.45	10.80	8.34	60	2.5%
Average	12.12	9.62	10.37	8.38	60	2.5%

- ❖ Total lose in 5 minutes is about 12.5% pass

Stage 2 Actuator Battery						
Trail No.	Volte without Load	Volte with load	Current without load	Current with load	Time Sec	Battery Lose %
Trail 1	12.30	11.90	9.78	9.16	60	0.4%
Trail 2	12.24	11.84	9.70	9.12	60	0.4%
Trail 3	12.20	11.81	9.65	9.09	60	0.4%
Average	12.25	11.85	9.71	9.12	60	0.4%

- ❖ Total loss in 5 minutes is about 2% pass

- **Operational limitations:**
  1- For the loading mechanism test, the tester should do at least three trails and then take the average in order to get accurate values.
  2- The battery testing, the battery should be fully charged in order to get proper values.

- **Precision and accuracy discussion:**
  1- As mentioned before, for the loading mechanism test there are other factors involve in measuring the time. The calculation made with neglecting the friction factor due to the rollers touching each other. Also the problem with the rubbers on the rollers, where they move during the operation until the get to a point where is no contact between them.
  2- To get data that are more precise for the battery testing, the battery

should be charged before doing the test. Then connect the battery to the proper device (motor, actuator). Then measure the volt and current without load first. For the measurement with load, the device should be turned on for 60 seconds. While the Multimeter is connected to the device, take the measurement when the timer hits 60 seconds.

- **Data storage:**
  1- For the loading mechanism test, the data will be gathered by counting the time by using a timer. Three trails will be made and all the data will be recorded in a paper. Then the data will be transferred into an Excel to do the calculations.
  2- For the battery testing, the data will be gathered by taking pictures of the values that the Multimeter give during the test. Then the data will be transferred into a table in word document.
- **Data presentation:**
  Both tests will be presented in the website in the result section http://abdullahaldakhail.wix.com/home as well as the engineering report.

Test Procedure: (formal procedure)

- **Specify time, duration:**

1- Loading mechanism test will take about 7 mints. Testing will take place in Hogue Hall.
2- Battery test will take about 15 minutes.

- **Place:**

1- Loading mechanism test was made in Hogue Hall.
2- Battery test was made in the workshop at home.

- **Specific actions to complete the test:**
  a) Loading Mechanism testing:

1) Inspect the loading rollers and make sure that the rubbers are touching each other to make sure that the rollers will drag the paper in.
2) Inspect and remove if there are any particles on the rubber of the roller or on the roller itself. This will make the paper go through the rollers smoothly.
3) Make sure that the paper loading motor is connected to 12-volt battery.
4) You should have 11” x 8.5” paper to complete this test.
5) Now run the motor by turning the middle switch on. You will find the switches at the beginning of the paper path.
6) Wait 3 seconds so that the motor gets to its highest speed.
7) Put the paper on the paper path and push it towards the roller gently.
8) Start counting time as soon as the paper gets to the roller.
9) Turn the switch off along with the timer after 20 seconds so that the folding process takes place while the paper still in the first roller.
10) After the folding process is completely done, turn the loading switch on again

along with the timer.

11) Wait until the paper is completely out for the roller.
12) Stop the time counter and record the time.

b) Battery time testing:

1) The battery should be charged at the beginning before the testing.
2) Then the battery is connected to the prober device (motor or actuator).
3) Then Multimeter should be connected to the device to take the first measurement “while the switch is in the off mode”.
4) Take a picture of the data.
5) Then turn on the switch and hook up the Multimeter to the device. Wait for 60 seconds.
6) Then take a picture of the data again.
7) Repeat step 1 through 6 accordingly for the other batteries.

- **Risk, safety, evaluation readiness, other?**
  Check for loosens wires before doing the battery test, if there is any connect them properly. Make sure that the wire connections are accurate before doing the test. Other than that, there are no risks as long as the tester followed procedure steps.
- **Discussion:**
  The tests were made to compare the collected values with the calculated values. Also, to figure out whether the devices are efficient or not. In order to get good data the test procedure should be followed step by step.

