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UNIVERSITY OF MANITOBA

FIXTURE DESIGNS FOR A TWO-TRACK CANTILEVER TOWER ASSEMBLY

Final Design Report

Modern Manufacturing Ltd.

MECH 4860: Engineering Design

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December 5, 2018

Acknowledgements

We would like to take this opportunity to express our sincerest gratitude to the individuals involved in the success of our capstone thesis.

We want to start off by thanking Modern Manufacturing Ltd. for providing us the opportunity to work on this project.

We want to thank our project advisor, Jim Sykes, for providing your time and your patience, and for listening to our concerns to which you provided guidance. Your instruction was vital to the success of this project. Thanks for your care over the semester long project.

Thank you Dr. Paul Labossiere for listening to our concerns to which you provided your insight and guidance. Thanks for sharing your knowledge and expertise over the semester, it was truly beneficial.

We would also like to thank Aidan Topping for being a part of the report evaluation process. Your knowledge and expertise helped our report become more organized and accessible. Your insight always improved our report. Thank you, Aidan.

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December 5th, 2018

Dr. Paul E. Labossiere, P.Eng.,
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Dear Paul Labossiere,

Team 3 is submitting to you our report entitled "Final Design Report – Two-Track Cantilever Tower Assembly Fixture Designs" on this Wednesday, December 5th, 2018.

Modern Manufacturing Ltd. (MML) has come to us to solve two key issues involved with fabrication of the two-track cantilever tower support structures. The design solutions must improve the present method of locating the gussets on the assemblies, and allow for the maneuverability of the support structures during fabrication.

Team 3 developed two design solutions, the gusset locator and trunnion, to which improve MML's assembly process of the two-track cantilever support structures. The gusset locator provides a means to efficiently and accurately locate the gussets on the support structure assemblies. The trunnion allows for the maneuvering of the sub-assemblies during fabrication.

This report begins with an introduction focusing on the project background, objectives, client-defined deliverables, constraints and limitations related to the project, customer needs and specifications, and then a brief statement on concept development used in the final design report mentioning the aspects of past concepts that were integrated into the final fixture designs. This is followed by the gusset locator and trunnion design sections. The details of design, method of operation, and a cost analysis are provided. Finally, a conclusions and recommendations section outlines how the final fixture designs satisfy the customer needs and potential design aspects that improve the overall functionality. A more detailed cost analysis and technical drawings are contained in the appendix of the report.

Please contact any member of Team 3 if you have any comments, questions or concerns you would like to express.

Yours Truly,

Justin Ilnisḱy	Simon Mitchell	Chris Kemp	Afzal Habib
Project Manager	Project Secretary	Project Member	Project Member

Executive Summary

Modern Manufacturing Limited (MML) is a railway communication equipment manufacturer who approached Team 3 with two issues regarding the assembly processes of a two track cantilever support structure. The issues MML are currently facing emphasize the large amounts of manual labor and slow throughput time of the fabrication of a cantilever support structure. Two design areas were identified, to which Team 3 provided MML with separate solutions to both of the areas. The two designs Team 3 created were the gusset locator and the trunnion.

The gusset locator is a fixture designed to locate and hold gussets on the cantilever support structure in place for the welders during the early stages the tower's fabrication. The gusset locator utilizes two laser measurement devices to position the fixture within the required tolerance of ±0.06in. The fixture is made primarily out of aluminum plate, in order to prevent any cross contamination between materials upon contact with the support structure during welding. The gusset locator has ergonomically incorporated low friction material strips that come into contact with the support structure, as to reduce the amount of effort required to move this fixture from one gusset location to the next.

The trunnion is a rotational mechanism which is used to hold the cantilever support structure horizontally and allow it to rotate during the final stages of fabrication. The trunnion is composed of three main components: the support structures, the mounting brackets, and the rotational driving components. The mounting brackets are the elements that position and secure the sub-assemblies of the cantilever support structure relative to one another. These mounting brackets provide the connection point to the two shafts, which are mounted on top of the support structures. One support structure is fixed to the ground and houses a gearbox to provide the necessary means of rotating the structure. The other support structure is mounted on casters, providing it the ability to move into position during installation of the cantilever support structure into the trunnion.

The team successfully delivered the designs of the gusset locator and the trunnion to the client, MML. The estimated cost of the two designs approached $27,000 CAD, satisfying the budget proposed by the client of $43,000.

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1 Introduction

Modern Manufacturing Ltd. (MML) has tasked Team 3 with creating preliminary designs of a set of fixtures to aid in the fabrication of a cantilever support structure. These include a fixture to locate gussets and a mechanism to rotate the structure during fabrication. This report outlines the details of each preliminary design.

1.1 Project Background

MML designs and manufacturers signal structures for railways across North America [1]. The signal structures contain two sub-assemblies: the support structure and the cantilever structure (Figure 1).

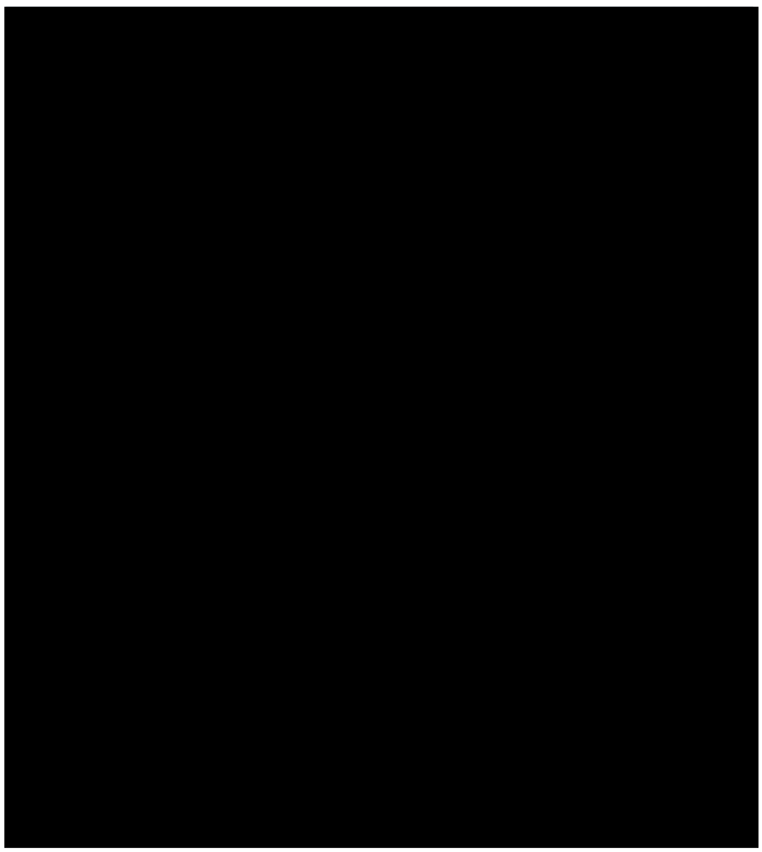

Figure 1: Two-track cantilever tower [1]

The two structures are manufactured separately and connected once the structures are fabricated. This project focuses on the manufacturing of the support structure for the two-track cantilever tower (Figure 2).

Figure 2: Cantilever support structure indicating key components [2]

The main components of the support structure are indicated in Figure 2 and currently assembled according to the following steps.

1. Base plate and support gussets are welded on the support members
2. Two support members are oriented by a fixture
3. Gusset locations are measured and welded to the support members
4. Truss members are welded on gussets
5. Steps 1 to 4 repeated for second sub-assembly
6. Two sub-assemblies are co-located and oriented by a fixture
7. Gusset locations are measured and welded to sub-assemblies
8. Truss members between sub-assemblies are welded on gussets

Team 3 has been tasked with solving two key issues with the assembling and welding process for the support structure. The first issue involves installing the gussets on the main support member during step 3. Currently, each gusset is manually measured before welding, which is a time consuming and inaccurate process. This method often leads to rework, as the gussets might not be oriented properly, or are out of positional tolerance. The second issue MML encounters is the manoeuvrability of the support structure during assembly steps 6-8. Manoeuvring refers to the rotation of the structure (Figure 3) to allow the welders access to all required weldment locations. Currently, crane hoists are used to slowly raise one side of the structure to allow it to rotate onto a desired side.

[redacted]

Figure 3: Axis of rotation during fabrication [2]

1.2 Objectives

The designs created for the gusset locator and rotational mechanism must satisfy the following objectives, as specified by the client:

1. Increase the efficiency and accuracy of measuring and locating each gusset along the four support members.
2. Enable the rotation of the support structure during its assembly process to allow for better access to welding locations.

1.3 Deliverables

In addition to the course requirements, MML requires a certain set of deliverables for the preliminary design of the gusset locator and rotation mechanism. A list of the client deliverables pertinent to the success of the project are provided:

- Gusset locator CAD models
- Gusset locator technical drawings
- Rotation mechanism CAD models
- Rotation mechanism technical drawings
- Bill of materials
- Cost breakdown of fixtures

1.4 Constraints and Limitations

Constraints and limitations were defined in the initial stages to ensure the success of the project. Identified were the cost, building material, accessibility and size. The cost of the two fixtures must not exceed the budget of $70,000 provided by MML. The material used to fabricate the two fixtures must not contaminate the two sub-assemblies of the cantilever support structure. The accessibility of the welding points must remain open and accessible during the assembly process. The size of the two fixtures must retain a minimal footprint on the shop floor at the MML facility.

1.5 Needs and Specifications

The gusset locator is to be designed to decrease the amount of manual measurement and reduce the time taken by the workers to fabricate the sub-assemblies of the cantilever support structure. The gussets must be located within the allowable tolerance of +/- 0.06in. The gussets must also be held rigidly in place with the gusset locator during assembly. The rotational mechanism must allow for easy installation of the sub assemblies, and provide access to all welding points once installed. In return, the simplified process of welding the support structure will decrease the total production time. Both designs must address proper safety and risk mitigation, as well as maintaining an ergonomic design.

1.6 Final Design Concept Integration

Features incorporated into the gusset locator design used ideas generated during the concept development stage of the project. The design to incorporate vertical and horizontal gussets simultaneously was derived from the recessed cavity gusset locator [Appendices C]. The adjustability aspect of the gusset locator was inspired by the flexibility of the spring alignment fixture [Appendices C].

The final mounting bracket concept, the circular end plates [Appendices C], were initially examined to reveal that there was a minimal amount of stress flowing through the outer diameter of the circular geometry. The final design of the mounting brackets evolved to account for this finding. As for the support structure mounting and mobility, the indexing pins with recessed holes concept [Appendices C] was later determined to be an insufficient means of location. The client recommended to have the mobile support structure guided in and out of position via a ground mounted track. The rest of the trunnion was designed off the final trunnion concept developed.

2 Gusset Locator Design

The gusset locator is a welding fixture used to assist in installing the gussets on the support members of each subassembly. There are two support members on each subassembly that require vertical and horizontal gussets. The fixture rests on top of the two members and can be moved to different gusset locations (Figure 4).

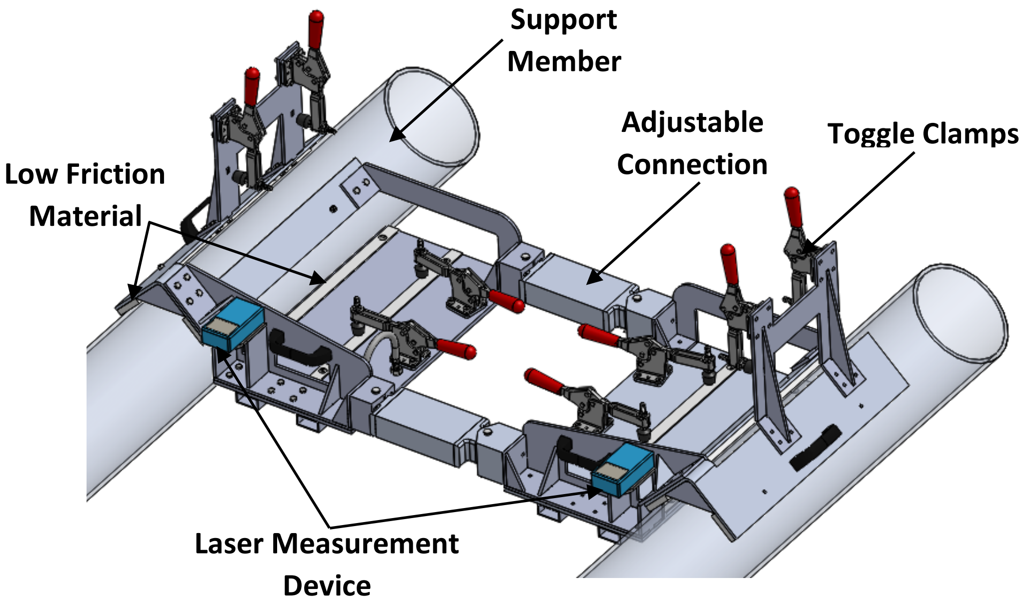

Figure 4: Final gusset locator design with main components identified

Low friction material is used at two locations to minimize the force required to move the gusset locator to different points (Figure 4). Each location is determined using laser measurement devices located on each side of the assembly. Two measurement devices are required as each side of the fixture is independent due to the adjustable connection. This is to accommodate for warpage in the support members which causes deviations in the distance and angle between each side. Toggle clamps are used to hold the gussets rigid during the welding procedure.

The gusset locator is primarily designed out of 0.25in 6061-T6 Aluminum. The client requested this as they had a concern of steel contaminating the aluminum support structure during the welding procedure. A thickness of 0.25in was used to make it durable and allow MML to use their own laser cutter to manufacture all the piece parts and fabricate the assembly in house. The design consists of welded sub assemblies that are bolted together. The welded parts have notches to assist with assembly.

2.1 Details of Design

Detailed preliminary drawings for all assemblies and parts for the gusset locator are in Appendices D.

2.1.1 Laser Measuring Device

The measuring device sourced for the gusset locator is the Bosch GLR 825 Laser distance measurer [3]. It satisfied the following requirements required for the gusset locator application.

- Accuracy less then ±0.06 in
- Range greater then 32 ft
- Continuous measurement
- Portable
- Mounting capability
- Durable
- Battery powered

Specifications, maintenance and an image of the device can be viewed in Appendices A. Note that the device uses a class 2 laser and should not be directed into the eye of any individual as it can lead to permanent eye damage or blindness [3]. To install the device on the gusset locator, a 1/4in – 20 thread hole is utilized. The hole is located in the centre on the rear of the device and is attached to the gusset locator by a thumb screw for easy adjustment and removal (Figure 5).

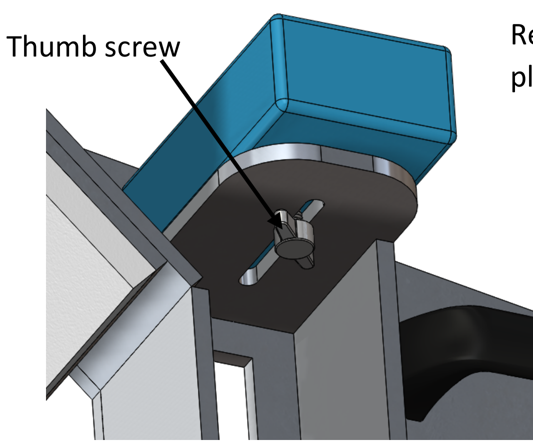

Figure 5: GLR 825 mounted to gusset locator

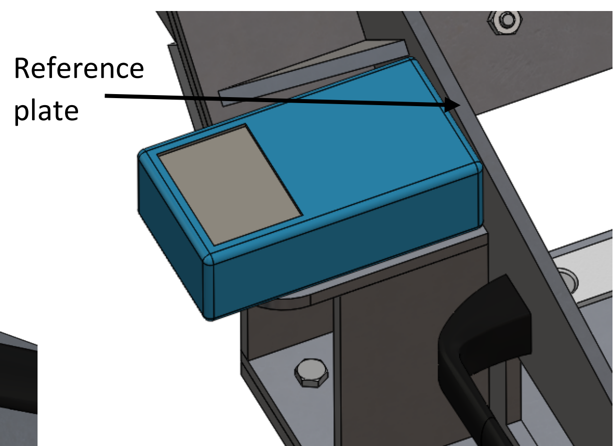

Figure 6: GLR 825 flush against reference plate

When installing the device on the gusset locator, careful attention must be payed to ensure the base of the device is flush against the reference plate (Figure 6). If this is not achieved, the dimensions in prescribed for each gusset location will be incorrect. Ensure the device is programed to measure from the base of the device as the measuring distance is there to the top of the base plate (Figure 7).

Figure 7: Laser measuring reference points

2.1.2 Adjustable Connection

The connection between the left and right side of the gusset locator can not be solid due to possible warpage of the support members it rests upon. It must allow for the distance and angle between each side of the gusset locator to change. The design created for the cross connection was based off a clevis bracket with a pin [4]. It is a common practice to use pins in joints instead of bolts and bushings as it allows for easy installation, replacement, and a tight tolerance joint [5]. The final connection design consists of four components (Figure 8). The fit at each of the joints and pin is specified to be a RC 4 close running fit to minimize play but still allow movement [6].

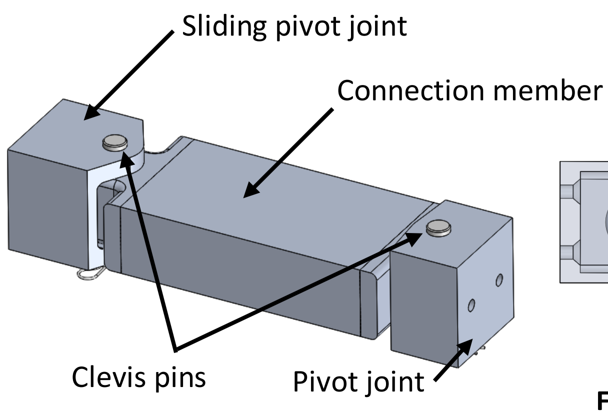

Figure 8: Cross connection assembly

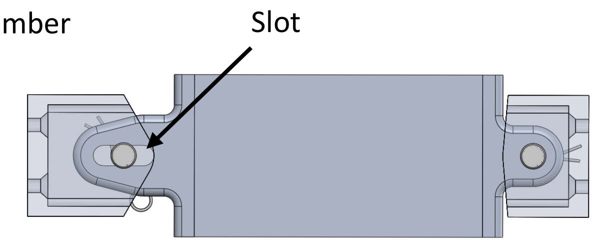

Figure 9: Top view of cross connection assembly

The pivot joint allows for only rotational motion at the clevis pin, while the sliding pivot connection allows for rotational and linear motion with the use of a slot at the connection point. The assembly limits ±5° of rotation and ±0.5 inches of linear motion at the joints allowing each side adequate adjustment to accommodate for support member warpage (Figure 10). Note the exact extent of warpage could not be provide by the client.

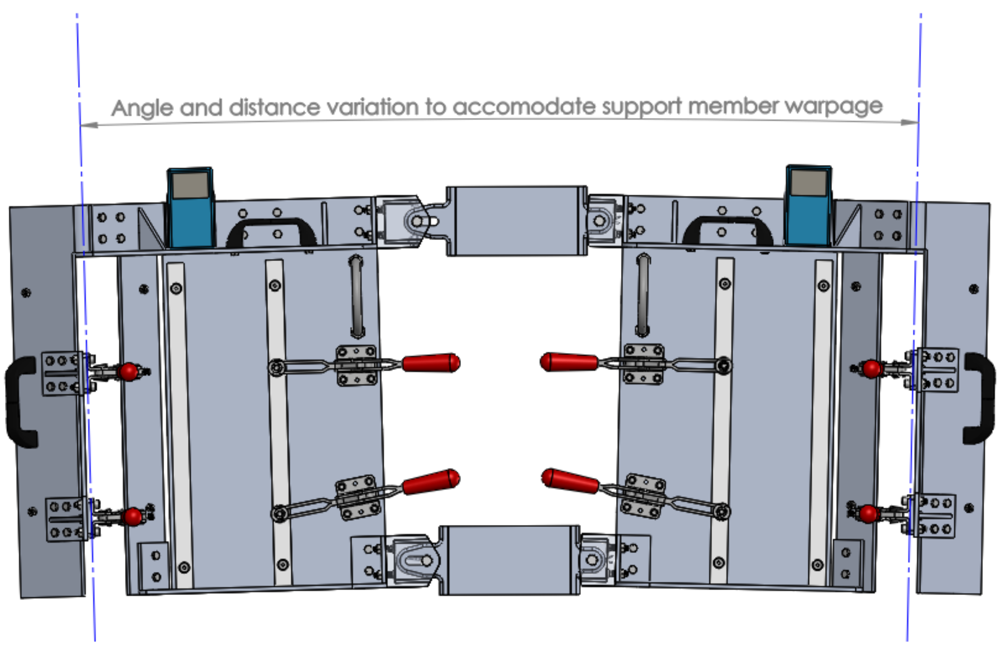

Figure 10: Angle and distance adjustability to accommodate for support member warpage

2.1.3 Low Friction Material

PTFE is used at certain locations on the gusset locator to minimize friction and aid in maneuvering the fixture to different locations along the support members. The material has the following specifications that meet the needs of the gusset locator.

- Low coefficient of friction
- Sufficient wear properties
- Adequate hardness

- High temperature resistance

Compared to other plastics, PTFE best overall satisfied the above requirements, other materials considered can be viewed in Appendices A of the report. It has one of the lowest friction coefficients of any other industrial plastic available, minimizing the force required to push/pull the structure [7]. The locations of the PTFE strips on the gusset locator are at the points of contact with the support member and beneath the horizontal gussets (Figure 11).

Figure 11: Points on gusset locator where low friction material is required

Another benefit of having the PTFE strips is they are easily replaceable after being subjected to wear from use. Having a combination of sufficient hardness and low friction will minimize the wear rate on the material. One location is in close vicinity of the welding point of a gusset, meaning it will be subject to high temperatures. It sits approximately 1in from the welding location and is on the opposite side of the plate. PTFE has a working temperature up to approximately 260^{o}C [8]. Tests have shown that at a distance 0.28in from a weld location on the opposite side of a 0.126in plate, the temperature has decreased to approximately 223^{o}C [9]. Since the gussets are 0.5 inch thick, the PTFE strips will not experience temperatures that exceed its working limit.

2.2 Operation of Fixture

After base plates are welded on two support members, they are installed in fixtures that ensure the members are square and in their correct orientation. The gusset locator is lifted into place by connecting the U-bolt lifting points to a crane or other lifting device. It is placed on top of the members (green) at the opposite end of the base plates (red) shown in Figure 12.

[redacted]

Figure 12: Initial placement of gusset locator on subassembly

Once in place, the gusset locator can be positioned to the first location by sliding the fixture with the installed push/pull handles. The laser measures from its base to the top of the base plates on the support structure. There are five locations on each subassembly the gusset locator needs to be positioned at to install all the gussets on the support members (Figure 13).

[redacted]

Figure 13: Subassembly #1 locations

All the gusset locations for both the subassemblies are the same except for position 2 (Table I). The readings from the measurement device for all five location on both sub assemblies is show in Table I. Note that the gussets must be installed in sequential order.

TABLE I: MEASUREMENT DEVICE READINGS FOR EACH GUSSET POSITION

[redacted]

It is recommended that the welding of gussets on one support member is done at a time as adjusting one side might cause the other side to shift out of position during operations. Once the correct reading is displayed, the gussets can be clamped into place.

[redacted]

Figure 14: Installation of gussets and spacer

Since there are large and small gussets at the same locations, a spacer must be used to compensate for the gap between the reference plate and the edge of the small gusset. Both the spacer and large gusset must be flush against the reference plate and support member. The small gusset must be flush against the spacer. There are a total of four types of spacers that must be used at certain locations.

- Spacer 1 – Positions 3, 4 and 5 on both sub assemblies (3 spacers required)
- Spacer 2 – Position 2 on sub assembly 1 (3 spacers required)
- Spacer 3 – Position 1 on both sub assemblies (1 spacer required)
- Spacer 4 – Position 2 on sub assembly 2 (1 spacer required)

At certain locations, as much as three spacers can be required at one time. Dimensions for each spacer can be viewed in the drawings in Appendices D.

After clamped in place the gussets are tack welded, unclamped and then the gusset locator can be moved to the next location. Continue to move to each subsequent location until position five, where the gusset locator can be lifted off the sub assembly. Repeat the procedure for the other subassembly.

2.3 Gusset Locator – Cost Analysis

The estimated cost of the gusset locator was priced based on raw materials and purchased parts (Table II). Fabrication and machining is not included in this analysis as the client indicated that the majority of the fixture can be manufactured at their facility.

TABLE II: TOTAL COST OF GUSSET LOCATOR

Gusset Locator		
Purchased Parts Cost	$ 2,821.23	CAD
Raw Materials	$ 715.57	CAD
Total	**$ 3,536.80**	CAD

A detailed cost breakdown and list of suppliers for the gusset locator can be viewed in Appendices A.

