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Paper Core Feeder System

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PAPER CORE FEEDER

By

SERGIO FLORES VELEZ

ABSTRACT

Paragon Films has always strived to increase productivity and decrease waist within their company. The plant located in Union Gap, Washington currently has two production lines operating 24/7 managed by 2 to 3 people. The heavy line produces 5000 to 10000 revolutions per roll. This production line has a three part system that automatically feeds the paper cores to the spool shafts to roll the films. Therefore, the employees during that shift do not have to worry about filling up the bin very often. On the other hand, the second production line, which produces the hand films, does not have a system that can feed paper cores to the spool shaft requiring more constant attention by the employees. The drive of this project was to design and manufacture a similar Core Feeder that would automatically feed the cores to the table. This design had size restriction due to the limited space beside the production line but would still manage to improve productivity in the plant. The Core Feeder System will allow employees to fill the bin with more than 200 and only be revisited every couple hours.

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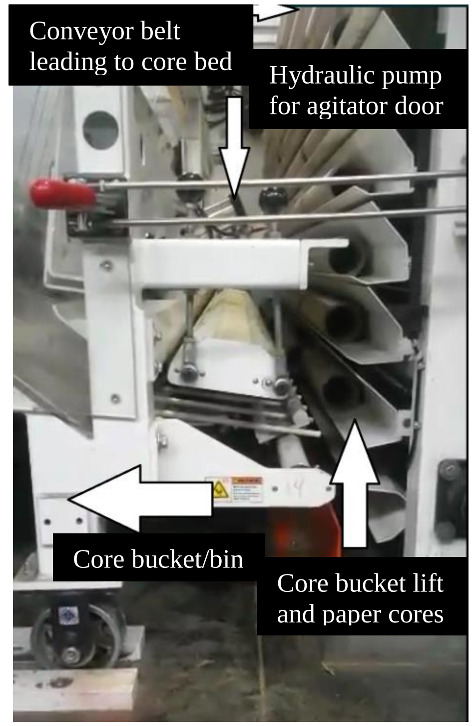
INTRODUCTION

Motivation



This past summer I worked for Paragon Films located in Union Gap Washington. One of their production lines, for the wrap films does not have a core feeder. The problem for the production line, without the core feeder, is having to go fill the bed of cores manually in short time periods. To add, the lines run 24/7 unless they slow them down for maintenance or other issues that occur on the machine so constant surveillance of the machine is necessary to avoid any wrap ups on the rollers.

During the time spent working there, most of the time, the employee assigned to work on that line would fall behind due to the constant struggle of having to go behind the wrapper and fill the bed with paper cores. As a prior employee of Paragon Films and knowing the hard work it took to get the job done, it is necessary to finish the project started by the plant manager. As a future engineer it is also my job to improve the efficiency of a system or design a device that will improve the work place.

Moreover, this project will also allow me to demonstrate the skills I have acquired through my years in the Mechanical Engineering and Technology Major at Central Washington University.

Function Statement

A device is needed that will be able to hold cores and lift the cores up to a conveyor belt that will then transfer the cores onto a smaller tilt belt that drops the cores onto a core bed.

Design Requirements

These are the requirements for the Paper Core Feeder:

- Must be able to attach to the existing bed and production line and detach.
- Must be able to hold up to a whole skid of cores, 525 cores at a time.
- It will keep up with demand of cores of wrap machine of 5-8 cores per 45 seconds.
- Has to be able to adjust to different core diameters ranging from 3 to 5 in.
- Core reservoir has to be at a safe distance of at least 3 feet.
- The loader must have a way of changing core lengths ranging from 12 to 30 in.
- Core reservoir will have gate to manually fill with cores.

- It must load cores to the table from the reservoir automatically.
- Must be able to run 24/7.
- Cost: Limit of $15,000.

Engineering Merit

For this project, material selection will be required to manufacture a solid base for the core reservoir to avoid any bending from the load, assuming a uniform load. Also, a selection of electric motors for the conveyor belts and chain drives including the best alternative of a gear type. Furthermore, designing or selecting gears for a lift system is also necessary. The design process will require bending stress number calculations: $s_t = \frac{W_t P_d}{FJ} K_o K_s K_m K_B K_v$. Keep in mind that this device will be running 24/7 so the appropriate selection is vital. Since this device will be detachable, a part has to be designed to fit on to the existing machine as well as the new feeder system.

Scope of this Effort

The device requires different systems to fully function, but an effort will be made to make the device work as one system. The whole system will include a core reservoir to hold the cores, a lift system, and the conveyor system to transfer the cores to an already existing bed. Most of the time that will be spent is doing SolidWorks drawings to check if the system will work as one and if there is any interference with all moving parts.

Success Criteria

Core feeder loads cores into machine. Core feeder keeps up with the demand of cores of the wrap machine and or lessen the time of having to manually place paper cores on wrap machine. Also, core feeder system maintains a constant supply of cores without overloading the wrap machine. To present this process a video will be taken when system is set by the production line. Starting from the core reservoir, a short video will be taken to show that the reservoir holds the amount of cores given by the requirements and that the cores are able to travel through the agitator door. Next, the video will show the transfer of the cores rolling on to the bucket lift, showing that they go into the bucket without falling. From here, it will show the travel time up to the conveyor belt which will then push the cores onto a tilting conveyor that loads the existing core bed. The device will be active for an entire day, 24hrs, to see how well it keeps up with the winder machine, if changes need to be made, they will be done so the following day.

Success of the project

The success of the project will ultimately come from the efficiency at which the machine runs and if it will keep up with the demand of the wrap machine. The wrap machine does each transfer in about 45 seconds, if the Core Feeder can keep up with the time frame then the device will have performed to its designed function. The process starts at the core reservoir, where all the cores will be manually loaded. The main function of the core reservoir is for holding the paper cores and for uniform release of the cores. The actuator door maintains the cores in the bin until more cores need to be loaded to the core lift. The core lift will be rotating constantly, pausing a couple seconds for the core release shaft to drop in the cores to the bucket. The lift will then transfer the cores up to the conveyor that. The conveyor will then transfer the cores to a second conveyor that will hold the cores until the required amount has been reached. Depending on the size of the cores, 6 to 8 cores will be lined up, after the amount desired is reached the conveyor will tilt down allowing the cores to roll onto the existing bed.

DESIGN & ANALYSIS

Approach: Proposed Solution

The design of the device was conceived while working for Paragon Films. The engineers at the plant had been working to come up with a design similar to the already existing Feeder of one of the production lines. To make a new Core Feeder, a complete different design had to be made but with similar parts and smaller available space. The production line without the Feeder system does Hand Films, which are significantly smaller than the Machine Films.

The design will contain three different components: core bin/reservoir, core bucket lift, and a conveyor belt system. The core bin has to have an area large enough to fit a pallet of cores, about 525 cores. The core lift will lift the cores up in core buckets to the conveyor belt which will then transfer the cores to a tilting conveyor that will fill the bed.

Design Description

The sketch on Appendix B shows an overall view of the proposed design. The design will consist of three sub-assemblies:

The core reservoir will be a basic box shape made from 2x2x.125 square steel frame. The 2x2 frame was selected since it would have less of a deflection than a 1x1, calculations are on Appendix A-7. Also, with the 2x2 the weld joint lengths will not be as long to support a larger load, calculations are seen on Appendix A-8. The back side of the reservoir will have an agitator door to allow the cores to pass through. The agitator door will have a pneumatic cylinder that will push the door high enough for the cores to slide through. The pneumatic cylinder was chosen to avoid an oil dripping down to the paper cores which could damage them, as well as avoiding the mess and extensive maintenance. Also located in the back lower end will be a roller that will act as a stopper for the cores to avoid overflow of the buckets shown on Appendix B Core Bin: Sub-Assembly 1. The sides of the core reservoir will have polycarbonate sheets to maintain the cores in the tube. The door in the front will also be polycarbonate. The polycarbonate material is stronger and more scratch resistant than other plastics. It was would be optically transparent to check for any core that has been placed wrong. The whole core reservoir will be mounted on four wheels. These wheels will be placed on a track to maintain a linear motion. As seen in the appendix, main assembly, the reservoir will be able to be rolled back while the lift stays fixed once it is set in place.

Next is the core lift which will be placed behind the core reservoir. The lift will also use 2x2x.125 square steel frame to stays consistent with the rest of the system. This lift will have two evenly spaced chains to provide stability and to avoid uneven lift. For the lift, a chain of about 13 feet will be selected with a 1in pitch which allows for a greater load support. Mott suggests to use 10% of the actual tensile strength of the chain, calculations can be seen on Appendix A-4. It will be powered by an electrical motor of about 1hp or less. The torque on the shaft will be solved and the motor will be selected, Appendix A-10. The core lift will carry the cores in core buckets up to a conveyor belt.

The last assembly will be the conveyor system. The conveyor system will be composed of two separate conveyors. The first will be where the cores are first dropped from the core lift. The second will be a tilting conveyor. This will be attached to the existing core table of the production line. The conveyor will run at so and so feet per second so that the next bucket of cores can drop onto the conveyor without stacking the cores excessively.

Benchmark

A production line in Paragon Films already has a similar Core Feeder system, but for a larger set of cores. The problem for the other production line is that it is for smaller core sizes. The solution will be similar. The already existing Core Feeder system has a large bin that holds the cores and a lift system that lifts the cores up to a conveyor. The new device will do just that but in a much smaller scale. This project is specific to this plant since they want to improve efficiency within the plant.

Performance Predictions

If everything goes as planned the Core Feeder should work efficiently with no interference in all moving parts. The overall weight of the system should be under 5000lbs which will be confirmed through the 3D solid modeling program SolidWorks. As well as the core lift. The chain selected from the lift assembly is well over the required limit which should increase the design life of the system overall. The conveyor system will not have high impact or carry a heavy load, therefore no slipping should occur.

Description Analyses

Core Reservoir:
For this part of the system we first need to determine the minimum required dimensions to fit the desired amount of cores. To start off, the area of the core circle was found first. Then multiplied by the amount of cores from the requirements to find a specific limit for the dimensions. Refer to Appendix A for the calculations.

Core Lift:
The core lift will have most of the load to carry. Here, we applied the design guidelines for the chain drive system from the book Machine Elements in Mechanical Design. Using the load of the core buckets and the cores, the max load on the chain was calculated. From the given value a chain was chosen. It was recommended that 10% of the average tensile value given for each roller chain be used. Refer to Appendix A for the calculations.

Conveyor System:
Selecting proper electric motors for conveyor belts as well as conveyor belt. The conveyor system will be light duty and low impact. Refer to Appendix A.

Scope of Testing and Evaluation

Testing the core reservoir will simply be done by dumping a whole pallet of cores into the reservoir. As for the bucket lift preliminary examinations will be done through the SolidWorks program to ensure proper chain drives are selected. Some of the initial testing of the conveyor belts will also be done in SolidWorks to assure proper electric motors are selected.

Analyses

Core Reservoir:
The design of the reservoir will depend on the length and diameter of the cores. Since there is a limited space for the whole system, the design must be compact. Adjustments to the dimensions of the reservoir will be made to minimize space use but still accomplishing the requirement of 525 paper cores. Refer to Appendix A for analyses. Next, the deflection of the beams that will be place under the floor to hold the cores was also calculated, refer to Appendix A #7. Since the beam will be welded on two sides, forces on the welds and the required length of welds was also calculated, refer to Appendix A #8.

Core bucket lift:
Calculating the required chain drive. Depending on the weight of the core buckets the proper chain number, with high enough tensile strength to support the load, will be selected. The buckets will have a cup like form to hold the paper cores without falling. The length of the buckets will depend on the reservoir dimensions. The buckets should be longer than the dimensions to assure that the cores will not tilt off to the sides as they are loaded. Refer to Appendix A for analyses.

Conveyor system:
Proper selection of conveyor type and electrical motors. The conveyor will be a low impact and light duty conveyor so motor size will be small, less than ½ hp. Also, belt width will be less than 5 inches since core diameters will go up to about 4 inches. Refer to Appendix A for analyses.

Device: Parts, Shapes and Conformation

The shape of the design will be compact since space is limited. It will also be powered by all electric motors. Core bin will be a basic box design with some alterations for the agitator door. Sides will be some type of clear plastic since no direct force will come in contact with the sides. Lift will contain "core buckets," a long scoop like bucket to hold cores as they are lifted. Depending on the available space the lift will stand straight or at an angle. Conveyor belts will be linear to each other. One belt will be in the rotation of the core buckets to assure no core falls, and it will also push the cores onto a second tilting conveyor belt that will drop cores to the existing core bed.

Device Assembly, Attachments:

The Core Feeder System will be constructed by three main assemblies: The reservoir system which holds the paper cores, a lift system to transfer the paper cores up to a conveyor belt. Also, the conveyor belt system which transfers the paper cores to the tilt conveyor. Drawings will be shown in Appendix B.

Tolerances, Kinematics, ergonomics etc.:

A concern for this project would be tolerance. The core reservoir not so much, only in the back side where the hydraulic cylinder will be and the agitator door. Here we would have to leave enough space for the agitator door to slide through the bin without it coming into contact with the sides of the reservoir.

For the core lift, SolidWorks will work best since there will be a rotation around a certain radius and the core buckets must not come into contact with each other. Since testing cannot be done at this early stage SolidWorks is the best option.

As far as interaction with the system, the person working will only have to manually fill the core reservoir. The system will run itself unless there is maintenance that needs to be done. The system will be close to the employees work space but will not obstruct any areas that the employees need to observe.

Technical Risk Analysis

Technical Risks will be analyzed three-fold: production, maintenance, and safety.

Cost is obviously a big concern. This system requires plenty of manufacturing as well as assembly. Although a limit is not set for the amount of money that can be spent, this system will be built in the most cost effective way.

Maintenance is also a big concern for this project. This system will be running 24/7 so it is crucial that the system and all its moving parts can be easily accessible for monthly maintenance checks.

Safety will also be analyzed. The system will be in an open area where workers will constantly come in contact with. Signs will be placed where necessary as well as covers for areas of moving parts.

Failure Mode Analysis, Safety Factors, and Operation Limits:

During the operation of the system, most of the stress will be come from the lifts chain drive. The chain drive will be carrying a heavy load during the extent of the systems operation, in this case 24/7 unless it us under maintenance, which could wear out the chain. If it were to fail it would be a pin on the chain due to continuous impact.

In addressing the theoretical loads, the safety factors have been established by the chain drive selection on 10% of its actual tensile strength. Which in turn gives the operation limit for the device. Most of the operation limits will be based on the selection of the components of each sub assembly given a theoretical load.

METHODS AND CONSTRUCTION

Description

Manufacturing the device will come in three separate working components: Core reservoir, bucket lift, and conveyor system.

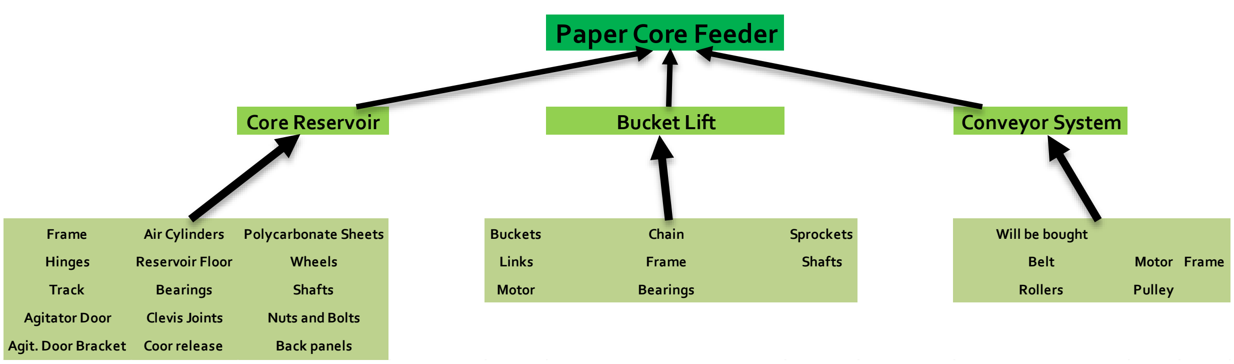
The reservoir will be manufactured with square metal hollow pipe, to reduce the overall weight. The front of the reservoir will have a horizontal door that will open down to allow the manual dumping of cores. The sides will have polycarbonate sheets to contain the cores and for visual purposes. The back end will be have the air cylinder attached to a welded on mount that will push the agitator door to allow the cores to flow through. All nuts and bolts required for this assembly will be bought through McMaster Carr. On Appendix B, Core Bin: Sub-Assembly 1, you can see the parts needed.

The bucket lift system will be constructed on site but each part of the lift will be contracted to metal fabricators. Each bucket is assumed to weigh about 30 pounds and a total of 30 buckets will be ordered to specifications. The motor for the lift will also be bought through McMaster-Carr as well as all the bearing and sprockets needed for the lift system. The skeleton of the lift will also be contracted out to a metal fabricator due to its size and weight. All nuts and bolts required for this assembly will be bought through McMaster Carr.

The conveyor system will be bought through a conveyor company. It will be mounted on the lift after the lift is fully assembled.

Drawing Tree

The drawing ends at the finished device. It is comprised of three separate components which will be attached to each other finalizing the device.



Parts List

<u>Original Design</u>

The table on Appendix C shows the parts needed for this project. The list shows the item numbers and the part name for that item. It also includes the drawing ID for each part for tracking throughout the project. The numbers on the IDs represent its sub-assembly designation, unless they are bought the IDs are taken from the item number. Numbers designated are 7, 8 and 9, and corresponding sub-assemblies are core reservoir, bucket lift, and conveyor. The drawings names have been developed to tell the type of part it is, i.e. MP7 is Mounting Plate for core reservoir. Drawing IDs will be critical in keeping track of each component and their corresponding assembly.

<u>10th Scale</u>

Added parts of the tenth scale are rapid prototyped: core reservoir, wheels, core divider, lift system, and buckets. Also included are Vex Robotics material such as: motors, bolts and nuts, framing plates, tracks (two types), shafts, collets, cortex, programming hardware kit, and encoder etc. Full parts list is on Appendix C.

Manufacturing Issues

This project requires welding for most of the system. The core reservoir will have the square beams connected together by welds. Although the welds are not extensive there is a few of them that will need to be done which will take some time. This may be done here in the welding shop by a student who is a certified welder. The skeleton of the core lift also requires weld but that may be contracted out to a metal fabricator shop.

The system itself will be controlled by sensors. Since we don't want it to overflow the existing core bed, sensors will be used to pause the machine momentarily.

Plenty of issues have surfaced these past couple of weeks. Redesign of the core reservoir assemble took place, although it was not extensive it delayed the manufacturing start about a week. Getting the "Go" on the core reservoir build has also pushed back the build quite a bit. Input from the professor also helped in pushing up certain tasks to make up for time lost. Parallel processing was a big part on trying to finish tasks on time.

The last few weeks of winter quarter the project required too many additions which could not have been made in time to finish manufacturing the device. Other measures were taken and it was decided that a scale model would be built instead. A colleague did a tenth scale model, it was decided that the device would also be a tenth scale model. Some parts for the model were rapid prototyped and the rest was Vex Robotics material and some Lego parts as well.

The first attempted part on the rapid prototype was the large reservoir. Unfortunately that part did not come out as expected so it had to be redone. Initially, the assembly was a combination of parts on SolidWorks but that did not turn out well. Professor Bramble looked over the SolidWorks file for the full assembly and after some deliberation it is believed that after the assembly was completed it was saved as a part, but that caused for the components in the assembly to become hollow which interrupted the rapid prototype machine and caused it to misread the drawing. The part had to be made as a single entity. During the time it was being redesigned the lift assembly was being printed along with the buckets that would go with it as well as the wheels that would go on the core reservoir. The lift assembly printed very well. After finishing the core reservoir part, a small practice part was made down to another 10^{th}. After some inspection of the small part it was concluded that it had everything needed and so the 24hr model had to begin. The part turned out good. The conveyor system was made up of all Vex Robotics material. During the build of the conveyor many parts were put on and taken off as adjustments had to be made to fit and make sure that everything was not interfering with other components.

Assembly, Sub-assembly, Parts, and Drawings:

After all three sub-assemblies have been made they will be attached to one another to form the final assembly. The skeleton of the core reservoir and the bucket lift will be manufactured first along with the buckets for the lift. During this time the parts for each of the sub-assemblies will be ordered so they will arrive around the same time the manufacturing is finished.

For the core reservoir the agitator door will be attached first. Then the hydraulic cylinder will be screwed on to the middle section of the back end of the core reservoir body, which will then be connected to the agitator door.

Once all the parts are in, the assembly for the lift will start. The lift will have to rods, on top and bottom, connected to the body with bearings on each end for rotations. This rods will have three spur gears equal distances apart for a uniform lift.

Assembly of the tenth scale model was by steps. First the conveyor system would be put together as the core reservoir and lift, along with its buckets, are being printed. After lift is printed it will be assembled to the conveyor belt and buckets attached to the Vex parts to allow for the rotation of the buckets. After core reservoir is finished it will be set as the last piece and then finally programmed will be written into the vex cortex to adjust the rotation and pause of the lift to stop at the right height for the “cores” (straws) to drop into the bucket. Conveyor will run constantly.

TESTING METHOD

Introduction

Original Design

Testing the device will come in three different areas and then a final analysis. First we will test the core reservoir, then the bucket lift, and then the conveyor system. After testing each component separately they will be assembled for a final test inspection to check that the device can work as one.

Testing the core reservoir will consist of its capacity, bending due to weight, and if cores will move through the agitator door. The capacity of the reservoir will be a visual measurement. A pallet contains 525 paper cores, if dimensions and calculations were done as intended than the reservoir should not overflow. Bending due to weight will be measured when full assembly is in place. The height from the floor to the bottom beam of the reservoir will be measured with a measuring tape to the nearest eight or sixteenth. After the cores are put in the same height will be measured again and based on deflection it will be compared to the predicted calculations.

Next, will be the testing of the lift. First we will check to see if it will be able to support the combined weight of the buckets and cores. Also visual inspection to check that buckets rotate around a large enough radius to avoid collision between buckets.

Similarly, the conveyor system will be a visual inspection of moving parts and clearance of gaps to avoid cores falling or jamming the conveyor. The selected conveyor will be a variable speed conveyor which will allow for adjustment depending on speed of film extruder. Ideally the output of the conveyor will be about 0:01:30 per 6 or 8 cores, but again it will depend on how fast the line will be ran at during each shift.

The Gantt chart on appendix E shows the tasks that will be done for testing.

10th Scale

Testing for the scale model will be similar to the original plan of the project.

Testing the core reservoir, will be the same as explained above. Bending due to weight of cores will not be a part of the testing for the scale model, being that it will be a small scale and the material of the reservoir will be of ABS plastic.

Testing the bucket lift will also be similar in the visual inspections. Mostly, it will be to see and assure that the system will rotate and lift buckets in a linear profile. This part of the model will also aid in assuring that the bucket bends are sufficient enough to keep the cores (straws in this case) inside the bucket.

The conveyor will also be similar to the original scale model. Visual inspection of the moving parts will be part of the testing as well as positioning of the conveyor by the bucket lift.

The Gantt chart on appendix b shows the tasks that will be done for testing, which will be replaced by the scale model.

Method/Approach

Original Design

Resources needed for the testing will be within the Paragon Warehouse.

Core reservoir testing will require a count of the total cores it will be able to hold. The total cores would be a whole pallet containing 525 cores. This does not include the cores already in the conveyor as the system is running.

For the core lift, preliminary testing will be done in SolidWorks to assure the lift rotates with no collision. Also bucket rotation and spacing to avoid bucket collision.

The conveyor system that will be bought will have a variable speed adjuster. Preliminary testing will be done on sight and speed will be adjusted to keep the existing core bed full. Overfilling the bed will also be avoided.

10^{th} Scale

For the tenth scale model an attempt will be made to reproduce the same testing for the actual system. Straws will be used to represent the paper cores. Being a tenth scale an estimated 55 to 60 straws, cut to length, will be used. Testing for core lift and conveyor would be visual. For the core lift core buckets, now 3D printed, will need to have enough radial space to assure that they will not collide. As for the conveyor, the actual one will be a variable controlled conveyor. The tenth scale replaced will also be variable controlled through the vex robotics cortex that has been built. Being a tenth scale model precision will not be much of a problem since most of the testing will be visual and timed. Data will be collected in sheets that will be made as the test is in process. It will be presented in sheet in excel and possible in charts to have a visual aid to show the discrepancies from the vex equipment.

Test Procedure

Original Design

Core reservoir test: Visual and mechanical.

Unload one pallet, 525 cores, into the core reservoir and check in bin will carry all cores. Run the hydraulic cylinders and check for interference. Agitator door should lift far enough for cores to flow through.

Bucket Lift test: Visual and mechanical.

Power the motor and run the lift. Ensure that lift will carry all cores without dropping any. Check to see if core will roll off onto the conveyor belt.

Conveyor Test: Visual

Check that belt does not move form center. Conveyor belt should also rotate fast enough for the other cores to fall into without piling up.

<u>10th scale</u>

The testing will be done in the senior project room from 11am to 12pm. The above tests will also be done for the 10th scale model. The following steps will be taken for the conveyor visual and timed test. Straws will represent cores.

Core Reservoir Test:

For the core reservoir test the following will be needed: 525 straws cut to a length of ¾" with a radius of about 3/16", Scale Reservoir with mini pneumatic cylinders connected and attached to Reservoir (including what came with Lego pneumatic kit, and camera to record observations. The sub-assembly should be constructed beforehand. Changes can be made to the amount of straws if necessary.

Being that the test will be done with scale model, essentially no risk will be taken. Do be careful while connecting tubes to pneumatic cylinders and any other input or outlet of the Lego kit. Consider changing the amount of straws being cut. Complete steps and procedure will be in the appendix...

Core Bucket Lift Test:

1. Have the following ready: 10th scale model set up, controller, cortex (should be attached to model base), extra batteries (optional), USB to controller cord, and full program (complete already, on USB Sony drive.). Make sure batteries are fully charged.
2. Open the RobotC program in computer.
3. Link Cortex and controller by turning both of them on. Note: program will run since it was downloaded to cortex beforehand also do not connect to desktop tower until system links.
4. Connect male end of USB cord into computer USB input and connect other end to controller program input.
5. Download program into cortex. (Done already)
6. Program should stop running once the program has been downloaded again.

7. Preload the lift scale model buckets with 2 straws for every bucket.
8. Read steps 9 through 13 before continuing.
9. Run program. Refer to check list, System Inspection, for steps 10 through 12.
10. Assure that conveyor spins fast enough for next set of straws to drop in. Record data and other observations.
11. Check if straws miss or are close to missing the conveyor when they drop. Record data and other observations, if any.
12. Inspect lift for any interference and or clashes between moving a stationary parts.
13. After system inspection is complete stop program.
14. Load Lift buckets with straws again. Have a timer ready.
15. Rerun program.
16. After 8 straws have been dropped by the conveyor stop timer. Record time.
17. If at least 6 straws have not dropped off the conveyor within 10 seconds, change the speed of the conveyor on the program code through the RobotC program.
18. Repeat as necessary until desired straws have been reached.
19. After speed has been set, repeat steps and time for 6 straws and 8 straws to check for consistency.

Being that the test will be done with scale model, essentially no risk will be taken. Battery changes will have to be made if consistency of the conveyor and motor is declining (triple A batteries). As far as safety goes, avoiding putting your finger in any gap that has moving parts to avoid pinching. To add, do not change code unless supervised by the author of the code and be cautious when handling the rapid prototyped parts.