Deliverables: (describe specific parameters and other outcomes)

- **Parameter values:**
  1- Loading mechanism testing: the average time was 55 seconds.
  2- Battery testing:
    a. Loading motor battery: the average battery charge lose 0.1%
    b. Second stage actuator battery: the average battery charge lose 0.4%
    c. Launcher motor battery: the average battery charge lose 12.5%
- **Calculated values:**
  1- Loading mechanism calculated time: 56 seconds
  2- Battery requirement: the machine should be working for at least 5 minutes.
- **Success criteria values:**
  1- Loading mechanism success value was 100% successful. Actually, the average loading time was faster by 1 second than the calculated time.
  2- Battery lose success criteria values:
    a. Loading motor battery after 5 minutes the total battery charge lose was 0.1%, which was a success.
    b. Second stage actuator battery after 5 minutes the total battery

charge lose was 2%, which also a success.

c. Launcher motor battery after 5 minutes the total battery charge lose was 12.5%, which still a success.

- **Conclusion:**

Two testing were made and all of them are related to time. The first test was to measure the time that the paper takes to complete the loading process. The second test was to measure how much charge the battery loses after five minutes when operating. For the first test, the goal was to deliver the paper to the second stage in 56 seconds. The test data however show that the time that took the paper to be delivered was 55 seconds, which hits that goal needed. This was due to the friction between the paper and the roller. The second test was prepared to three batteries and the goal was to get the machine working for at least five minutes. The first battery tested was the loading motor battery. After five minutes, the battery lost about 0.1% from its charge. The second battery tested was, stage two actuators. After five minutes, the battery lost about 0.4% from its charge. The last battery tested was the launcher motor battery. After five minutes, the battery lost about 12.5% from its charge. All of the three tests were successful and met the requirement.

Report Appendix

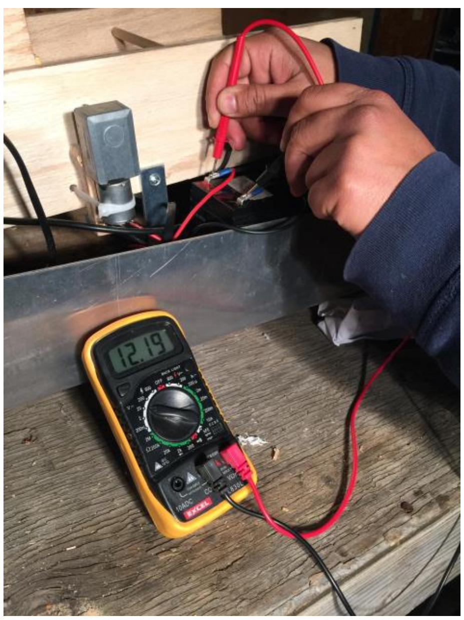
Loading Time Test:

Paper Loading Testing	
Trail No.	Time sec
Trail 1	55
Trail 2	54
Trail 3	56
Trail 4	55
Average	55

Loading Mechanism Battery Testing:

Volte Measurements:

1- Measuring the volt without load.



2- Measuring the volt with load

Current Measurements:

1- Measuring the current without load.

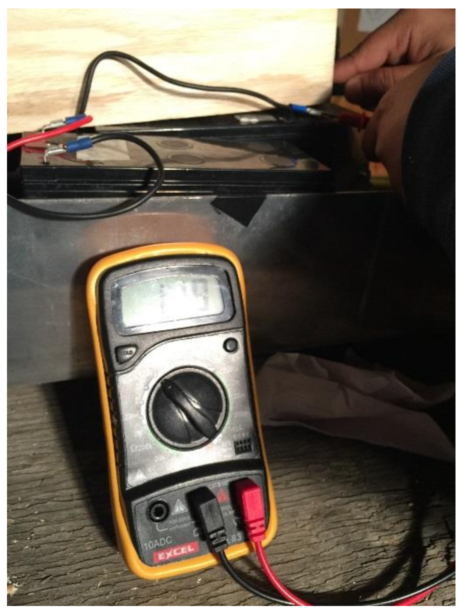
2- Measuring the current with load.

Stage 2 Actuator Battery Testing

Volte Measurements:

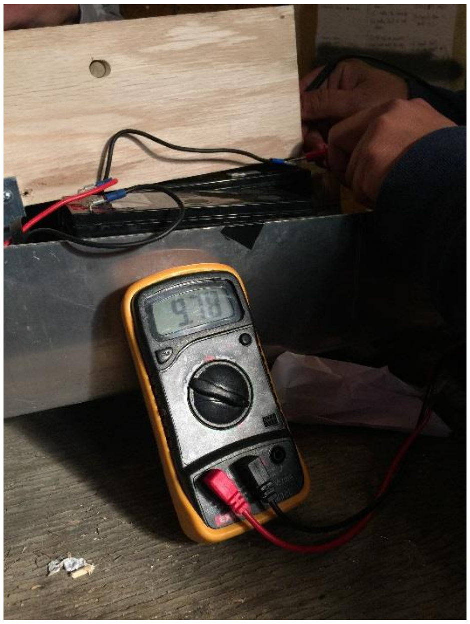
2- Measuring the volt without load.