3 Trunnion Design

The trunnion design is a rotational mechanism used to support and position two sub-assemblies of the cantilever support tower for fabrication. The two sub-assemblies are fabricated prior to the use of the trunnion, and once installed, the trunnion may rotate the structure to allow welders to work in a preferred position. The trunnion design consists of two sides, broken down into three components: the support structures, the mounting brackets and the rotational driving components (Figure 15).

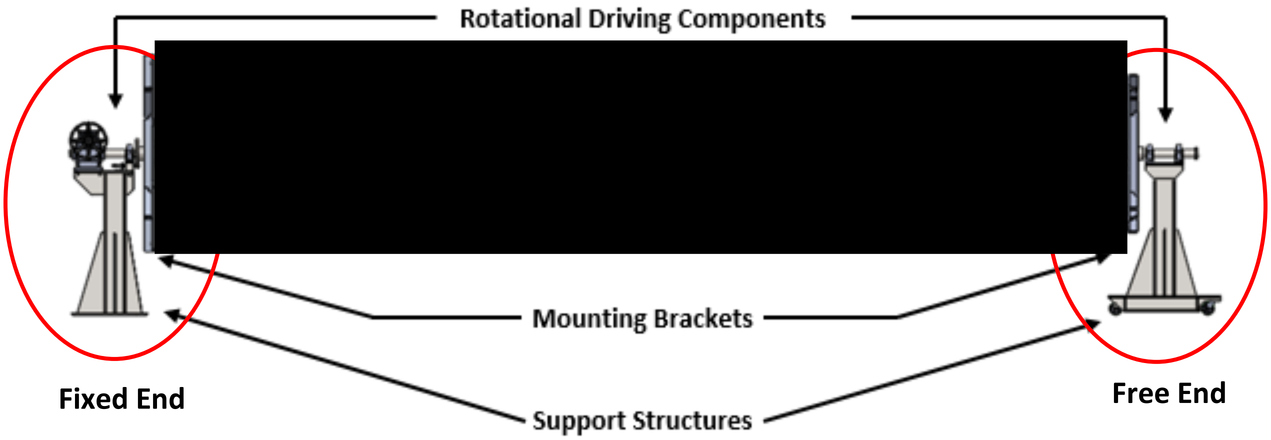

Figure 15: Final trunnion design with main components identified

The support structures are used to provide a mounting platform for the rotational driving components used to support and rotate the trunnion. Mounted to the support structure at the fixed end are the drive system components. The drive system consists of a manually operated gearbox and driveshaft. To lock the rotational position of the trunnion, a locking mechanism has been integrated into the design of the driveshaft. On the free end, two trunnion seats are mounted to the support structure to locate and secure the shaft. The mounting brackets are used to locate and secure the cantilever support tower assemblies prior to installation in the trunnion. The mounting brackets are designed to connect to the shafts via connection brackets.

3.1 Details of Design

Detailed preliminary drawings for all assemblies and parts of the trunnion are in Appendices E.

3.1.1 Shaft Designs

The driveshaft system is an assembly of three functional components: the driveshaft, locking plate and the connection bracket (Figure 16). The driveshaft is used to transmit the torque output of the gearbox onto the component in which the locking plate and connection bracket are mounted to. A keyed joint is used to secure the mounted components to the driveshaft (Figure 17).

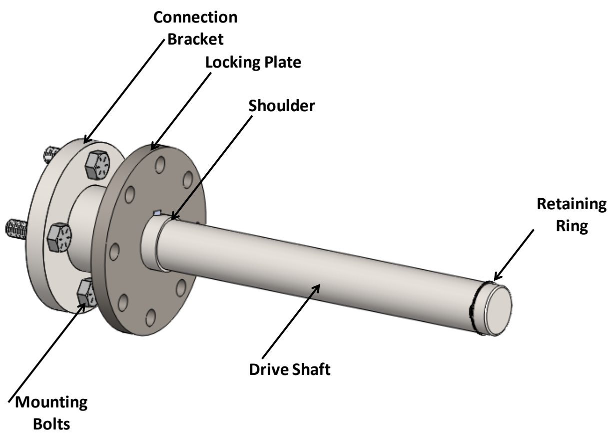

Figure 16: Key features of the driveshaft

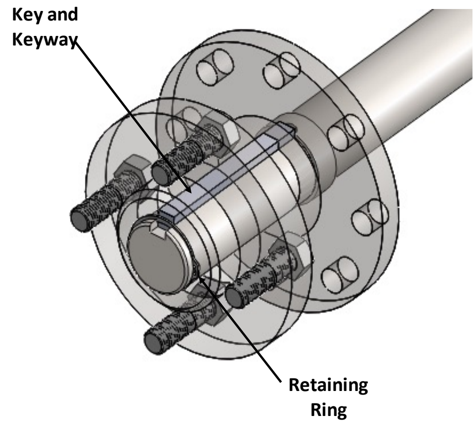

Figure 17: Front view of driveshaft

The locking plate is located via a shaft shoulder on the driveshaft. Once the locking plate is in position, the connection bracket sleeves onto the driveshaft until it presses up to the locking plate. The locking plate is used to connect the driveshaft system to the locking mechanism, while the connection bracket is used to connect the driveshaft system to the mounting bracket.

The lock mechanism is an assembly consisting of two functional components: the pin mechanism and the locking plate (Figure 18). The locking plate is independent of the lock mechanism and located on the driveshaft. The pin mechanism consists of three functional components: the lock pin, spring and angle bracket. This mechanism engages with the locking plate to lock the position of the trunnion and able to do so every 30 degrees. The lock pin naturally wants to engage with the locking plate due to the spring in its relaxed state when fully engaged. The operator must provide a pulling force on the locking pin to disengage it from the locking plate to rotate the trunnion to a new position. The angle bracket and mounting block are used to guide and support the locking pin during its operation.

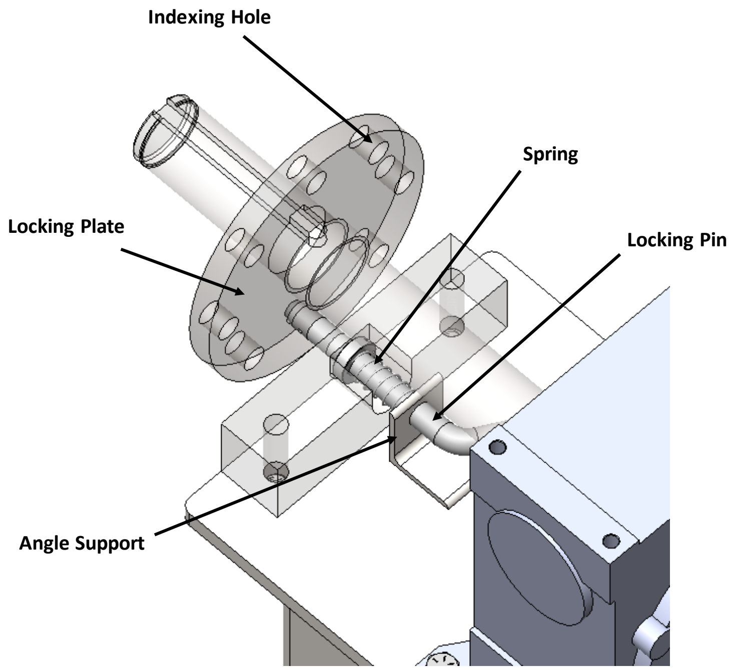

Figure 18: Lock mechanism for the trunnion

Located at the opposite end of the trunnion is the free shaft system consisting of three functional components: the free shaft, connection bracket and clamping shaft collar. The free shaft is used to support the rotation of the trunnion and is the component onto which the connection bracket and clamping shaft collar are mounted to. The connection bracket is located via a shoulder on the free shaft and secured through a keyed joint.

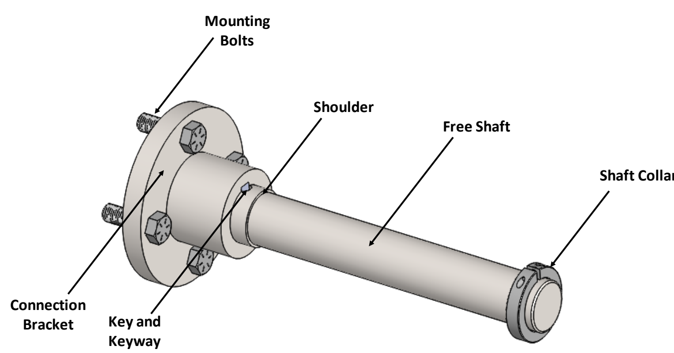

Figure 19: Key features of the free shaft

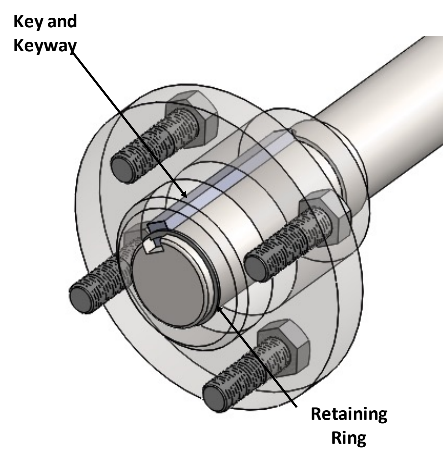

Figure 20: Front view of free shaft

The mounted components perform independent functions. The connection bracket is used to connect the free shaft to the mounting bracket, while the clamping shaft collar is used to secure the free shaft in its bearing supports. In addition, the position of the clamping shaft collar determines the amount of free shaft adjustability.

The material used to manufacture the driveshaft and free shaft is C1144 Steel Cold Drawn. The properties of C1144 Steel make it suitable for shafting due to the high tensile strength it possesses.

3.1.2 Gearbox and Bearing Supports

The gearbox chosen to drive the rotation of the trunnion is a 30:1 single-stage worm gear reducer with a 1-1/8in dia. keyed input and 2-15/16in hollow output shaft. The gearbox is manually operated by a hand wheel attached to the input connection. A driveshaft is fitted into the hollow output shaft and secured via a keyed joint. The gearbox is able to produce an output torque of 6845lb-in, an output torque sufficient to overcome the rotational inertia of the trunnion. The gearbox is mounted to the top platform of the fixed support structure of the trunnion (Figure 21). Additional space is provided at the gearbox output to accommodate the mounting block of the lock mechanism.

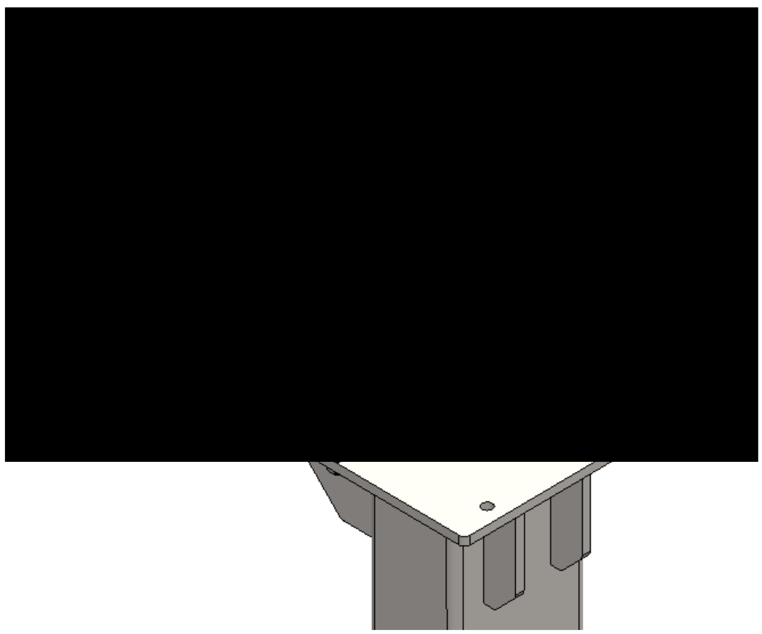

Figure 21: Features of the gearbox

A sleeve bearing is mounted to the mounting block of the lock mechanism and used to support the radial loads of the operational trunnion at the fixed end (Figure 22). Two sleeve bearings are used to seat the free shaft and provide bearing support at the free end with a center distance of 10.88in (Figure 22). The sleeve bearings at the fixed and free end feature a ball and socket unit manufactured from cast iron that allows for ±2 degrees of self-alignment. This makes for ease of installation during assembling of the support structures. The bearings self-lubricate by its own sleeve material manufactured from a carbon-graphite compound. The coefficient of friction of the sleeve material is low making adhesion difficult.

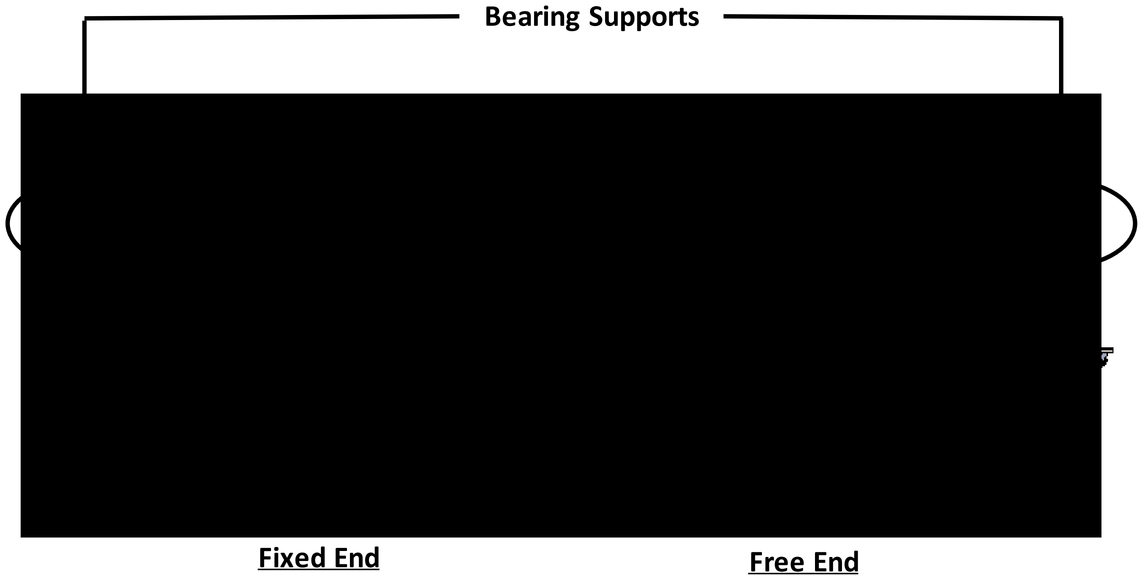

Figure 22: Locations of the bearing supports

3.1.3 Support Structures

Two steel support structures were designed to support the weight of the cantilever support structure, the mounting brackets, and the rotational driving components. The two support structures are unique to their side, as one is fixed to the ground and the other is mobile. Both are constructed from a 12in x 8in x 0.375in rectangular steel tube and vary sizes of steel plates. Calculations performed to determine the sizing of the support structure's components can be found in Appendices B. The fixed support structure is to be bolted to the concrete floor at MML using expansion anchors (Figure 23). The fixed support houses the driving components of the trunnion, in which the user interacts with to power the rotation.

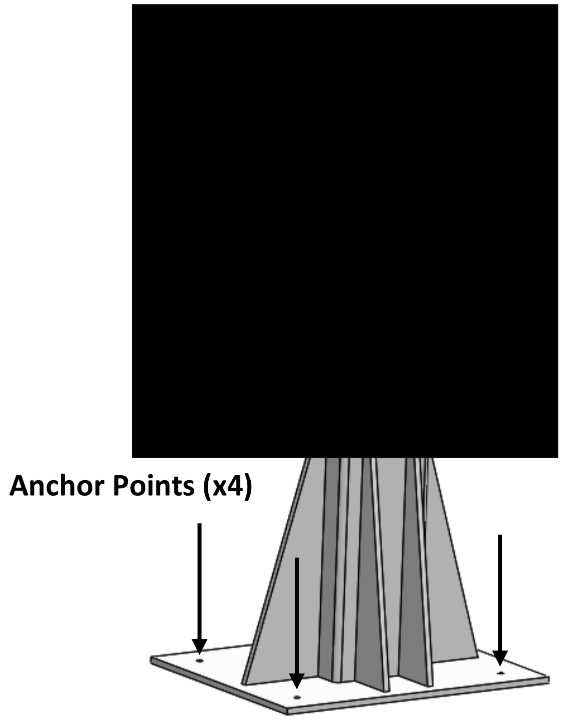

Figure 23: Fixed support structure

The mobile support structure is mounted on four casters and located onto a guidance track for ease of installation into the mounting bracket (Figure 24). Handles have been added for ease of handling, and cart brakes are incorporated to prevent any unwanted movement during trunnion operation.

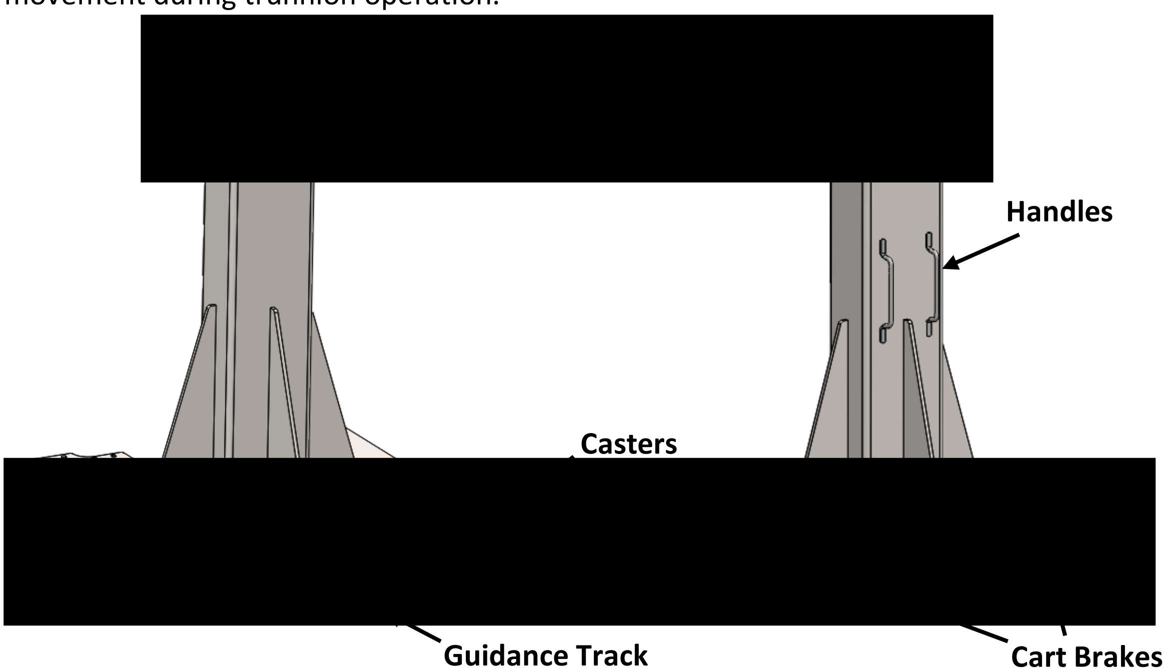

Figure 24: Front (left) and back (right) views of the mobile support structure

The mobile support structure's base was designed to ensure structural stability. The structure's center of mass was calculated and compared to the width of the caster spacing. The casters were then repositioned to a minimum distance of double the centre of gravity from the ground to prevent tipping of the structure.

A guidance track (Figure 25) was designed to locate the mobile support structure in position to mate with the corresponding mounting bracket. The guidance track is constructed of two guiding rails that direct the pins at the bottom of the mobile support structure in line with the fixed support structure. An end plate ensures the mobile support structure is the correct distance away from the fixed support structure. The guidance track is mounted to the ground with shoulder bolts to allow for ease of installation. Hooks are placed on the guidance track to allow the workers to easily lift the track from the floor.

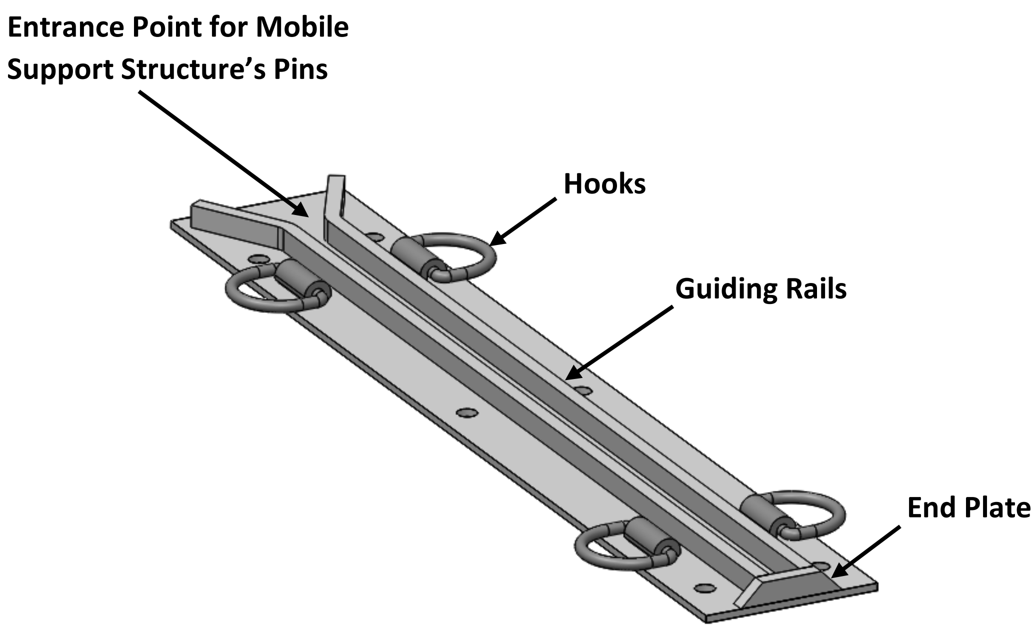

Figure 25: Guidance track

3.1.4 Mounting Brackets

The mounting brackets are sub-components of the trunnion that locate and secure the two sub-assemblies in their final orientation. The mounting brackets are unique to the top and bottom of the support structure, and consist of three components: the base plate, the locators, and the clamping mechanism (Figure 26).

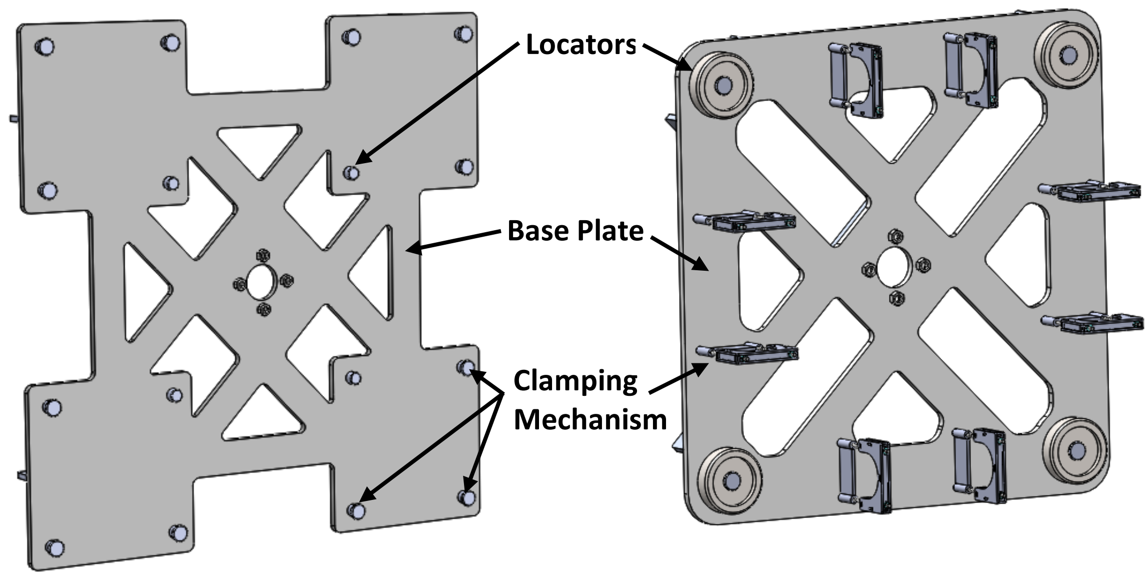

Figure 26: Bottom (left) and top (right) mounting bracket

The base plate of each mounting bracket is made from 1in thick 6061 aluminum plate. It is reinforced with 0.75in think 6061 aluminum plate. Calculations performed to determine and justify these dimensions are found in Appendices B. The base plates contain locations for each locator, each clamping mechanism, and the central mounting connection. Locators provide alignment points for internal features on the support structures base plates and open tube ends. The internal features position themselves onto the locators and slide towards the back of the base plate. Clamping mechanisms are then used to secure the support tower to the base plates so it can be maneuvered to the trunnion. The bottom mounting bracket utilizes pins that insert into each hole in the support structure base plate, extending into the mounting brackets base plate, and bolted from the back (Figure 27).