Conveyor Test:

Conveyor test will be similar to bucket lift test since both were programmed at the same time with the RobotC program.

Deliverables

Full test report will be in appendix I, the following is a summary of the testing results and evaluation of the system.

<u>Original Design</u>

Core reservoir holds 525 cores.
Agitator door allows flow of cores.
No interference between moving parts on core bucket.

Lift rotates and pauses correctly for cores to drop in.
Buckets do not collide.
No interference between moving parts.

Conveyor speed is set to have at least 6 coress go off the conveyor.

Results and documentation will be given in appendix G and H.

10th Scale

Core reservoir holds 10% of the actual cores.
Agitator door allows flow of cores.
No interference between moving parts on core bucket.

Lift rotates and pauses correctly for cores to drop in.
Buckets do not collide.
No interference between moving parts.

Conveyor speed is set to have at least 6 straws go off the conveyor. Procedure checklist will be in appendix I along with the full report.

PROPOSED BUDGET

Original Design

This project will be sponsored by Paragon Films located in Union Gap. Final design and parts decision will be made by a Paragon Films engineer. Although there was no specified budget limit by Paragon Films an initial limit of $30,000 was set, subject to change.

For this project, the main material will be ASTM A500 shaped, grade C. Being a structural steel it would be ideal for the dimensions and structure of the design. The back wall of the core bin will be SAE 1020 as well as the agitator door and the "floor" of the bin. For the sides, a see through acrylic was chosen for supervision purposes. Core buckets for the lift will be sheet metal, since there are 20+ buckets sheet metal was the best option apart from aluminum.

The main part supplier will be www.mcmaster.com. For the most part all nuts and bolts will be bought from the previous website. The budget also contains the part cost estimated and actual. Refer to Appendix D for proposed budget.

This project will be sourced out to a manufacturer, as the building process begins the actual prize for each machined part will be noted.

10th Scale

Budget for the scale model was made while the model was being constructed. The prize for the reservoir was calculated based on the prize of $\$6.00/in^3$. A total was estimated to be below $200 dollars based on the total the amount of volume of material in SolidWorks. After printing the parts and computing the prize per cubic inch the total came out to be $130. Appendix D shows the created budget.

SCHEDULE

Original Design

A proposed schedule, which is subject to change, was created to organize this project and to ensure that it stays on track. The schedule will act as a good guideline to keep the project focused and on track.

The proposed schedule contains hours that might be spent building and making the system as well as hours spent writing the proposal. Also, hours will be estimated for the building and assembling of each of the subassemblies.

To ensure that this project is finished, milestones and deliverables have been set to dates that are constrained by the MET 495 course. This project will be completed by the last week of the third quarter. Refer to Appendix E for schedule/Gantt chart.

10th Scale

Schedule for the scale model will be identical to the original design. Other parameters will be considered and changed depending on the sub-assembly. Building will begin during the supposed set schedule for the original project due to some setbacks. Project scale model is estimated to take 2 or 3 weeks. Finished product will be complete a couple days before the actual due date. Refer to Appendix E for the schedule.

PROJECT MANAGEMENT

Human Resources:

For this project turning to Professor Pringle and Professor Johnson for design help was a must. Also for my SolidWorks drawings I asked Professor Bramble for assistance. As my major human resource it would be Jon Reemts, an engineer at Paragon Films.

Physical Resources:

For this project the machine shop will be used as well as the welding shop. Most of the parts that will be made will required facing and drilling. The parts for this project will be made through a manufacturer chosen by Paragon Films. Although the parts will not be made by myself it will be noted, for each part, what process was taken to manufacture it.

Soft Resources:

This project mostly required the design program SolidWorks. SolidWorks smoothed the way for designing this project. Being able to see the parts and full assemblies helped in deciding what needed to changed.

Financial Resources:

The majority of this project will be funded by Paragon Films. Work that will be done in the machine shop will be at the expense of the time spent making the parts necessary for this project to function correctly.

DISCUSSION

Design Evolution

The design started very basic. This was simply to get a visual of how much floor space it was going to take up given a small working area. It started with the core reservoir. At first, this design was relatively large, more than 9ft in length, which was not ideal for the space provided. Being that the core reservoir was 9ft, the bucket lift and the conveyor system both had to be the same length. Those dimensions would have required large amounts of material and extensive labor work, which would have resulted in a substantial cost.

As the process continued the measurements of the bin got smaller, in turn reducing the size of the lift and the conveyor system. Working with smaller dimensions really helped out in decreasing the cost, but it also produced more difficulties in tolerances and the sizing all the other components. The agitator door had to be resized to fit the new dimensions for the core reservoir, as well as drilled holes for the height adjustment for the cores. All of the walls also had to be changed to accommodate the final dimension of the core reservoir. Also, initially two large hydraulic pumps were going to be used, but the amount of cores in the reservoir lessened which reduced the amount of force the agitator door needed to push the cores.

The bucket lift also went through some extensive redesigning. Along with the core reservoir, the size of the lift was minimized greatly. The overall weight of the lift was brought down to about a third its initial weight.

It is expected that the core reservoir will bend (some amount). Which will not influence the travel of the cores under the agitator door. The chain selected for the bucket lift is well above the estimated max weight on the lift, hypothetically speaking it should not fail. Also, the amount of buckets selected for the lift should leave enough clearance such that when traveling around the gear path there will be no collision between buckets.

Changes to the core reservoir design had really affected the proposed schedule. Initially there was a tie rod cylinder for the agitator door, but then it was then realized that it would not work since there was going to be some type of tilt due to the motion of the door. It was redesign to fit another single air cylinder with pinned ends so that the cylinder would not have any type of side loading and avoid early failure of the cylinder. Further analysis was done to calculate the shear on the pin to check for the minimum size of the pin.

Project Risk Analysis

Time will be and has been the major risk factor. Related to other projects, this one in particular has more parts and is larger in size. Redesigning has also been a major risk factor. Due to the lack of time there is only so much redesigning and improvements that could be done.

Successful

This project will be successful. The time spent on redesigning and analyzing the whole system will not go in vain. Fall quarter has been a great learning experience. Getting involved in a project and the actual process has opened my eyes to a whole new world of information. Although this project is for a particular company, I can still use the skills I have acquired in other projects that I may have.

Next Phase

The project will not be perfect but will do its assigned function. Continue to improve proto-type design in its overall use and continue to facilitate the work for current employees.

CONCLUSION

The motivation behind this project was to help improve employee efficiency in Paragon Films. A core feeder system has been conceived, analyzed, and designed that will improve employee efficiency and satisfy the function requirements as described in the opening of this proposal. Parts have been specified, sourced, and budgeted for acquisition. Construction will begin when Paragon Films gives the “Go” for the final design.

This project will perform great because it will have accomplished its basic requirements listed in the beginning of this proposal. The core reservoir is predicted to hold 664cores, which is well above the requirement of one pallet, 525 core. It will also be able to release the cores without getting jammed under the agitator door. The overall dimension of the reservoir will also allow for easy movement since the weight of it, when empty, will be 410lb seen on Appendix B Sub-Assembly 1. The lift will also reduce the amount of space needed for the whole system. Initially it was intended to be at an angle, but redesigning standing up reduced the amount of length required for the whole system.

ACKNOWLEDGEMENTS

This project would not have been possible if Alex (Plant Manager) and Jon Reemts had not put in hand the opportunity to complete this project. They have been a great help throughout the course of this project and have mentored me in the process. As a future engineering I truly appreciate what the opportunity they have given me.

Acknowledgments of gratitude also go to the following people who have seen this project to culmination:

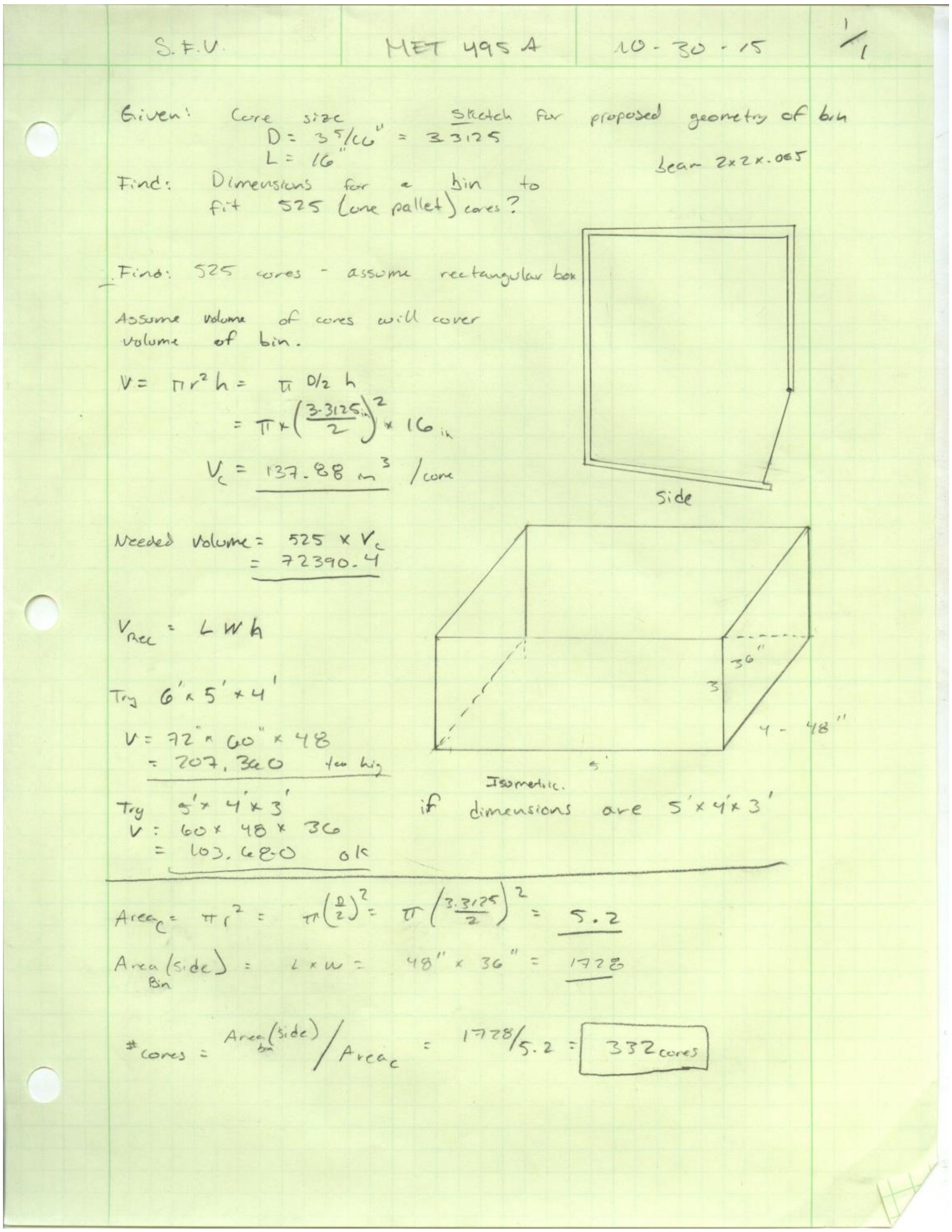
- Professor Charles Pringle, Masters in Mechanical Engineering Technology, for his assistance and expertise with the structural analysis from the beginning to the end of the project.

- Dr. Craig Johnson, Professional Engineer who is head of the Mechanical Engineering department at CWU, for his assistance and expertise to represent my design.

- A special thanks to Professor Ted Bramble for taking the time to answer question related to my design and expertise in ANSI-Y14.5 standard of drawings.

Appendix A – Analyses

1: Dimensions Calculations



S.F.U. | MET 495 A | 10 - 30 - 15 | 1/1

Given: Core size
$D = 3\,5/16'' = 3.3125$
$L = 16''$

Find: Dimensions for a bin to fit 525 (one pallet) cores?

Find: 525 cores - assume rectangular box

Assume volume of cores will cover volume of bin.

$V = \pi r^2 h = \pi\, D/2\, h$
$= \pi \times \left(\frac{3.3125_{in}}{2}\right)^2 \times 16_{in}$
$V_c = 137.88\ in^3$ /core

Needed volume $= 525 \times V_c$
$= 72390.4$

$V_{Rec} = LWh$

Try $6' \times 5' \times 4'$
$V = 72'' \times 60'' \times 48$
$= 207{,}360$ too big

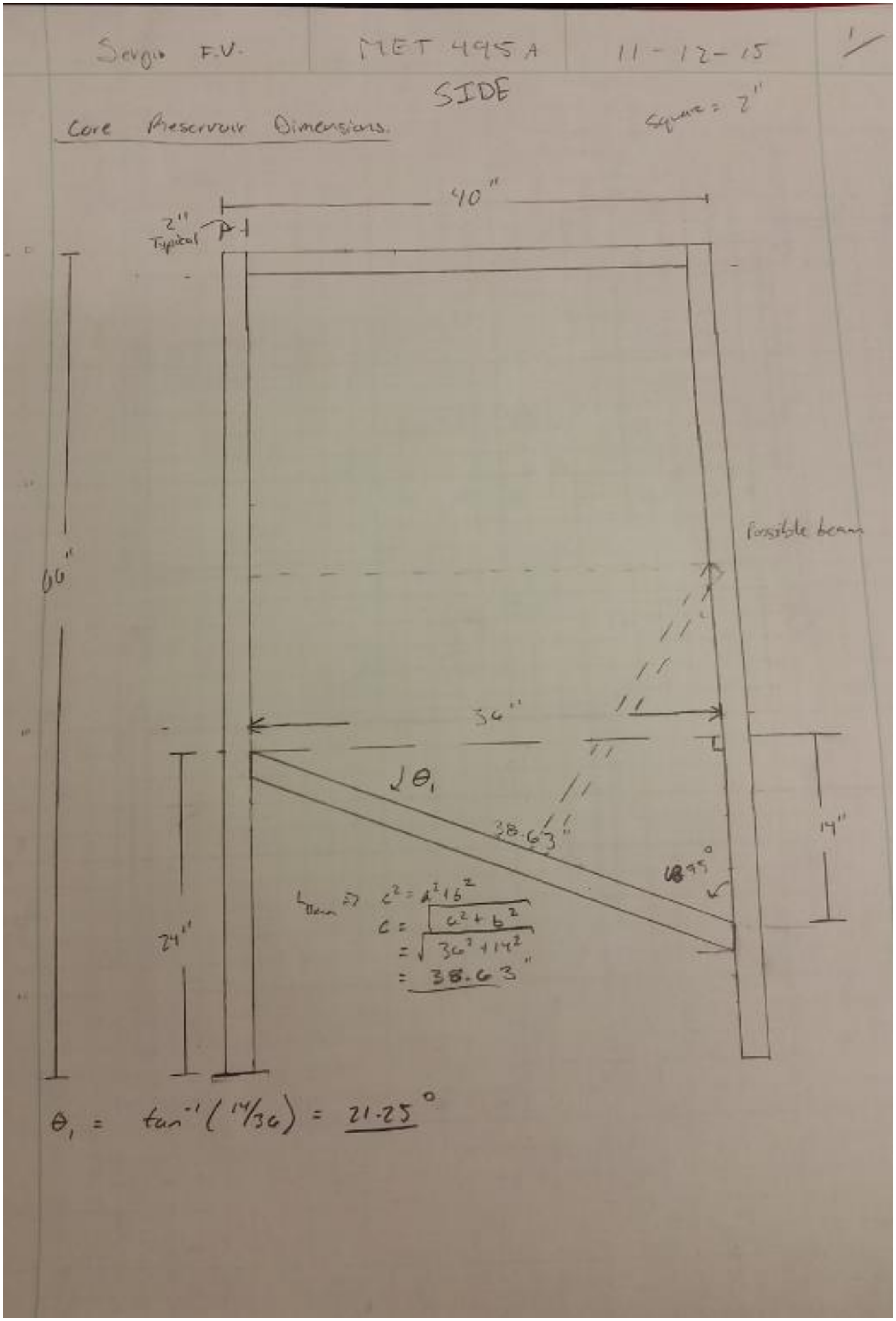
Try $5' \times 4' \times 3'$
$V: 60 \times 48 \times 36$
$= 103{,}680$ ok

$Area_c = \pi r^2 = \pi\left(\frac{D}{2}\right)^2 = \pi\left(\frac{3.3125}{2}\right)^2 = 5.2$

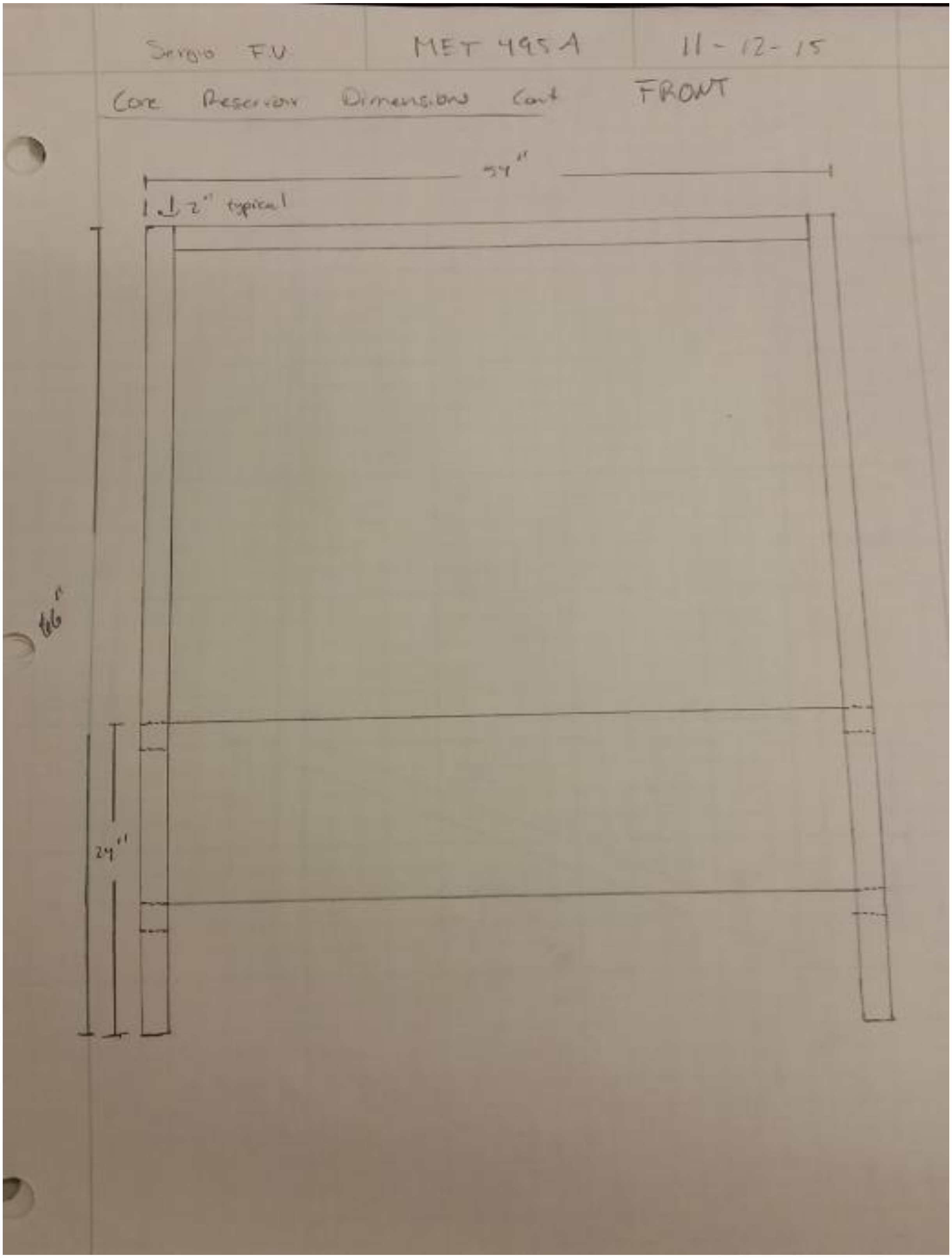
$Area(side)_{Bin} = L \times W = 48'' \times 36'' = 1728$

$\#cores = Area_{bin}(side) / Area_c = 1728/5.2 = 332$ cores

2: Core Reservoir Drawings: Side



3: Core Reservoir Drawings: Front



4: Chain Drive Design

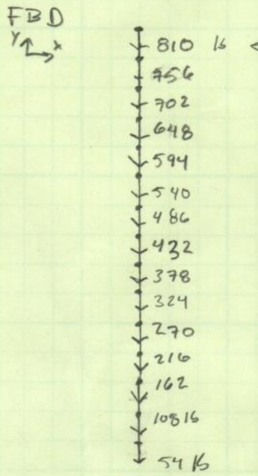
Sergio Flores V.	MET 418	11-3-15	1/1

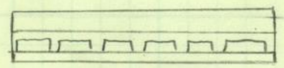
Given: Sketch
core buckets: 30 lb each (assumed)
paper cores: 3 Lb each

Find: Design chain drive and appropriate chain size

Soln: Assume 15 buckets on side w/ paper core (tube)

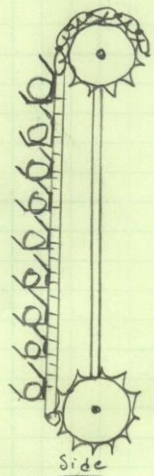
FBD





6 cores up to 8 cores

Front



note: each load is equal to bucket weight + 8 core weights = 54 lb

* 15 b × 30 lb = 450 lb
8 cores × 3 lb = 24 × 15 b = 360 lb

Total = 810 lb

Assuming uniform weight

Table 7-5

Recommended that 10% of Avg. tensile strength be used

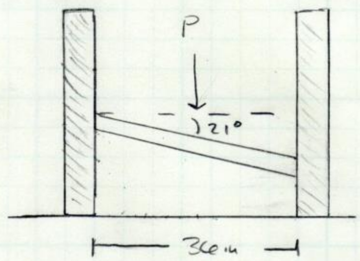
Chain #60	5/8" pitch	8500 lb (Avg)	10% = 810 lb	- ok
#80	1" pitch	14500 lb (Avg)	10% = 1450 lb	- Better

Select chain #80 - Common

5: Normal Forces on Beam

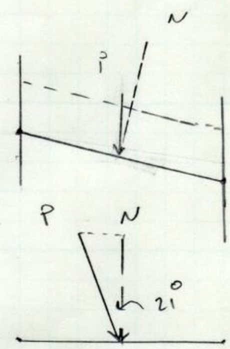
Sergio F.U. | MET 495 A | 12-9-15 | 1/1

Given: Sketch
$P = 1575$ lb ↙ Assumed highest weight when loaded



Find: Normal force on beam

Soln:
FBD



$P = 1575$ lb

$\uparrow + \sum F_x = 0$; $-P\cos 21° - N = 0$

$N = \cdot 1575 \cos(21°) = 1470.4$ lb

$N \approx 1471$ lb

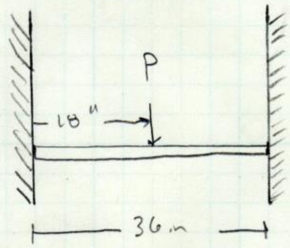
6: Resultant Forces on Reservoir Beam

Sergio F.U. | MET 495 A | 12-9-15 | 1/1

Given: sketch -

P = 1470 lb

Fixed at both ends (Welded)



Find: Resultant Forces

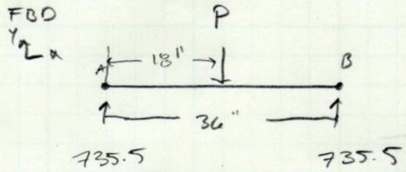
Shear & Moment diagram

Max moment & Shear max

σ - due to bending

Soln:

FBD



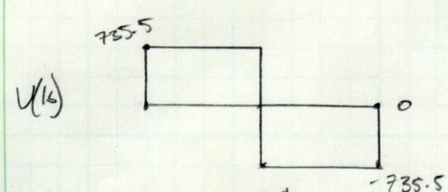
$\circlearrowleft + \Sigma M_A = 0; \quad -P(18\,in) + B(36\,in) = 0$

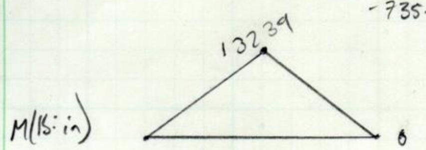
$B = \dfrac{1471\,lb(18\,in)}{36\,in}$

$B = 735.5$

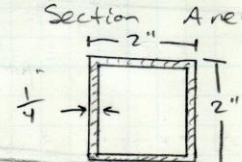
$\uparrow + \Sigma F_y = 0; \quad -1471 + 735.5 + A = 0$

$A = 735.5$





Section Area



$A = 2 \times 2 = 4\,in^2$

$A = 1.5 \times 1.5 = 2.25\,in^2$

$A\,total = 1.75\,in^2$

$\tau_{max} = F/A = \dfrac{735.5\,lb}{1.75\,in^2} = 420.3\,psi$

$M_{max} = 13239\,lb \cdot in$

Stress due to bending

$I = .91\,in^4$

$\sigma = Mc/I = \dfrac{13239\,lb \cdot in \times 1\,in}{.91\,in^4}$

$= 14{,}548.4\,psi$

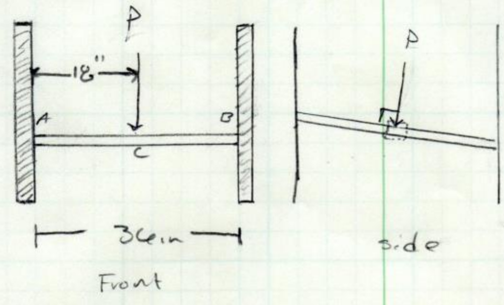
7: Deflection on Reservoir Beam

Sergio Flores | MET 495 A | 12 - 8 - 15 | 1/1

Core Reservoir - Base bending

Given: Sketch
P = 1471 lb
Fixed at both ends
ASTM A 36 - Steel - Square tube
↳ E = 29 x 10^6 psi

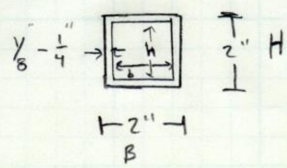
Find: Deflection @ C



Soln: $y_{max_c} = \frac{-PL^3}{48EI}$

L = 36 in → L^3 =
E = 29 x 10^6 psi
P = 1471 lb

Preselected tube 2" x 2"



$I_{1/8} = \frac{BH^3 - bh^3}{12}$

$= \frac{(2" \times 2"^3) - (1.75" \times 1.75"^3)}{12}$

$= .552 \text{ in}^4$

$y_{max_c} = \frac{-1471 \text{ lb}(36 \text{ in})^3}{48(29 \times 10^6 \frac{lb}{in^2}) \times .552 \text{ in}^4} =$ **.089 in down**

Try 1/4 thickness

$I_{1/4} = \frac{2" \times 2"^3 - (1.5" \times 1.5"^3)}{12}$

$= .91 \text{ in}^4$

$y_{max_c} = \frac{-1471 \text{ lb}(36 \text{ in})^3}{48(29 \times 10^6 \frac{lb}{in^2})(.91 \text{ in}^4)} =$ **.0542 in down**

(Consider changing material).