2- Measuring the volt with load

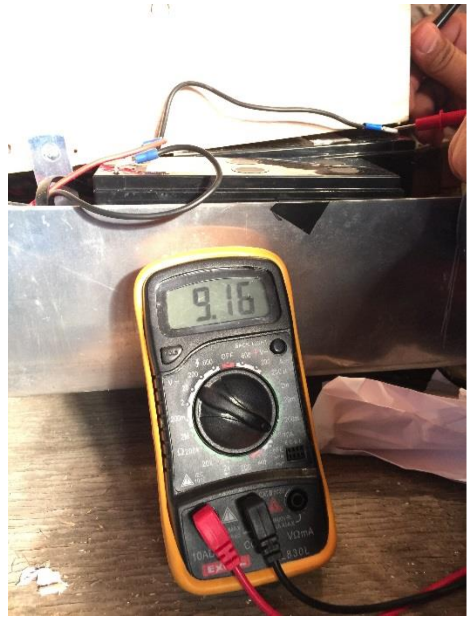


Current Measurements:

2- Measuring the current without load.



2- Measuring the current with load.



Launcher Battery Testing

Volte Measurements:

3- Measuring the volt without load.

2- Measuring the volt with load

Current Measurements:

3- Measuring the current without load.

2- Measuring the current with load.

Loading mechanism Battery						
	Volte without Load	Volte with load	Current without load	Current with load	Time Sec	Battery Lose %
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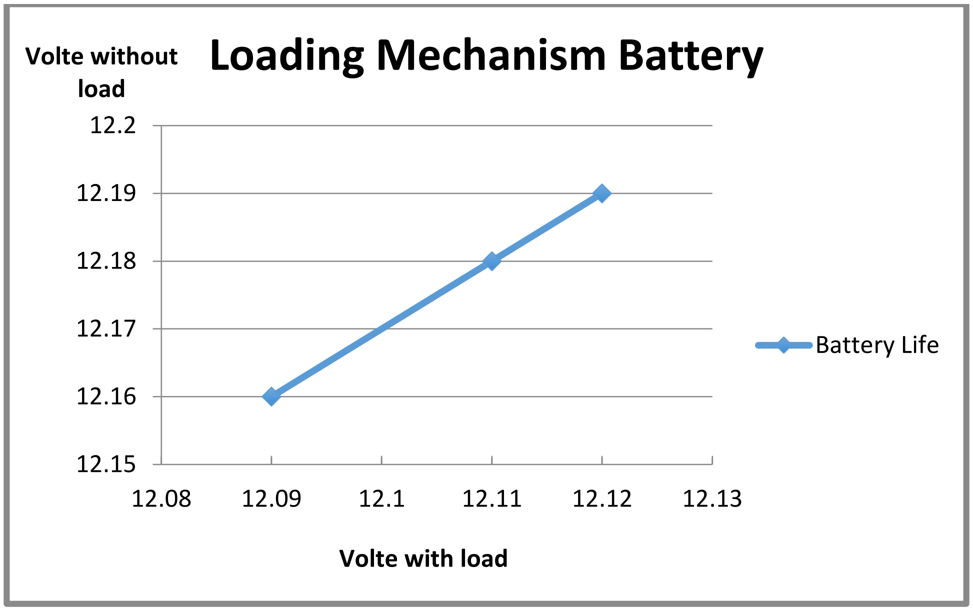