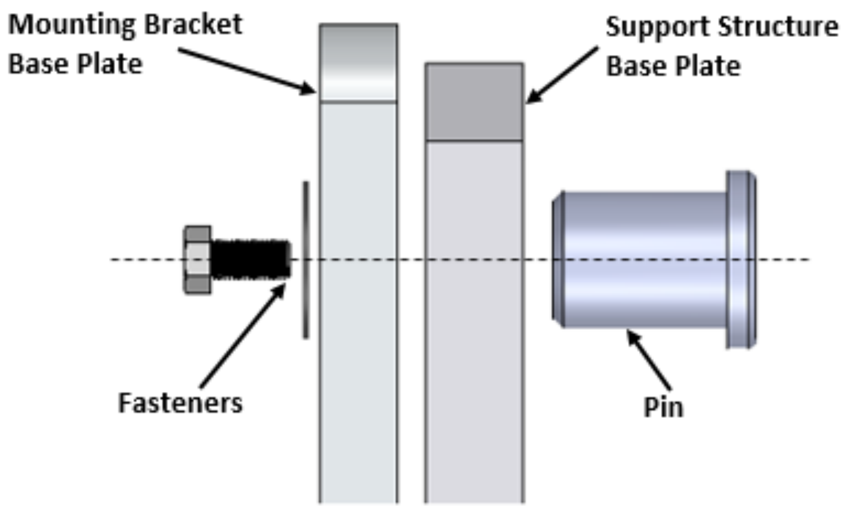

Figure 27: Bottom mounting bracket clamping mechanism

The top mounting bracket has custom clamps that fit overtop of the cross members of the sub-assemblies. Threaded rod extends from the bottom of the base plate, to the top of the clamp, providing the means of fastening (Figure 28).

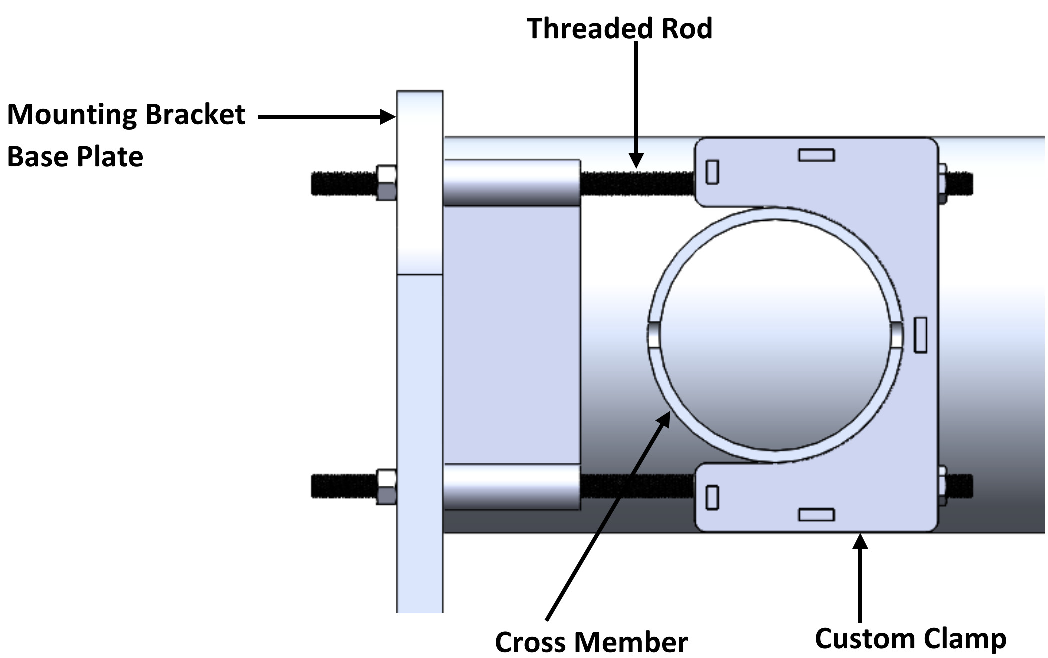

Figure 28: Top mounting bracket clamping mechanism

3.2 Operation of Trunnion

Upon completion of the two sub-assemblies, the mounting brackets are installed onto the open end and the base plate end (Figure 29). The mounting brackets are indicated by the soft red hue in Figure 29. Once the mounting brackets are installed, the two sub-assemblies are ready for final fabrication.

[redacted]

Figure 29: Sub-assemblies installed into the mounting brackets

Final fabrication requires transporting the fixed sub-assembly to the location of the support structures of the trunnion. The fixed sub-assemblies are hoisted over to this desired location (Step 1 of Figure 30). Once the fixed sub-assembly is in position, it moves overtop of the connection bracket on the driveshaft at the fixed end of the trunnion (Step 2 of Figure 30). Once the bottom mounting bracket is securely connected to the support structure at the fixed end, the mobile support structure is guided into position via a ground mounted track (Step 3 of Figure 30). This requires an operator to push the support structure to mate the connection bracket into the mounting bracket of the open end of the fixed sub-assembly. The free shaft of the mobile support structure is allowed to move axially within its trunnion seats for ease of installation. The hoists are removed once the structure is secured to both ends, and at this point the trunnion is fully operational. The manually operated gearbox located on the fixed support structure is used to rotate the assembly to a desired angular position. A locking mechanism is used to lock the position to ensure the workers safety during fabrication.

Figure 30: Installing the sub-assemblies/mounting brackets into the trunnion

3.3 Trunnion – Cost Analysis

The design of the trunnion was priced based on raw materials and purchased parts (Table III) needed for complete construction of the design. Manufacturing of individual components has not been accounted for because the client indicated most manufacturing can be performed at their facility.

TABLE III: TOTAL COST OF THE TRUNNION

Trunnion			
Purchased Parts	$	12,135.85	CAD
Raw Materials	$	10,592.09	CAD
Total	$	22,727.94	CAD

A detailed cost breakdown and list of suppliers for the trunnion can be viewed in Appendices B.

4 Conclusion

Two individual designs were created to resolve issues MML was having with the manufacturing of a two-track cantilever support structure. The first design is the gusset locator which assists in locating and welding the gussets in place along the support members of the structure (Figure 31). It is primarily designed out of aluminum plate to minimize the risk of contaminating the aluminum support structure with steel during the welding procedure.

Figure 31: Final gusset locator design

The gusset locator utilizes laser distance measurement devices to locate the gussets along the support members within an accuracy of ±0.06in. To allow the structure to slide with minimal effort along the support, PTFE strips are used at the contact areas to minimize friction. Gussets are held rigidly in place with the use of toggle clamps.

The second design created is the trunnion which allows for the rotation of the support structure during fabrication (Figure 32). The trunnion consist of two ends, one fixed and one free, which support the weight of the support structure through a rotational assembly. Shafts are supported with plain bearings, allowing rotation of the structure through manual input of a gearbox at the fix end. The free end is removable after the fabrication process is complete to minimize the footprint of the structure.

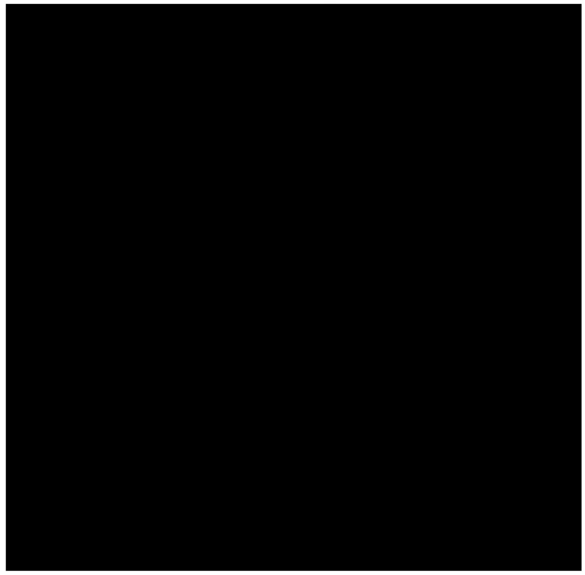

Figure 32: Final trunnion design

The support structure is held rigidly in place with the use of mounting brackets that are fixed to the base plate and open end of the structure. The trunnion can be rotated in 30^{o} intervals before a locking pin actuates and locks the position of the structure. This is an added feature to ensure the safety of the welders working near the structure.

During the design phases simplicity and ergonomics were considered to create designs that are intuitive to use and require low physical demand. Each structure can primarily be manufactured in house. Preliminary design models, drawings and a Bill of Materials are supplied to the customer and are required to be reviewed by a professional engineer prior to its fabrication. The combined price of both the gusset locator and trunnion came in under budget at an estimated $27,000. This leaves $43,000 of budget if any parts require fabrication outside of MML's facility.

5 Recommendations

5.1 Gusset Locator

The gusset locator was designed to satisfy the customer needs and certain recommendations have been developed by Team 3 to add to its functionality. PTFE strips are used as the low friction material as it satisfied that the fixtures requirements and minimized the force required to move it. Other materials can be tested after fabrication to find the material that better suites the operation of the fixture, these materials include are UHMW, Nylon, and HDPE. The materials have different properties indicated in Appendices A that may achieve a better result then what was predicted.

The laser measuring device will be measuring against an aluminum surface. The surface observed on the base plates did not have any visual reflection or extreme roughness making them an ideal surface to measure off of. If the surface is causing false readings in the measurement device, a laser target can be purchased and placed at the lasers target to improve the measurement accuracy [10].

Readings for the laser measurement device are listed in Table I and the welders need access to these values during fabrication. It is recommended that these values be etched or printed on an adhesive label on the gusset locator. This allows the operator access to the values at all times during its operation and eliminates the possibility of misplacing the values.

5.2 Trunnion

Upon completion of the trunnion design, certain specifics should be considered or reviewed before further progression with this design. One unknown during the design was the composition of the concrete floor at MML. The floor should be inspected to ensure it can handle the loading and bolts proposed in this design. If this cannot be performed, installing new concrete pads at the locations of the trunnion’s support structures would be recommended.

Another recommendation addresses the weight of the trunnion. The support structures each have a significant weight to them. Material removal could be performed on the components of the structure to minimize weight if necessary. If this is carried out, further analysis and design studies would have to be performed to ensure structural strength and loading capabilities.

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[7] Curbell Plastics. (2016, Jan. 16). *Plastic Properties Table* [Online]. Available: Available: https://www.curbellplastics.com/Research-Solutions/Plastic-Properties [Dec. 23 2018].

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Appendices A – Gusset Locator Items

List of Figures

List of Tables

A.1 Potential Low Friction Materials

A total of four different plastic materials were considered for the use as a low friction material for the gusset locator (Table AI).

TABLE AI: LOW FRICTION MATERIALS [A1]

Materials	Coefficient of Dynamic Friction	Shore D Hardness
PTFE	0.1	55
UHMW	0.1 - 0.2	64
Nylon	0.28	80
HDPE	0.29	69

All the materials above can be used on the gusset locator, but PTFE was chosen due to its low friction and high temperature properties [A2]. If temperature is not above 60^{o}C on the base of the plate at the point of contact with the plastic strips, UHMW can be used. It has a similar friction coefficient but improved hardness which may improve wear on the material if it is an issue with PTFE. Nylon and HDPE both have substantially higher friction coefficients, but higher hardness. If PTFE is wearing relatively fast, Nylon or HDPE should be tested to maximize the life cycle of the plastic strip.

A.2 Specifications of GLR 825 Laser Distance Measurer

The GLR 825 Laser distance measurer will be used on the gusset locator to determine its location along the support members (Figure A1).

Figure A1: GLR 825 Bosch Laser Distance Measurer [A3]

The GLR 825 has the following specifications that satisfy the needs for the gusset locator (Table AII). A complete set of specifications and the user manual is available online [A4].

TABLE AII: Key specifications of GLR 825 Laser distance measurer [A4]

GLR 825 Specifcations	
Accuracy	±0.04in
Range	825ft
Portable	Yes (AAA batteries)
Continuous Meaurement	Yes
Mountable	Yes (1/4in-20in thread hole on rear)

The device must be set to continuous measurement mode to ensure the readings for each gusset location is valid. Refer to the user manual for instructions to change to the continuous mode setting [A4]. To ensure the device works properly, dust and other contamination that can block the laser should be cleared or wiped clean with a microfiber cloth to prevent scratching of the lens. Solvents or other cleaning agents should not be used as they can potentially damage the lens.

If the laser is in favourable conditions but the accuracy is not being satisfied, the base plate of the support structure may not be an adequate surface for the laser to use. A laser view enhancer target can be purchase and attached to the base plate to improve the reading accuracy [A5].

A.3 Gusset Locator Maintenance

Components on the gusset locator will need to be monitored to ensure the device stay in proper working condition.

- Laser
- PTFE Strips
- Adjustable Connection

The laser measurement device is a calibrated device, meaning it requires re-calibration at certain time intervals. The time interval at which the device should be sent in for calibration is determined from the provider. If the device is not giving accurate readings in favourable conditions, it should be sent in for calibration.

The PFTE strips will wear at the points of contact with the gussets and support members after a certain amount of usage. The strips should be replaced after they have reduced in thickness by 0.03in. By doing this, it ensures the gusset will stay in the tolerance of ±0.06in specified by MML.

The adjustable connection is also a point that will wear over continued use. Although the joint is not being operated at high speeds, the weight of the structure will cause a bending forces at the joints. Over time this will lead to the tight tolerance fit having play which can cause failure to meet the angular tolerance. Replace the clevis pin on the joint first if this occurs. If there is still play, the entire should will require replacement.

A.4 Gusset Locator Cost Analysis

A list of suppliers used for the raw materials and purchased parts is listed below.

- McMaster Carr (MC) [A6}
- Johnston Industrial Plastics (JP) [A7]
- Acklands Grainger (AG) [A8]
- Midwest Steel and Aluminum (MS) [A7]

If the prices of purchased parts and raw materials were sourced from an American provider, it was converted to the Canadian dollar. The amount of raw material was based on the length, rectangular area or volume required to cut or machine the part out. A cost analysis was performed for the gusset locator, identifying both the purchased parts (Table AIII) and the raw materials (Table AIV).

TABLE AIII: COST BREAKDOWN OF PURCHASED PARTS FOR GUSSET LOCATOR

Gusset Locator					
Gusset Locator Purchased Parts					
Part Number	**Description**	**Supplier**	**Price Per Unit**	**Quantity**	**Total Price**
29605T470	1/2"-13 316 Stainless Steel U-Bolt	MC	$ 28.56	2	$ 57.11
92240A542	1/4"-20 1" Long 18-8 Stainless Steel Hex Head Screw	MC	$ 0.15	20	$ 3.06
92196A584	5/16"-18 1-1/8" Long 18-8 Stainless Steel Socket Head Screw	MC	$ 0.80	32	$ 25.66
92210A542	1/4"-20 1" Long 18-8 Stainless Steel Hex Drive Flat Head Screw	MC	$ 0.24	16	$ 3.89
92210A585	5/16"-18 1-1/4" Long 18-8 Stainless Steel Hex Drive Flat Head Screw	MC	$ 0.55	8	$ 4.44
92240A537	1/4"-20 1/2" Long 18-8 Stainless Steel Hex Head Screw	MC	$ 0.11	8	$ 0.87
92240A540	1/4"-20 3/4" Long 18-8 Stainless Steel Hex Drive Flat Head Screw	MC	$ 0.13	28	$ 3.52
95462A029	1/4"-20 Grade 5 Zinc Plated Nut	MC	$ 0.06	64	$ 3.75
95462A030	5/16"-18 Grade 5 Zinc Plated Nut	MC	$ 0.09	40	$ 3.43
95462A033	1/2"-13 Grade 5 Zinc Plated Nut	MC	$ 0.19	4	$ 0.75
91185A917	1/4"-20 1/2 " Long Plastic Head Thumb Screw	MC	$ 1.13	2	$ 2.26
1661A400	Plastic Pull Handle	MC	$ 5.27	12	$ 63.20
97245A730	Clevis Pin	MC	$ 2.36	4	$ 9.43
5091A610	Low Profile Hold-Down Clamps	MC	$ 138.92	8	$ 1,111.35
BOSGLR825	Bosch Laser Distance Measurer GLR 825	AG	$ 449.00	2	$ 1,525.32
92240A540	1/4"-20 3/4" Long 18-8 Stainless Steel Hex Drive Flat Head Screw	MC	$ 0.20	16	$ 3.19
Total					**$ 2,821.23**

The total price of each raw material was determined based on a price per unit. If a price per unit was not supplied, sizes of the material were sourced based on how many were required to meet the determined quantity (Table AIV).

TABLE AIV: COST BREAKDOWN OF RAW MATERIALS FOR GUSSET LOCATOR

Gusset Locator Raw Materials					
Description	**Supplier**	**Quantity**	**Units**	**Cost/Unit**	**Total Price**
0.375" THK 6061-T6 Aluminum Plate	MS	570	sq.in	[redacted]	$ 125.37
0.25" THK 6061-T6 Aluminum Plate	MS	1460	sq.in	[redacted]	$ 285.35
3"x3" 6061-T6 Aluminum Stock	MS	11	in	[redacted]	$ 56.55
4"x2"x0.09" 6061-T6 Aluminum C-Channel	MS	14.5	in	[redacted]	$ 25.26
0.25" THK PTFE	JP	40	sq.in	$ 0.34	$ 18.02
0.5" THK PTFE	JP	227.5	sq.in	$ 0.68	$ 205.02
Total					**$ 715.57**

The total cost of the gusset locator is $3,586.80 which is the sum of the raw material and purchased part costs.

Appendices A References

[A1] Curbell Plastics. (2016, Jan. 16). *Plastic Properties Table* [Online]. Available: Available: https://www.curbellplastics.com/Research-Solutions/Plastic-Properties [Dec. 23 2018].

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Appendices B - Trunnion Items

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B.1 Gearbox Selection

ABB Motor and Mechanical Inc. (ABB) offer right-angle speed reducers, the DODGE® Tigear-2 [B1]. The chosen Tigear-2 gearing system is a 30:1 single-stage worm gear reducer with 1-1/8in dia. keyed input and 2-15/16in hollow output shaft. The gear case is manufactured from ASTM A48 Class 30 gray iron. The synthetic lubricant, Klubersynth UH1 6-460, is the recommended lubrication for the gearing system [B1]. The Tigear-2 is designed to produce and hold an output torque and maximum overhung load of 6845lb-in and 5600lb, respectively. The Tigear-2 meets the requirements on compactness and ruggedness, high reduction ratio and torque multiplication, self-locking feature, and ease of installation. Prior to installation or operation, the operator is advised to take a thorough read of instructions provided online. [B2]

B.1.1 Gearbox Configuration

The input is a solid 1-1/8in dia. keyed input shaft with a 1/4in SQ. x 1-1/2in keyway used to secure the 12in dia. hand wheel. The output is a 2-15/16in hollow output shaft with a 3/4in x 0.56in x 4.50in key. The hollow output shaft is sized to allow the driveshaft to fit. Outside the hollow output is a sleeve bearing used to support the solid shaft. DODGE® specifies the tolerance of the input and hollow output shaft at ±0.0005in and 0.0010in, respectively [B1].

B.1.2 Sealing System

The Tigear-2 is an enclosed gearing system sealed with a unique seal design manufactured in-house at the ABB factory. The seal design produces better hydrodynamic film between the seal and the shaft than conventional trimmed lip seal designs. The uniqueness of the seal design is ABB's sinusoidal lip design. The sinusoidal lip of the wave seal pumps lubricant back and pushes contaminants away [B1].

B.1.3 Gear Casing Material

The gear case is manufactured from Class 40 gray iron. Class 40 gray iron has excellent strength and wear properties, making it rugged and suitable in the MML facility working environment. Other attractive qualities include good vibration damping, low rate of thermal expansion and resistance to thermal fatigue.

B.1.4 Specified Lubrication

A synthetic lubricant, Klubersynth UH1 6-460, is recommended for lubrication of the gearing system [B1]. Klubersynth UH1 6-460 is a high performance lubricant for standard temperatures. The lubrication is based on poly-glycol and several additives. Due to the special poly-glycol base and additives, wear and friction is reduced considerably. The lubricant is factory filled by ABB eliminating possible contamination of the lubricant [B1]. The shelf life is around 36 months in a dry, frost-free environment and in the unopened original container. No routine scheduled oil changes are required [B3].

B.2 Bearing Support Selection

In addition to gearing systems ABB offer DODGE® SOLIDLUBE plain bearings. These plain bearings self-lubricate by its own sleeve material manufactured from a carbon-graphite compound. The bearing housing contains an inner ball and socket unit between the housing I.D. and the O.D. of the bearing insert providing self-alignment of ±2 degrees. The selected plain bearing is a 3/4in thru 3in pillow block with a 2-15/16in bore diameter. The plain bearing option is suitable for low speed and limited shaft movement. The radial load rating is 5970lbs up to 10rpm. The maximum base load and cap or side loading are 12000 and 4151lbs. The maximum thrust load is 597lbs [B4]. Prior to installation or operation, DODGE® provides instructions online that requires a thorough read [B5].

B.2.1 Bearing Material

The sleeve material of DODGE® SOLIDLUBE plain bearings is manufactured from a carbon-graphite compound. Carbon-graphite has excellent thermal durability and thermal shock resistance, and has superior coefficient of friction on steel surfaces and thermal expansion than other bearing materials. The low coefficient of friction makes adhesion difficult. The static coefficient is from 0.20 to 0.30 and the dynamic coefficient is from 0.05 to 0.15, respectively [B6].

B.2.2 Clearance Issues

Clearance is influenced by the shaft and bearing due to thermal expansion and tolerance. The fixture design is operated in the environment indoors the MML facility and never to be exposed to the environment outdoors. The indoor environment is kept to a comfortable working temperature for the workers. The expected heat generated due to friction is likely insignificant because the application is for low speed and limited shaft movement. Therefore, there should be no clearance issue due to shaft and bearing expansion.

The shaft tolerance should be +0.000/-0.002 for commercial steel shafting, hardened to 35 Rockwell “C” or better, and 10 to 20 micro-inches on the surface finish. A surface finish greater than 20 micro-inches will lessen bearing life, and surface finish less than 10 micro-inches will inhibit the lubricant film. There should be no clearance issue due to tolerance if the guidelines are followed [B6].

B.3 Shaft Material Properties

The building material used for the shafts is ASTM C1144 Steel. It has high tensile properties and excellent machinability, making it a suitable material to construct the shafts. The properties of the material were gathered from the product reference guides prepared by Russel Metals provided on their website [B7].

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TABLE BI: MECHANICAL PROPERTIES FOR THE SHAFTING MATERIAL

Mechanical Properties of ASTM C1144 Steel	
Condition	Cold Drawn
Machinability	85
Tensile Strength	100
Yield Point	90
Rockwell Hardness	96B

B.4 Calculation Spreadsheets for Trunnion Design

B.4.1 Shaft Sizing Spreadsheet

A shaft sizing spreadsheet determined the appropriate drive shaft and free shaft sizes at the fixed-end and free-end of the trunnion. The stress analysis calculated the shearing and bending stresses at the bearing supports and the point where each shafts meet with the mounting brackets. The model used to perform the initial stress analysis assumes the trunnion is simply supported, the center of gravity of the assembly in the trunnion occurs at the mid-span, and the mass of the assembly is concentrated at the center of gravity. A sample of the input parameters are provided:

TABLE BII: INPUT PARAMETERS TO SHAFT SIZING SPREADSHEET

[redacted]

A miscellaneous weight has been included. It accounts for the weight of the mounting brackets and any unforeseen weight, if any. For instance, if an individual is pressing down or leaning on the trunnion, additional load is placed on the system. A maximum miscellaneous weight of 2000lb was simulated in the calculation procedure.

The shear force and bending moment diagrams of Figure B1 and Figure B2 are used to determine the shaft stresses at points A, B, D, and E. Points A and E are the bearing support locations. Referring to Figure B1 and Figure B2, points A and E are subject to shear forces and no bending moments. Points B and D are the points where the shafts meet with the mounting brackets. Referring to Figure B1 and Figure B2, points B and D are subject to both a shear force and bending moment. With the center of gravity located at the mid-span, the forces on either side are equal in magnitude, thus, for this reason only points A and B are calculated.