8: Welded Joint Calculations

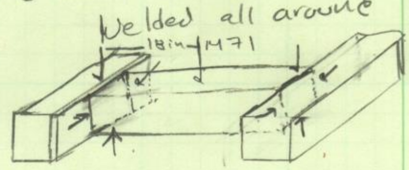
S.F.U.	MET 495 A	12-8-15	1/2

Welded Joints

Given: Sketch

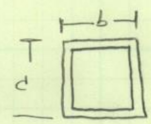
$P = 1471$ lb
2×2 ASTM A-36 Steel (2"×2"×1/4")
$E = 29 \times 10^6$ psi

Find: min. weld size with safety factor of 2.



Soln: Bending

From Mott (5th Edition) Ch. 20



$f = M / S_w \qquad S_w = bd + d^2/3$

$S_w = (2 \times 2) + (2^2)/3 = \underline{5.33\ in^2}$

$M = \underline{26{,}478\ lb \cdot in}$

$f = \frac{26478\ lb \cdot in}{5.33\ in^2} = 4967.7 = \boxed{4968\ \frac{lb}{in}}$

For E60

$w = f / \text{allowable force per in of leg}$

$= \frac{4968\ lb/in}{9{,}600\ lb/in\ \text{per in}} = .5175 = \boxed{.52\ in}$

For E70

$w = \frac{4968\ lb/in}{11{,}200\ lb/in\ \text{per in}} = .4436 = \boxed{.44\ in}$

S.F.U.	MET 495A	12-12-15	2/2

Welded joints Cont.

Previous page shown for one cantilever "like" weld

- Beam design will be welded at both ends.

* Both ends welded

$M = 26{,}478$ lb·in

$S_w = 5.33\ in^2$

$$F = M/S_w = \frac{26{,}478\ lb \cdot in}{5.33\ in^2} = 4968\ \frac{lb}{in}$$

$$\Rightarrow \frac{4968\ \frac{lb}{in}}{2} = \boxed{2484\ lb/in}$$

for E60 $\quad \omega = F/$allowable force per in of leg

$$\omega = \frac{2484\ lb/in}{9{,}600\ lb/in\ per\ in} = .258 \approx \boxed{.26''}$$

for E70

$$\omega = \frac{2484\ lb/in}{11{,}200\ lb/in\ per\ in} = .222 = \boxed{.22''}$$

9: Endurance Strength

S.F.U. | MET 495 A | 12-10-15 | 1/

Endurance strength

Given:

ASTM A36 Stee - Square tube

Find: S'_n

Solu: Appendix 7 · ASTM A-36 $S_u = 58\text{ ksi}$ $S_y = 36\text{ ksi}$

$$S'_n = S_n (C_m)(C_{st})(C_R)(C_s)$$

$S_n = 23\text{ ksi}$ Fig 5-8 pg. 172 Mott

$C_m = 1.00$ wrought steel pg. 171

$C_{st} = 1.00$ Bending pg. 171

$C_R = .81$ 99% reliability Table 5-2 pg. 173

$C_s = .83$

$$- D_e = .808\sqrt{hb} = .808\sqrt{2'' \times 2''} = 1.616 \approx 1.62\text{ in}$$

$$.3 < D \le 2.0 \Rightarrow C_s = \left(\frac{D}{.3}\right)^{-.11}$$

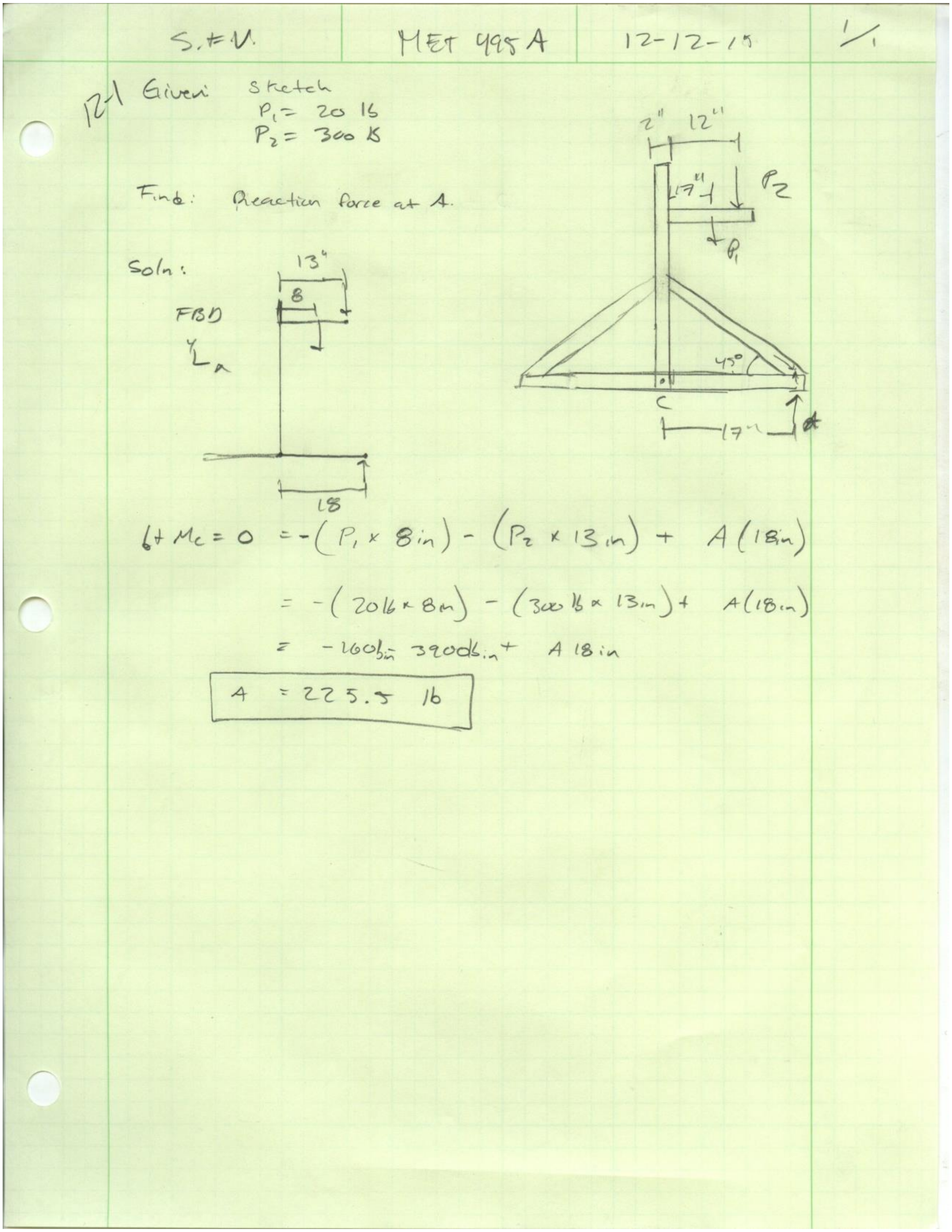
$$C_s = \left(\frac{1.62}{.3}\right)^{-.11} = .83$$

$$S'_n = 23{,}000\text{ psi}(1.0)(1.0)(.81)(.83)$$

$$= 15{,}462.9$$

$S'_n \approx 15463\text{ psi}$

10: Equilibrium on Lift Leg



S. & V. | MET 495 A | 12-12-15 | 1/1

12-1 Given: Sketch
$P_1 = 20$ lb
$P_2 = 300$ lb

Find: Reaction force at A.

Soln:

FBD

$$\circlearrowleft + M_C = 0 = -(P_1 \times 8\,in) - (P_2 \times 13\,in) + A(18\,in)$$

$$= -(20\,lb \times 8\,in) - (300\,lb \times 13\,in) + A(18\,in)$$

$$= -160\,lb\,in \;\; 3900\,lb\,in + A\,18\,in$$

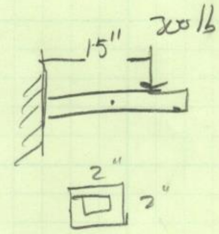
$$\boxed{A = 225.5\ lb}$$

11: Deflection on Cantilever Beam

S.F.V	MET 495A	12-12-15	1/1

Given: Previous sketch – 12-1

Find: Deflection on cantilever beam



Soln: $y_b = y_{max} = \frac{-PL^3}{3EI}$

$$I_x = \frac{BH^3 - bh^3}{12} = \frac{2\times 2^3 - 1.75(1.75^3)}{12} = .552\ in^3$$

$$y_{max} = \frac{-300\,lb \times (15\,in)^3}{3(30\times10^6\,psi)(.552\,in^3)}$$

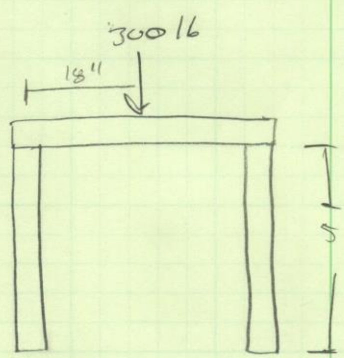
$y_{max} = .02$ in down

12: Design Change: Holding Conveyor

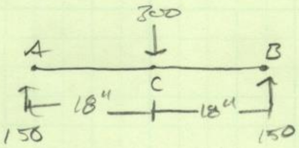
S.F.V. | MET 495 A | 12-13-15 | 1/

Given: design

Find: a) reaction forces on ends
b) and buckling on beams.



Soln: FBD



a)

$\circlearrowleft + M_A = 0 = (-300\text{ lb} \times 18\text{ in}) + 36\text{ in}(B)$

$B = \dfrac{(-300 \times 18)}{36} = \boxed{150\text{ lb}}$

b) FBD — 150 lb — Fixed-Fixed

2" × 2", $\frac{1}{8}$ typ.

$A = (2 \times 2) - (1.75^2) = .94$

$r = \sqrt{I/A} = \sqrt{\dfrac{.552}{.94}}$

$r = .766$

$L_e = KL = .65 \times 60\text{ in} = 39\text{ in}$

$SR = L_e / r_{min} = 39/.766 = 50.9$

$C_c = \sqrt{\dfrac{2\pi^2 E}{S_y}} = \sqrt{\dfrac{2\pi^2(30\times10^6)}{51\text{ ksi}}} = 107.75$

1020 cold rolled $S_y = 51$ ksi

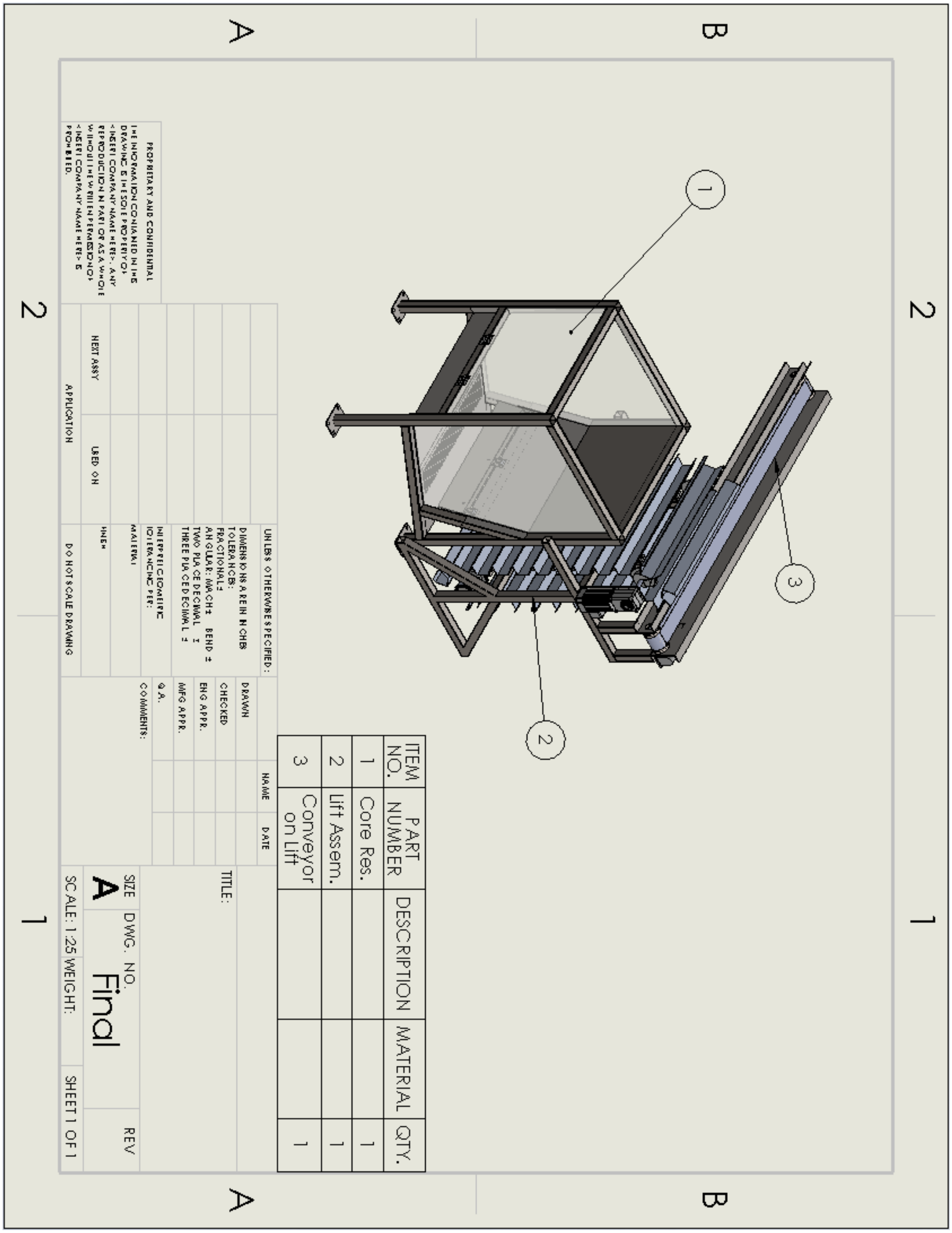
Short

$P_{cr} = A S_y\left[1 - \dfrac{S_y(KL/r)^2}{4\pi^2 E}\right] = .94\text{ in}^2(51\text{ ksi})\left[1 - \dfrac{51\text{ ksi}\,(.65 \times 60\text{ in}/.766)^2}{4\pi^2(30\times10^6)}\right]$

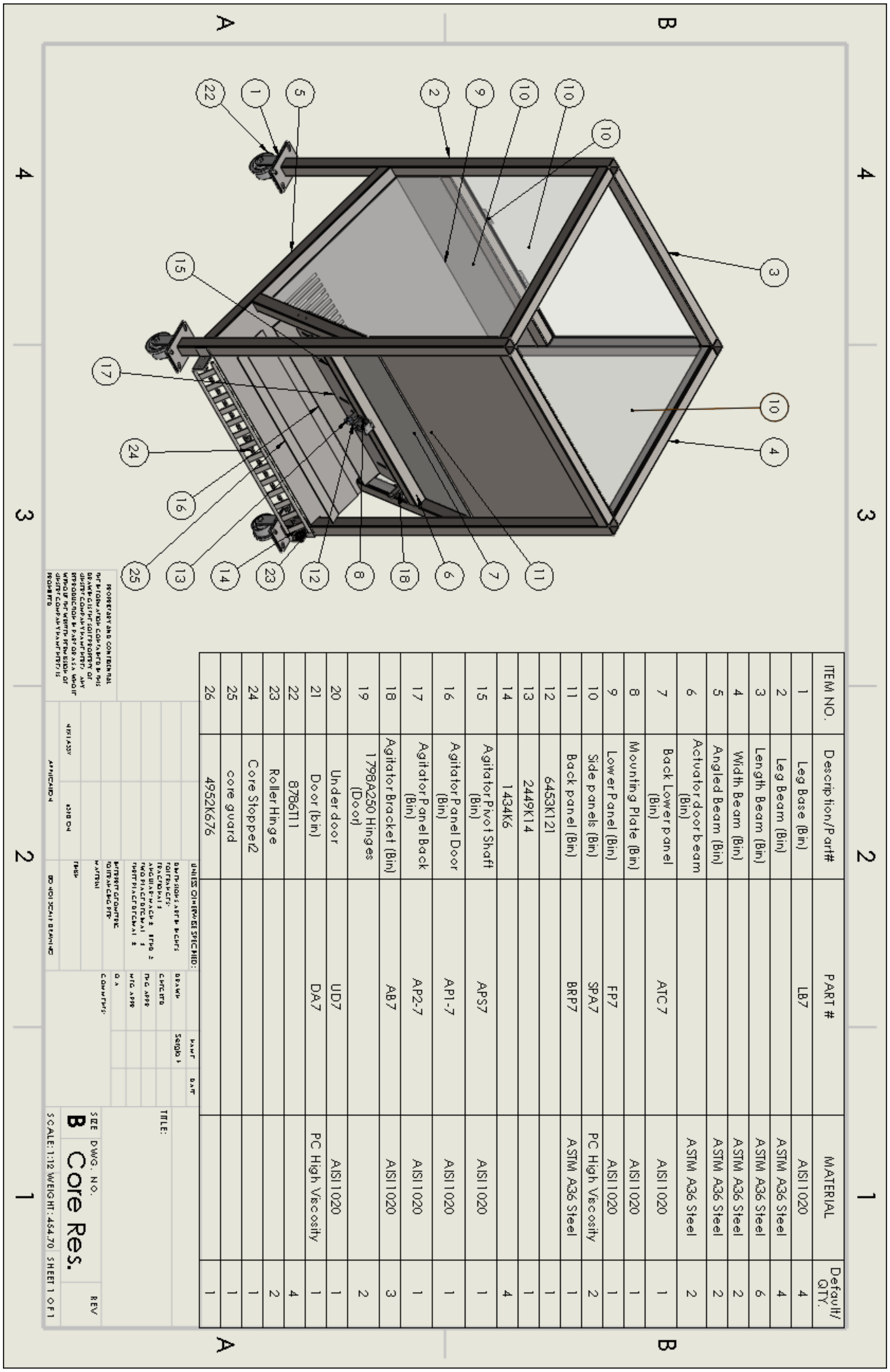
$\boxed{P_{cr} = 42588.7}$

Appendix B – Drawings

Main Assembly:

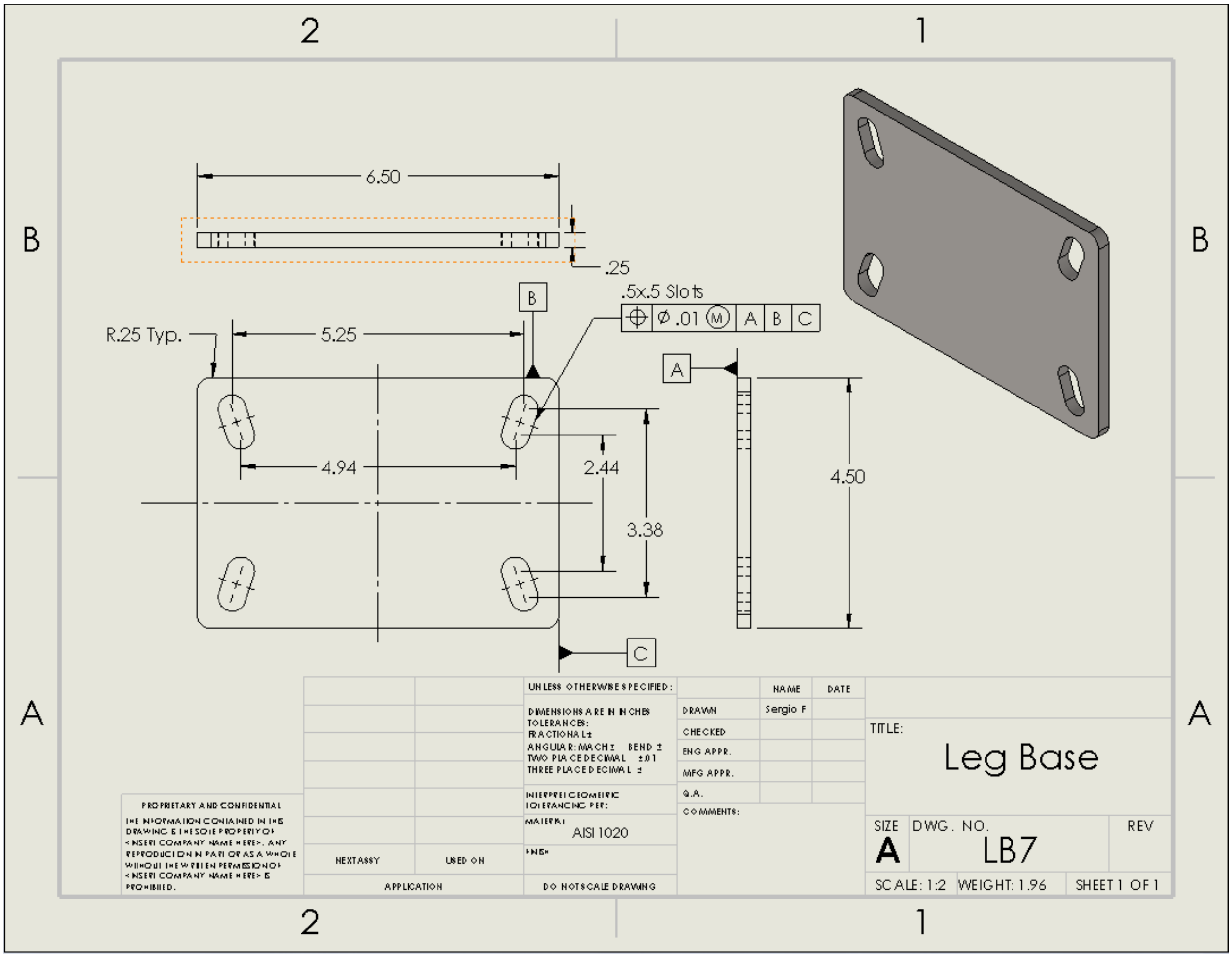


Core Bin: Sub-Assembly 1

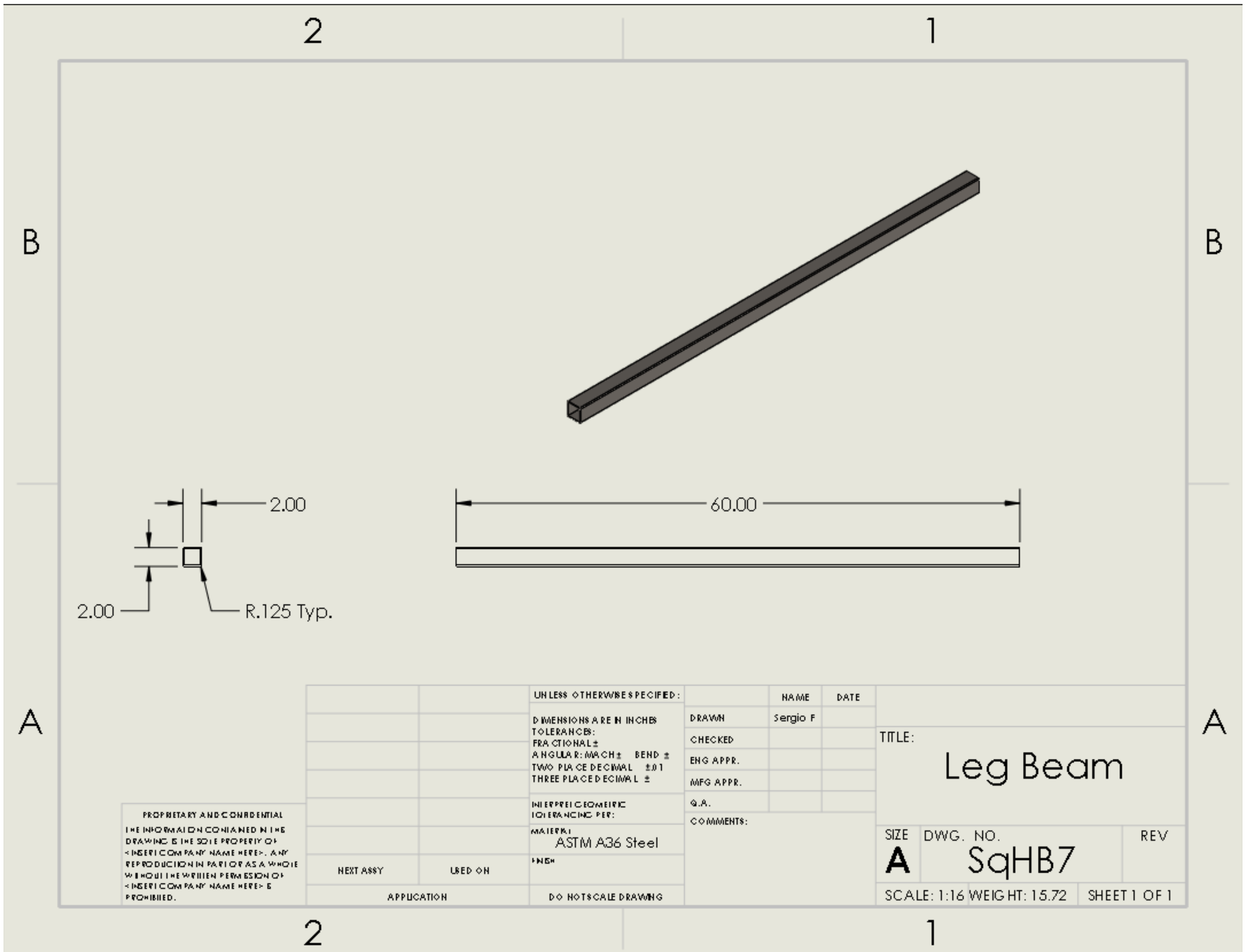


ITEM NO.	Description/Part#	PART #	MATERIAL	Default/ QTY.
1	Leg Base (Bin)	LB7	AISI 1020	4
2	Leg Beam (Bin)		ASTM A36 Steel	4
3	Length Beam (Bin)		ASTM A36 Steel	6
4	Width Beam (Bin)		ASTM A36 Steel	2
5	Angled Beam (Bin)		ASTM A36 Steel	2
6	Actuator door beam (Bin)		ASTM A36 Steel	2
7	Back Lower panel (Bin)	ATC7	AISI 1020	1
8	Mounting Plate (Bin)		AISI 1020	1
9	Lower Panel (Bin)	FP7	AISI 1020	1
10	Side panels (Bin)	SPA7	PC High Viscosity	2
11	Back panel (Bin)	BRP7	ASTM A36 Steel	1
12	6453K121			1
13	2449K14			1
14	1434K6			4
15	Agitator Pivot Shaft (Bin)	APS7	AISI 1020	1
16	Agitator Panel Door (Bin)	AP1-7	AISI 1020	1
17	Agitator Panel Back (Bin)	AP2-7	AISI 1020	1
18	Agitator Bracket (Bin)	AB7	AISI 1020	3
19	1798A250 Hinges (Door)			2
20	Under door	UD7	AISI 1020	1
21	Door (bin)	DA7	PC High Viscosity	1
22	8786T11			4
23	Roller Hinge			2
24	Core Stopper2			1
25	core guard			1
26	4952K676			1