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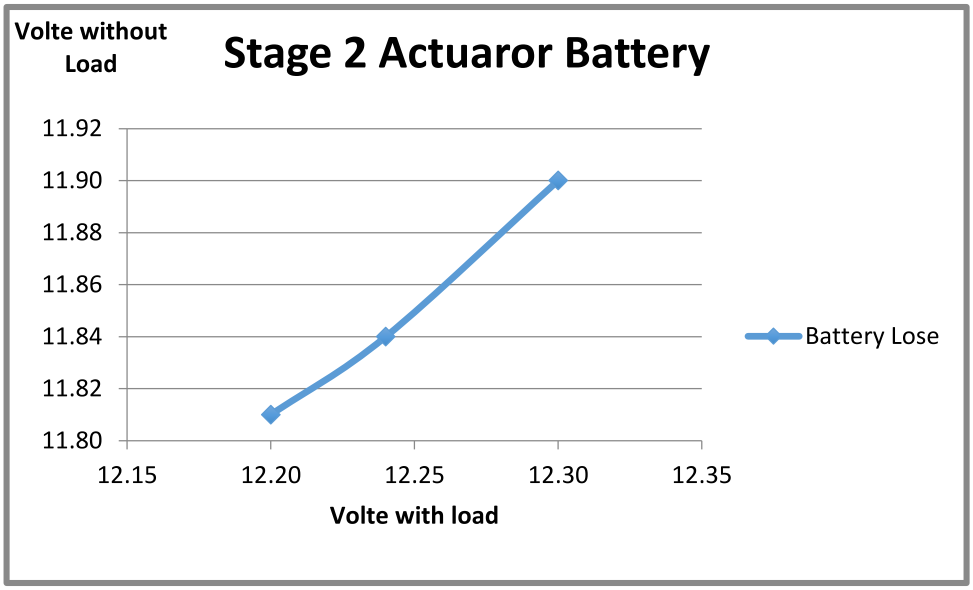

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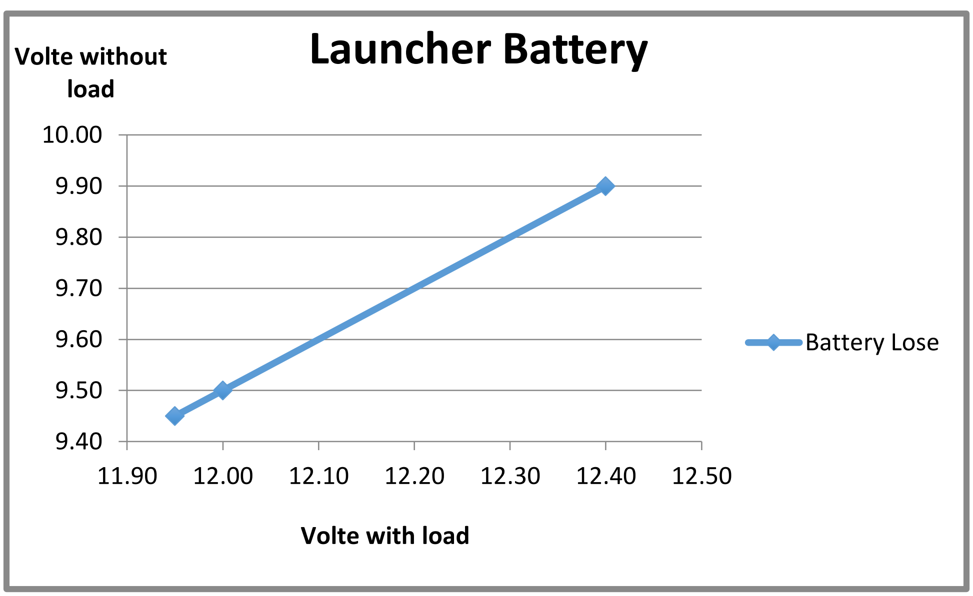

Appendix H – Resume/Vita

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Objective

A dedicated, hardworking, and highly motivated person aims to get a job that allows me to improve my Engineering skills.

Education and Credentials

- **Mechanical Engineering Technology**

Central Washington University expected June 2016

- **English Language Courses**

1- *Inlingua Vancouver Language school,* Canada. 2011

2- *ILAC - International Language Academy of Canada* 2012

Related Experience

- Welding course Tig, Mig and Arc welding 2015
- Three dimensional Modeling, Solid works also AutoCAD 2014
- Machining course Engine Lathe, Milling machine, Drill press 2014

Treasurer at UCCS, Union Of Consumer Cooperation Societies 2007 - 2011

Honors and Awards

Granted a full scholarship of five years King Abdullah program. 2011

Ministry of Higher Education, Saudi Arabia

Qualifications

Ability to work in teamwork and independently

Languages

Mother Tongue: Arabic.

Other Language: English- IELTS overall score 6.0

Personal Skills

Computer skills: Microsoft Word, PowerPoint, and Excel, Solid Works, AutoCAD.

Communication skills: ability to express opinions and share ideas.

References

Available upon request.