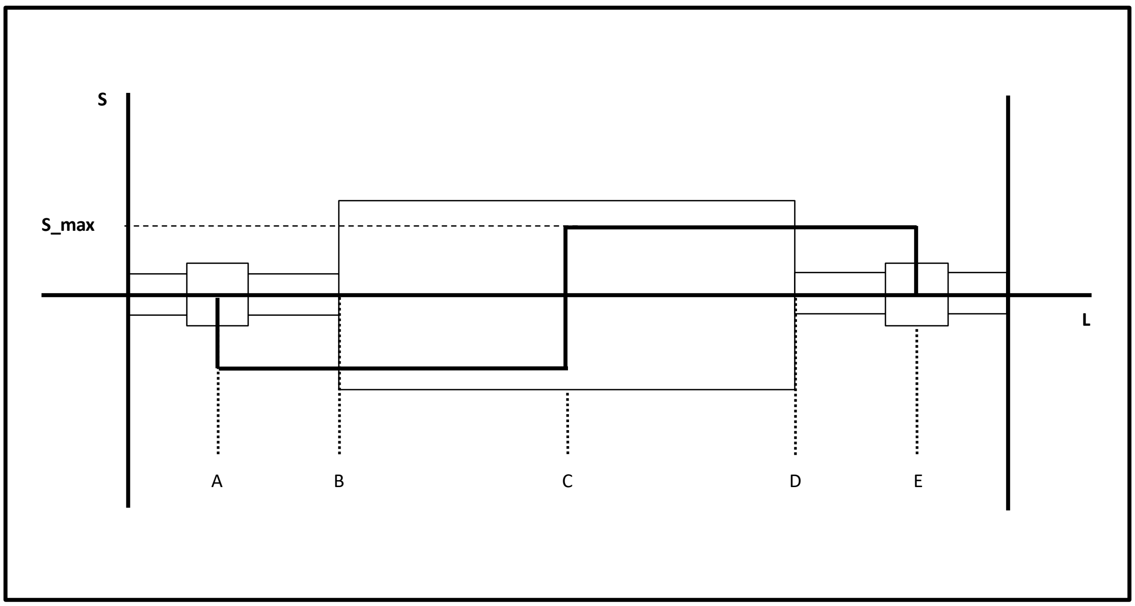

Figure B1: Shear force diagram for the assembly in the rotation mechanism

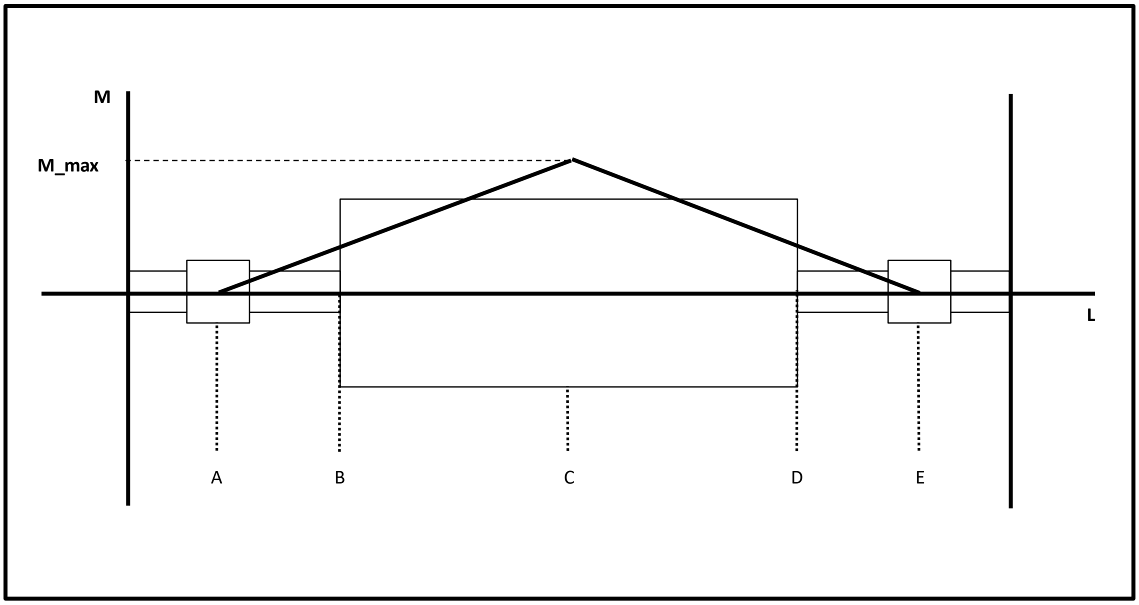

Figure B2: Bending moment diagram for the assembly in the rotation mechanism

Two design scenarios are examined. The first scenario (Scenario 1) considers the shaft stresses produced by the assembly in the trunnion. The assumption made in the first scenario is the trunnion is balanced. The second scenario (Scenario 2) examines the stresses produced by an eccentric load acting on the trunnion. The sub-assembly turned by 90 degrees in the trunnion is the eccentric load (Figure B3). The sub-assembly offset by 24in from the trunnion axis of rotation (Point O) produces an external torque. No external torque is produced in Scenario 1.

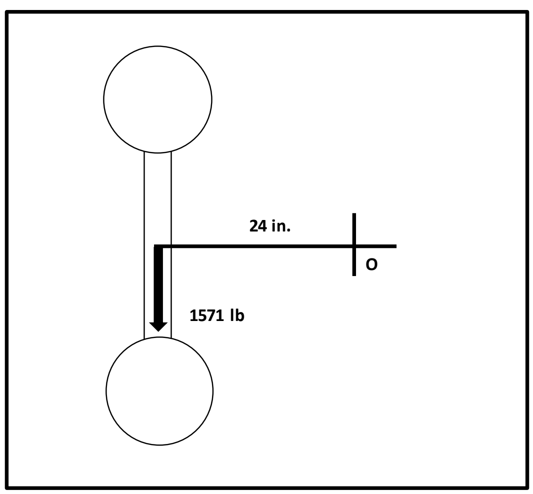

Figure B3: Torque produced by only installing one sib-assembly rotated by 90 degrees

Summarized in Table BIII and Table BIV are the results from the initial stress analysis to determine the shaft stresses due to the weight of the assembly. The simulated miscellaneous weight was set to 0lb for this stress analysis. Scenario's 1 and 2 yielded different results with scenario 1 being the higher stress condition, and therefore, determined the minimum allowable diameter.

TABLE BIII: EXPECTED LOAD CONDITION FOR MISC. WEIGHT OF 0LB

	Scenario 1	Scenario 2
Concentrated load (lb)	3141.4328	1570.7164
Reaction Force, Point A (lb)	1570.7164	785.3582
Bending Moment, Point B (lb-in)	18848.5968	9424.1668
External torque (lb-in)	0	37697.1936
Minimum allowable diameter (in)	0.456	2.169

As seen, shear stresses at point A and bending stresses at point B are below the yield strength of the material, and within the safety factor of 3.

TABLE BIV: SHAFT STRESSES FOR MISC. WEIGHT OF 0LB

	Scenario 1	Scenario 2
Shear Stress, Point A (psi)	850	19233.33
Bending Stress, Point B (psi)	18808.3336	9404.1668

Summarized in Table BV and Table BVI are the results from an initial stress analysis with a miscellaneous weight of 2000lb. Scenario's 1 and 2 yielded different results with scenario 1 being the higher stress condition, and therefore, determined the minimum allowable diameter. Since the minimum allowable diameter of this load condition produced a larger minimum allowable diameter, this determined the shaft size. The value was rounded up to the nearest standard dimension.

TABLE BV: EXPECTED LOAD CONDITION FOR MISC. WEIGHT OF 2000LB

	Scenario 1	Scenario 2
Concentrated load (lb)	5141.4328	3570.7164
Reaction Force, Point A (lb)	2570.7164	1785.3582
Bending Moment, Point B (lb-in)	30848.5968	21424.2984
External torque (lb-in)	48000	85697.1936
Minimum allowable diameter (in)	2.383	2.859

As seen, shear stresses at point A and bending stresses at point B are below the yield strength of the material, and within the safety factor of 3.

TABLE BVI: SHAFT STRESSES FOR MISC. WEIGHT OF 2000LB

	Scenario 1	Scenario 2
Shear Stress, Point A (psi)	11262.17	19233.33
Bending Stress, Point B (psi)	13446.478	9338.556

The allowable strength of the material was determined by dividing the yield strength by a safety factor of 3. This produced an allowable strength of 33,333.33psi. The allowable shear strength was approximated by the distortion energy theory by multiplying the yield strength by 0.577, and then dividing by the safety factor of 3.

B.4.2 Support Structure Components Sizing Spreadsheet

Structural tube sizing spreadsheet determined the appropriate structural tube dimensions at the fixed end and free-end of the trunnion. The support structures at the free and fixed end have the same dimensions therefore structural analysis was conducted for the fixed end. Structural analysis included stress analysis and bending analysis which were performed on the similar model discussed in the shaft sizing spreadsheet (Figure B1). Trunnion is assumed to be supported at points A and E by support structures and the center of gravity of the tower assembly occurs at the mid-span. A sample of input parameters are provided:

TABLE BVII: INPUT PARAMETERS TO SUPPORT STRUCTURE

[redacted]

Rectangular structural tube of thickness 0.375in was chosen from the available structural tubes in the market. The load on the structural tube by the trunnion was assumed to be uniaxial (Figure B4).

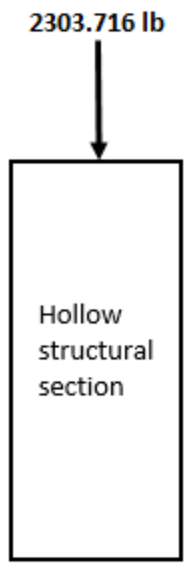

Figure B4: Uniaxial load on the structural tube

The shear force diagram (Figure B1) and bending moment diagram (Figure B2) were used to determine stresses at points A and E where the bending moments are zero. Another moment was considered due to forces produced by eccentric load acting on the trunnion (Figure B3). The structural analysis was ignored as it concluded smaller dimensions of the structural tube then the bending analysis.

TABLE BVIII: SUPPORT STRUCTURE BENDING ANALYSIS

Bending Analysis	
Deflection	0.01 in
Bending moment	37697.19 lb.in
Support structure length	52.06 in
Modulus of elasticity	29000 ksi
Cross section dimensions	
Base	8 in
Height	10 in

The bending analysis determined the dimensions of the structural tube to be greater than 8x10in. Further buckling analysis was conducted to satisfy load requirements on the support structure. The load applied on the structural tube (2303.716lb, Figure B4) is way less than the $P_{critical}$ load (9.5×10^6 lb) generated through buckling analysis confirming that the structural tube is safe from deformation due to buckling.

Four heavy duty expansion anchors manufactured by Hilti will be used to secure the fixed support structure to the concrete floor [B8]. The expansion anchors satisfy the weight requirements of the trunnion. As the details of the concrete floor were not provided by the client, team assumed the concrete to be cracked with the lowest compressive strength of 2,500 psi.

TABLE BIX: HSL–3 EXPANSION ANCHOR SPECIFICATIONS [B8]

Parameters	Value
Drill bit diameter	18 mm
Embedment height	80 mm
Length of anchor	131 mm
Allowable tension	4360 lb
Allowable shear	9390 lb
Part number	371781
Price	$346 (US)

The mobile support structure will be supported by two rigid casters [B9] in the front and two swivel casters [B10] in the rear. All the casters will be sourced out from Hamilton.

TABLE BX: RIGID CASTER SPECIFICATIONS

Parameters	Value
Load capacity	1050 lb
Overall height	6.5 in
Wheel diameter	5 in
Bearing type	Precision ball
Caster material	Cast iron
Wheel material	Polyurethane
Weight	11 lb
Part number	R-WH-5DB
Price	74.82 (US)

TABLE BXI: SWIVEL CASTER SPECIFICATIONS

Parameters	Value
Load capacity	1050 lb
Overall height	6.5 in
Wheel diameter	5 in
Bearing type	Precision ball
Caster material	Cast iron
Wheel material	Polyurethane
Weight	11 lb
Part number	S-WH-5DB
Price	$132.8 (US)

The guidance track will be secured to the concrete floor using six shoulder bolts [B10] and six drop in anchors [B11] which will be sourced out from boltdepot.com.

TABLE BXII: SHOULDER BOLT SPECIFICATIONS

Parameters	Value
Head height	0.375 in
Head diameter	0.875 in
Shoulder diameter	0.625 in
Thread diameter	0.5 in
Thread length	0.75 in
Thread count	13
Length	0.5 in
Material	Stainless steel 316
Part number	20180
Price	$18.08 (US)

TABLE BXIII: DROP IN ANCHOR SPECIFICATIONS

Parameters	Value
Hole size	0.625 in
Diameter	0.5 in
Thread depth	1.25 in
Thread count	13
Length	2 in
Material	Zinc plated steel
Part number	10803
Price	$0.71 (US)

B.4.3 Mounting Bracket Size Selection

A mounting bracket spreadsheet was made to determine an acceptable thickness for their base plates. Calculations for the base plates of the mounting brackets are very complex, as they have a unique geometry and many points as to where forces will be applied. To determine if the proposed plate thickness was acceptable, a simple bending calculation was performed on the smallest cross sectional area on the base plate after material removal had been conducted. It is to note that this calculation does not replicate a real scenario these plates will experience, since no loading will be applied directly into the plates.

TABLE BXIV: MOUNTING BRACKET BASE PLATE AXIAL LOADING YIELD CHECK

Parameters	Value
Aluminum Yield Strength	35000 psi
Plate Thickness	1 in
Plate Base Width	23 in
Distance to Structural End Points	24 in
Force to Yield Plate	22361.11 lbs

This calculation reassures that the mounting plates will require a substantial loading in order for them to fail. With this, the specified thickness, and extra backing support was added to ensure the structural strength of these plates.

A more relatable calculation was performed to determine the minimum hole size/ shaft diameter required to support the structure with different amount of support points. These dimensions were used to ensure the central hub and locating pins are of sufficient sizing.

TABLE BXV: MINIMAL HOLE DIAMETER TO SUPPORT CANTILEVER SUPPORT STRUCUTRE

Parameters	Value
Aluminum Yield Strength	35000 psi
Plate Thickness	1 in
Force	3141 lbs
Required Diameter for 1 Pin	0.090 in
Required Diameter for 4 Pins	0.022 in

The calculated dimensions predict that the minimum pin diameter must be greater than 0.09in to support the total weight of the cantilever support structure. All pins and holes designed to support the structure exceed this dimension by a great amount.

B.5 Trunnion Cost Analysis

A list of suppliers used for the raw materials and purchased parts is listed below.

- McMaster Carr (MC) [B14]
- Carr Lane (CL) [B15]
- Wajax (WJ) [B16]
- Motion Industries (MI) [B17]
- Hilti (HT) [B18]
- Hamilton (HM) [B19]
- Midwest Steel and Aluminum (MS) [B20]

A cost analysis was performed for the trunnion, identifying both the purchased parts (Table BXVI) and the raw materials (Table BXVII). All parts are reported in U.S. dollars.

TABLE BXVI: COST BREAKDOWN OF PURCHASED PARTS FOR THE TRUNNION

Part Number	Description	Supplier	Price Per Unit	Quantity	Total Price
Trunnion					
Trunnion Purchased Parts					
Fixed Support Structure					
47S30H DOD	Gearbox	WJ	$ 3,819.38	1	$3,819.38
P2B-LT7-215	Bearing	MI	$ 1,055.35	1	$1,055.35
CL-12-HWAF	Modified Hand Wheel	CL	$ 189.73	1	$ 189.73
90146A233	1" Hitch Pin, 6-3/4" Usable Length	MC	$ 13.17	1	$ 13.17
6435K180	Shaft Collar for 1" Shaft	MC	$ 3.26	1	$ 3.26
9657K547	Compression Spring, 3" Long	MC	$ 9.55	0.17	$ 1.59
91257A876	Hex Head Screw, Grade 8 Steel, 3/4"-16 Thread Size, 2-3/4" Long	MC	$ 2.66	4	$ 10.64
94895A840	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 3/4"-16 Thread Size	MC	$ 2.60	0.4	$ 1.04
91257A925	Hex Head Screw, Grade 8 Steel, 7/8"-9 Thread Size, 6" Long, Partially Threaded	MC	$ 7.15	2	$ 14.30
94895A842	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 7/8"-9 Thread Size	MC	$ 8.12	0.2	$ 1.62
371781	Concrete Anchors	HT	$ 346.00	0.2	$ 69.20
Mobile Support Structure					
P2B-LT7-215	Bearing	MI	$ 1,055.35	2	$2,110.70
91257A913	Hex Head Screw, Grade 8 Steel, 7/8"-9 Thread Size, 3" Long, Partially Threaded	MC	$ 3.51	4	$ 14.04
94895A842	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 7/8"-9 Thread Size	MC	$ 8.12	0.4	$ 3.25
92620A626	Hex Head Screw, Grade 8 Steel, 3/8"-16 Thread Size, 1-1/4" Long	MC	$ 8.13	0.96	$ 7.80
94895A031	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 3/8"-16 Thread Size	MC	$ 7.77	0.24	$ 1.86
R-WH-5DB	Hamilton Rigid Caster	HM	$ 74.82	2	$ 149.64
S-WH-5DB	Hamilton Swivel Caster	HM	$ 132.80	2	$ 265.60
2728T220	Locking Plate, 6-3/4" Extended and 5-3/4" Retracted Height	MC	$ 44.59	2	$ 89.18
1871A690	1018 Carbon Steel Weld-on Pull Handle, 2-1/16" Projection	MC	$ 3.57	2	$ 7.14
Top Mounting Bracket					
94895A038	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 1"-8 Thread Size	MC	$ 13.08	0.4	$ 5.23
91090A118	Zinc-Plated Steel Oversized Washer, 1/2" Screw Size, 0.531" ID, 2" OD, 0.042"- 0.051" THK	MC	$ 6.06	0.16	$ 0.97
92620A744	Hex Head Screw, Grade 8 Steel, 1/2"-20 Thread Size, 1" Long	MC	$ 9.87	0.4	$ 3.95
94895A825	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 1/2"-20 Thread Size	MC	$ 8.54	0.64	$ 5.47
90322A168	Steel Threaded Rod, 1/2"-20 Thread Size, 6 Feet Long	MC	$ 27.40	3.5	$ 95.90
Bottom Mounting Bracket					
94895A038	Steel Hex Nut, Grade 8, Zinc Yellow-Chromate Plated, 1"-8 Thread Size	MC	$ 13.08	0.4	$ 5.23
91090A118	Zinc-Plated Steel Oversized Washer, for 1/2" Screw Size, 0.531" ID, 2" OD, 0.042"- 0.051" THK	MC	$ 6.06	0.48	$ 2.91
92620A744	Hex Head Screw, Grade 8 Steel, 1/2"-20 Thread Size, 1" Long	MC	$ 9.87	1.2	$ 11.84
Free Shaft and Connections					
6435K760	Clamping Shaft Collar, for 2-15/16" Diameter, Black-Oxide 1215 Carbon Steel	MC	$ 28.23	1	$ 28.23
97633A478	External Retaining Ring, for 2-15/16" OD, Black-Phosphate 1060-1090 Spring Steel	MC	$ 2.48	1	$ 2.48
92620A959	Hex Head Screw, Grade 8 Steel, 1"-8 Thread Size, 3-1/4" Long	MC	$ 6.68	4	$ 26.72
Drive Shaft and Connections					
97633A478	External Retaining Ring for 2-15/16" OD, Black-Phosphate 1060-1090 Spring Steel	MC	$ 2.48	2	$ 4.96
92620A959	Hex Head Screw, Grade 8 Steel, 1"-8 Thread Size, 3-1/4" Long	MC	$ 6.68	4	$ 26.72
Track					
3028T310	Pivoting Weld-on Tie-Down Ring	MC	$ 6.46	4	$ 25.84
Total					$8,074.95

The total price of each raw material was determined based on a price per unit. If a price per unit was not supplied, sizes of the material were sourced based on square inches.

TABLE BXVII: COST BREAKDOWN OF RAW MATERIALS FOR THE TRUNNION

Raw Materials					
Description	**Supplier**	**Quantity**	**Units**	**Cost/Unit**	**Total Price**
Steel Plate					
0.25'' THK STL Plate	MS	216	sq.in	[redacted]	$ 52.12
0.50" THK STL Plate	MS	2976	sq.in	[redacted]	$ 528.69
0.75'' THK STL Plate	MS	3040.75	sq.in	[redacted]	$ 829.13
1'' THK STL Plate	MS	121	sq.in	[redacted]	$ 98.78
Aluminum Plate					
0.25'' THK 6061 Aluminum Plate	MS	952	sq.in	[redacted]	$ 86.09
0.375'' THK 6061 Aluminum Plate	MS	144	sq.in	[redacted]	$ 27.71
0.75'' THK 6061 Aluminum Plate	MS	3840	sq.in	[redacted]	$ 883.71
1'' THK 6061 Aluminum Plate	MS	8810	sq.in	[redacted]	$ 3,060.67
Round Bar Stock					
1.75'' DIA 6061 Aluminum Solid Bar	MS	9	in	[redacted]	$ 13.95
2.25'' DIA STL Solid Bar	MS	42	in	[redacted]	$ 62.13
3.25'' DIA XX Solid Bar	MS	60.3	in	[redacted]	$ 191.11
8'' DIA STL Solid Bar	MS	8	in	[redacted]	$ 228.97
10'' DIA STL Solid Bar	MS	13	in	[redacted]	$ 436.33
Miscellaneous					
0.75'' SQ Key Stock (98510A226)	MC	25.5	in	$ 0.94	$ 23.95
3''x3''x0.25'' STL Angle Bar	MS	3	in	[redacted]	$ 7.24
3.25''x3'' STL Bar Stock	MS	12	in	[redacted]	$ 63.14
8''x12''x0.375'' STL Rectangular Tube	MS	106	in	[redacted]	$ 454.05
					$ 7,047.77

The total cost of the trunnion is $22,727.94 which is the sum of the raw material and purchased part costs. The dollar value is converted in Canadian dollars.

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Appendices C – Concept Development

Recessed Cavity Gusset Locator

Recessed cavities are approximately half the size of the gusset, allowing the fixture to slide out from underneath the gussets once welded in place. Clamps are used to secure the gussets in place during welding. The vertical gusset supports swing on top of the members of the structure to locate the vertical gussets.

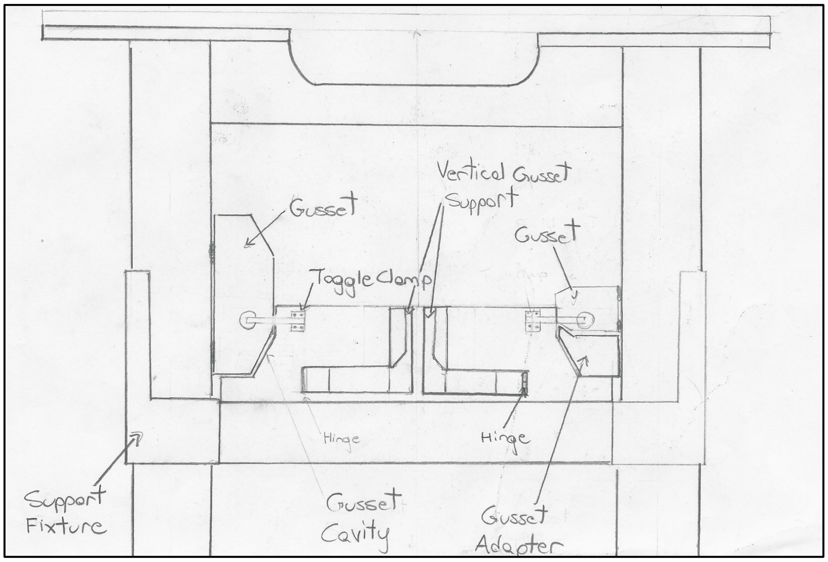

Figure C1: Recessed cavity gusset locator

Spring Alignment Locator

Two recessed gusset plates are connected to each other by rails. A spring produces enough pressure to secure the fixture in place between the two structural members. The spring also allows the two sides to be pushed together to aid in fixture removal.

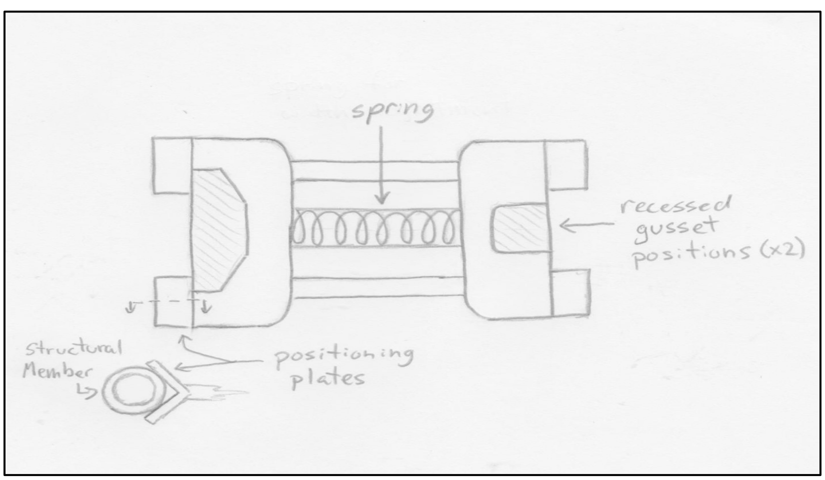

Figure C2: Spring alignment locator

Circular Mounting Bracket

Two machined end plates create the mounting brackets. Base plate recesses are cut into one of the mounting brackets, while cylinder boots provide mounting for the other end of the tower assembly.