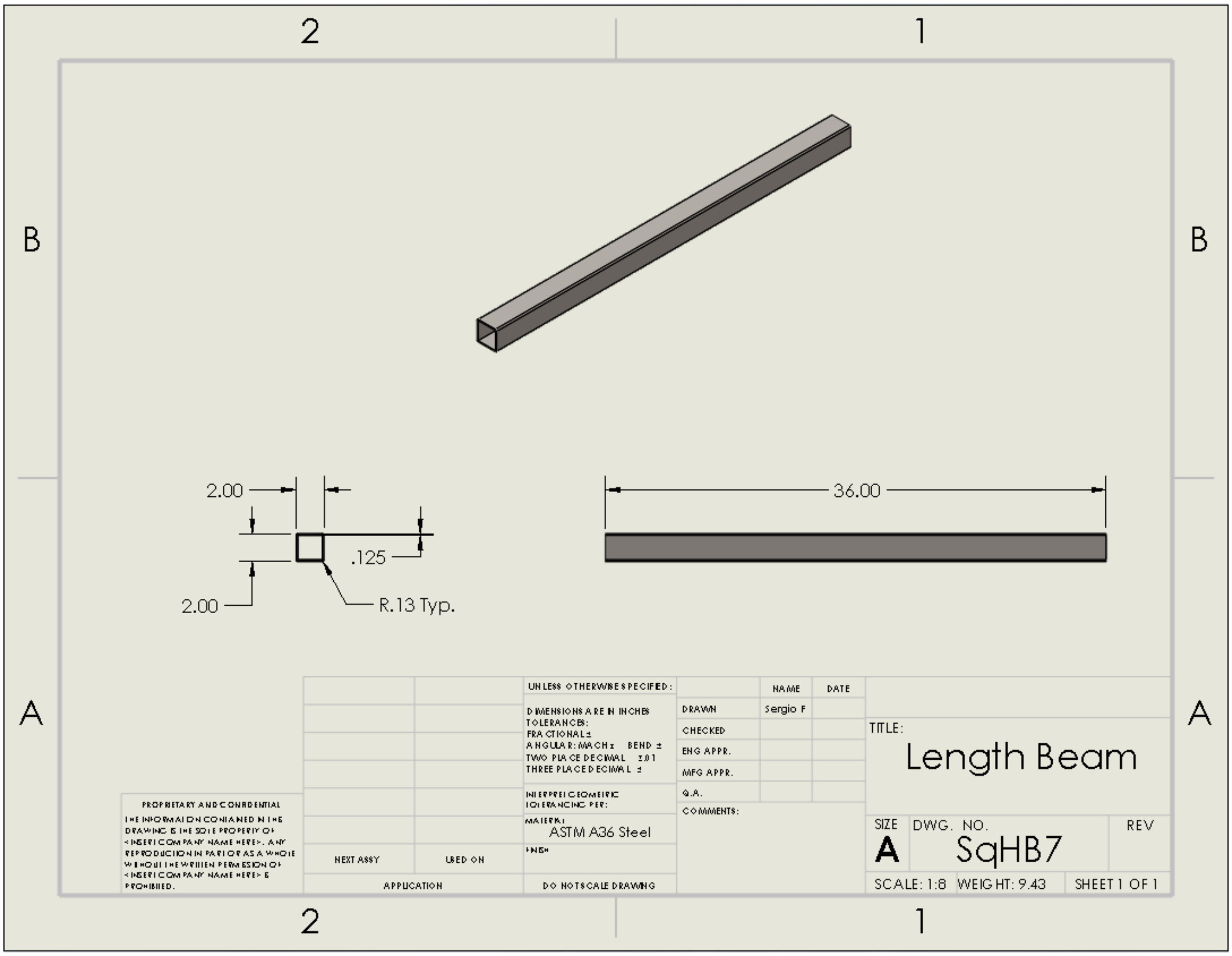
Sub- Assembly 1: Part 1



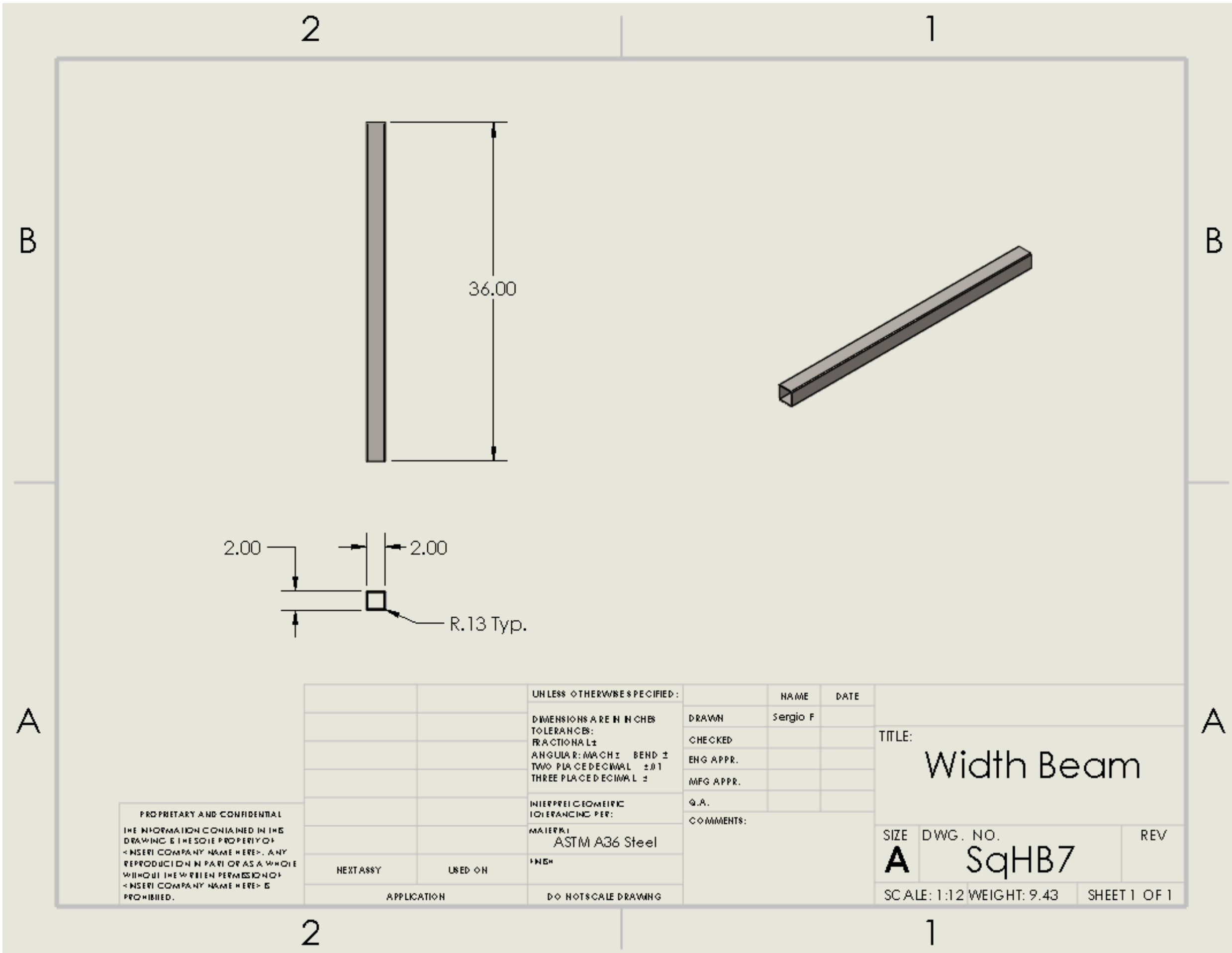
Sub- Assembly 1: Part 2



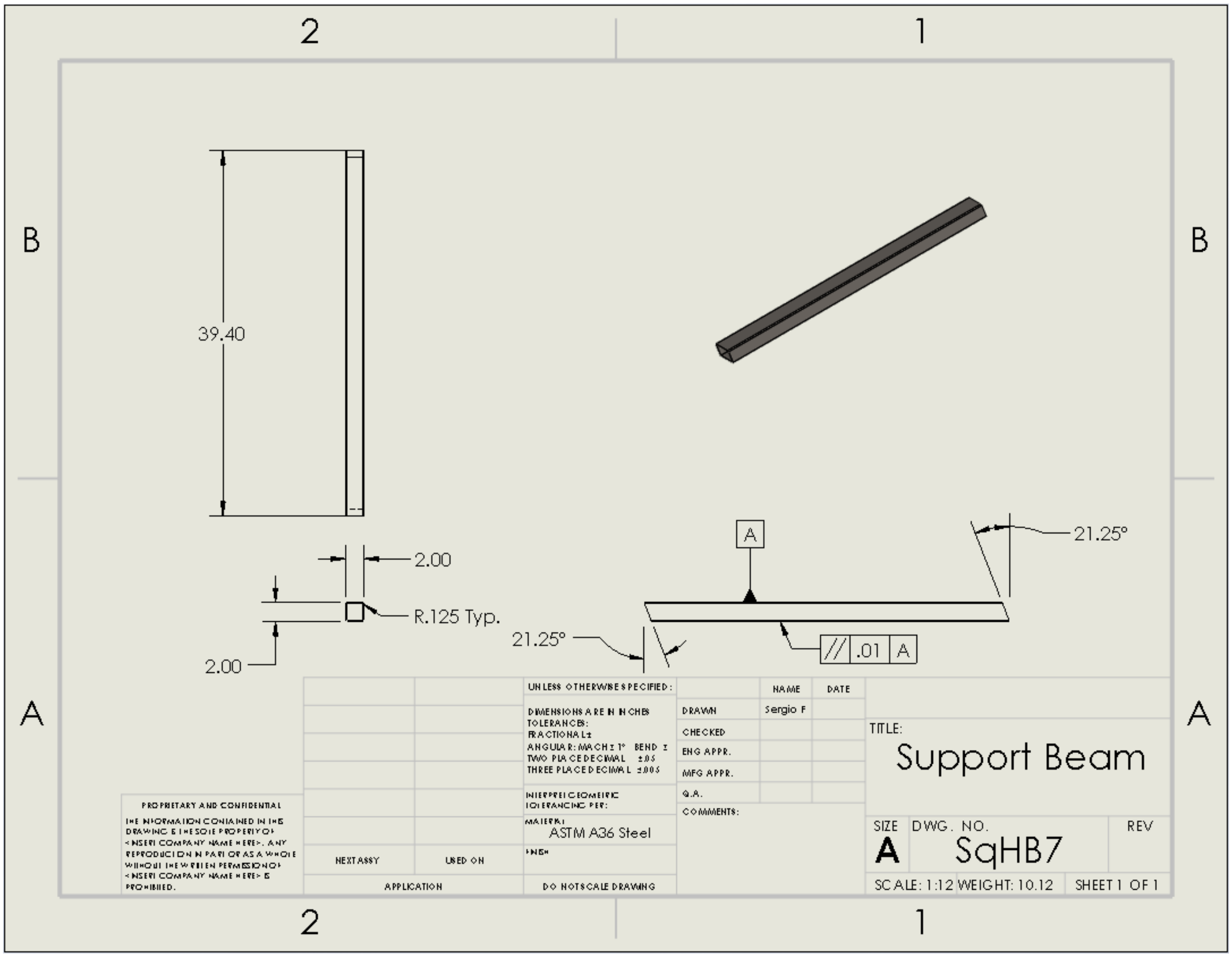
Sub- Assembly 1: Part 3



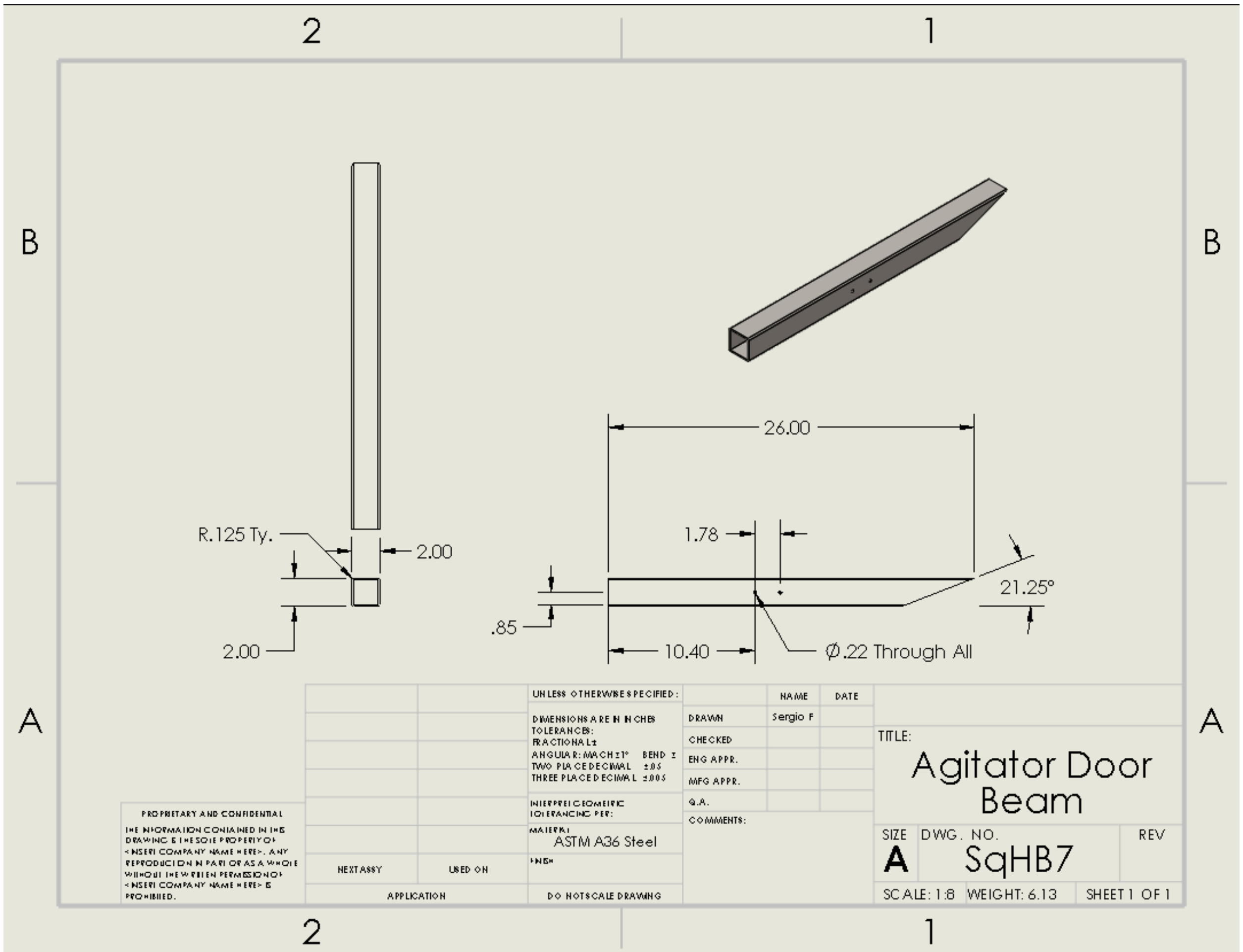
Sub- Assembly 1: Part 4



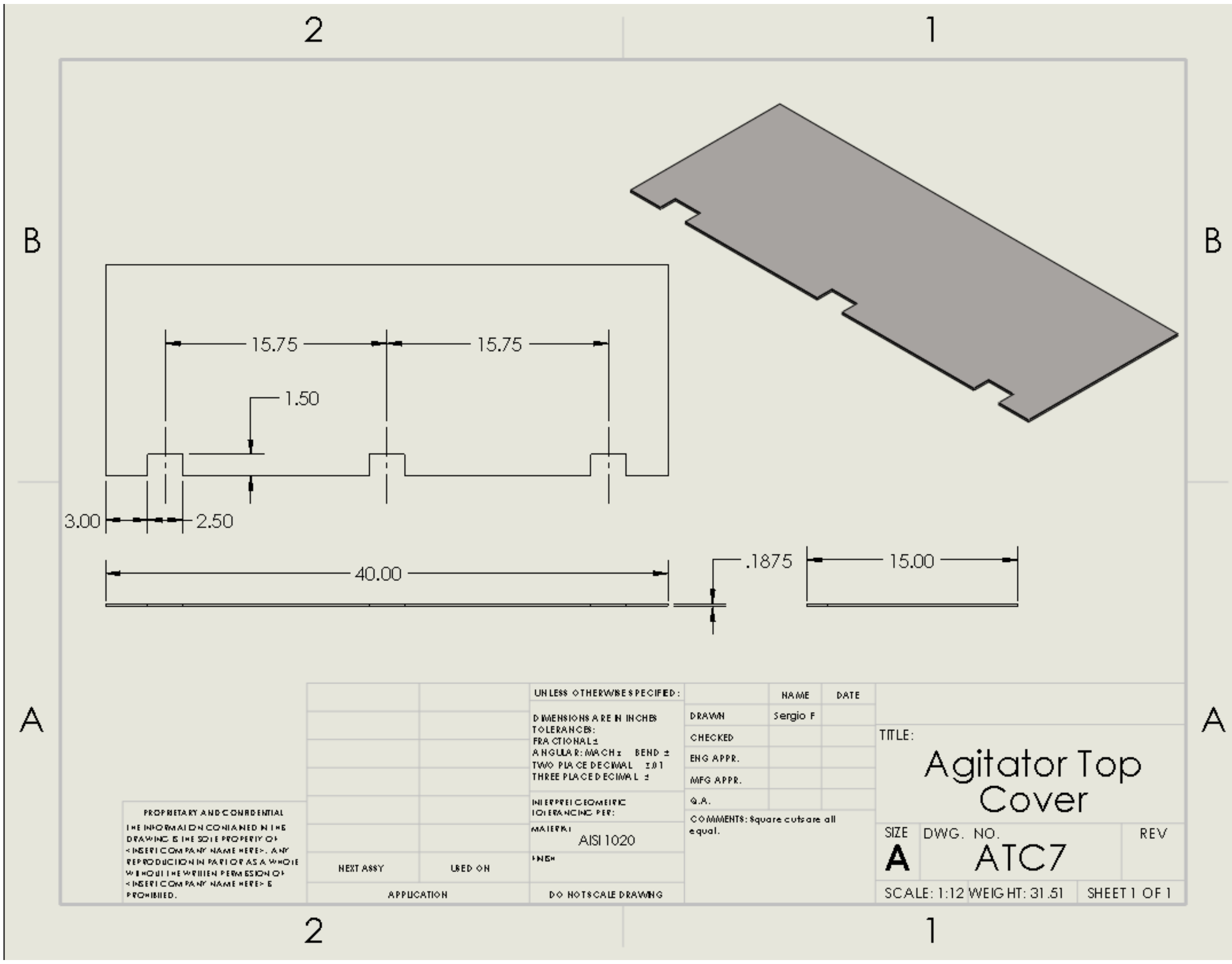
Sub- Assembly 1: Part 5



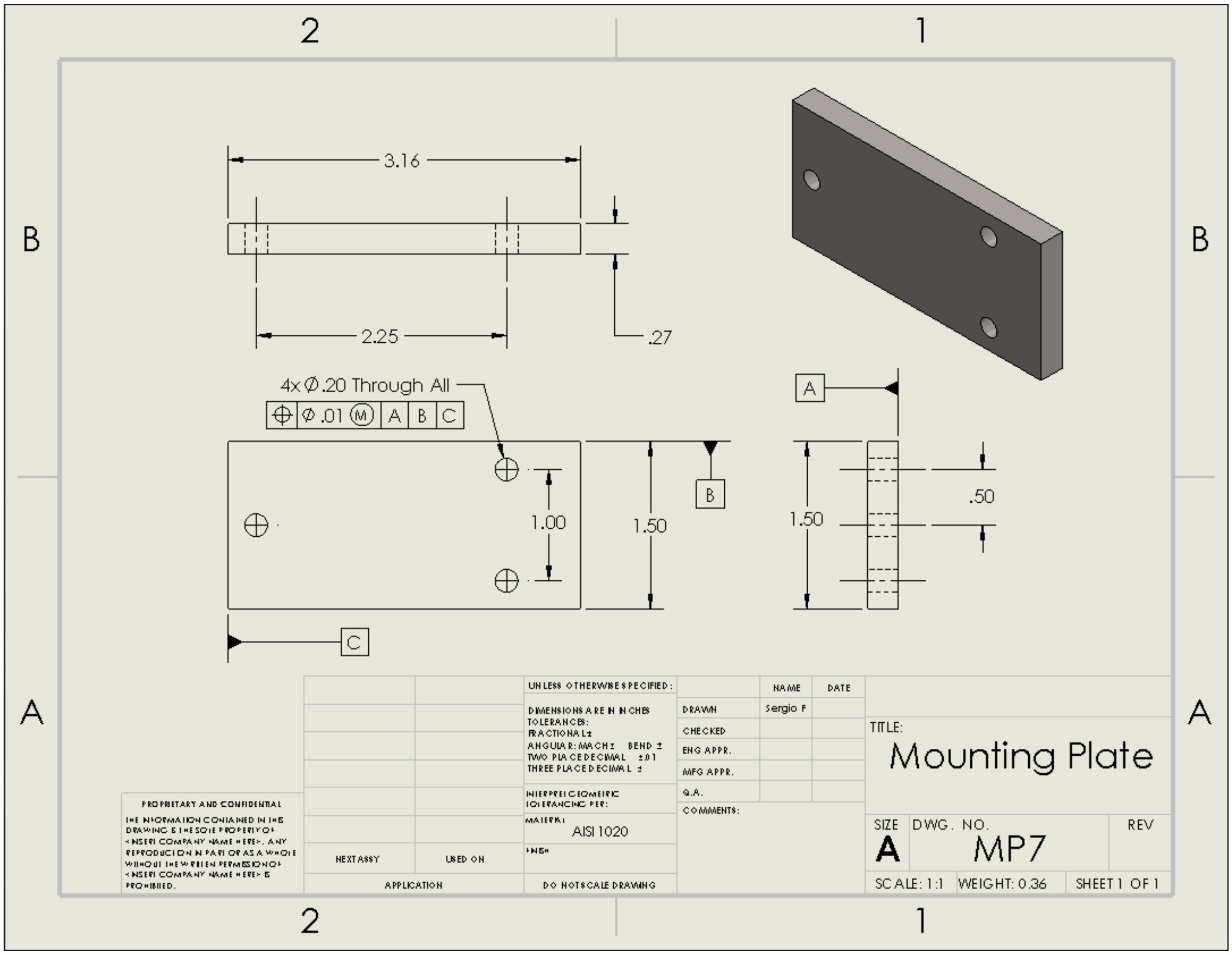
Sub- Assembly 1: Part 6



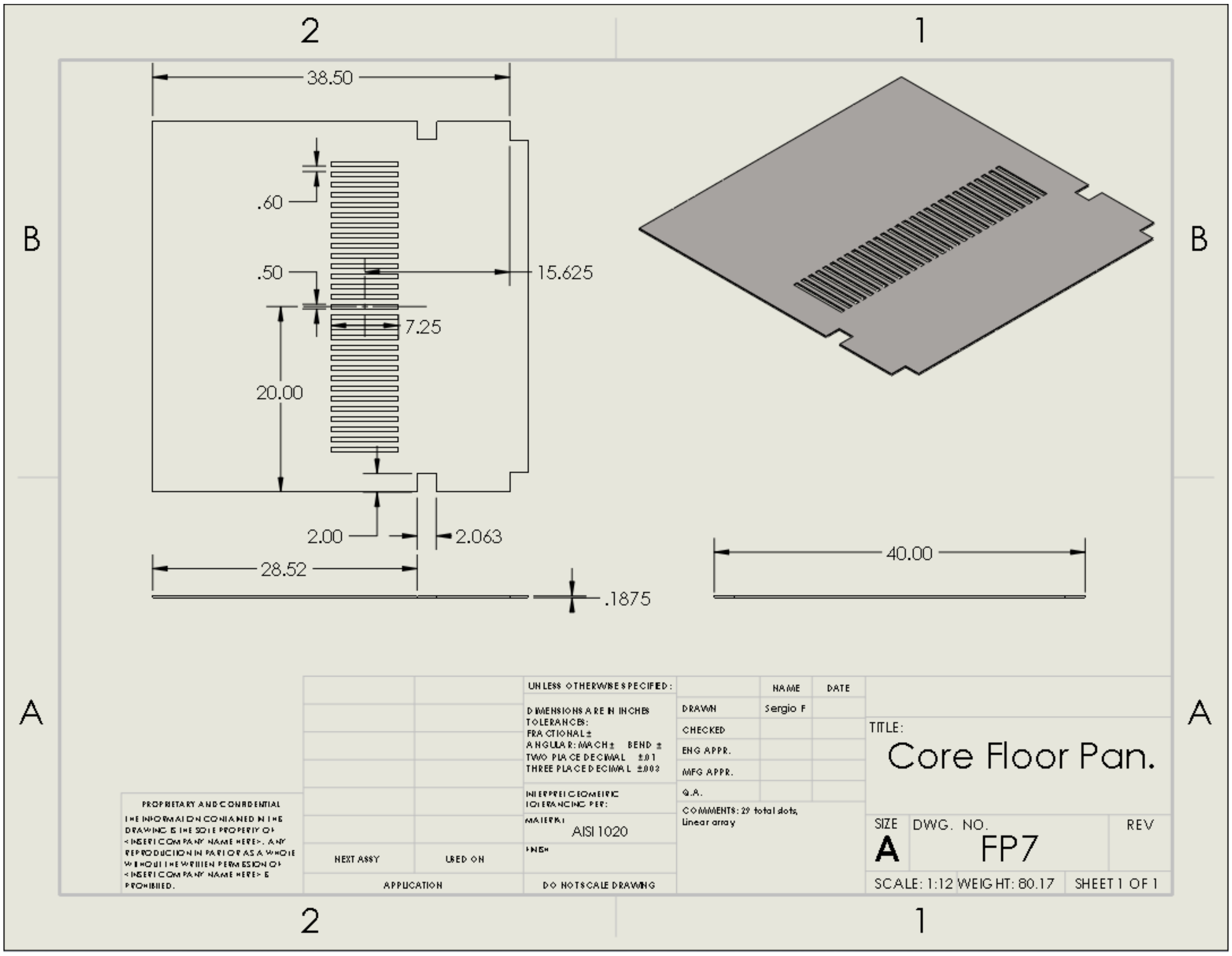
Sub- Assembly 1: Part 7



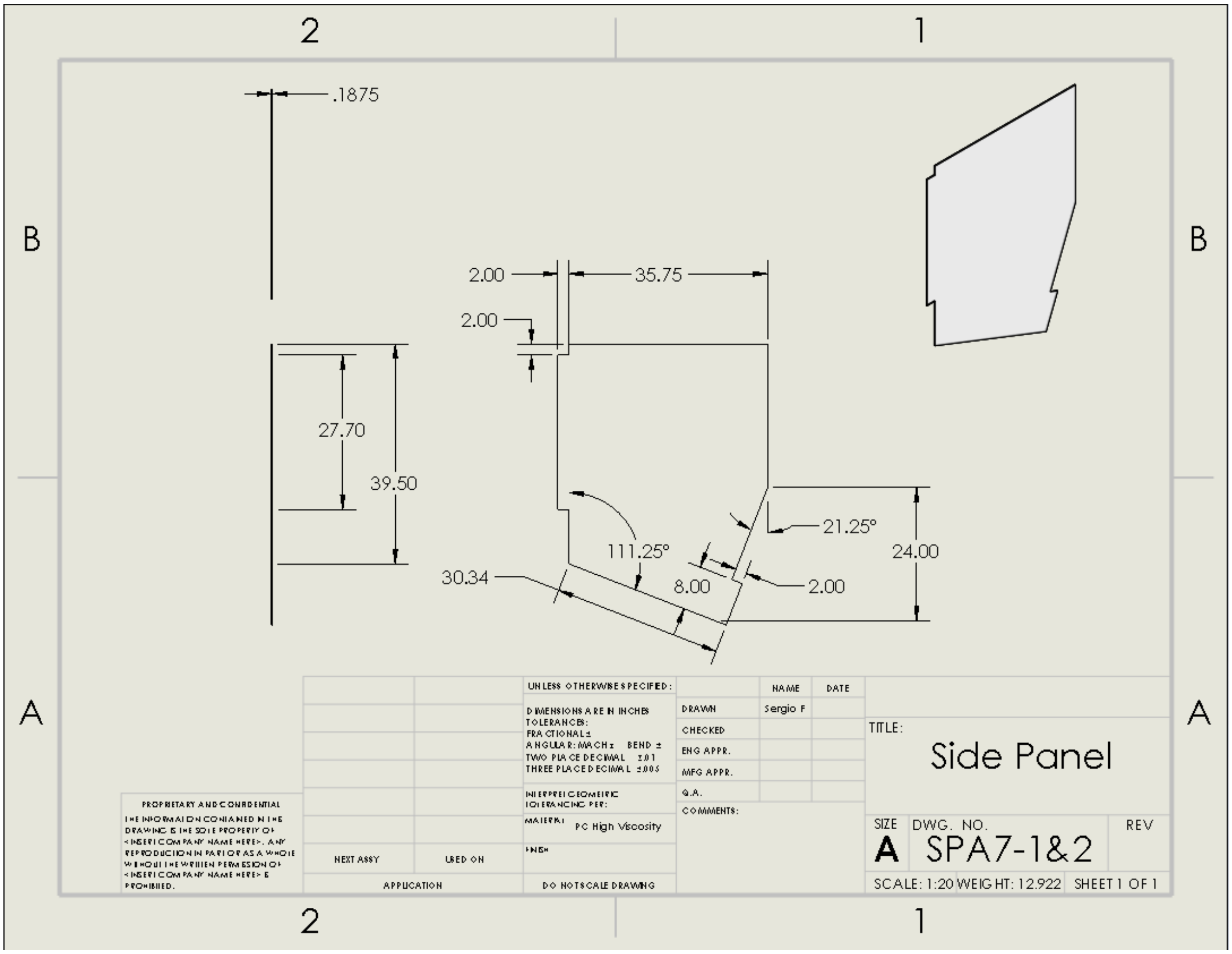
Sub- Assembly 1: Part 8



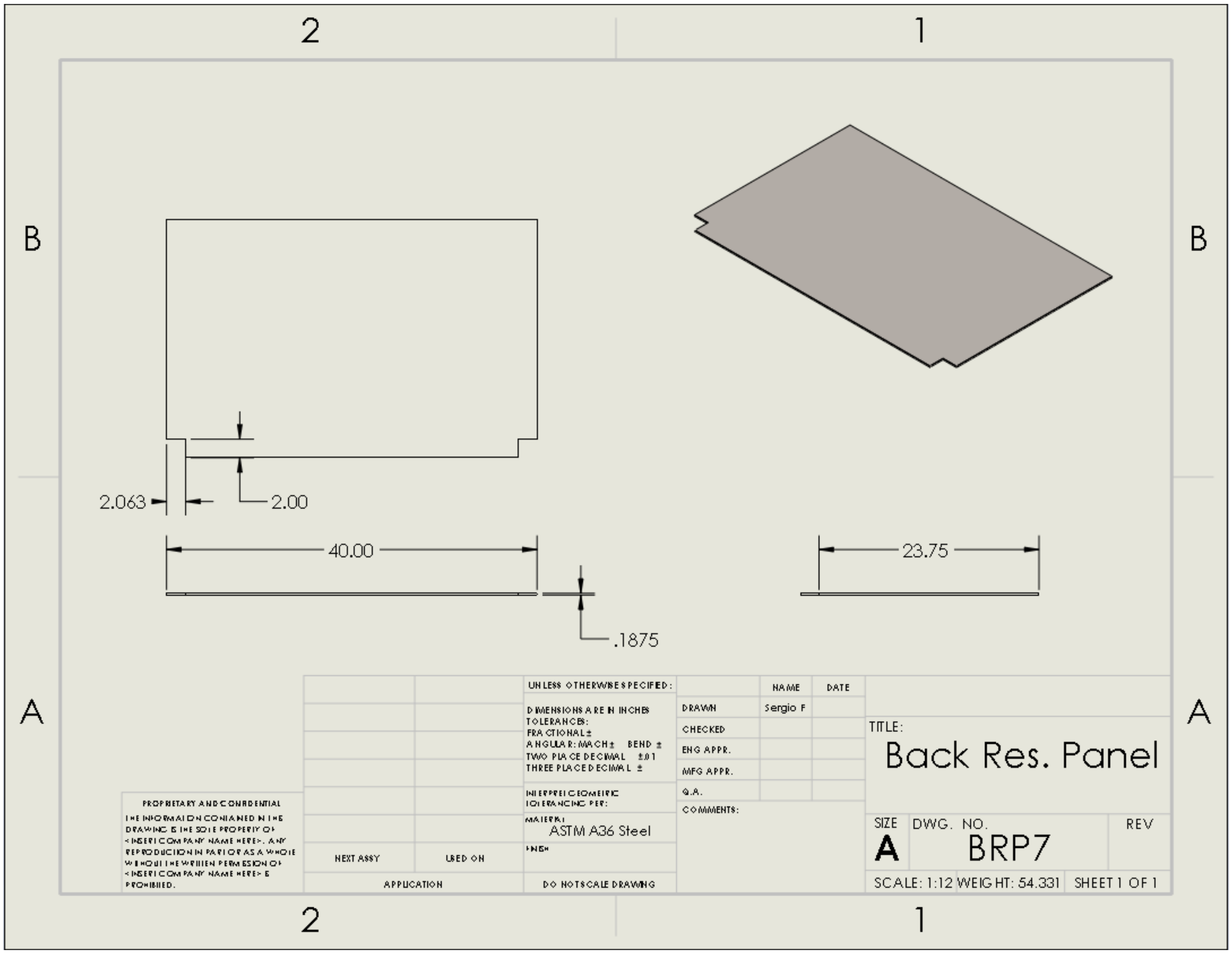
Sub- Assembly 1: Part 9



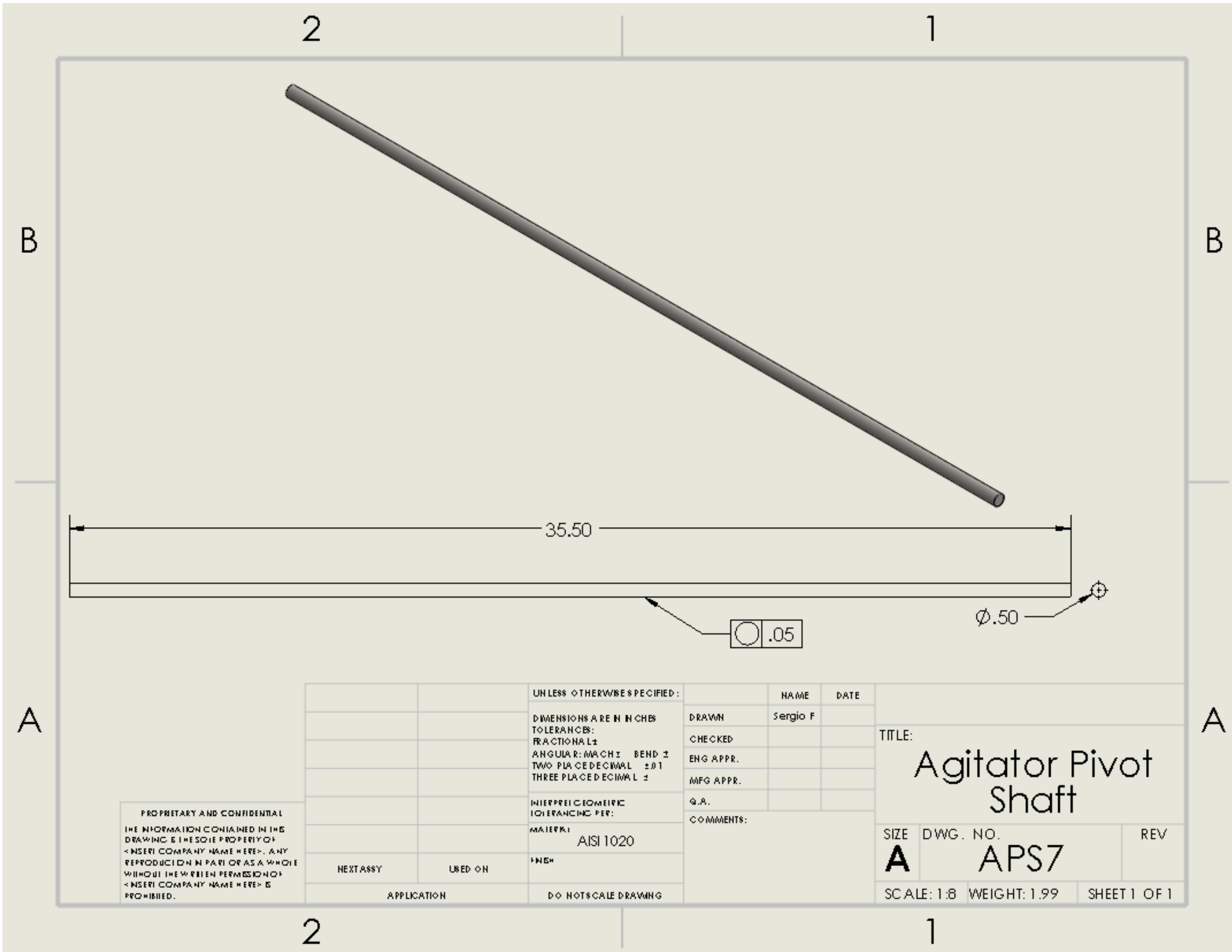
Sub- Assembly 1: Part 10



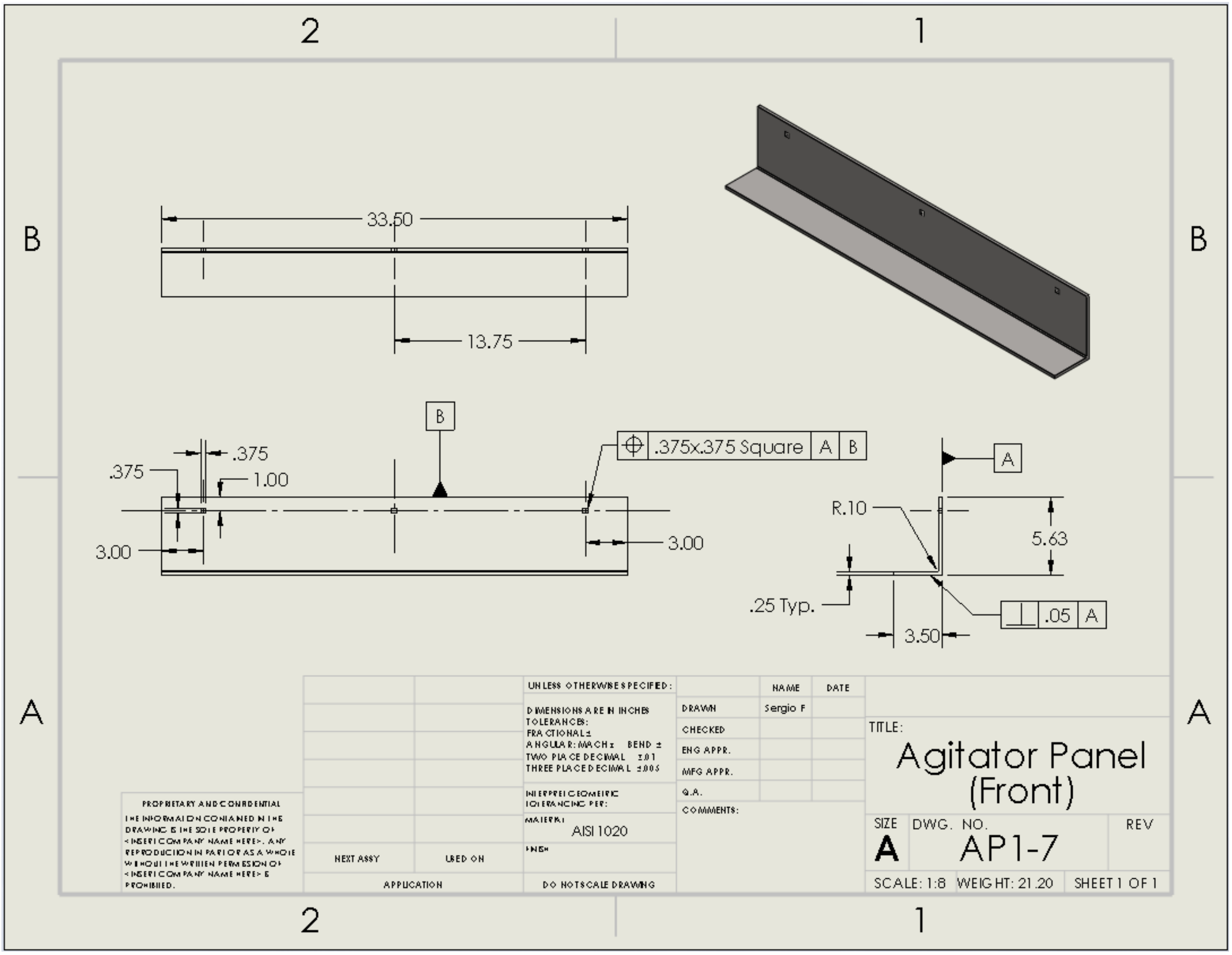
Sub- Assembly 1: Part 11



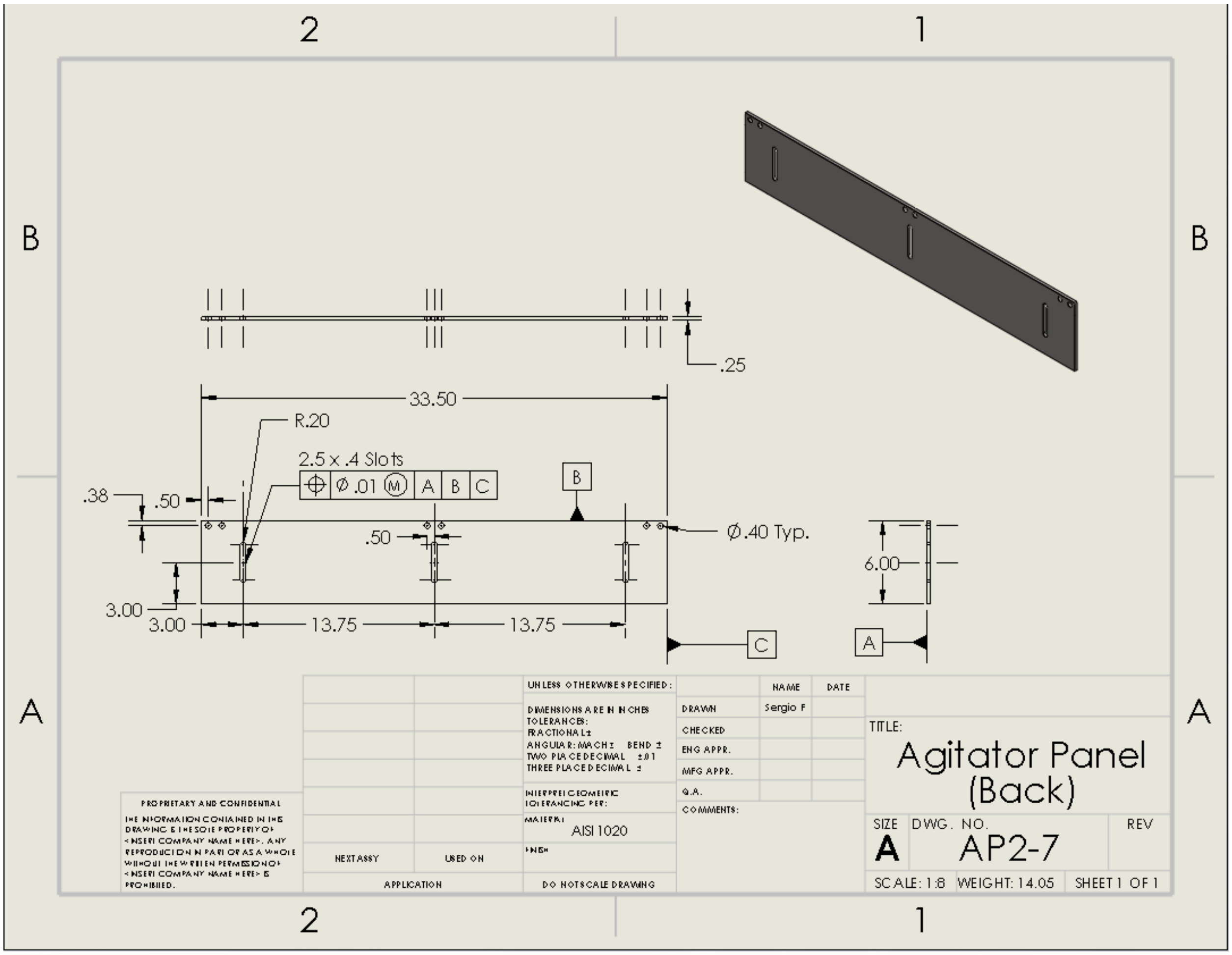
Sub- Assembly 1: Part 12