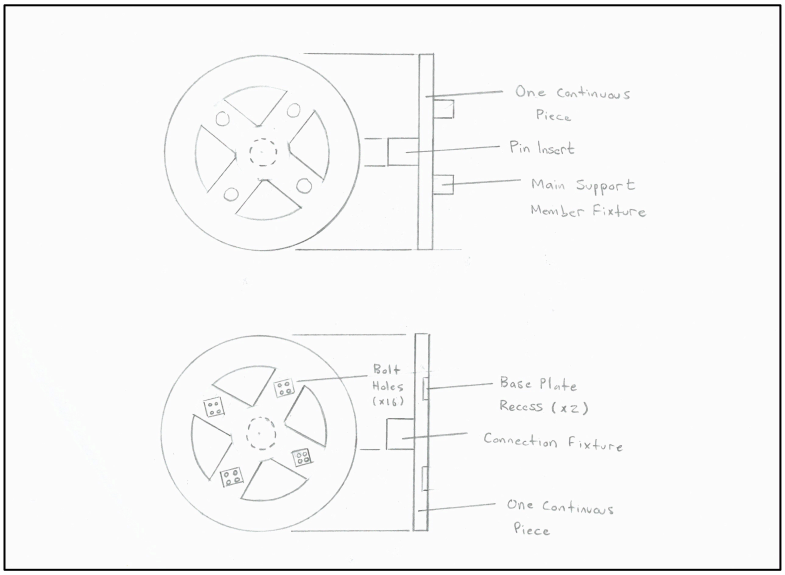

Figure C3: Circular mounting bracket

Indexing Pins with Recessed Holes

The base of the trunnion structure will have four legs. The legs will be inserted into indexing cavities installed in the floor to locate the structure.

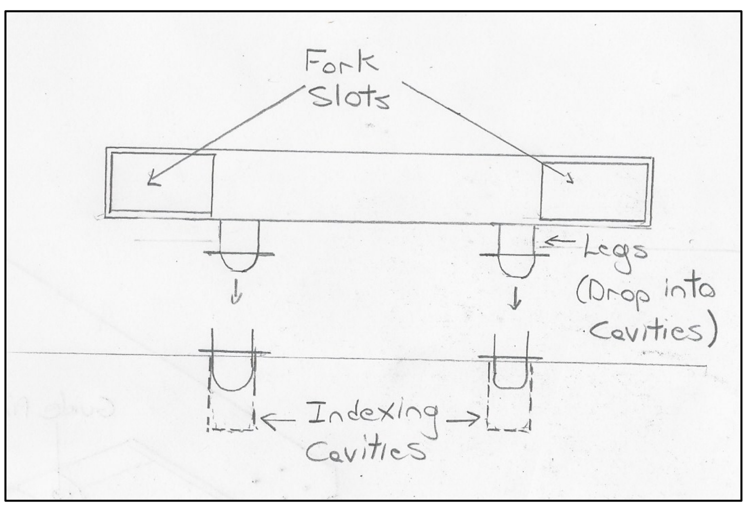

Figure C4: Indexing pins with recessed holes

Final Trunnion Concept

The final trunnion concept generated by Team 3 is shown in Figure C5.

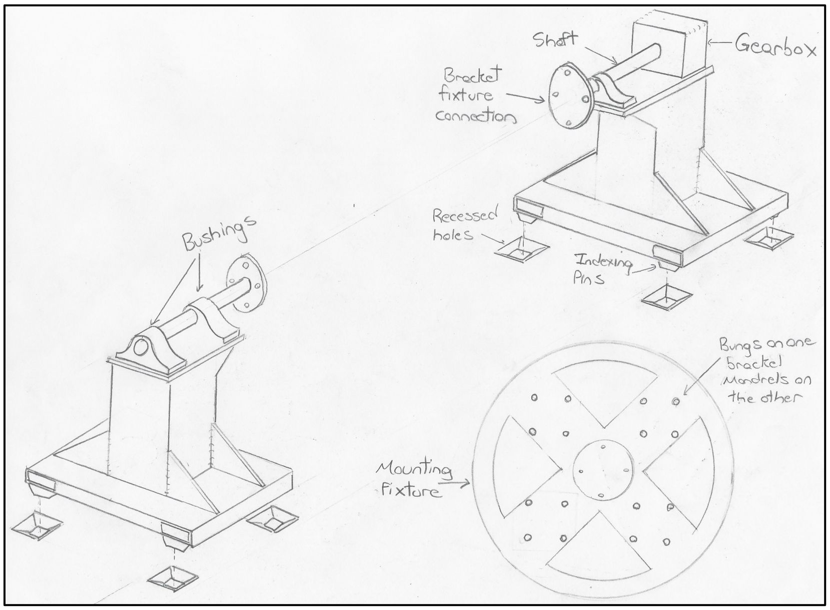

Figure C5: Final trunnion concept

Appendices D – Gusset Locator Preliminary Drawings

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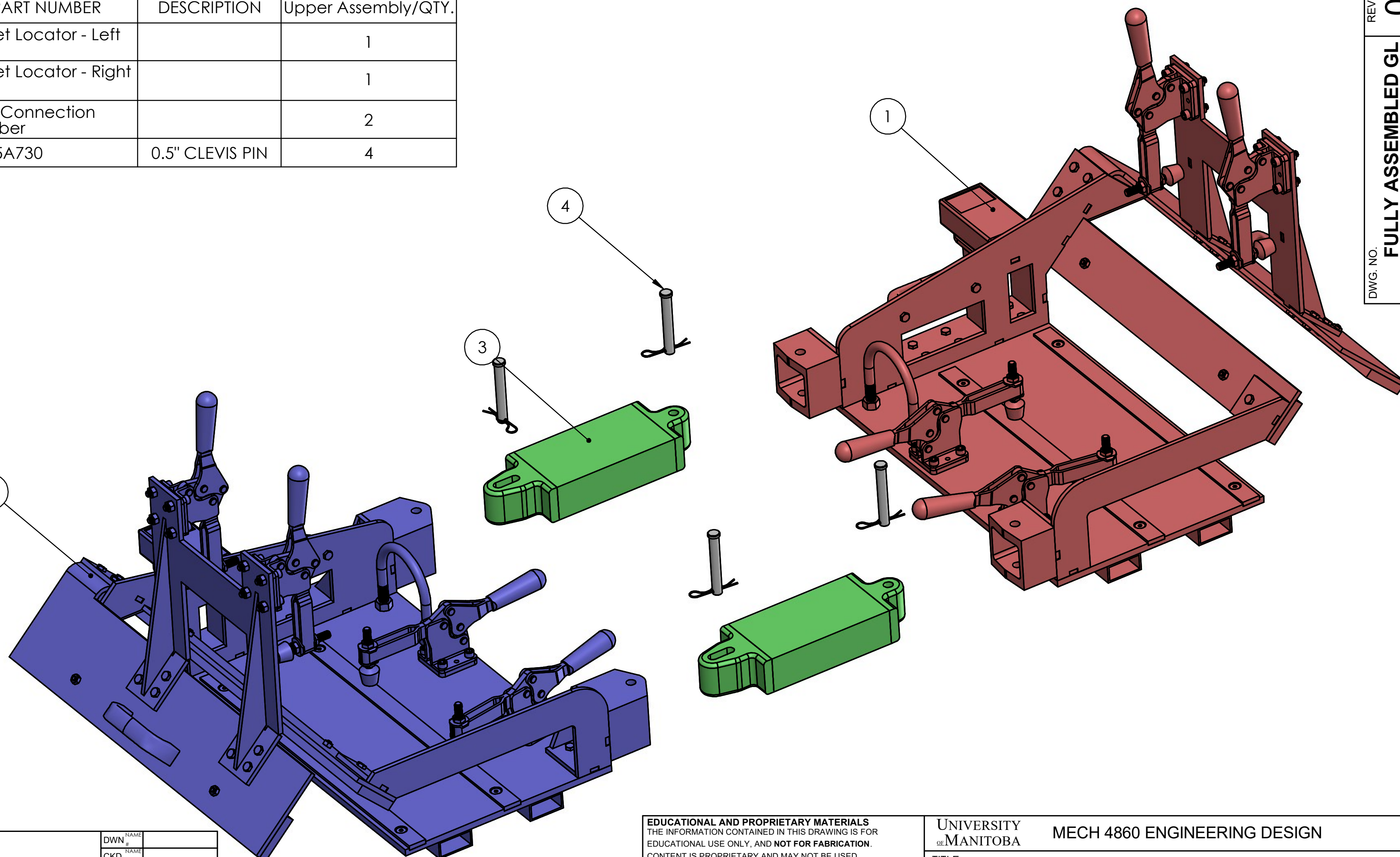
ITEM NO.	PART NUMBER	DESCRIPTION	Upper Assembly/QTY.
1	Gusset Locator - Left Side		1
2	Gusset Locator - Right Side		1
3	Pivot Connection Member		2
4	97245A730	0.5" CLEVIS PIN	4



REV	DATE Y/M/D	DESCRIPTION		
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DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

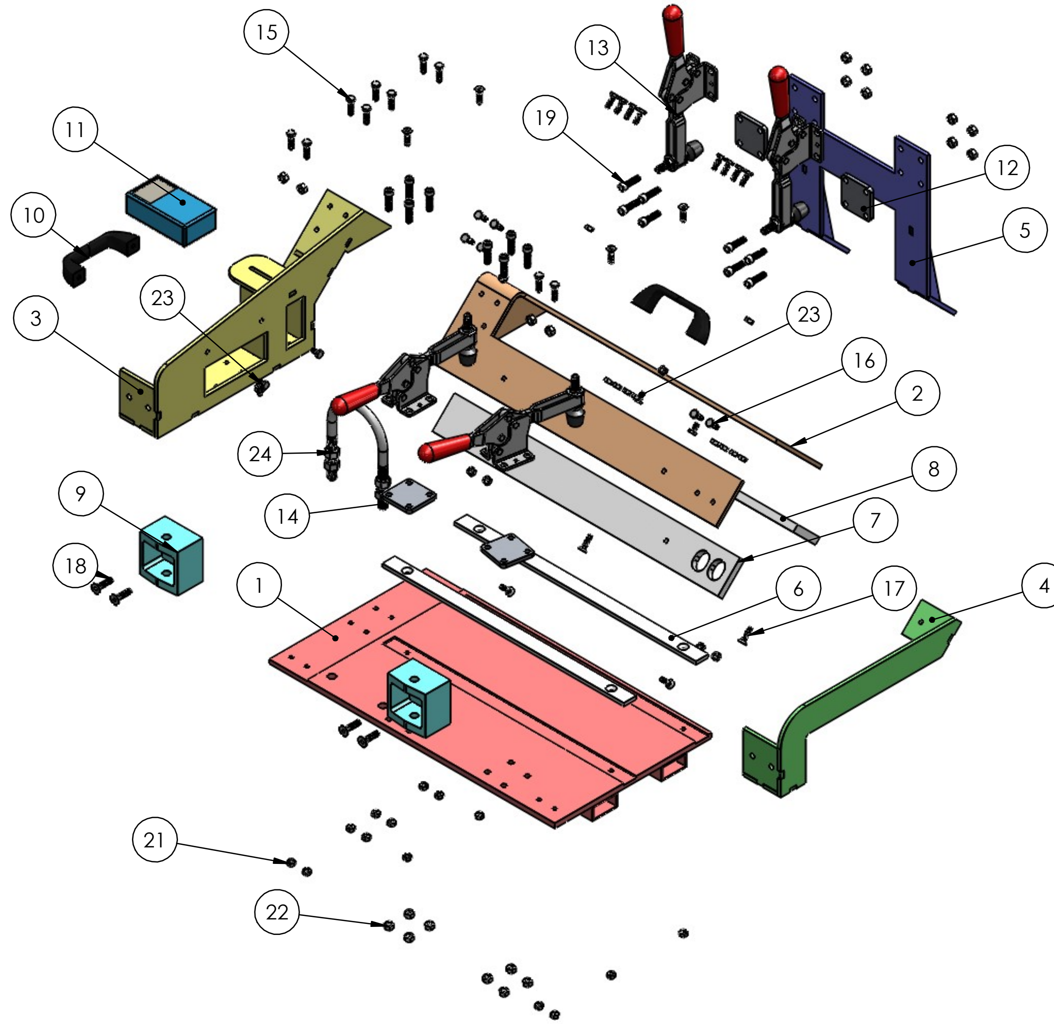
TITLE:
FULLY ASSEMBLED GL
TEAM 3

SIZE **B** | DWG. NO. **FULLY ASSEMBLED GL** | REV 0

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 1

REV 0 — DWG. NO. FULLY ASSEMBLED GL

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Main Support Plate - LS		1
2	Angle Support LS		1
3	Main Connection Bracket - LS		1
4	Support Bracket - LS		1
5	Vertical Gusset Support		1
6	PTFE Strip - Below Gusset		2
7	PTFE Strip 1 - Below AS		1
8	PTFE Strip 2 - Below AS		1
9	Female Pivot Bracket		2
10	1661A4	HANDLE	2
11	Bosch Measurement Device		1
12	Clamp Spacer		4
13	5091A610_LOW-PROFILE HOLD-DOWN TOGGLE CLAMP		4
14	29605T470	0.5"-13 U-BOLT	1
15	92240A542	0.25"-20 1" LONG HEX HEAD	10
16	92240A540	0.25"-20 0.75" LONG HEAD	14
17	92210A542	0.25"-20 1" LONG FLAT HEAD	8
18	92210A585	0.3125"-18 1-0.25" LONG FLAT HEAD	4
19	92196A584	0.3125"-18 1-0.125" LONG SOCKET HEAD	16
20	91185A917	0.25"-20 0.5" LONG THUMB SCREW	1
21	95462A029	0.25"-20 GRADE 5 NUT	32
22	95462A030	5/16"-18 GRADE 5 NUT	20
23	92240A537	0.25"-20 0.5" LONG HEX HEAD	4
24	95462A033	0.5"-13 GRADE 5 NUT	2



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			DWN	
			CKD	
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			CKD	

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UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

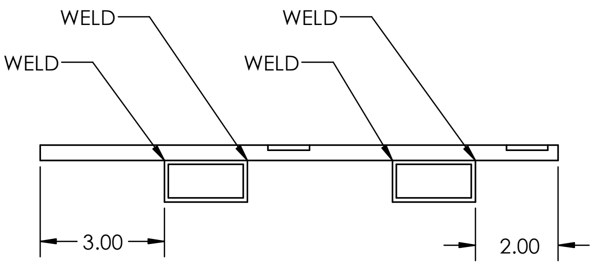
TITLE:
GUSSET LOCATOR - LEFT SIDE
TEAM 3

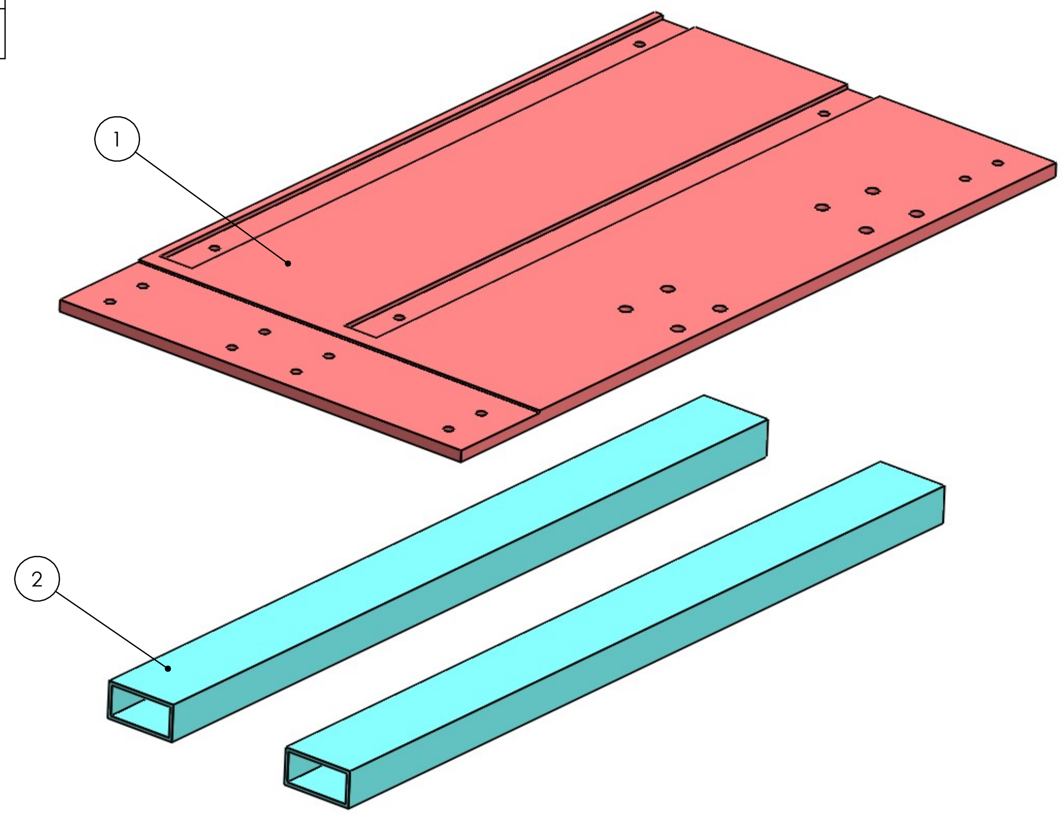
SIZE **B** | DWG. NO. **GUSSET LOCATOR - LEFT SIDE** | REV

SCALE: 1:7 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **GUSSET LOCATOR - LEFT SIDE** | REV

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	MSP - Machined Plate LS		1
2	MSP - 1x2 Rectangular Tube	1"x2" - 0.095" 6061-T6 STOCK	2





REV	DATE Y/M/D	DESCRIPTION		
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			CKD	
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			CKD	

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DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

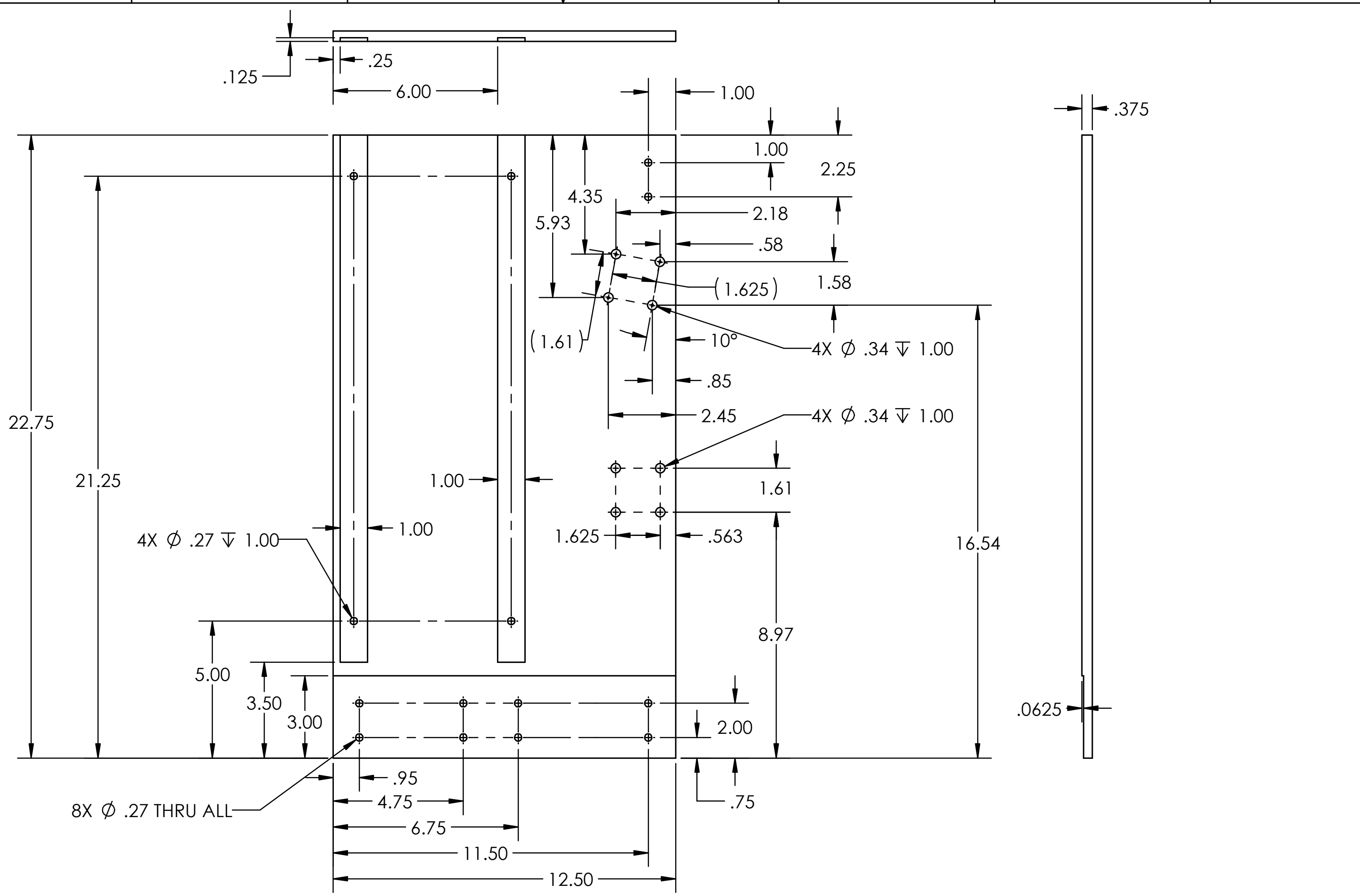
MECH 4860 ENGINEERING DESIGN

TITLE:
MAIN SUPPORT PLATE - LS
TEAM 3

SIZE: **B** | DWG. NO. **MAIN SUPPORT PLATE - LS** | REV 0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **MAIN SUPPORT PLATE - LS** | REV 0



REV 0

DWG. NO. MSP - MACHINED PLATE LS

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 6061-T6

FINISH: √

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

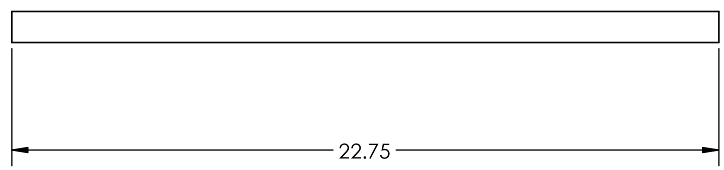
MECH 4860 ENGINEERING DESIGN

TITLE:
MSP - MACHINED PLATE LS
TEAM 3

SIZE	DWG. NO.	REV
B	MSP - MACHINED PLATE LS	0

SCALE: 1:4 | WEIGHT: 9.655LBS | SHEET 1 OF 1

DWG. NO. MSP - 1X2 RECTANGULAR TUBE REV 0



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN NAME # / CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
1"X2"X0.095" 6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

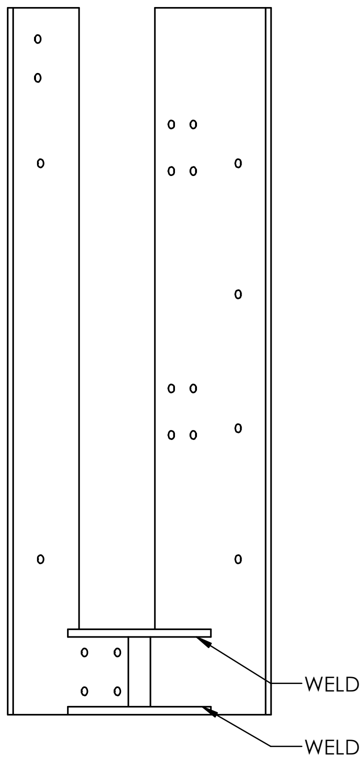
MECH 4860 ENGINEERING DESIGN

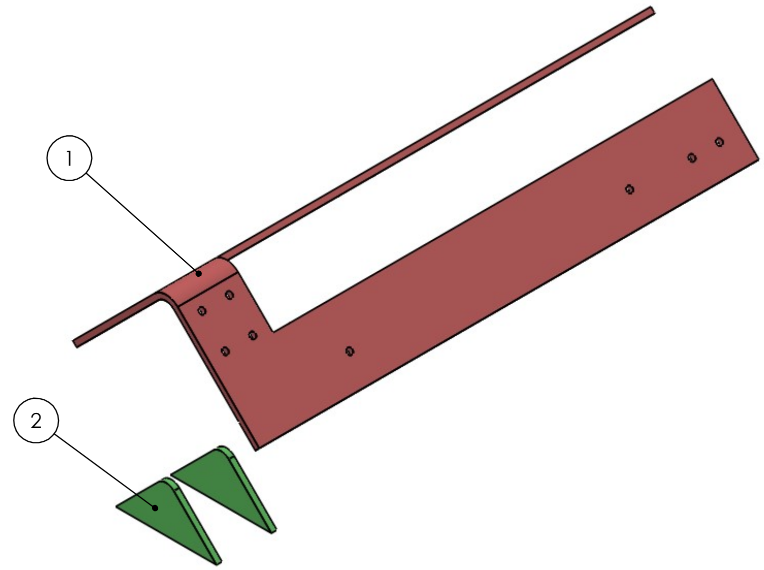
TITLE:
TRACK BASE
TEAM 3

SIZE **B** DWG. NO. **MSP - 1X2 RECTANGULAR TUBE** REV 0

SCALE: 1:4 WEIGHT: 1.18LBS SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	AS - Bent Plate LS		1
2	AS - Plate		2





			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN SM	
			CKD	
REV	DATE Y/M/D	DESCRIPTION		

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

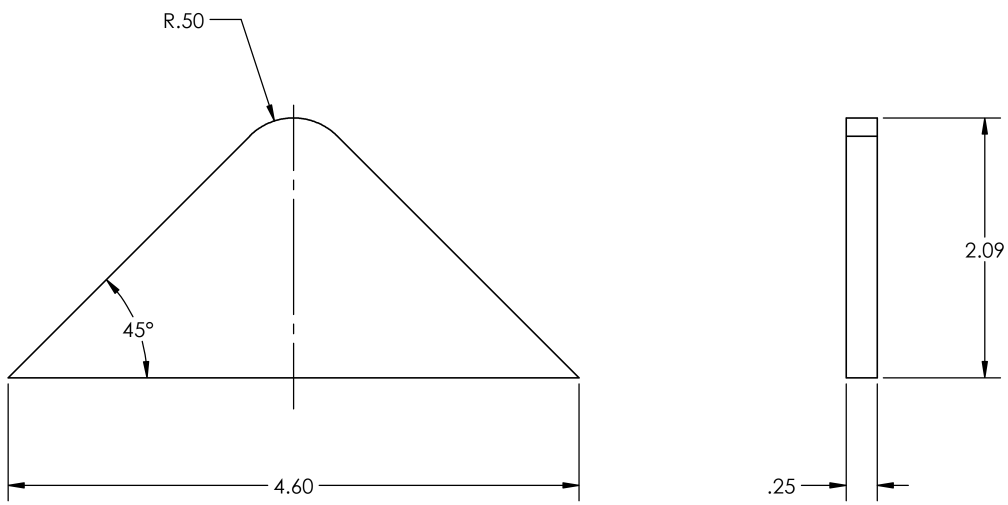
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
ANGLE SUPPORT LS
TEAM 3

SIZE **B** | DWG. NO. **ANGLE SUPPORT LS** | REV 0

SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **ANGLE SUPPORT LS** REV 0



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 6061-T6

FINISH: √

DO NOT SCALE DRAWING

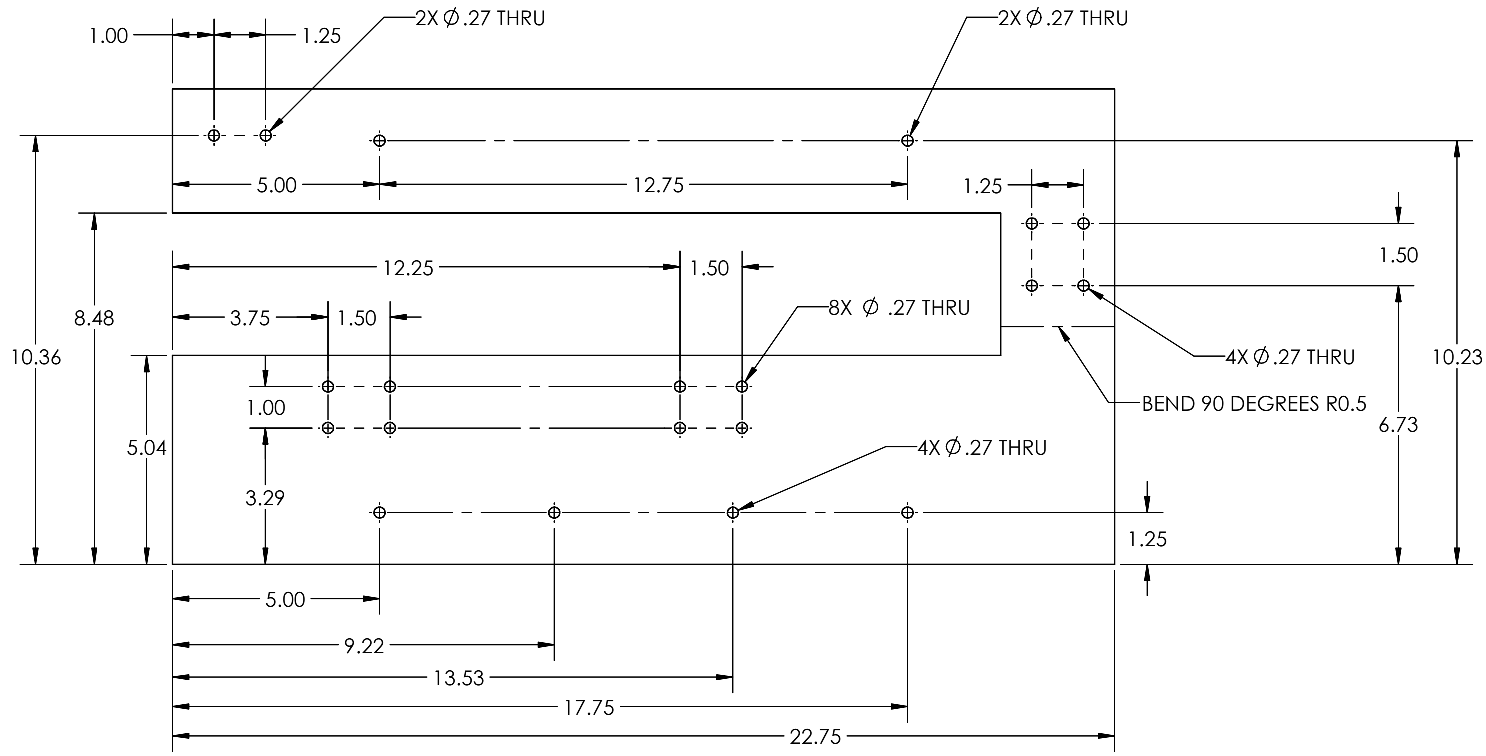
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **AS - PLATE**
TEAM 3

SIZE: **B** | DWG. NO. **AS - PLATE** | REV 0

SCALE: 1:1 | WEIGHT: 0.13LBS | SHEET 1 OF 1

DWG. NO. **AS - PLATE** | REV 0



REV	DATE Y/M/D	DESCRIPTION		
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
0	18/11/28	DRAWING CREATED	DWN NAME #	
			CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6

FINISH
✓

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

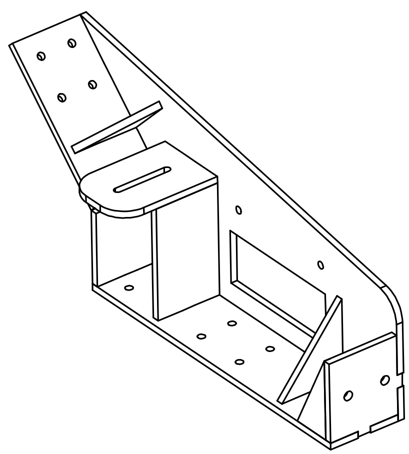
TITLE:
AS - BENT PLATE LS
TEAM 3

SIZE **B** | DWG. NO. **AS - BENT PLATE LS** | REV 0

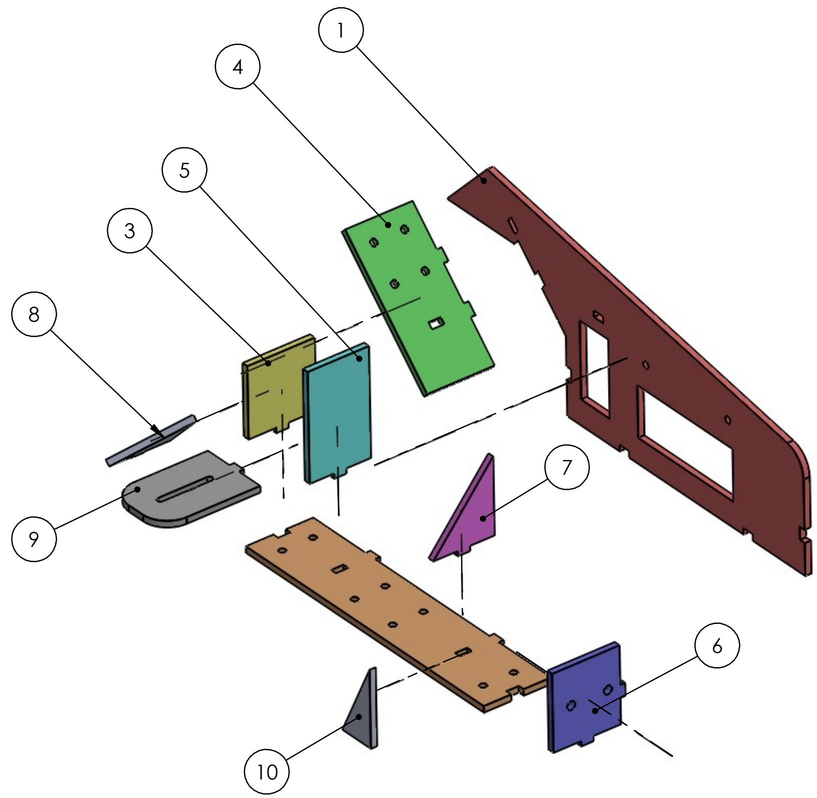
SCALE: 1:3 | WEIGHT: 4.67LBS | SHEET 1 OF 1

REV 0
DWG. NO. AS - BENT PLATE LS

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	MCB - Plate 1		1
2	MCB - Plate 2		1
3	MCB - Plate 3		1
4	MCB - Plate 4		1
5	MCB - Plate 5		1
6	MCB - Plate 6		1
7	MCB - Rib 1		1
8	MCB - Rib 2		1
9	MCB - Laser Mount		1
10	MCB - Rib 3		1



WELD ASSEMBLY



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

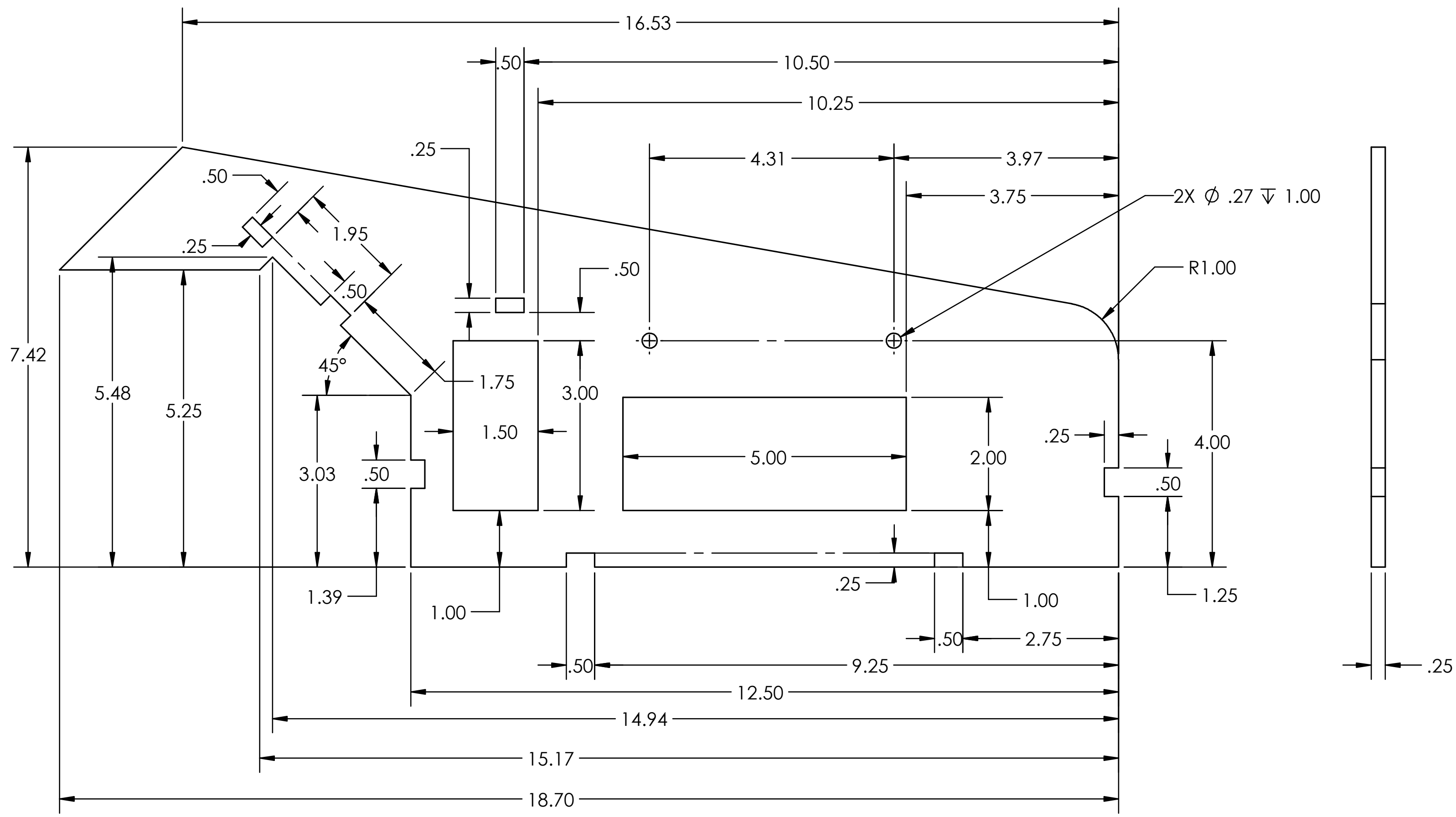
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
MAIN CONNECTION BRACKET - LS
TEAM 3

SIZE: **B** | DWG. NO. **MAIN CONNECTION BRACKET - LS** | REV 0

SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **MAIN CONNECTION BRACKET - LS** REV **0**



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH
√

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UNIVERSITY of MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - PLATE 1
TEAM 3

SIZE **B**

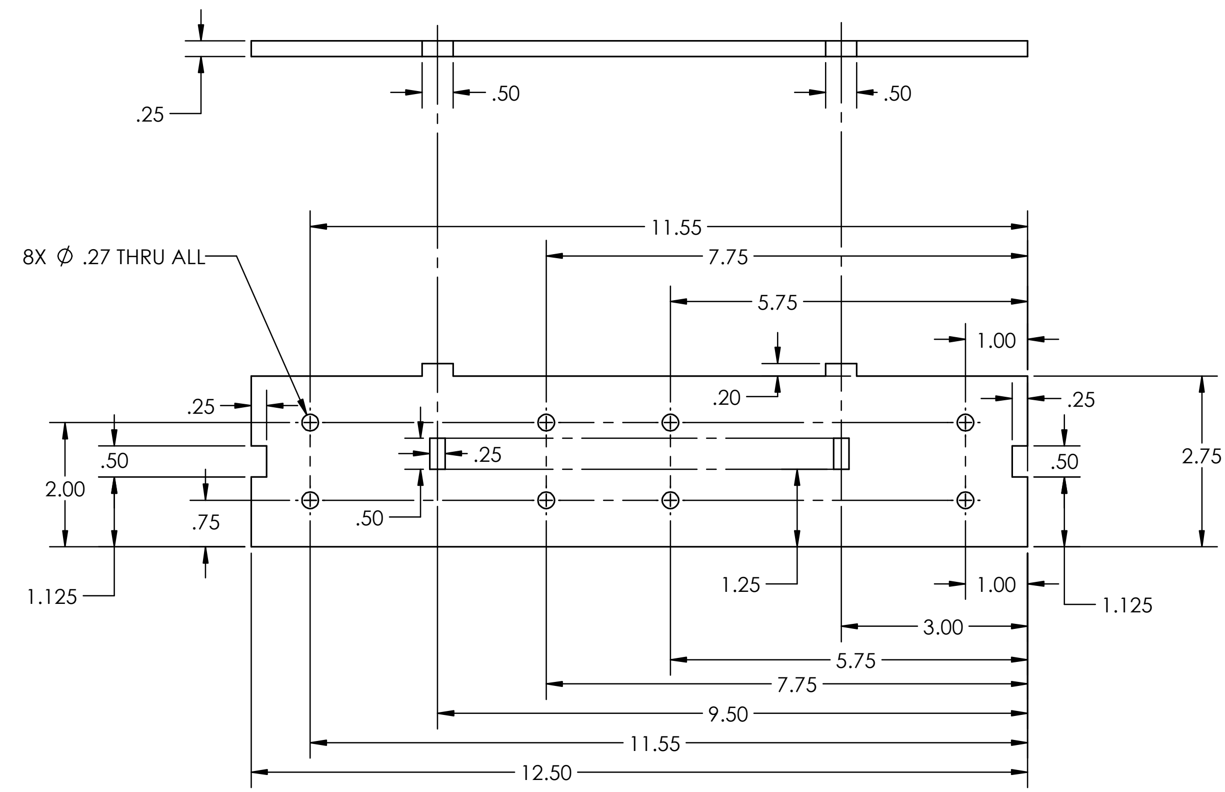
DWG. NO. **MCB - PLATE 1**

REV 0

SCALE: 1:2 | WEIGHT: 1.62 | SHEET 1 OF 1

REV 0

DWG. NO. **MCB - PLATE 1**



REV 0

DWG. NO. MCB - PLATE 2

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
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FINISH

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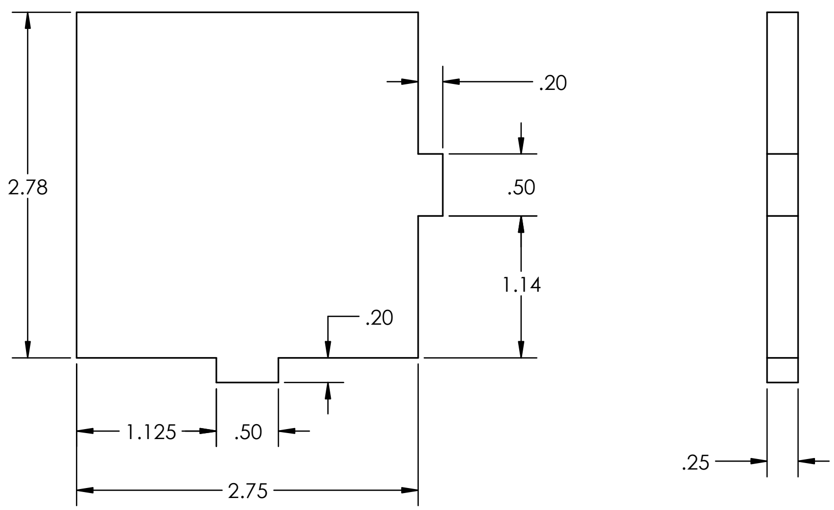
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MBC - PLATE 2
TEAM 3

SIZE **B** | DWG. NO. **MCB - PLATE 2** | REV 0

SCALE: 1:2 | WEIGHT: 0.82LBS | SHEET 1 OF 1



REV 0

DWG. NO. MCB - PLATE 3

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
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UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

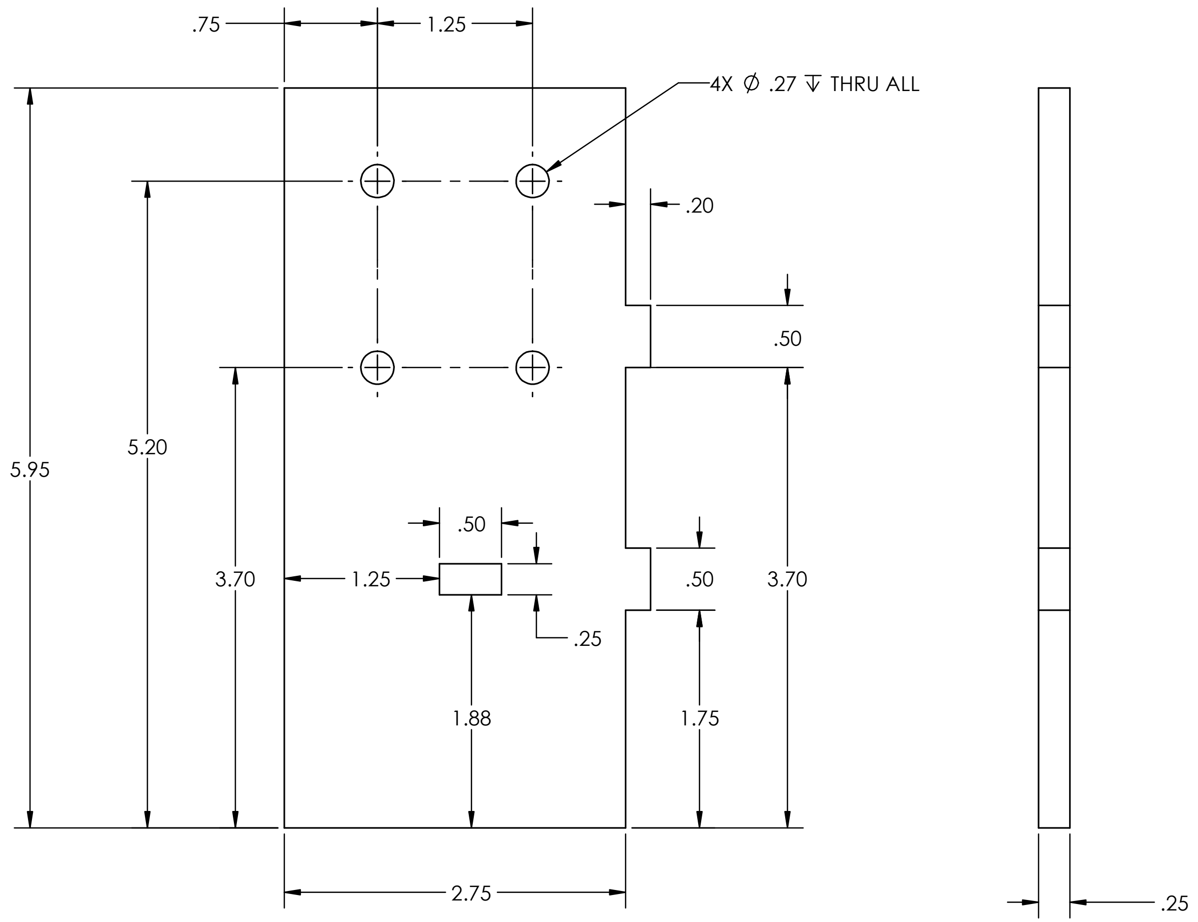
TITLE:
MCB - PLATE 3
TEAM 3

SIZE **B** | DWG. NO. **MCB - PLATE 3** | REV 0

SCALE: 1:1 | WEIGHT: 0.19LBS | SHEET 1 OF 1

REV 0

DWG. NO. MCB - PLATE 4



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 6061-T6

FINISH: √

DO NOT SCALE DRAWING

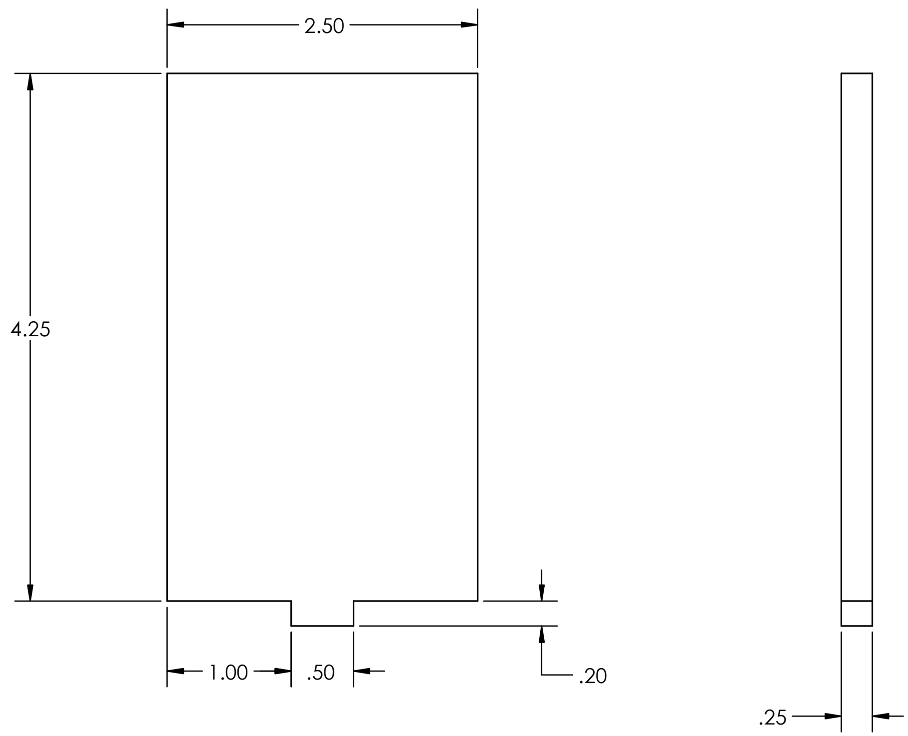
UNIVERSITY of MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE: **MCB - PLATE 4**
TEAM 3