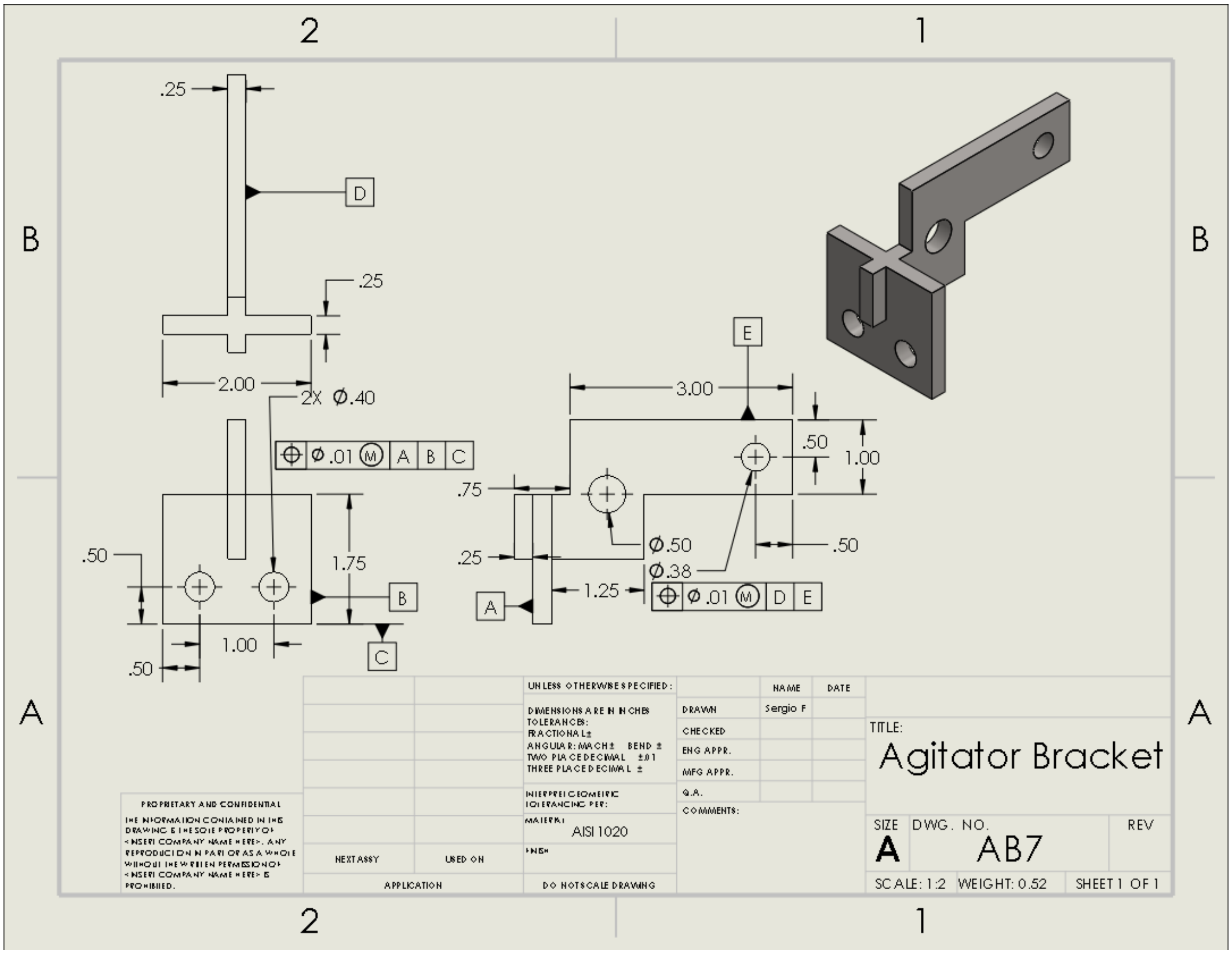
Sub- Assembly 1: Part 13



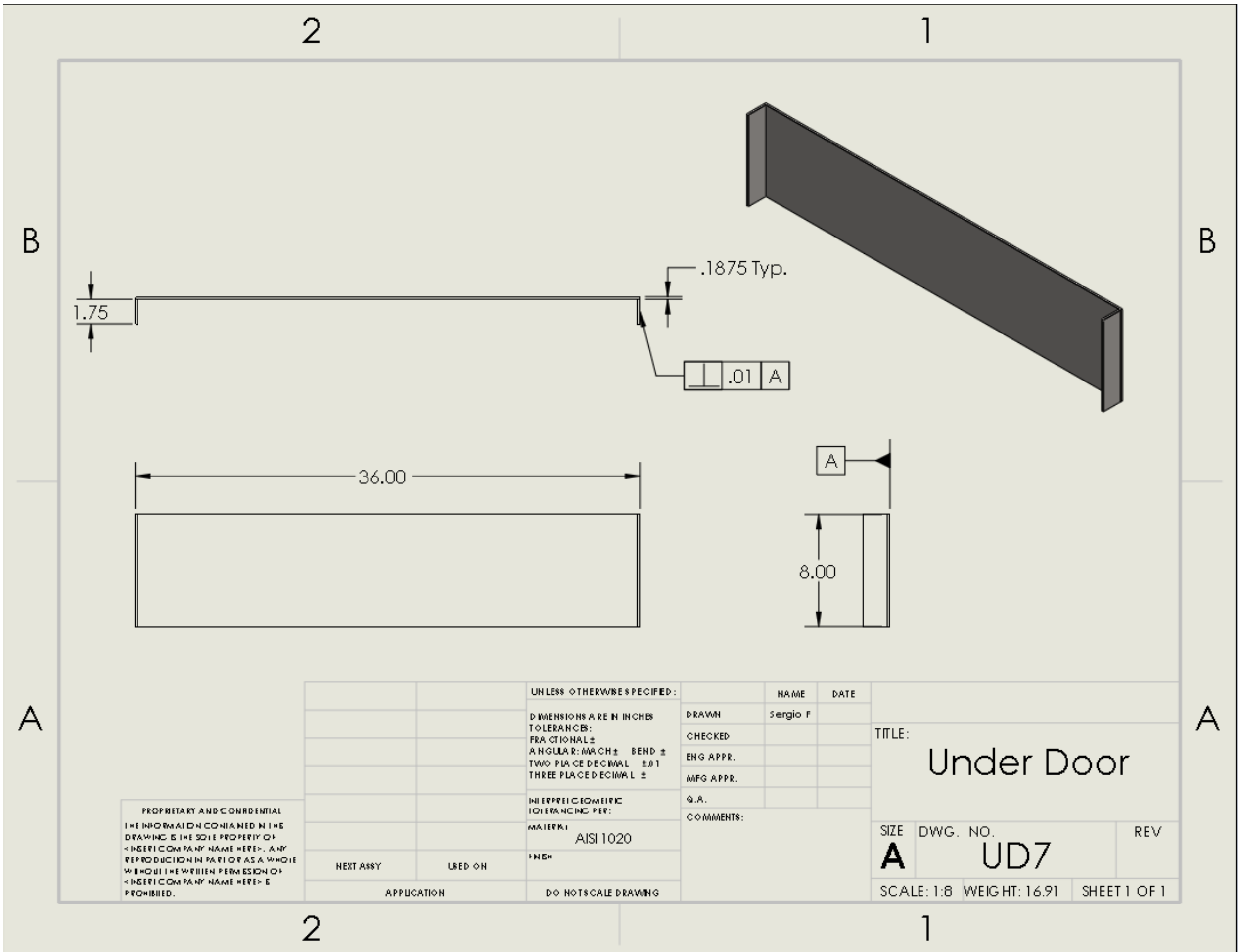
Sub- Assembly 1: Part 14



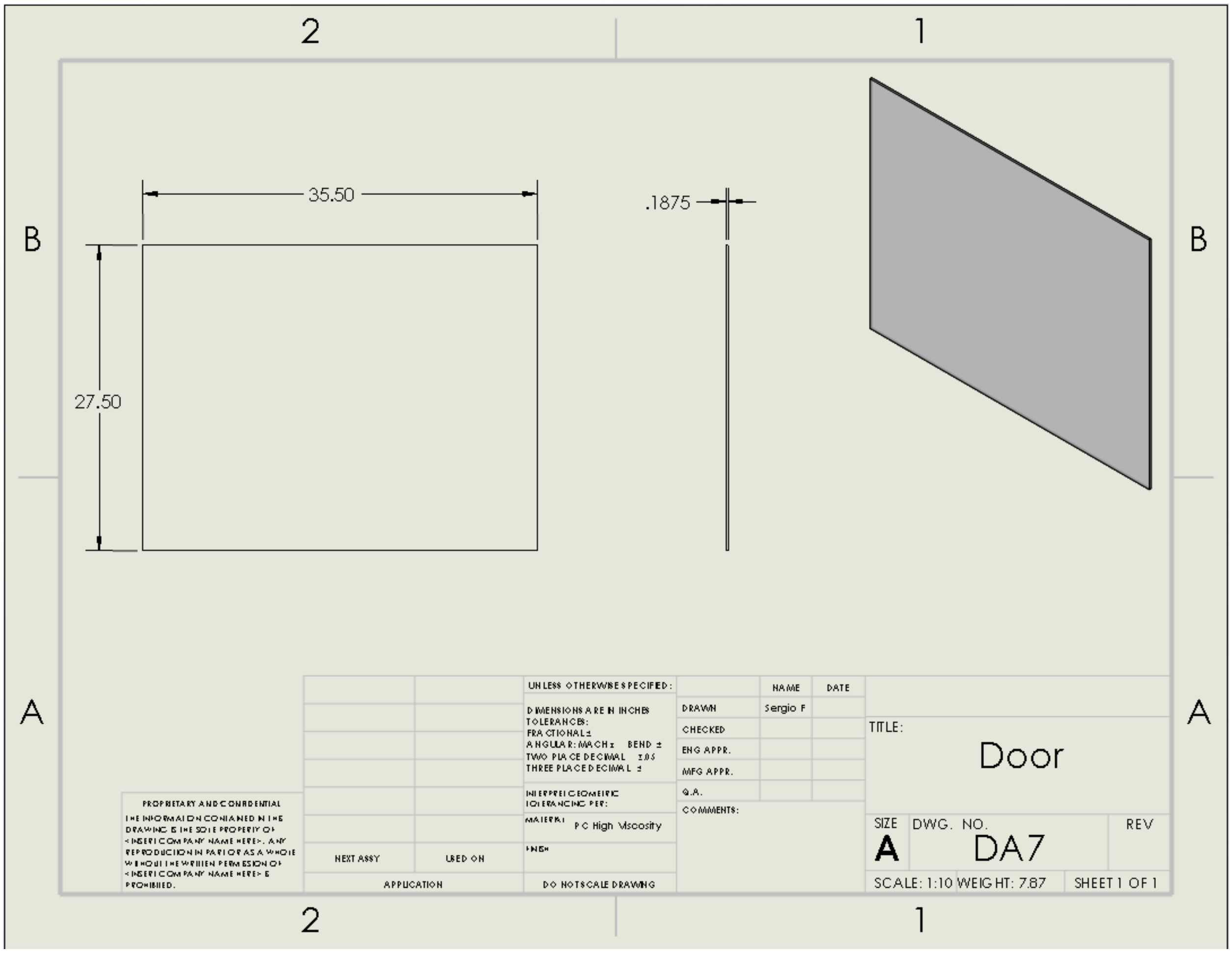
Sub- Assembly 1: Part 15



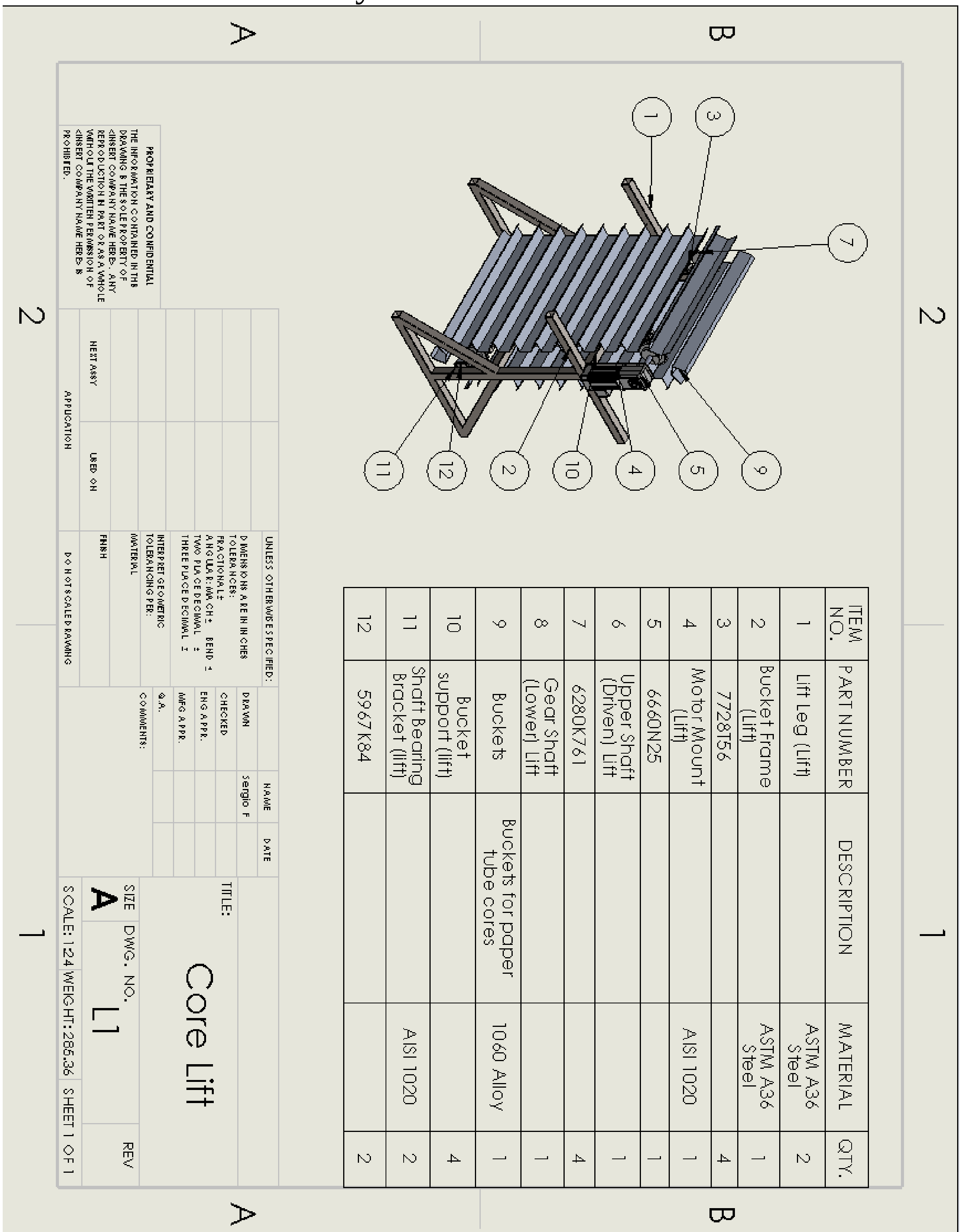
Sub- Assembly 1: Part 16



Sub- Assembly 1: Part 17

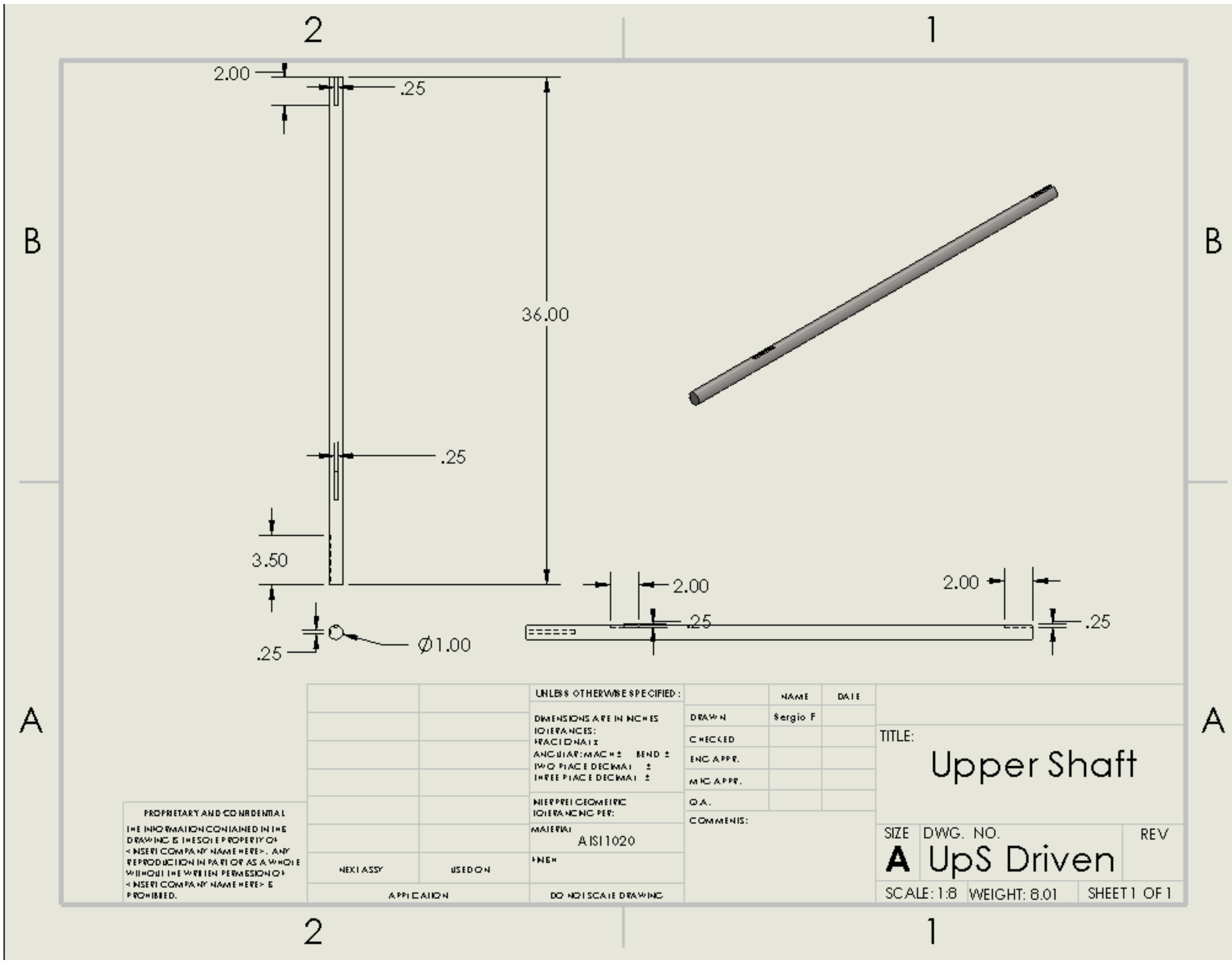


Core Lift: Sub-Assembly 2

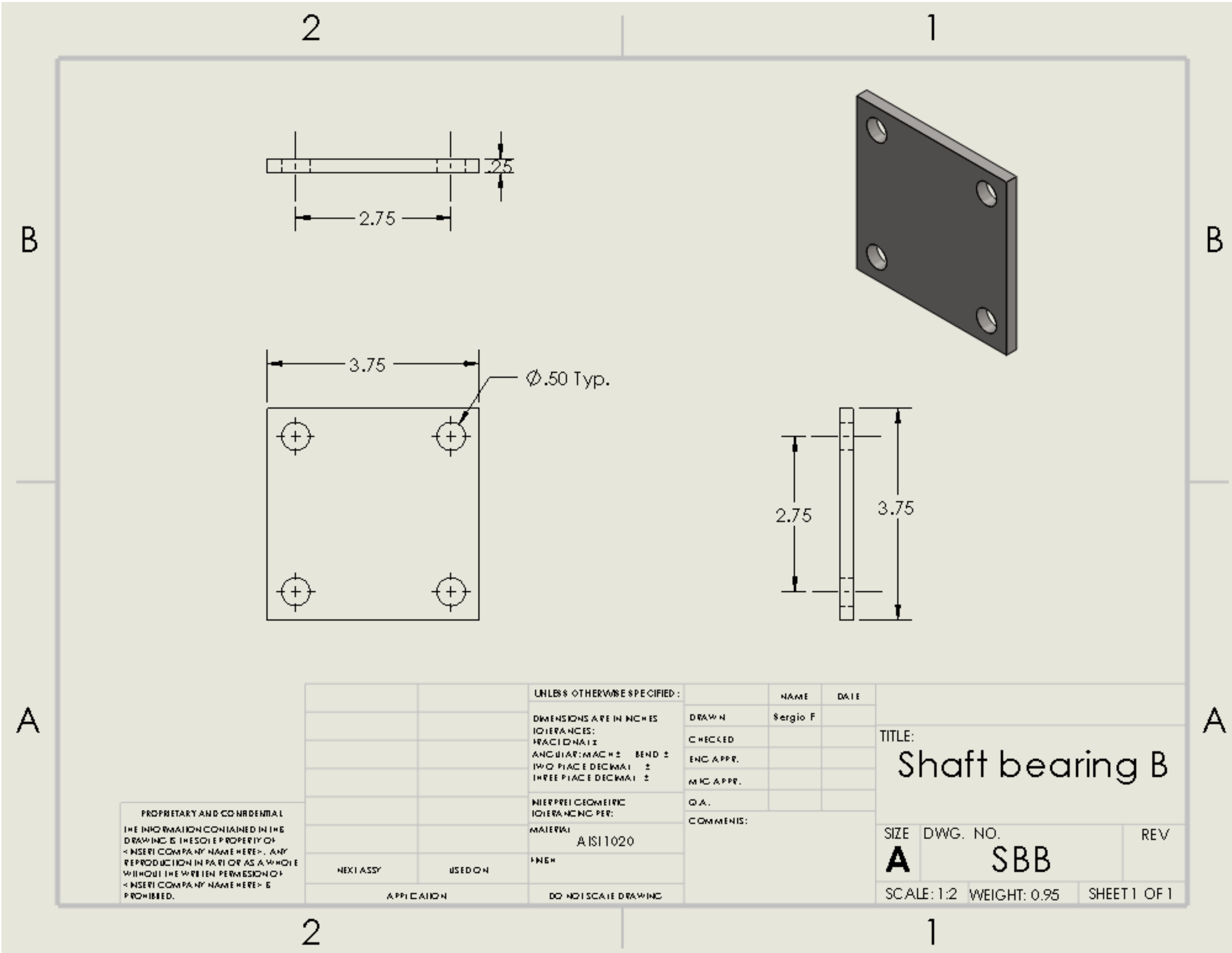


ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	QTY.
1	Lift Leg (Lift)		ASTM A36 Steel	2
2	Bucket Frame (Lift)		ASTM A36 Steel	1
3	7728T56			4
4	Motor Mount (Lift)		AISI 1020	1
5	6660N25			1
6	Upper Shaft (Driven) Lift			1
7	6280K761			4
8	Gear Shaft (Lower) Lift			1
9	Buckets	Buckets for paper tube cores	1060 Alloy	1
10	Bucket support (lift)			4
11	Shaft Bearing Bracket (lift)		AISI 1020	2
12	5967K84			2

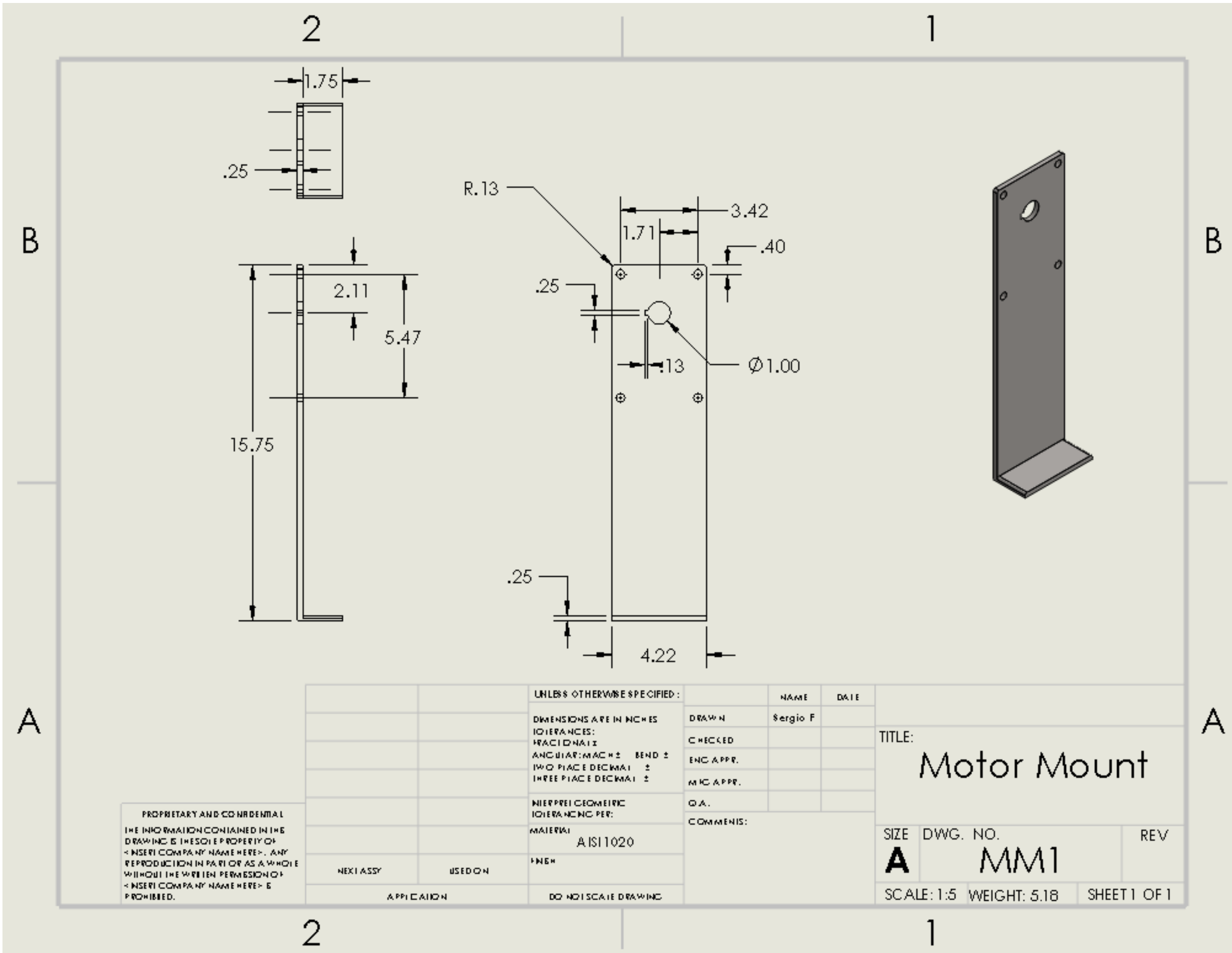
Sub-Assembly 2: Part 1



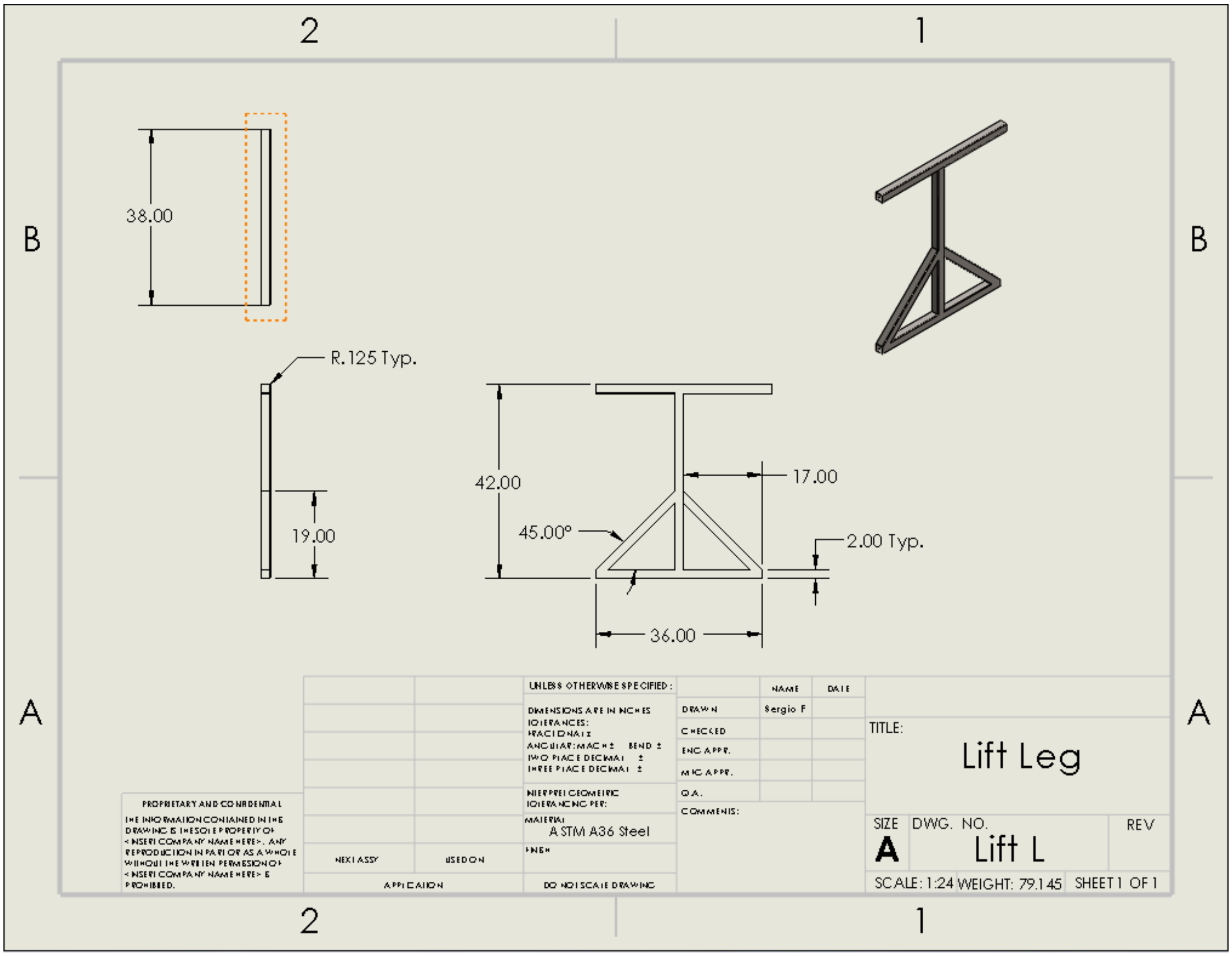
Sub-Assembly 2: Part 2



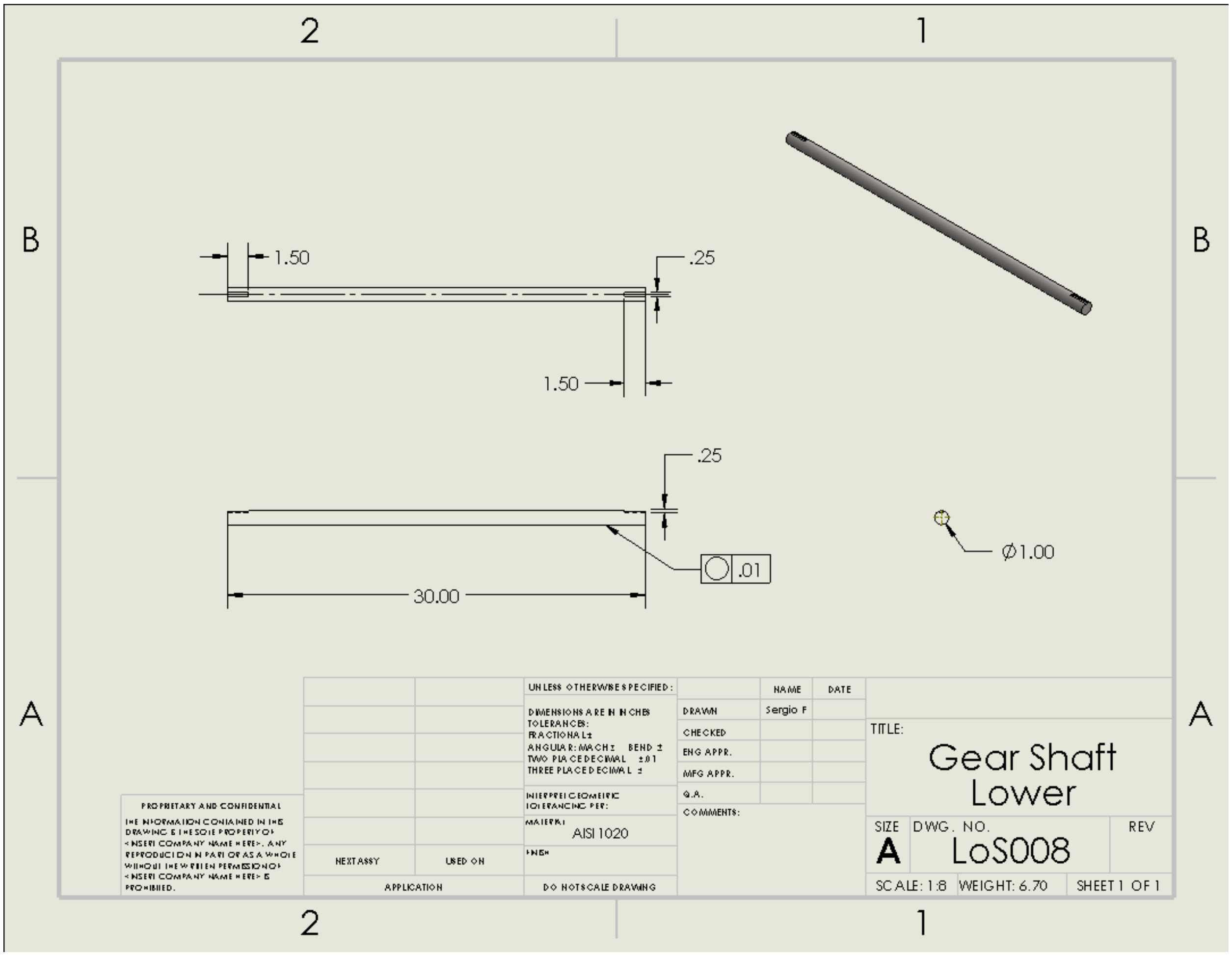
Sub-Assembly 2: Part 3



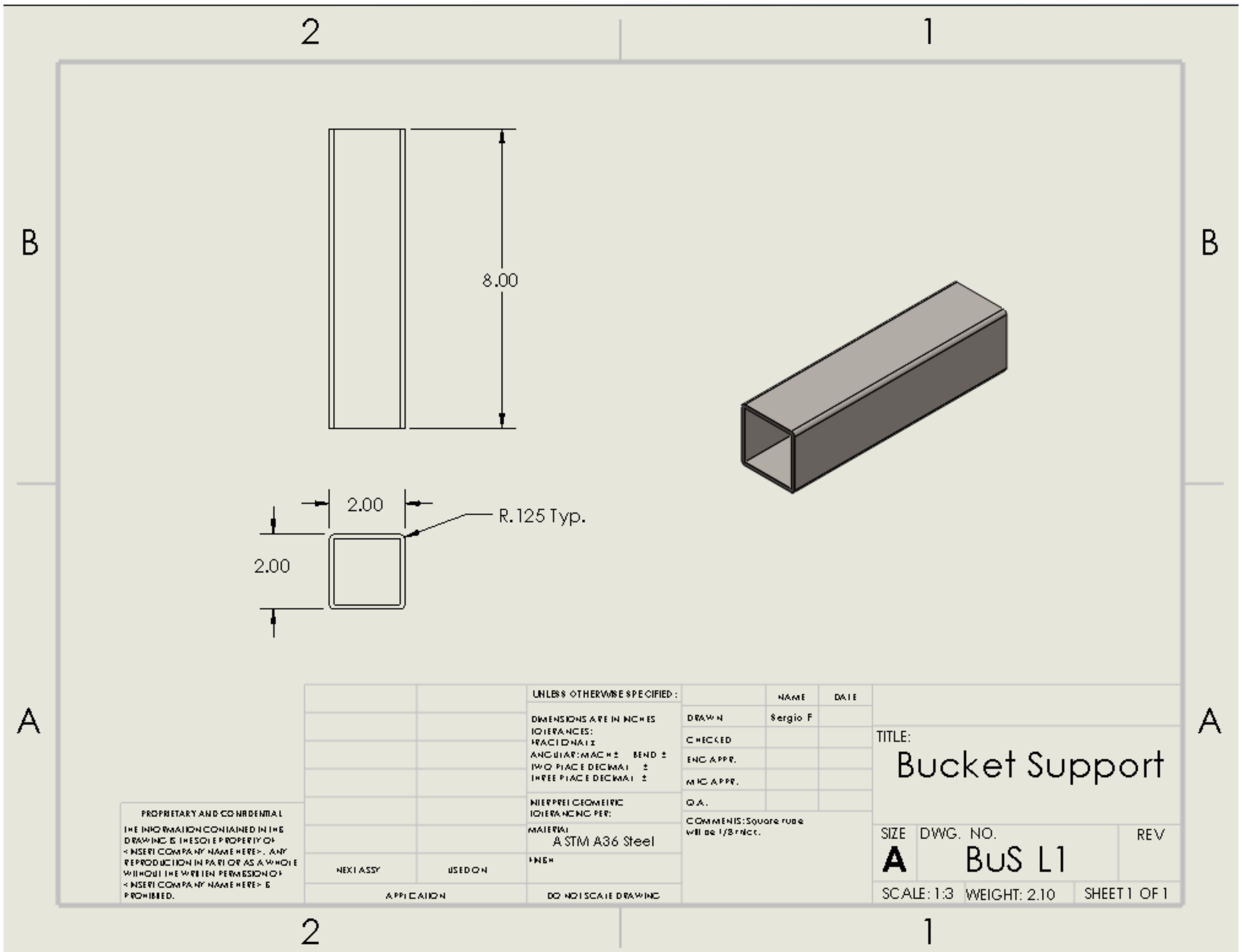
Sub-Assembly 2: Part 4



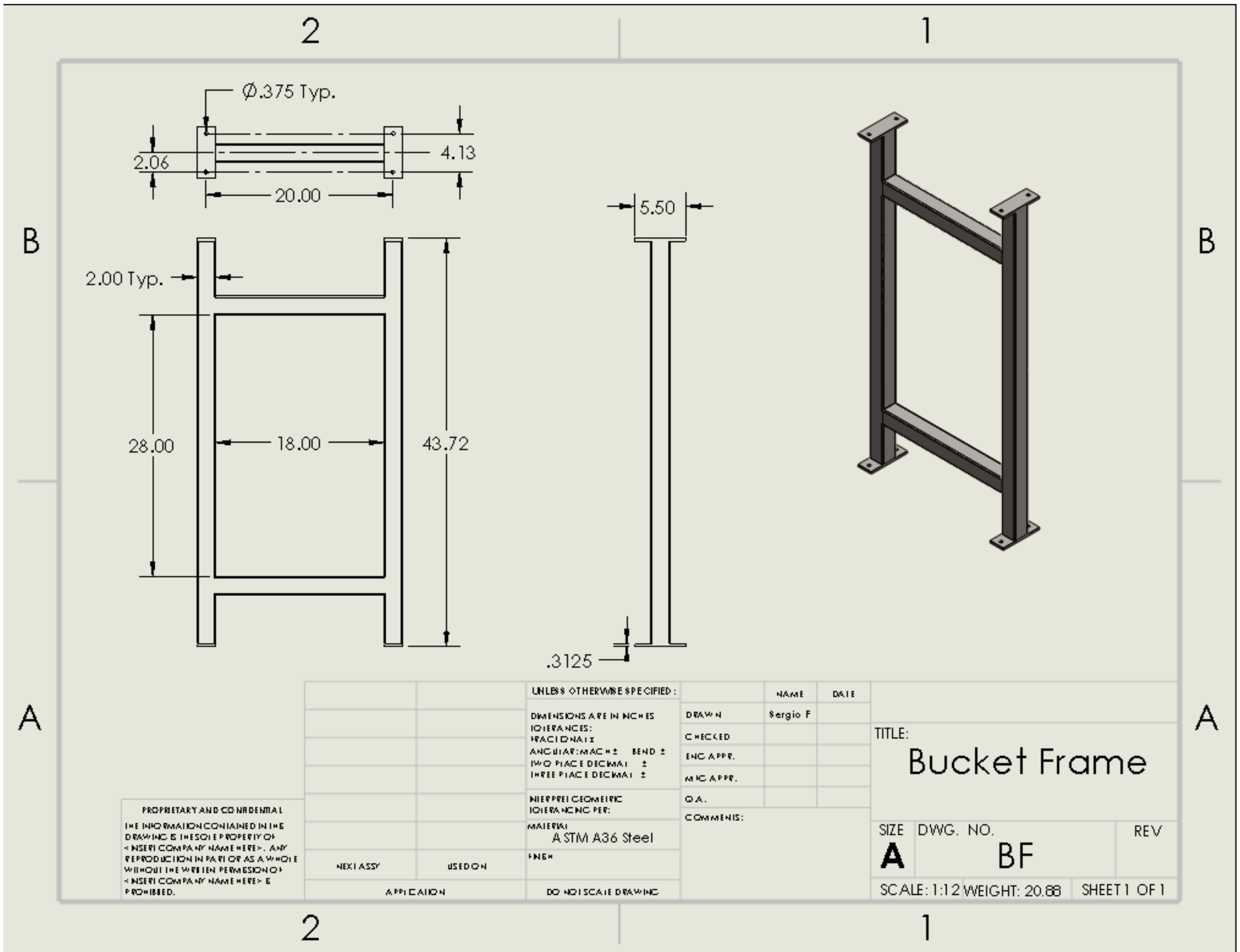
Sub-Assembly 2: Part 5



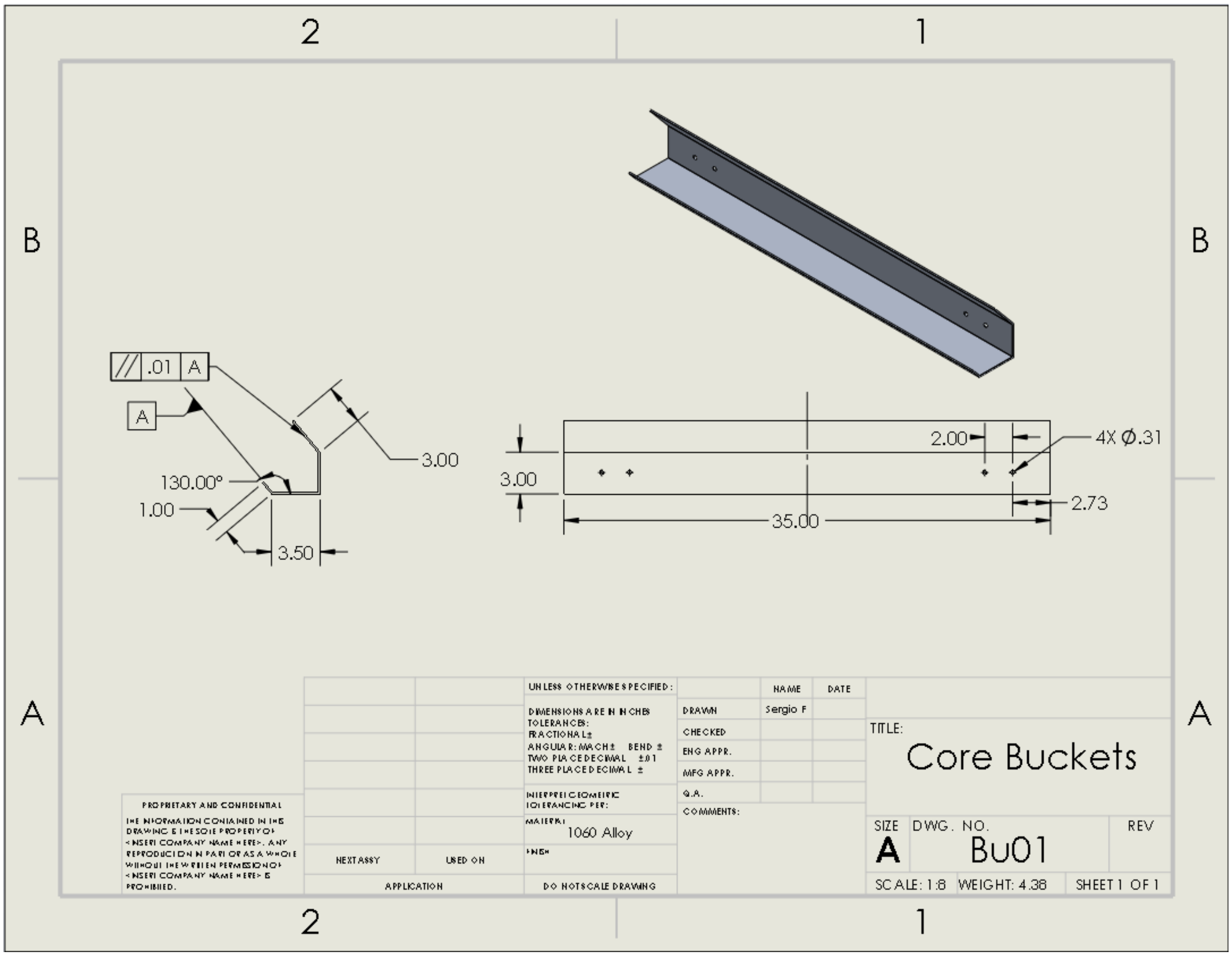
Sub-Assembly 2: Part 6



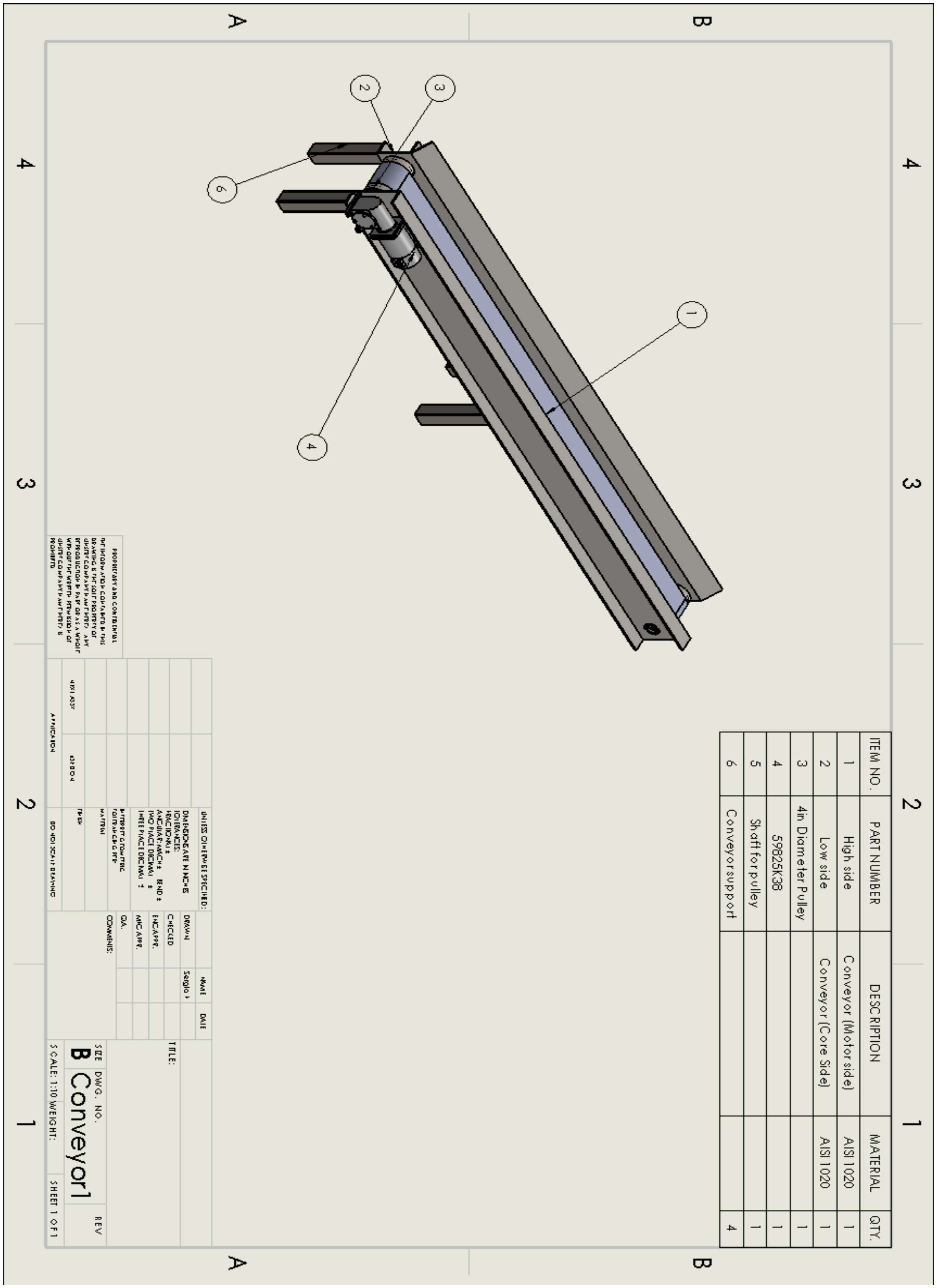
Sub-Assembly 2: Part 7



Sub-Assembly 2: Part 8



Conveyor: Sub-Assembly 3



Appendix C – Parts List

Part Summary			
Item #	**Parts**	**Drawing ID**	**Source**
1	2x2 Square Hollow Beam	SqHB7	
2	Air Cylinder	6453K120	McMaster-Carr
3	Cylinder Clevis	2449K140	McMaster-Carr
4	Hinges	1798A250	McMaster-Carr
5	Needle Bearings	1434K600	McMaster-Carr
6	Mounting Plate (Cylinder)	MP7	
7	Agitator Bracket	AB7	
8	Agitator Panel (Front)	AP17	
9	Agitator Panel (Back)	AP27	
10	Agitator Pivot Shaft	APS7	
11	Agitator Top Cover	ATC7	
12	Back Reservoir Panel	BRP7	
13	Under Door Panel	UD7	
14	Floor Panel	FP7	
15	Door (Acrylic)	DA7	
16	Side Panels (Acrylic)	SPA7	
17	Base Mounted Steel Ball B	5967K840	McMaster-Carr
18	Sprockets	6280K761	McMaster-Carr
19	Lift Motor	6660N250	McMaster-Carr
20	Flanged-Mounted Ball B	7728T560	McMaster-Carr
21	Core Buckets	CB8	
22	ANSI Roller Chain #80	RC8	McMaster-Carr
23	Electric Motor	EM8	McMaster-Carr
24	Motor Mount	MM8	
25	Shaft Bearing Bracket	SBB8	
26	Upper Shaft	UpS8	
29	Lower Shaft	LoS8	
30	Pulley	57506K124	McMaster-Car
31	Belt	B9	
32	Conveyor Motor	59825K38	McMaster-Car
33	Conveyor Frame	CF9	
34	Shaft for Pulley	Sp9	
35	Tensioner	T9	McMaster-Car

10th Scale Parts

10th Scale Parts Rapid Prototype
Core Reservoir
Lift System
Buckets
Wheels
Core Divider
Vex Robotics Material
Cortex
Vexnet Key
Motors
Chassis rails
Square Shaft
Bearing Flat
Motor Coupler
Spacers
Shaft Collar
Keps nut
Nylock Nut
Long motor screw
Short motor screw
Tread Links
Tread/attachment link
6 tooth sprockets
12 tooth sprockets

Appendix D – Budget

Original Design

Budget							
ID	**Parts**	**Amount Estimated**	**Quantity**	**Total $**	**Actual Prize**	**Total $**	**Source**
SqHB7	2x2 Square Hollow Beam **	$ 1,000.00	1	$ 1,000.00		$ -	
6453K120	Air Cylinder	$ 100.00	2	$ 200.00	$ 101.42	$ 202.84	
2449K140	Cylinder Clevis	$ 20.00	1	$ 20.00	$ 5.11	$ 5.11	
1798A250	Hinges	$ 5.00	2	$ 10.00	$ 5.68	$ 11.36	
1434K600	Needle Bearings	$ 35.00	2	$ 70.00	$ 10.32	$ 20.64	
MP7	Mounting Plate (Cylinder)*	$ 30.00	1	$ 30.00		$ -	
AB7	Agitator Bracket*	$ 40.00	1	$ 40.00		$ -	
AP17	Agitator Panel (Front)*	$ 200.00	1	$ 200.00		$ -	
AP27	Agitator Panel (Back)*	$ 150.00	1	$ 150.00		$ -	
APS7	Agitator Pivot Shaft*	$ 30.00	1	$ 30.00		$ -	
ATC7	Agitator Top Cover*	$ 75.00	1	$ 75.00		$ -	
BRP7	Back Reservoir Panel*	$ 120.00	1	$ 120.00		$ -	
UD7	Under Door Panel*	$ 50.00	1	$ 50.00		$ -	
FP7	Floor Panel*	$ 50.00	1	$ 50.00		$ -	
DA7	Door (Acrylic)*	$ 60.00	1	$ 60.00		$ -	
SPA7	Side Panels (Acrylic)*	$ 70.00	2	$ 140.00		$ -	
5967K840	Base Mounted Steel Ball B	$ 50.00	4	$ 200.00	$ 77.93	$ 311.72	
6280K761	Sprockets	$ 90.00	4	$ 360.00	$ 83.31	$ 333.24	
6660N250	AC Gear Motor (Lift)	$ 500.00	1	$ 500.00	$ 635.73	$ 635.73	
7728T560	Flanged-Mounted Ball B	$ 40.00	4	$ 160.00	$ 44.91	$ 179.64	
CB8	Core Buckets*	$ 25.00	25	$ 625.00		$ -	
RC8	ANSI Roller Chain #80	$ 50.00	2	$ 100.00		$ -	
EM8	Electric Motor (Lift)	$ 250.00	1	$ 250.00		$ -	
MM8	Motor Mount*	$ 55.00	1	$ 55.00		$ -	
SBB8	Shaft Bearing Bracket	$ 30.00	2	$ 60.00		$ -	
UpS8	Upper Shaft*	$ 35.00	1	$ 35.00		$ -	
LoS8	Lower Shaft*	$ 35.00	1	$ 35.00		$ -	
5706K12	Pulley	$ 70.00	2	$ 140.00	$ 88.55	$ 177.10	
B9	Belt	$ 50.00	1	$ 50.00		$ -	
59825K38	Conveyor Motor	$ 500.00	1	$ 500.00	$ 517.19	$ 517.19	
CF9	Conveyor Frame	$ 300.00	1	$ 300.00		$ -	
Sp9	Shaft for Pulley	$ 30.00	2	$ 60.00		$ -	
T9	Tensioner	$ 50.00	1	$ 50.00		$ -	
	Total:	**$ 4,195.00**		**$ 5,725.00**		**$ 2,394.57**	

Parts marked with (*) are based on material and labor cost.

Part marked with (**) is based on material and labor cost and an overall length required.

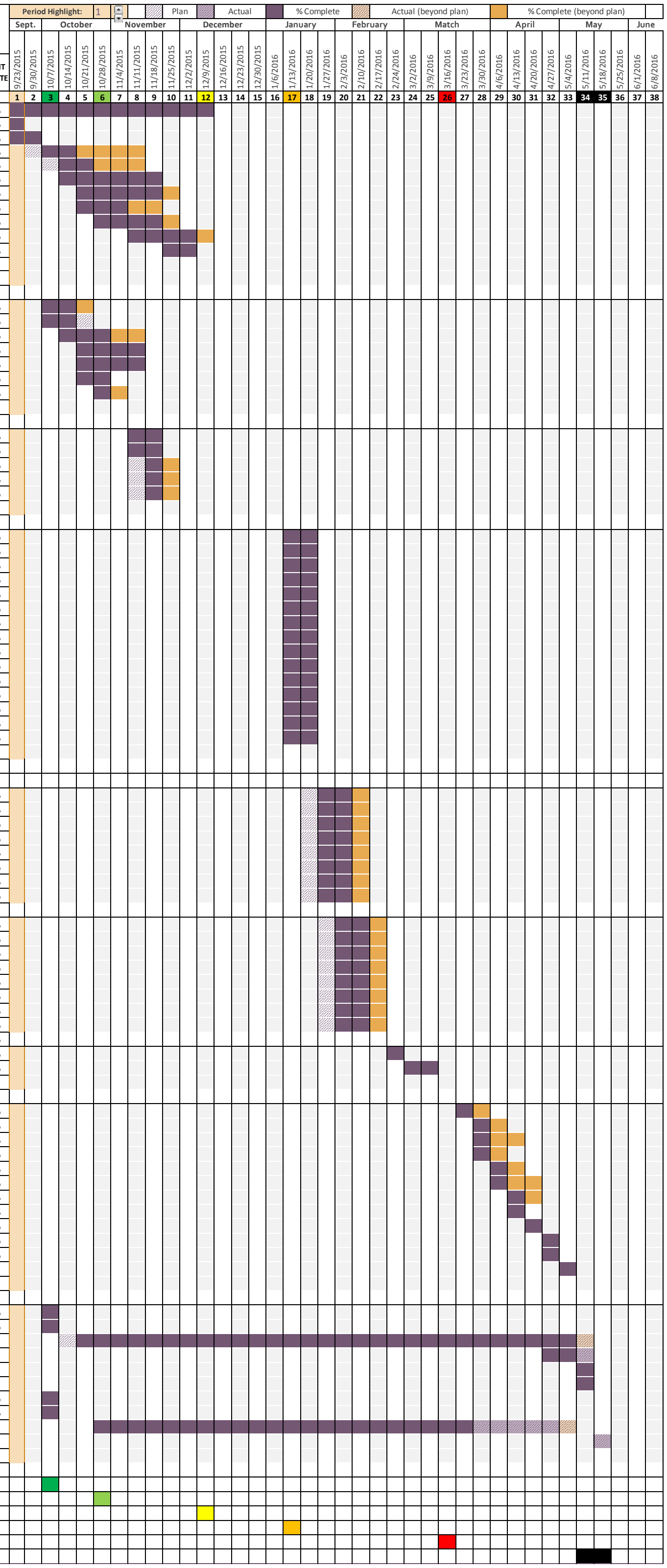
10th Scale

Budget - ($6.00/in^3)			
Component	**Quantity**	**Volume**	**Prize**
Reservoir	1	15.26	91.56
Lift	1	5.39	32.34
Buckets	10	0.21	1.26
Divider Sheet	1	0.84	5.04
Wheel Base Set up	4	0.08	0.48
	Total:	**21.78**	**130.7**

Appendix E – Schedule/Gantt Chart

Senior Project