SIZE: **B** | DWG. NO. **MCB - PLATE 4** | REV 0

SCALE: 1:1 | WEIGHT: 0.40LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

EDUCATIONAL AND PROPRIETARY

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MATERIAL: 6061-T6

FINISH: √

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - PLATE 5
TEAM 3

SIZE: **B**

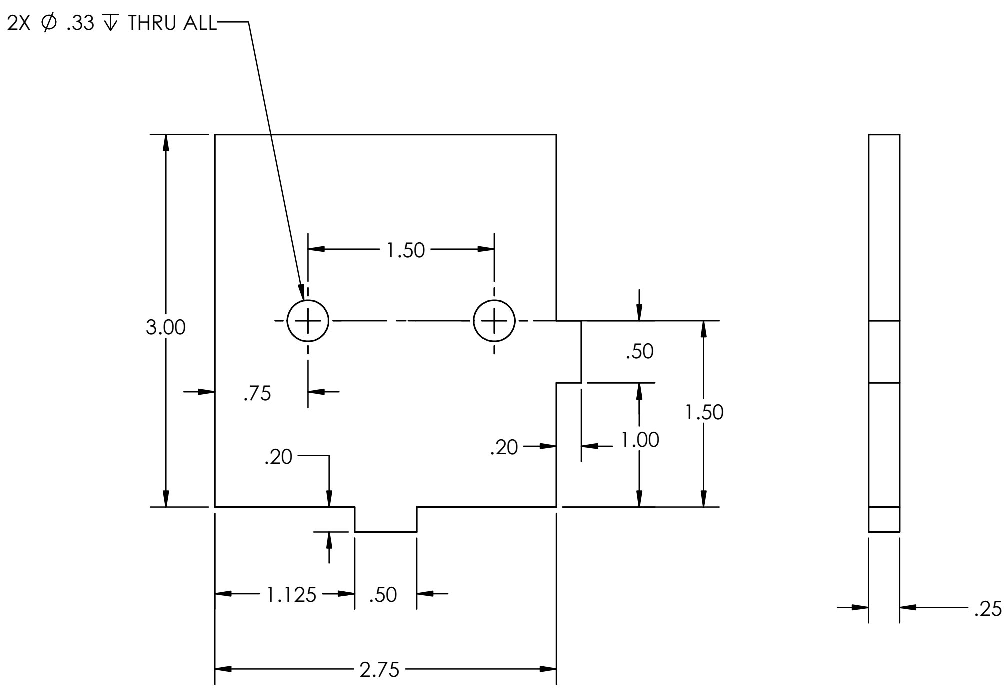
DWG. NO. **MCB - PLATE 5**

REV: 0

SCALE: 1:1 | WEIGHT: 0.26LBS | SHEET 1 OF 1

REV 0

DWG. NO. **MCB - PLATE 5**



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

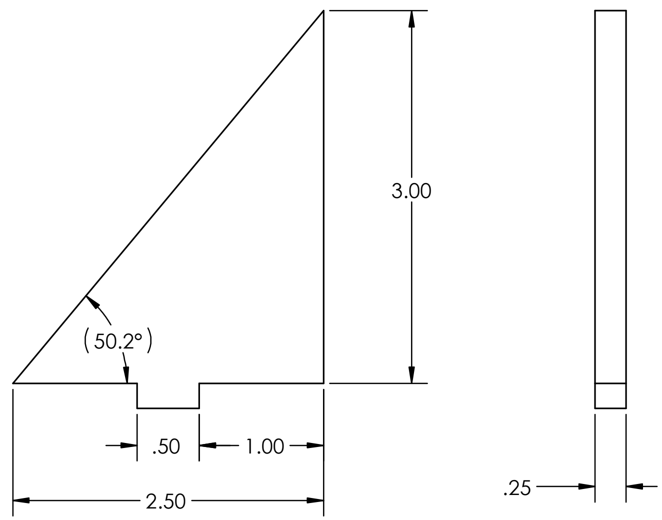
MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - PLATE 6
TEAM 3

SIZE **B** | DWG. NO. **MCB - PLATE 6** | REV 0

SCALE: 1:1 | WEIGHT: 0.20LBS | SHEET 1 OF 1

DWG. NO. **MCB - PLATE 6** REV 0



REV 0

DWG. NO. MCB - RIB 1

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
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FINISH

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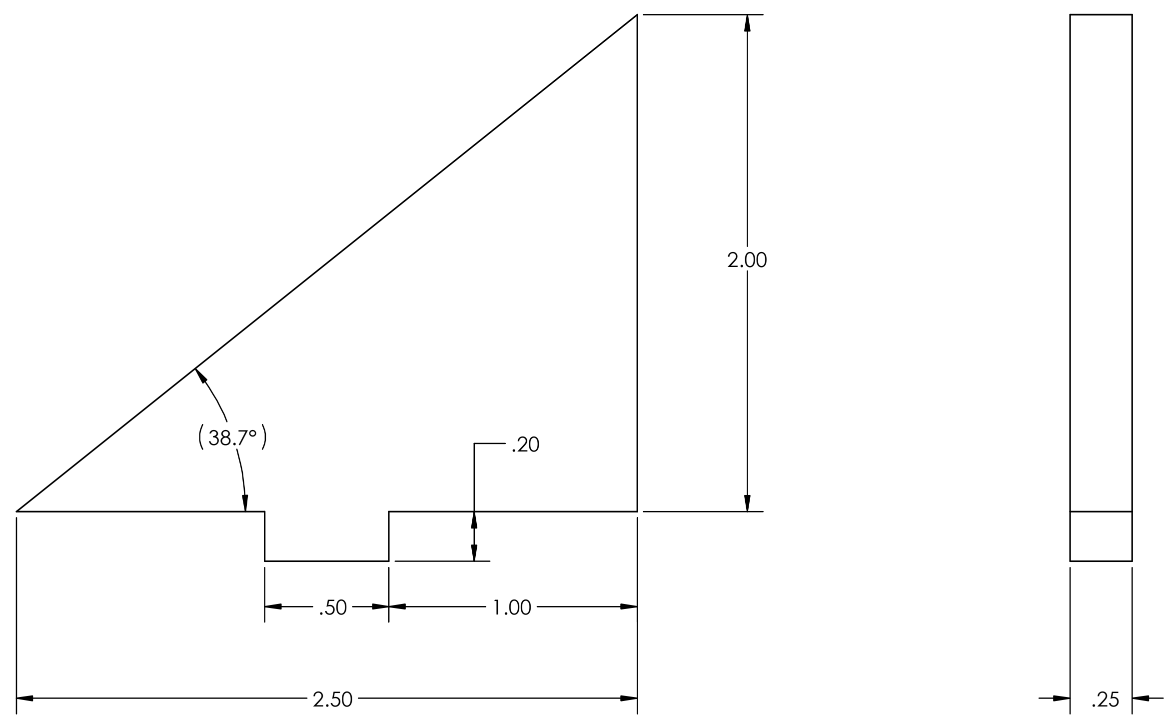
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - RIB 1
TEAM 3

SIZE **B** | DWG. NO. **MCB - RIB 1** | REV 0

SCALE: 1:1 | WEIGHT: 0.09LBS | SHEET 1 OF 1



REV 0

DWG. NO. MCB - RIB 2

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
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FINISH

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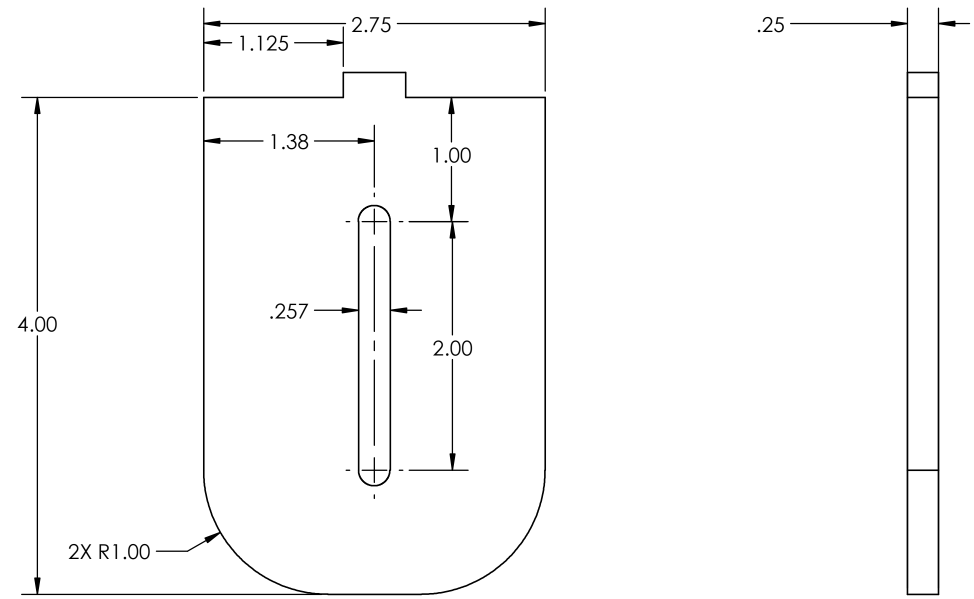
UNIVERSITY of MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - RIB 2
TEAM 3

SIZE **B** | DWG. NO. **MCB - RIB 2** | REV 0

SCALE: 2:1 | WEIGHT: 0.06LBS | SHEET 1 OF 1



DWG. NO. **MCB - LASER MOUNT** REV 0

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
MCB - LASER MOUNT

FINISH

DO NOT SCALE DRAWING

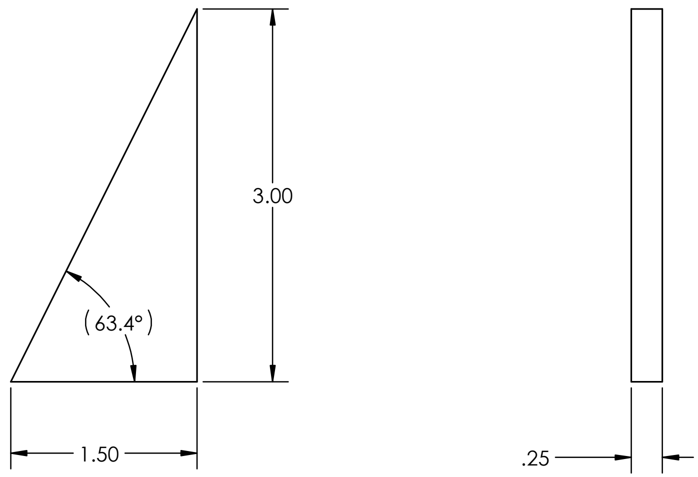
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - LASER MOUNT
TEAM 3

SIZE **B** | DWG. NO. **MCB - LASER MOUNT** | REV 0

SCALE: 1:1 | WEIGHT: 0.25LBS | SHEET 1 OF 1



REV 0

DWG. NO. MCB - RIB 3

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

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MATERIAL
6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MCB - RIB 3
TEAM 3

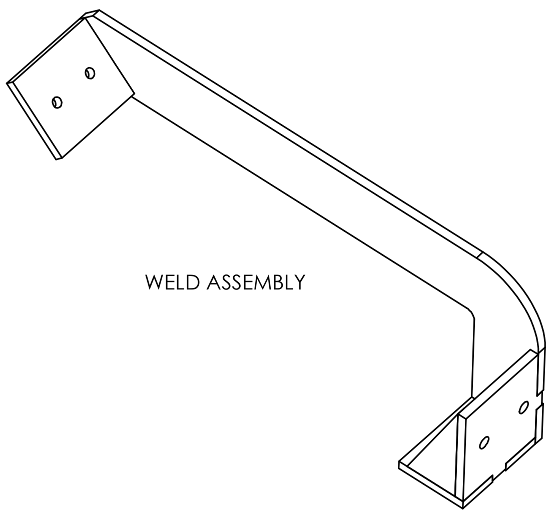
SIZE **B**

DWG. NO. **MCB - RIB 3**

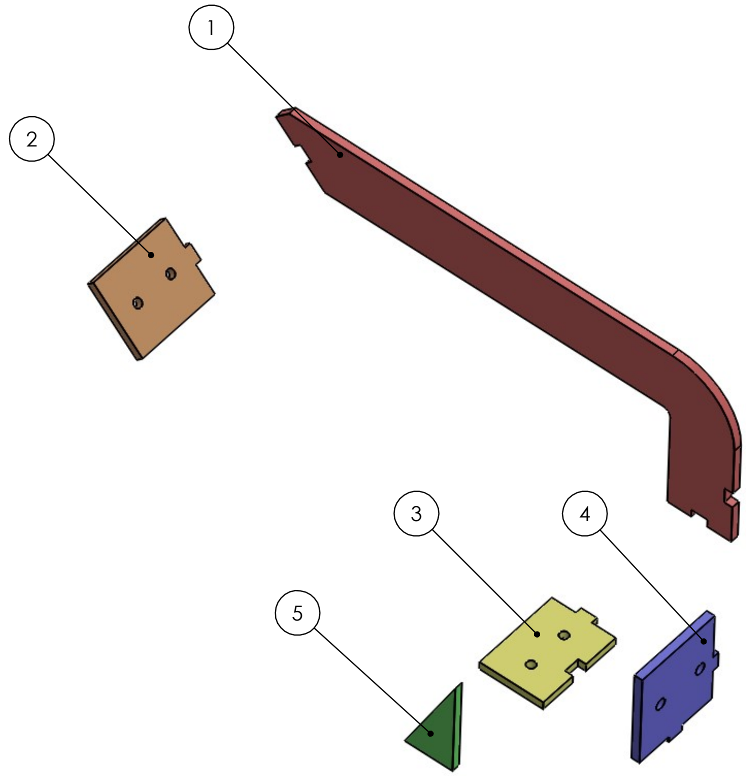
REV 0

SCALE: 1:1 | WEIGHT: 0.05LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SB - Plate 1		1
2	SB - Plate 2		1
3	SB - Plate 3		1
4	MCB - Plate 6		1
5	MCB - Rib 3		1



WELD ASSEMBLY



			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN SM / CKD	
REV	DATE Y/M/D	DESCRIPTION		

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

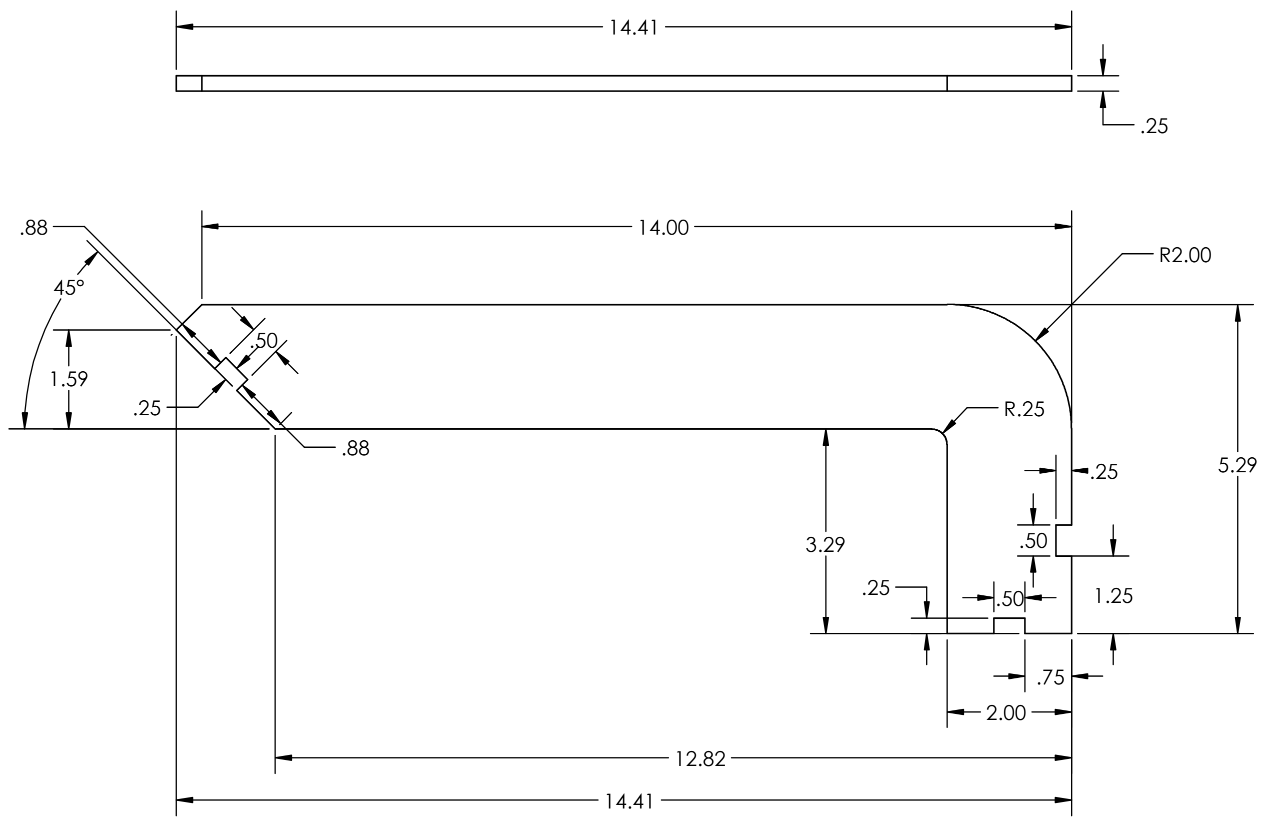
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
SUPPORT BRACKET - LS
TEAM 3

SIZE	DWG. NO.	REV
B	SUPPORT BRACKET - LS	0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

DWG. NO. SUPPORT BRACKET - LS
REV 0



REV 0

DWG. NO. SB - PLATE 1

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE ±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL 6061-T6

FINISH

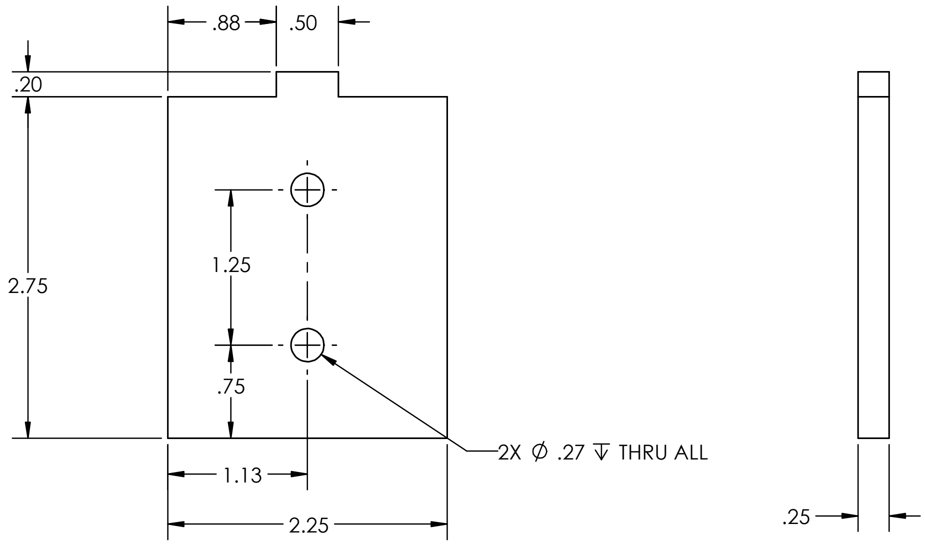
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **SB - PLATE 1**
TEAM 3

SIZE **B** | DWG. NO. **SB - PLATE 1** | REV 0

SCALE: 1:2 | WEIGHT: 0.8LBS | SHEET 1 OF 1



REV 0

DWG. NO. SB - PLATE 2

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH
√

DO NOT SCALE DRAWING

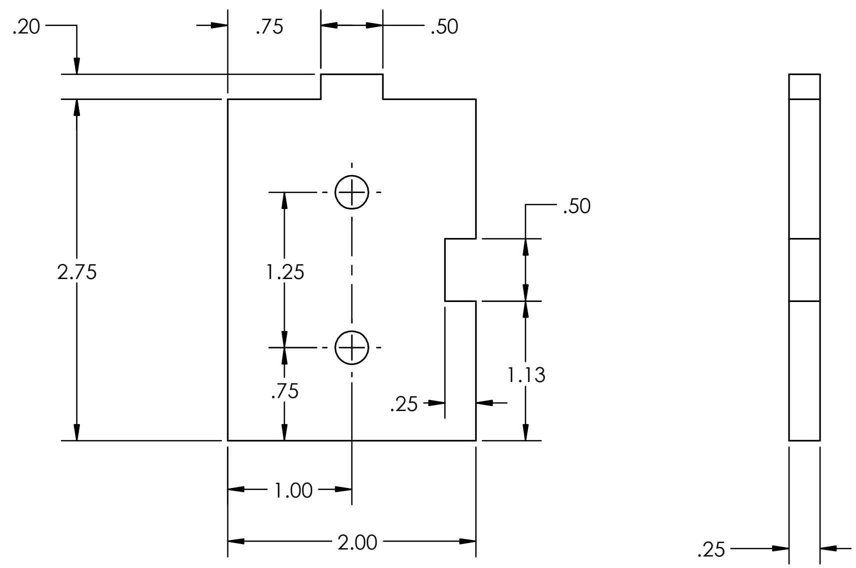
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
SB - PLATE 2
TEAM 3

SIZE	DWG. NO.	REV
B	**SB - PLATE 2**	0

SCALE: 1:1 | WEIGHT: 0.15LBS | SHEET 1 OF 1



REV 0

DWG. NO. SB - PLATE 3

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE ±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 6061-T6

FINISH

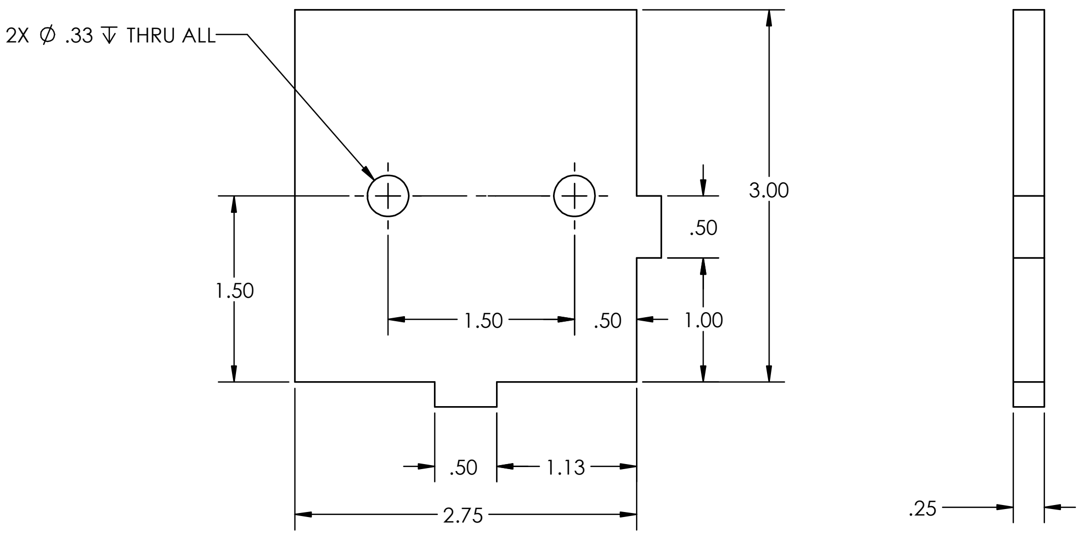
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **SB - PLATE 3**
TEAM 3

SIZE: **B** | DWG. NO. **SB - PLATE 3** | REV 0

SCALE: 1:1 | WEIGHT: 0.13LBS | SHEET 1 OF 1



REV 0

DWG. NO. MCB - PLATE 6

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL: 6061-T6

FINISH: ✓

DO NOT SCALE DRAWING

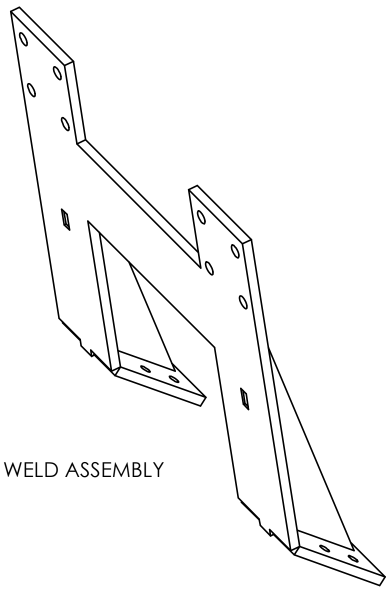
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **MCB - PLATE**
TEAM 3