<--Task ID	ACTIVITY	EST. TIME (HRS)	ACT. TIME (HRS)	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
	PERIODS							
1	**Proposal**			1	12	1	12	100%
1a	Problem Statement	2	1	1	1	1	1	100%
1b	Introduction	2	4	1	2	1	2	100%
1c	Design & Analysis	5	8	2	3	3	6	100%
1d	Methods & Contruction	6	5	3	3	4	5	100%
1e	Parts	7	14	4	6	4	6	100%
1f	Drawings	6	10	5	5	5	6	100%
1g	Testing Method	1.5	3	5	3	5	5	100%
1h	Budget	7	5	6	4	6	5	100%
1i	Schedule	7	10	8	4	8	5	100%
1j	Discussion	1	1	10	2	10	2	100%
1k	Conclusion, Acknowldgements and References	1	3					
	Subtotal	45.5	64					
2	**Analysis**							
2a	Core Reservoir Capacity	2	3	3	2	3	3	100%
2b	Reservoir Bending	1	1	3	3	3	2	100%
2c	Lift Chain Drive System	1.5	2	4	3	4	5	100%
2d	Equations of Equilibrium (Lift)	2	3	5	4	5	4	100%
2e	Reaction Forces on Lift Frame	2	4	5	4	5	4	100%
2f	Torsion on Lift Shaft	2	3	5	2	5	2	100%
2g	Tolerance	3	5	6	1	6	2	100%
	Subtotal	13.5	21					
3	**Documentation**							
3a	Resevoir Dimensions	5	10	8	2	8	2	100%
3b	Bucket Lift Dimensions	5	12	8	2	8	2	100%
3c	Conveyor Design	3	6	8	2	9	2	100%
3d	Improve Resevoir Dimensions	4	5	8	2	9	2	100%
3e	Improve Lift Dimensions	4	5	8	2	9	2	100%
	Subtotal	21	38					
4	**Part Construction**							
4a	Purchase all Materials Necessary for Frames	2	0	17	2	17	2	100%
4b	Source out Hydraulic Mount	1	0	17	2	17	2	100%
4c	Source out Agitator bracket	1	0	17	2	17	2	100%
4d	Source out Front Agitator Panel	1	0	17	2	17	2	100%
4e	Source out Agitator Panel	1	0	17	2	17	2	100%
4f	Source out Agitator Top cover	1	0	17	2	17	2	100%
4g	Source out Reservoir Back Panel	1	0	17	2	17	2	100%
4h	Source out under Door Panel	1	0	17	2	17	2	100%
4i	Soucre out Floor Panel	1	0	17	2	17	2	100%
4j	Source out Door and Side Panels for Reservoir	1	0	17	2	17	2	100%
4k	Source out Core Buckets	1	0	17	2	17	2	100%
4l	Source out Motor mount	1	0	17	2	17	2	100%
4m	Source out Shaft bearing bracket (Lift)	1	0	17	2	17	2	100%
4n	Source out lift shafts	1	0	17	2	17	2	100%
4p	Update Website	2	0	17	2	17	2	100%
	Subtotal	17	0					
5	**Assembly Construction**							
5a	Construct Core Reservoir							
5a-1	Weld Frame and Weld on Leg Base	8	0	18	3	19	3	100%
5a-2	Set and weld Reservoir Floor	1	0	18	3	19	3	100%
5a-3	Set and weld Under Door cover	0.5	0	18	3	19	3	100%
5a-4	Assemble and Install Agitator Door	3	0	18	3	19	3	100%
5a-5	Weld on Air Hydraylic Mount	0.5	0	18	3	19	3	100%
5a-6	Set and Weld Agitator Top Cover	1	0	18	3	19	3	100%
5a-7	Set and Weld Back Wall	1	0	18	3	19	3	100%
5a-8	Install Side Panels	2	0	18	3	19	3	100%
5b	Construct Bucket Lift							
5b-1	Weld Side legs to Bucket Frame	8	0	19	3	20	3	100%
5b-2	Install upper and lower shaft bearings	1	0	19	3	20	3	100%
5b-3	Install upper and lower shaft	1	0	19	3	20	3	100%
5b-4	Weld on Motor mount	1	0	19	3	20	3	100%
5b-5	Install Motor and Insert Shaft	2	0	19	3	20	3	100%
5b-6	Align Gears Two inches from bucket from	2	0	19	3	20	3	100%
5b-7	Attach Buckets to Chain	10	0	19	3	20	3	100%
5b-8	Install chain connections to gears	3	0	19	3	20	3	100%
5c	Construct Conveyor							100%
5c-1	Buy	0.5	0	23	1	23	1	100%
5d	Assemble for Main Assembly	10	0	24	2	24	2	100%
	Subtotal	55.5	0					
6	**Device Evaluation**							
6a	List Parameters	2	2	27	1	27	2	100%
6b	Desing Testing and Scope	4	3	28	1	28	2	100%
6c	Obtain Resources	3	2	28	1	28	3	100%
6d	Make Test Sheets	3	1	28	1	28	2	100%
6e	Plan Analysis	4	2	29	1	29	2	100%
6f	Test Plan	5	10	29	1	29	3	100%
6g	Device Testing	8	9	30	1	30	2	100%
6g-1	Test Core Reservoir	3	2	30	1	30	1	100%
6g-2	Test Lift	3	2	31	1	31	1	100%
6g-3	Test Conveyor	3	2	32	1	32	1	100%
6h	Take Testing Pictures and Video	3	2	32	1	32	1	100%
6i	Update Website	2	10	33	1	33	1	50%
	Subtotal	43	47					
7	**495A Deliverables**							
7a	Get Report Guide	0.25		3	1	3	1	100%
7b	Make Report Outline	3		3	1	3	1	100%
7c	Write Report	30		4	30	5	30	99%
7d	Make Presentation Outline	4		32	3	32	3	75%
7e	Create Presentation for Source	4		34	1	34	1	50%
7f	Practice Presentation	2		34	1	34	1	10%
7g	Make CD Deliverables List	3		3	1	3	1	100%
7h	Write 495A Deliverable on Paper	2		3	1	3	1	100%
7i	Update Website	4		6	27	6	28	80%
7j	Source Presentation	3		35	1	35	1	0%
	Subtotal	55.25	0					
	Project Milestones							
	Problem Go-noGo							
	Draft Proposal							
	Complete Proposal							
	Sumbit Updated Proposal							
	Complete Project Build and Submitted							
	Source							



Appendix F – Testing Report

Testing Report was done separately and will be included as is. ..\Senior Proj. Class III\Test Plan.docx.

TEST REPORT

For

PAPER CORE FEEDER

By

SERGIO FLORES VELEZ

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Testing Report

Introduction

<u>Original Design</u>

Testing the device will come in three different areas and then a final analysis. First we will test the core reservoir, then the bucket lift, and then the conveyor system. After testing each component separately they will be assembled for a final test inspection to check that the device can work as one.

Testing the core reservoir will consist of its capacity, bending due to weight, and if cores will move through the agitator door. The capacity of the reservoir will be a visual measurement. A pallet contains 525 paper cores, if dimensions and calculations were done as intended than the reservoir should not overflow. Bending due to weight will be measured when full assembly is in place. The height from the floor to the bottom beam of the reservoir will be measured with a measuring tape to the nearest eight or sixteenth. After the cores are put in, the same height will be measured again and based on deflection it will be compared to the predicted calculations.

Next, will be the testing of the lift. First we will check to see if it will be able to support the combined weight of the buckets and cores. Also visual inspection to check that buckets rotate around a large enough radius to avoid collision between buckets. Additional inspections will include bend radius of buckets and at what position cores roll off of the bucket down to the conveyor.

Similarly, the conveyor system will be a visual inspection of moving parts and clearance of gaps to avoid cores falling or jamming the conveyor. The selected conveyor will be a variable speed conveyor which will allow for adjustment depending on speed of film extruder. Ideally the output of the conveyor will be about 0:01:30 per 6 or 8 cores, but again it will depend on how fast the line will be ran at during each shift.

The Gantt chart on appendix B shows the tasks that will be done for testing.

<u>10th Scale</u>

Testing for the scale model will be similar to the original plan of the project.

Testing the core reservoir, will be the same as explained above. Bending due to weight of cores will not be a part of the testing for the scale model, being that it will be a small scale and the material of the reservoir will be of ABS plastic.

Testing the bucket lift will also be similar in the visual inspections. Mostly, it will be to see and assure that the system will rotate and lift buckets in a linear profile. This part of the model will also aid in assuring that the bucket bends are sufficient enough to keep the cores (straws in this case) inside the bucket.

The conveyor will also be similar to the original scale model. Visual inspection of the moving parts will be part of the testing as well as positioning of the conveyor by the bucket lift.

The Gantt chart on appendix b shows the tasks that will be done for testing, which will be replaced by the scale model.

Method/Approach

<u>Original Design</u>

Resources needed for the testing will be within the Paragon Warehouse.

Core reservoir testing will require a count of the total cores it will be able to hold. The total cores would be one pallet containing 525 cores. This does not include the cores already in the conveyor as the system is running. The actuator door and core drop will be controlled by pneumatic cylinders, so an air supply (already within the Warehouse) will be used.

For the core lift, preliminary testing will be done in SolidWorks to assure the lift rotates with no collision. Also bucket rotation and spacing to avoid bucket collision. On site testing will consist of visual and some mechanical inspection. If calculations were done correctly, the motor should be able to support and rotate without overworking.

The conveyor system that will be bought will have a variable speed adjuster. Preliminary testing will be done on sight and speed will be adjusted to keep the existing core bed full. Overfilling the bed will also be avoided. Ideally 6 to 8 core every 90 seconds, depending on what the line is being run at.

Data collection will occur at the time of testing for each of the sub-assemblies. Data sheets for the reservoir testing will be modeled through excel and pass fail checklists will also be modeled for each of the sub-assemblies.

<u>10th Scale</u>

For the tenth scale model an attempt will be made to reproduce the same testing for the actual system. Straws will be used to represent the paper cores. Being a tenth scale an estimated 55 to 60 straws, cut to length, will be used. Testing for core lift and conveyor would be visual. For the core lift core buckets, now 3D printed, will need to have enough radial space to assure that they will not collide. As for the conveyor, the actual one will be a variable controlled conveyor. The tenth scale replaced will also be variable controlled through the vex robotics cortex that has been built. Being a tenth scale model precision will not be much of a problem since most of the testing will be visual and timed. Data will be collected in sheets that will be made as the test is in process. It will be presented in sheet in excel and possible in charts to have a visual aid to show the discrepancies from the vex equipment.

Data collection will be similar to original specifications.

Test Procedure

<u>Original Design</u>

Core reservoir test: Visual and mechanical.

Unload one pallet, 525 cores, into the core reservoir and check in bin will carry all cores. Run the hydraulic cylinders and check for interference. Agitator door should lift far enough for cores to flow through.

Bucket Lift test: Visual and mechanical.

Power the motor and run the lift. Ensure that lift will carry all cores without dropping any. Check to see if core will roll off onto the conveyor belt.

Conveyor Test: Visual

Check that belt does not move form center. Conveyor belt should also rotate fast enough for the other cores to fall into without piling up.

<u>10th Scale</u>

The testing will be done in the senior project room from 11am to 12pm. The above tests will also be done for the 10^{th} scale model. The following steps will be taken for the each separate sub-assembly test. Straws will represent cores.

Core Reservoir Test:

For the core reservoir test the following will be needed: 525 straws cut to a length of ¾” with a radius of about 3/16”, Scale Reservoir with mini pneumatic cylinders connected and attached to Reservoir (including what came with Lego pneumatic kit, and camera to record observations. The sub-assembly should be constructed beforehand. Changes can be made to the amount of straws if necessary.

Steps

1. Pump enough air into the small white container with blue air pump to allow the pneumatic cylinders to extend and retract properly.
2. Extent and retract the agitator cylinder and core drop cylinder. Record any observations.
3. Fill reservoir with straws, do not allow any to flow through the agitator door. Record Observations
4. Extend agitator cylinder to allow straws to flow through. Record observations.
5. Adjust and repeat as many times needed for even flow of straws through agitator door.

Being that the test will be done with scale model, essentially no risk will be taken. Do be careful while connecting tubes to pneumatic cylinders and any other input or outlet of the Lego kit. Consider changing the amount of straws being cut.

Core Bucket Lift Test:

20. Have the following ready: 10th scale model set up, controller, cortex (should be attached to model base), extra batteries (optional), USB to controller cord, and full program (complete already, on USB Sony drive.). Make sure batteries are fully charged.
21. Open the RobotC program in computer.
22. Link Cortex and controller by turning both of them on. Note: program will run since it was downloaded to cortex beforehand also do not connect to desktop tower until system links.
23. Connect male end of USB cord into computer USB input and connect other end to controller program input.
24. Download program into cortex. (Done already)
25. Program should stop running once the program has been downloaded again.
26. Preload the lift scale model buckets with 2 straws for every bucket.
27. Read steps 9 through 13 before continuing.
28. Run program. Refer to check list, System Inspection and Data, for steps 10 through 12.
29. Assure that conveyor spins fast enough for next set of straws to drop in. Record data and other observations.
30. Check if straws miss or are close to missing the conveyor when they drop. Record data and other observations, if any.
31. Inspect lift for any interference and or clashes between moving and stationary parts.
32. After system inspection is complete stop program.
33. Load Lift buckets with straws again. Have a timer ready.
34. Rerun program.
35. After 8 straws have been dropped by the conveyor stop timer. Record time.
36. If at least 6 straws have not dropped off the conveyor within 10 seconds, change the speed of the conveyor and/or lift on the program code through the RobotC program.
37. Repeat as necessary until desired straws have been reached.
38. After speed has been set, repeat steps and time for 6 straws and 8 straws to check for consistency.

Being that the test will be done with scale model, essentially no risk will be taken. Battery changes will have to be made if consistency of the conveyor and motor is declining (triple A batteries). As far as safety goes, avoiding putting your finger in any gap that has moving parts to avoid pinching. To add, do not change code unless supervised by the author of the code.

Conveyor Test:

Conveyor test will be similar to bucket lift test since both were programmed at the same time with the RobotC program.

1. Have the following ready: 10th scale model set up, controller, cortex (should be attached to model base), extra batteries (optional), USB to controller cord, and full program (complete already, on USB Sony drive.). Make sure batteries are fully charged.
2. Open the RobotC program in computer.
3. Link Cortex and controller by turning both of them on. Note: program will run since it was downloaded to cortex beforehand also do not connect to desktop tower until system links.
4. Connect male end of USB cord into computer USB input and connect other end to controller program input.
5. Download program into cortex. (Done already)
6. Program should stop running once the program has been downloaded again.
7. Preload the lift scale model buckets with 2 straws for every bucket.
8. Read steps 9 through 13 before continuing.
9. Run program. Refer to check list, System Inspection and Data, for steps 10 through 12.
10. Assure that conveyor spins fast enough for next set of straws to drop in. Record data and other observations.
11. Check if straws miss or are close to missing the conveyor when they drop. Record data and other observations, if any.
12. Inspect lift for any interference and or clashes between moving and stationary parts.
13. After system inspection is complete stop program.
14. Load Lift buckets with straws again. Have a timer ready.
15. Rerun program.
16. After 8 straws have been dropped by the conveyor stop timer. Record time.
17. If at least 6 straws have not dropped off the conveyor within 10 seconds, change the speed of the conveyor and/or lift on the program code through the RobotC program.
18. Repeat as necessary until desired straws have been reached.
19. After speed has been set, repeat steps and time for 6 straws and 8 straws to check for consistency.

Being that the test will be done with scale model, essentially no risk will be taken. Battery changes will have to be made if consistency of the conveyor and motor is declining (triple A batteries). As far as safety goes, avoiding putting your finger in any gap that has moving parts to avoid pinching. To add, do not change code unless supervised by the author of the code.

Deliverables

Original Design

Core reservoir holds 525 cores.
Agitator door allows flow of cores.
No interference between moving parts on core bucket.

Lift rotates and pauses correctly for cores to drop in.
Buckets do not collide.
No interference between moving parts.

Conveyor speed is set to have at least 6 coress go off the conveyor.

Results and documentation sheets will be given in appendix A and B.

10th Scale

Core reservoir holds 10% of the actual cores.
Agitator door allows flow of cores.
No interference between moving parts on core bucket.

Lift rotates and pauses correctly for cores to drop in.
Buckets do not collide and do not drop cores prematurely.
No interference between moving parts.

Conveyor speed is set to have at least 6 straws go off the conveyor. Procedure checklists will be in appendix C.

The data from table 1 is the recorded times and inspection comments for each test. As explained from previous test instructions, the lift and the conveyor are similar due to the fact that they both had to be programmed together through RobotC. Each test was done separately and accordingly to assure that each part and parameter was checked. A checklist was made for the conveyor along with the lift. A data sheet with different trials was also created for the time depending on how many cores were transferred down the conveyor.

After testing, a couple things were added to the system. First, the cylinder for the agitator door would travel to far back, so some stops (nuts) were epoxied to the reservoir. Same with the core drop cylinder. It would retract to far back, and when it would extend it would push against the core drop instead of rotating. Stops were also added to the steps that hold the core drop.

For the conveyor, extra vex parts were bolted on. Initially, two small plates were bolted on to act as guards for the straws but they were not sufficient. An extra longer piece was bolted to prevent the straws from sliding under the conveyor belt. Also, a thin piece was added to the lift side of the conveyor to cover the gap that also allowed the straws to get stuck. The clearance of the conveyor slides to the buckets is very tight, so no adjustment were made to the part of the system.

From table 1, the times for 6 cores was sufficient and below the required time. For 8 cores the time was above the required time. The original design would require an average time of about 90 seconds. For the 10th scale model that would amount to about 9 seconds plus or minus 2 seconds. The average for the six cores is 7.37 seconds. The average for 8 cores is 11.96 seconds. Both of these times would improve the employees time spent manually putting cores onto the bed.

System Inspection and Data		
Operation/Task	**Pass**	**Fail**
Conveyor Speed	√	
Notes: Conveyor speed is adjusted enough to allow the straws to avoid colliding with the next pair. Could be ajusted to fit the needs of production. Conveyor speed was adjusted prior to testing on the RobotC program, as well as lift. They should be the same for all tests.		
Cores Drop into Conveyor	√	
Notes: Cores do drop into conveyor. Adjustments had been made, prior to testin, to avoid contact with the core buckets and the conveyor slide. Conveyor could be adjustment higher so straws do not bounce, but collision with buckets could result in doing so.		
Interference/Clash	√	
Notes: No interference or collisions detected. Enough spacing on left and right of chain lift with buckets. Idler was added, prior to testing, since chain links were loose. Conveyor is also free of interference, more components were added since straws would get stuck or go under conveyor.		
Bucket Clearance	√	
Notes: Buckets clear beyond expected point. Could improve on bucket desing and size if necessary. Lift height could also be improved to provide more clearance on bottom end of the rotation of the buckets.		

Core Data/Coveyor					
Trial	**Number of Cores**	**Conveyor Speed**	**Lift Speed**	**Time**	**Comments**
1	6	48	45	7.93s	Time was started when the first pair of cores dropped onto conveyor. Used the lap time timer to get both elapsed times.
2	6	48	45	6.81s	
3	6	48	45	7.37s	
1	8	48	45	10.71s	
2	8	48	45	13.65s	
3	8	48	45	11.52s	

Reservoir			
Objective	**Pass**	**Fail**	**Comments**
Hold 525 Cores	√		Calculations were made for the amount of cores that were needed. Calculations do have discrepensies since straws are not exactly 1/10th of actual sized cores. Need more pressure in tank for core drop cylinder, the core drop has friction causing the cylinder to not work efficiently.
Agitator door cylinder	√		
Agitator door holds straws	√		
Agitator door allows flow	√		
Core drop cylinder	√		
Core Drop	√		
Moveable	√		

Table 1: Test Data

Appendix A – Data Forms

System Inspection and Data		
Operation/Task	**Pass**	**Fail**
Conveyor Speed		
Notes:		
Cores Drop into Conveyor		
Notes:		
Interference/Clash		
Notes:		
Bucket Clearance		
Notes:		

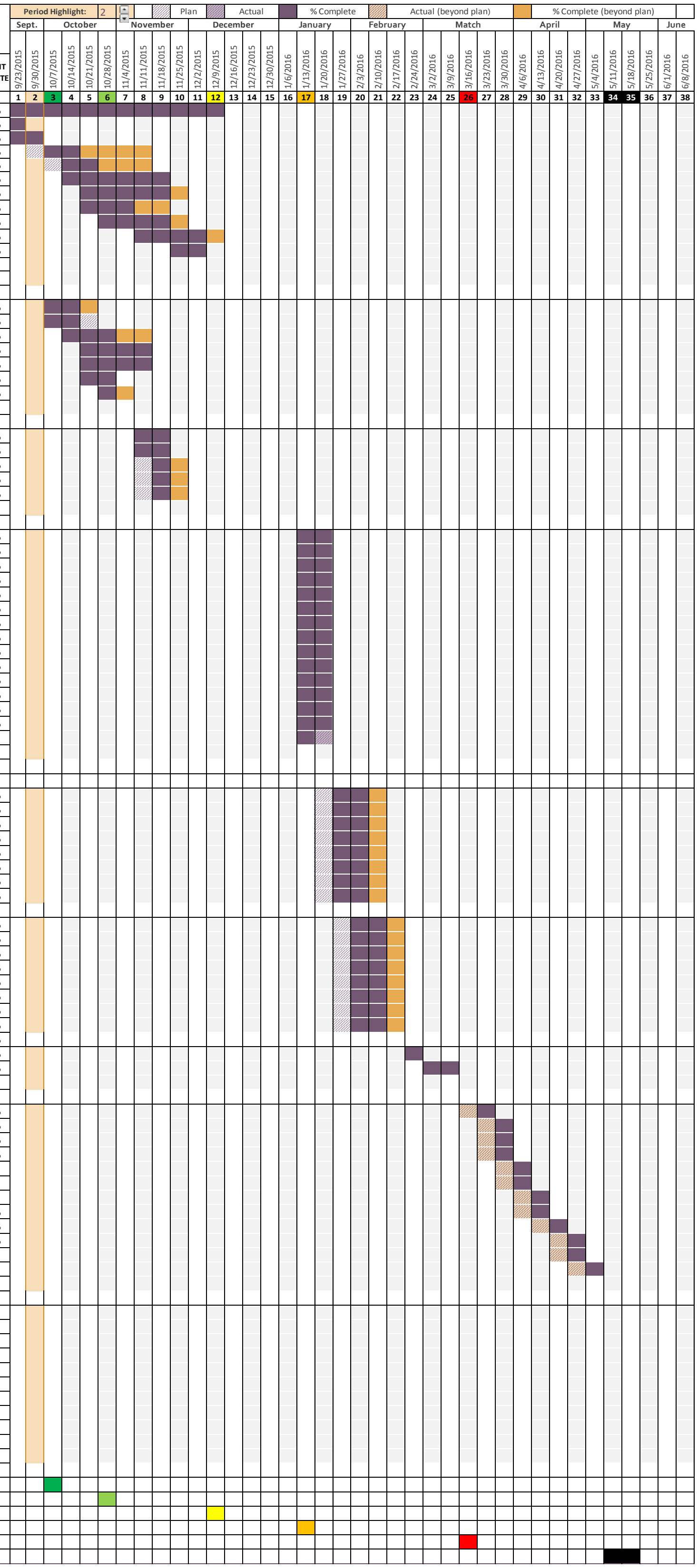
Core Data/Coveyor					
Trial	**Number of Cores**	**Conveyor Speed**	**Lift Speed**	**Time**	**Comments**
1	6				
2	6				
3	6				
4	8				
5	8				
6	8				

Reservoir			
Objective	**Pass**	**Fail**	**Comments**
Hold 525 Cores			
Agitator door cylinder			
Agitator door holds straws			
Agitator door allows flow			
Core drop cylinder			
Core Drop			
Moveable			

Appendix B – Gannt Chart

Senior Project

<--Task ID	ACTIVITY	EST. TIME (HRS)	ACT. TIME (HRS)	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
	PERIODS							
1	**Proposal**			1	12	1	12	100%
1a	Problem Statement	2	1	1	1	1	1	100%
1b	Introduction	2	4	1	2	1	2	100%
1c	Design & Analysis	5	8	2	3	3	6	100%
1d	Methods & Contruction	6	5	3	3	4	5	100%
1e	Parts	7	14	4	6	4	6	100%
1f	Drawings	6	10	5	5	5	6	100%
1g	Testing Method	1.5	3	5	3	5	5	100%
1h	Budget	7	5	6	4	6	5	100%
1i	Schedule	7	10	8	4	8	5	100%
1j	Discussion	1	1	10	2	10	2	100%
1k	Conclusion, Acknowldgements and References	1	3					
	Subtotal	45.5	64					
2	**Analysis**							
2a	Core Reservoir Capacity	2	3	3	2	3	3	100%
2b	Reservoir Bending	1	1	3	3	3	2	100%
2c	Lift Chain Drive System	1.5	2	4	3	4	5	100%
2d	Equations of Equilibrium (Lift)	2	3	5	4	5	4	100%
2e	Reaction Forces on Lift Frame	2	4	5	4	5	4	100%
2f	Torsion on Lift Shaft	2	3	5	2	5	2	100%
2g	Tolerance	3	5	6	1	6	2	100%
	Subtotal	13.5	21					
3	**Documentation**							
3a	Resevoir Dimensions	5	10	8	2	8	2	100%
3b	Bucket Lift Dimensions	5	12	8	2	8	2	100%
3c	Conveyor Design	3	6	8	2	9	2	100%
3d	Improve Resevoir Dimensions	4	5	8	2	9	2	100%
3e	Improve Lift Dimensions	4	5	8	2	9	2	100%
	Subtotal	21	38					
4	**Part Construction**							
4a	Purchase all Materials Necessary for Frames	2	0	17	2	17	2	100%
4b	Source out Hydraulic Mount	1	0	17	2	17	2	100%
4c	Source out Agitator bracket	1	0	17	2	17	2	100%
4d	Source out Front Agitator Panel	1	0	17	2	17	2	100%
4e	Source out Agitator Panel	1	0	17	2	17	2	100%
4f	Source out Agitator Top cover	1	0	17	2	17	2	100%
4g	Source out Reservoir Back Panel	1	0	17	2	17	2	100%
4h	Source out under Door Panel	1	0	17	2	17	2	100%
4i	Soucre out Floor Panel	1	0	17	2	17	2	100%
4j	Source out Door and Side Panels for Reservoir	1	0	17	2	17	2	100%
4k	Source out Core Buckets	1	0	17	2	17	2	100%
4l	Source out Motor mount	1	0	17	2	17	2	100%
4m	Source out Shaft bearing bracket (Lift)	1	0	17	2	17	2	100%
4n	Source out lift shafts	1	0	17	2	17	2	100%
4p	Update Website	2	0	17	2	17	2	50%
	Subtotal	17	0					
5	**Assembly Construction**							
5a	Construct Core Reservoir							
5a-1	Weld Frame and Weld on Leg Base	8	0	18	3	19	3	100%
5a-2	Set and weld Reservoir Floor	1	0	18	3	19	3	100%
5a-3	Set and weld Under Door cover	0.5	0	18	3	19	3	100%
5a-4	Assemble and Install Agitator Door	3	0	18	3	19	3	100%
5a-5	Weld on Air Hydraylic Mount	0.5	0	18	3	19	3	100%
5a-6	Set and Weld Agitator Top Cover	1	0	18	3	19	3	100%
5a-7	Set and Weld Back Wall	1	0	18	3	19	3	100%
5a-8	Install Side Panels	2	0	18	3	19	3	100%
5b	Construct Bucket Lift							
5b-1	Weld Side legs to Bucket Frame	8	0	19	3	20	3	100%
5b-2	Install upper and lower shaft bearings	1	0	19	3	20	3	100%
5b-3	Install upper and lower shaft	1	0	19	3	20	3	100%
5b-4	Weld on Motor mount	1	0	19	3	20	3	100%
5b-5	Install Motor and Insert Shaft	2	0	19	3	20	3	100%
5b-6	Align Gears Two inches from bucket from	2	0	19	3	20	3	100%
5b-7	Attach Buckets to Chain	10	0	19	3	20	3	100%
5b-8	Install chain connections to gears	3	0	19	3	20	3	100%
5c	Construct Conveyor							100%
5c-1	Buy	0.5	0	23	1	23	1	100%
5d	Assemble for Main Assembly	10	0	24	2	24	2	100%
	Subtotal	55.5	0					
6	**Device Evaluation**							
6a	List Parameters	2		27	1	27		100%
6b	Desing Testing and Scope	4		28	1	28		100%
6c	Obtain Resources	3		28	1	28		100%
6d	Make Test Sheets	3		28	1	28		100%
6e	Plan Analysis	4		29	1	29		95%
6f	Test Plan	5		29	1	29		95%
6g	Device Testing	8		30	1	30		95%
6g-1	Test Core Reservoir	3		30	1	30		100%
6g-2	Test Lift	3		31	1	31		100%
6g-3	Test Conveyor	3		32	1	32		100%
6h	Take Testing Pictures and Video	3		32	1	32		25%
6i	Update Website	2		33	1	33		50%
	Subtotal	43	0					
7	**495A Deliverables**							
7a	Get Report Guide	0.25						
7b	Make Report Outline	3						
7c	Write Report	30						
7d	Make Presentation Outline	4						
7e	Create Presentation for Source	4						
7f	Practice Presentation	2						
7g	Make CD Deliverables List	3						
7h	Write 495A Deliverable on Paper	2						
7i	Update Website	4						
7j	Source Presentation	3						
	Subtotal	55.25	0					
	Project Milestones							
	Problem Go-noGo							
	Draft Proposal							
	Complete Proposal							
	Sumbit Updated Proposal							
	Complete Project Build and Submitted							
	Source							



Appendix C – Procedure Checklist

Core Reservoir:

- ☐ Pump enough air into the small white container with blue air pump to allow the pneumatic cylinders to extend and retract properly.
- ☐ Extent and retract the agitator cylinder and core drop cylinder. Record any observations.
- ☐ Fill reservoir with straws, do not allow any to flow through the agitator door. Record Observations
- ☐ Extend agitator cylinder to allow straws to flow through. Record observations.
- ☐ Adjust and repeat as many times needed for even flow of straws through agitator door.

Lift/Conveyor:

- ☐ Have the following ready: 10^{th} scale model set up, controller, cortex (should be attached to model base), extra batteries (optional), USB to controller cord, and full program (complete already, on USB Sony drive.). Make sure batteries are fully charged.
- ☐ Open the RobotC program in computer.
- ☐ Link Cortex and controller by turning both of them on. Note: program will run since it was downloaded to cortex beforehand also do not connect to desktop tower until system links.
- ☐ Connect male end of USB cord into computer USB input and connect other end to controller program input.
- ☐ Download program into cortex. (Done already)
- ☐ Program should stop running once the program has been downloaded again.
- ☐ Preload the lift scale model buckets with 2 straws for every bucket.
- ☐ Read steps 9 through 13 before continuing.
- ☐ Run program. Refer to check list, System Inspection and Data, for steps 10 through 12.
- ☐ Assure that conveyor spins fast enough for next set of straws to drop in. Record data and other observations.
- ☐ Check if straws miss or are close to missing the conveyor when they drop. Record data and other observations, if any.
- ☐ Inspect lift for any interference and or clashes between moving and stationary parts.
- ☐ After system inspection is complete stop program.
- ☐ Load Lift buckets with straws again. Have a timer ready.
- ☐ Rerun program.
- ☐ After 8 straws have been dropped by the conveyor stop timer. Record time.
- ☐ If at least 6 straws have not dropped off the conveyor within 10 seconds, change the speed of the conveyor and/or lift on the program code through the RobotC program.
- ☐ Repeat as necessary until desired straws have been reached.
- ☐ After speed has been set, repeat steps and time for 6 straws and 8 straws to check for consistency.

Appendix G – Vita

Sergio Flores Velez

◆ 1301 Canal Ave. ◆ Tieton, WA. 98947 ◆ (509) 930-7850 ◆ floress@cwu.edu

◆ https://www.linkedin.com/in/sergiofloresvelez

Objective

Develop my skills in an entry level position, and gain experience that could develop my career, while serving in a growth oriented company that will offer diverse job responsibilities in mechanical engineering.

Education

Bachelor of Science Degree in Mechanical Engineering Technology **2009- Present**
Specialization: Manufacturing

Completed Coursework: Basic Electricity, Basic Electronics, Metallurgy, Machining, Advanced Machining, Statics, Strength of Materials, Mechanical Desing I and Mech. Design II, 3D-Modeling and Advanced 3D-modeling, CAD/CAM, Thermodynamics, Fluid Dynamics, Plastics and Composites, Hydraulics and Pneumatics, Quality Control, and Production Technology/Lean Manufacturing.

Bachelor of Arts in Spanish **2009-2014**
CENTRAL WASHINGTON UNIVERSITY- ELLENSBURG, WA
GPA: 3.2

Employment History

12/2015-Present- PARAGON FILMS – Inter
Union Gap, WA
Duties: Design and Manufacture safety fences for lines and base brackets to bolt to concrete. Assisted with and Designed systems for future improvements.

7/2015-9/2015- PARAGON FILMS – Summer Help
Union Gap, WA
Duties: Boxed and packaged rolls of machine and hand films. Did quality checks constantly.

6/2012-9/2012- ARON VILLEGAS CONSTRUCTION CO.- Laborer
Esparto, CA
Duties: Set up equipment, cut wood according to plans, put siding on houses, painted inside and outside of houses, roofing, and general residential construction practices.

Skills Summary

- Bilingual (Spanish/English)
- Computer Programs: AutoCad, Solid Works, and Microsoft Office

Organizations and Certifications

- American Society of Mechanical Engineers (ASME) Club Member
- SolidWorks Association - Mechanical Design Certification