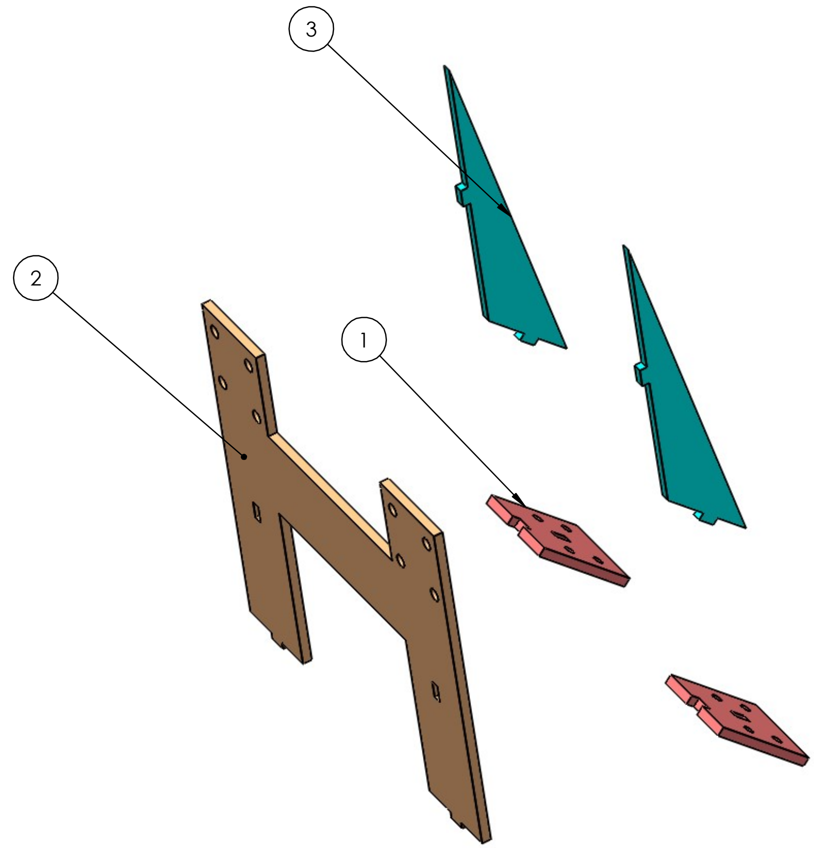
SIZE: **B** | DWG. NO. **MCB - PLATE 6** | REV 0

SCALE: 1:1 | WEIGHT: 0.13LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	VGS - Plate 1		2
2	VGS - Plate 2		1
3	VGS - Plate 3		2



WELD ASSEMBLY



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN SM / CKD	

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DIMENSIONAL UNIT: INCHES

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

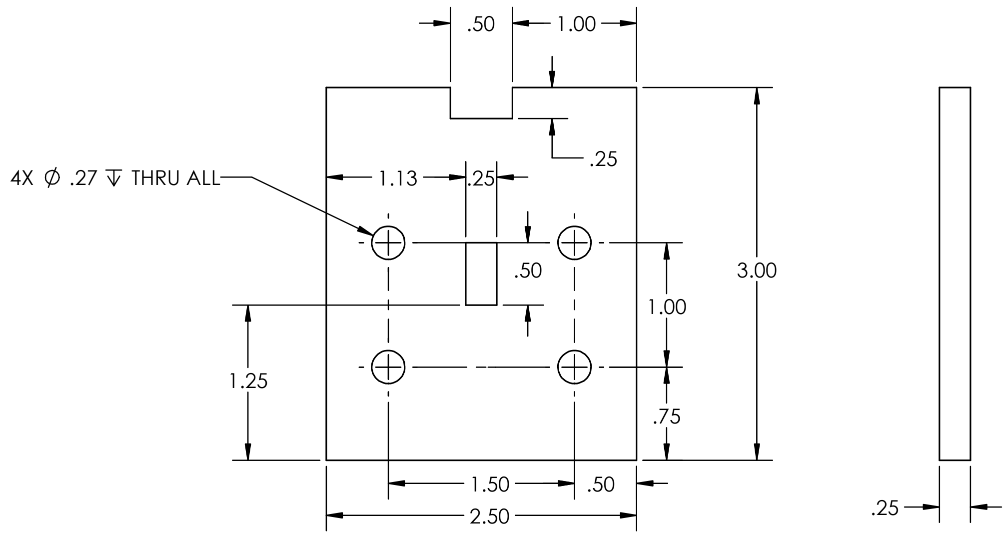
TITLE: **VERTICAL GUSSET SUPPORT**
TEAM 3

SIZE: B | DWG. NO.: VERTICAL GUSSET SUPPORT | REV: 0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

DO NOT SCALE DRAWING

DWG. NO. VERTICAL GUSSET SUPPORT REV 0



REV 0

DWG. NO. VGS - PLATE 1

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

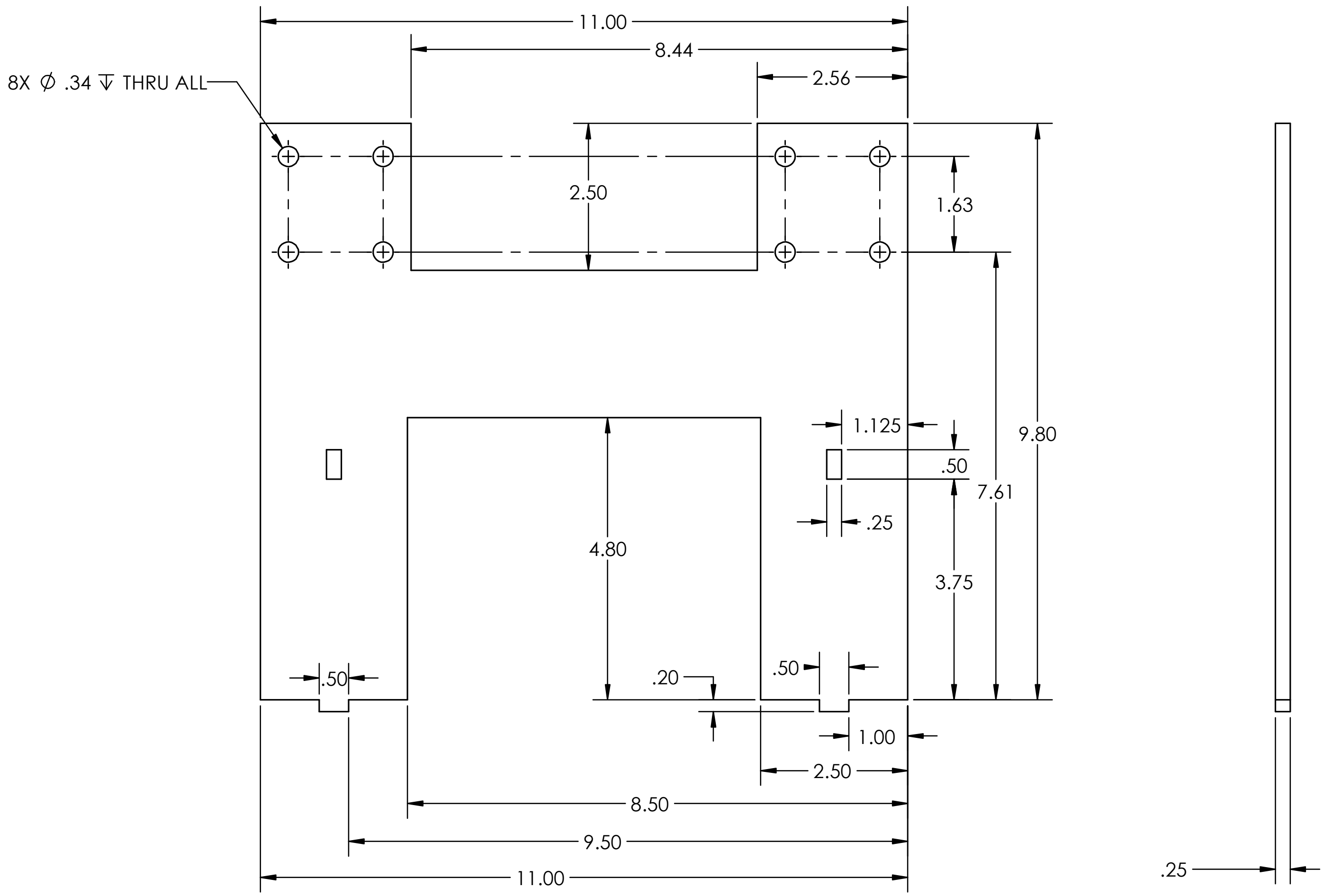
TITLE:
VGS - PLATE 1
TEAM 3

SIZE **B**

DWG. NO. **VGS - PLATE 1**

REV 0

SCALE: 1:1 | WEIGHT: 0.2LBS | SHEET 1 OF 1



REV 0

DWG. NO. VGS - PLATE 2

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6

FINISH
✓

DO NOT SCALE DRAWING

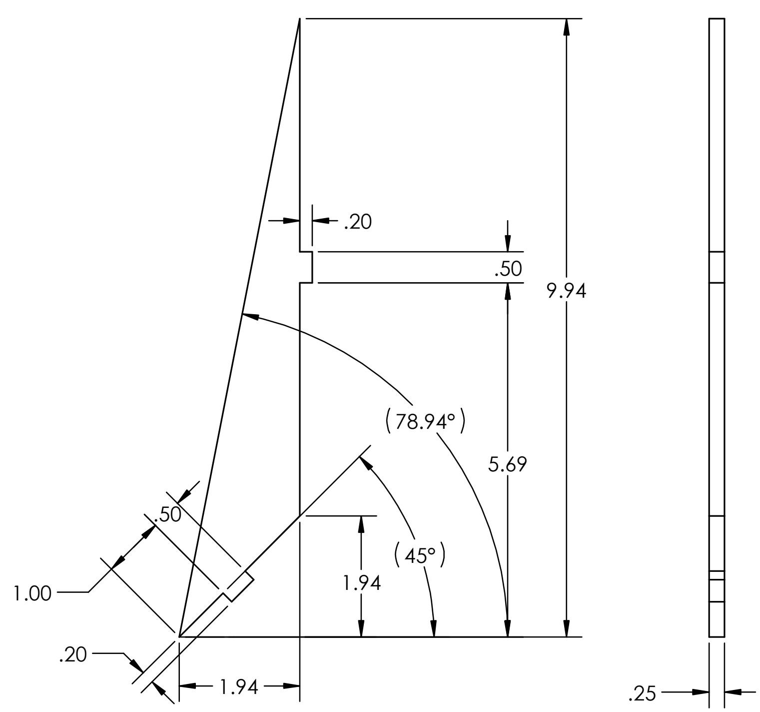
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
VGS - PLATE 2
TEAM 3

SIZE **B** | DWG. NO. **VGS - PLATE 2** | REV 0

SCALE: 1:2 | WEIGHT: 1.55 | SHEET 1 OF 1



REV 0

DWG. NO. VGS - PLATE 3

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL: 6061-T6

FINISH: ✓

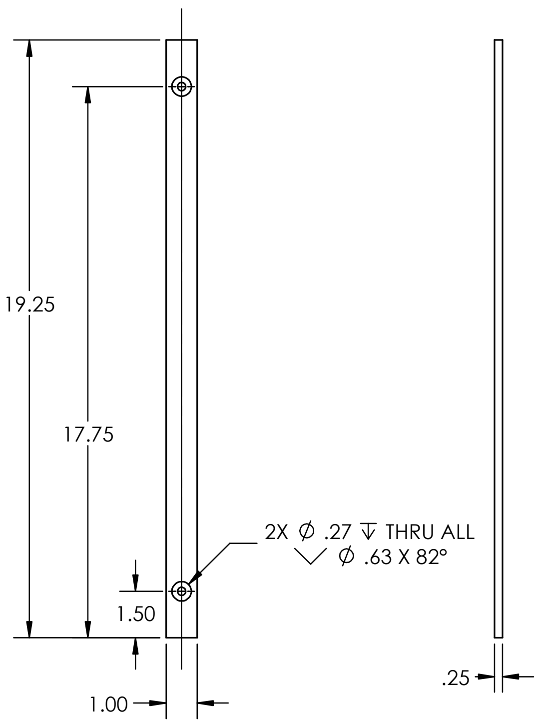
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **VGS - PLATE 3**
TEAM 3

SIZE: **B** | DWG. NO. **VGS - PLATE 3** | REV 0

SCALE: 1:2 | WEIGHT: 0.19 | SHEET 1 OF 1



REV 0
DWG. NO. PTFE STRIP - BELOW GUSSET

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: PTFE

FINISH: ✓

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UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

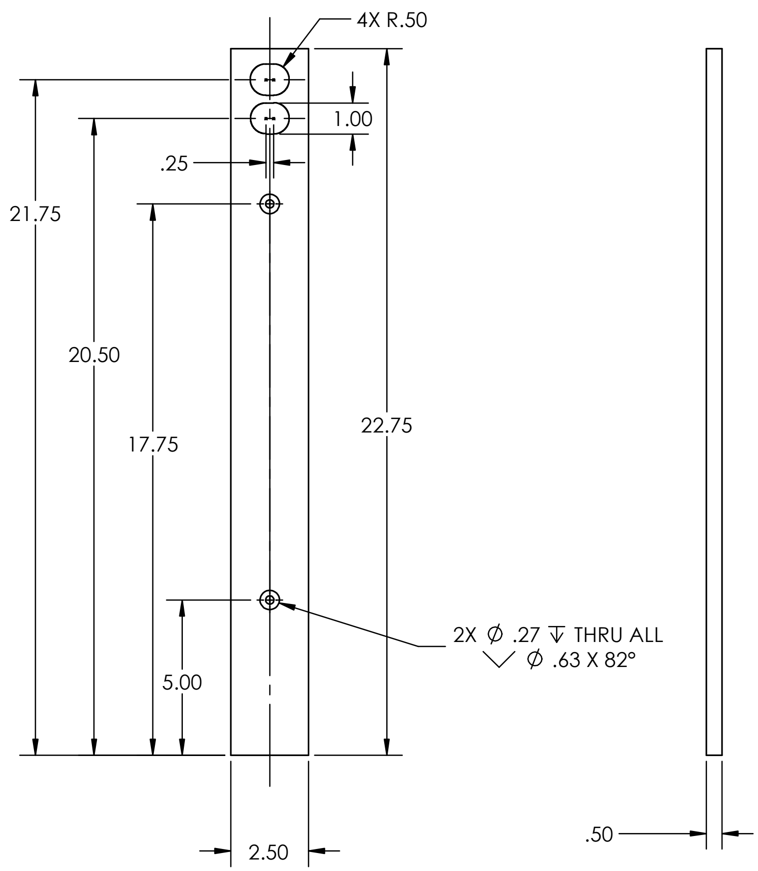
TITLE:
PTFE STRIP - BELOW GUSSET
TEAM 3

SIZE: **B**

DWG. NO. **PTFE STRIP - BELOW GUSSET**

REV: 0

SCALE: 1:4 | WEIGHT: 0.4LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: PTFE

FINISH: ✓

DO NOT SCALE DRAWING

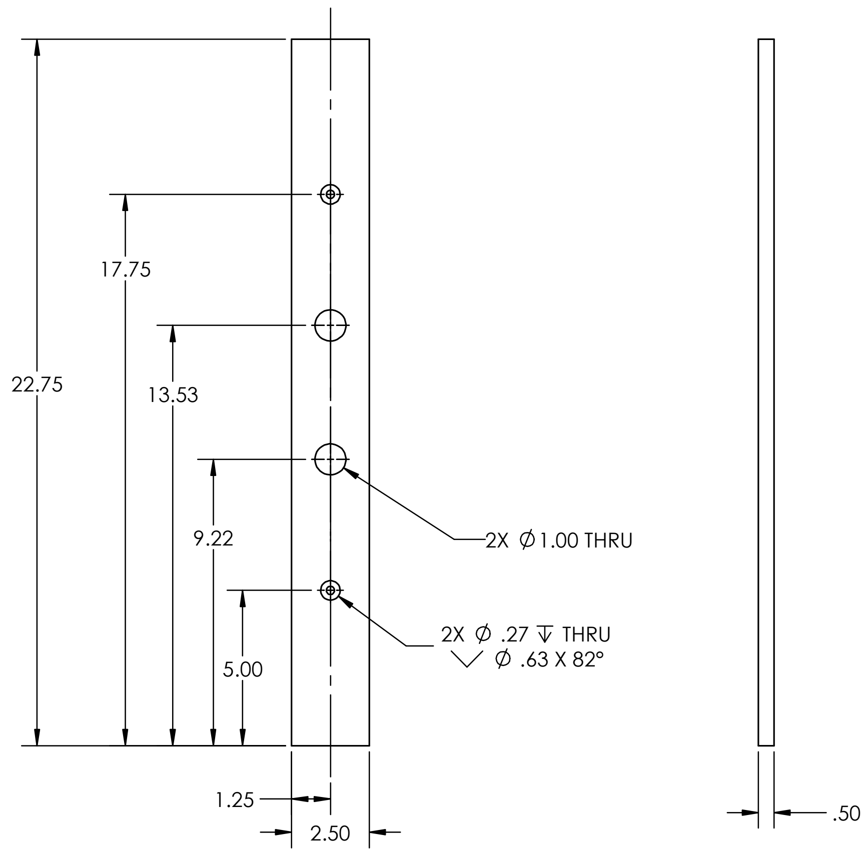
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **PTFE STRIP 1 - BELOW AS**
TEAM 3

SIZE: **B** | DWG. NO. **PTFE STRIP 1 - BELOW AS** | REV 0

SCALE: 1:4 | WEIGHT: 2.29 | SHEET 1 OF 1

REV 0
DWG. NO. PTFE STRIP 1 - BELOW AS



DWG. NO. PTFE STRIP 2 - BELOW AS — REV 0

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES
X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE
±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: PTFE

FINISH

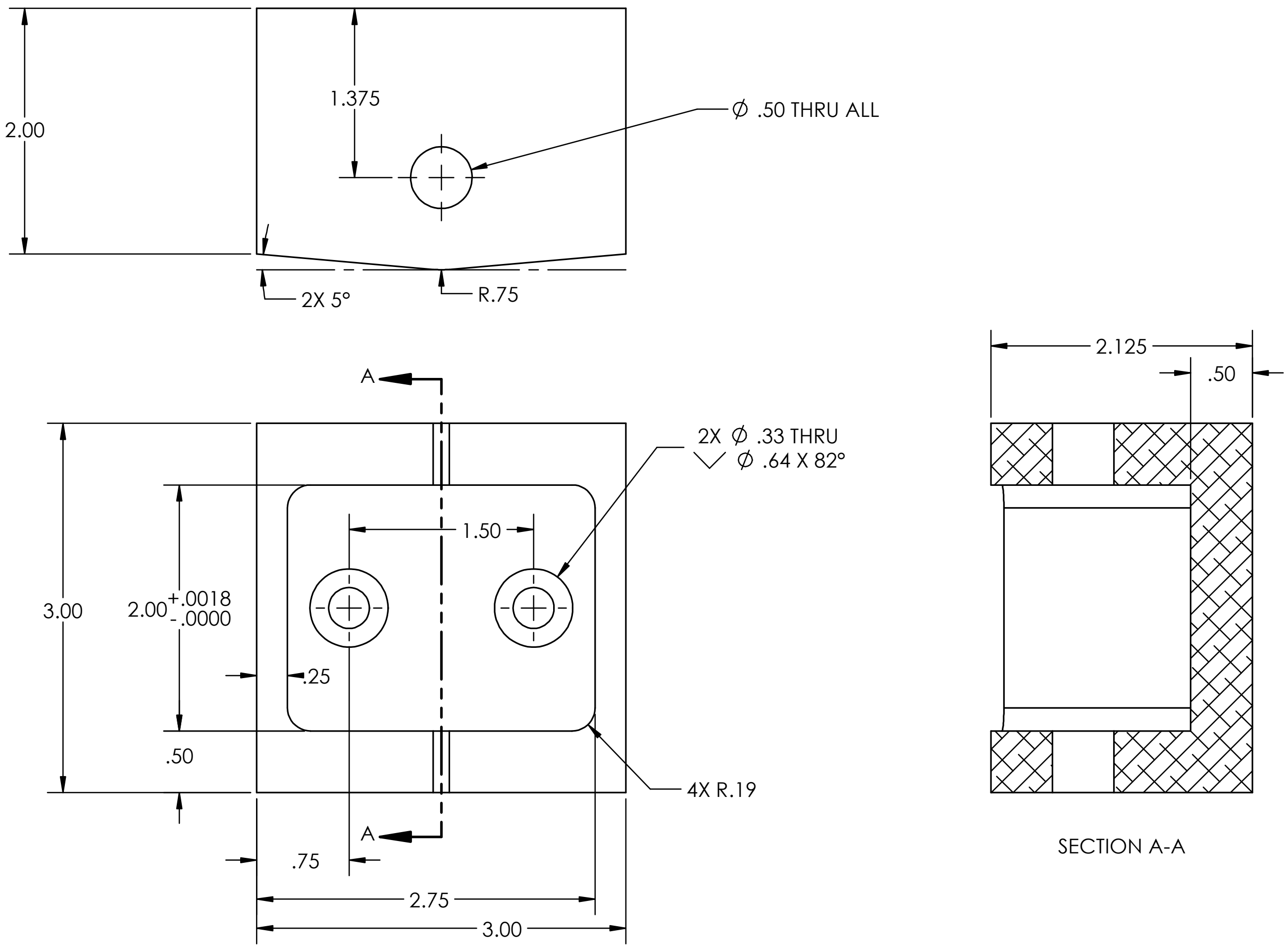
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **PTFE STRIP 2 - BELOW AS**
TEAM 3

SIZE: **B** | DWG. NO. **PTFE STRIP 2 - BELOW AS** | REV 0

SCALE: 1:4 | WEIGHT: 2.31LBS | SHEET 1 OF 1



REV 0

DWG. NO. FEMALE PIVOT BRACKET

REV	DATE Y/M/D	DESCRIPTION	
0	18/11/28	DRAWING CREATED	DWN / CKD

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

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UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

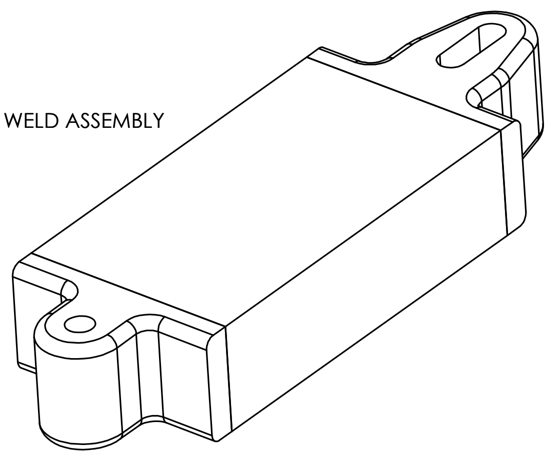
TITLE:
FEMALE PIVOT BRACKET
TEAM 3

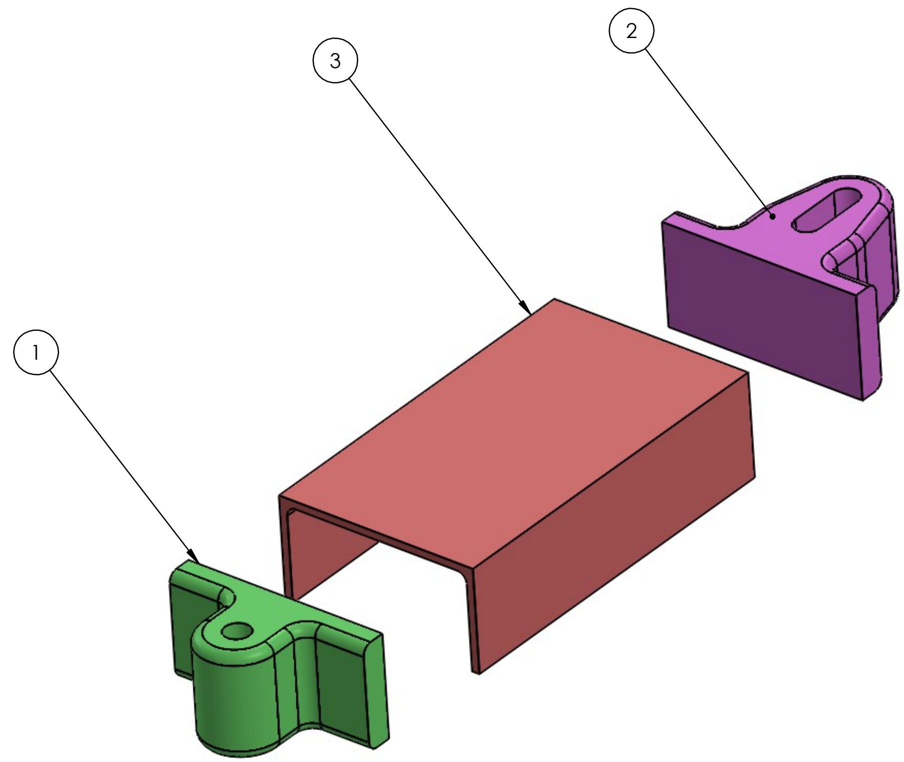
SIZE **B** | DWG. NO. **FEMALE PIVOT BRACKET** | REV 0

SCALE: 1:1 | WEIGHT: 1.02LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	PCM - Male Pivot Bracket		1
2	PCM - Male Sliding Pivot		1
3	PCM - 4X2X0.15 C Channel		1

WELD ASSEMBLY





REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN SM	
			CKD	

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DIMENSIONAL UNIT: INCHES

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

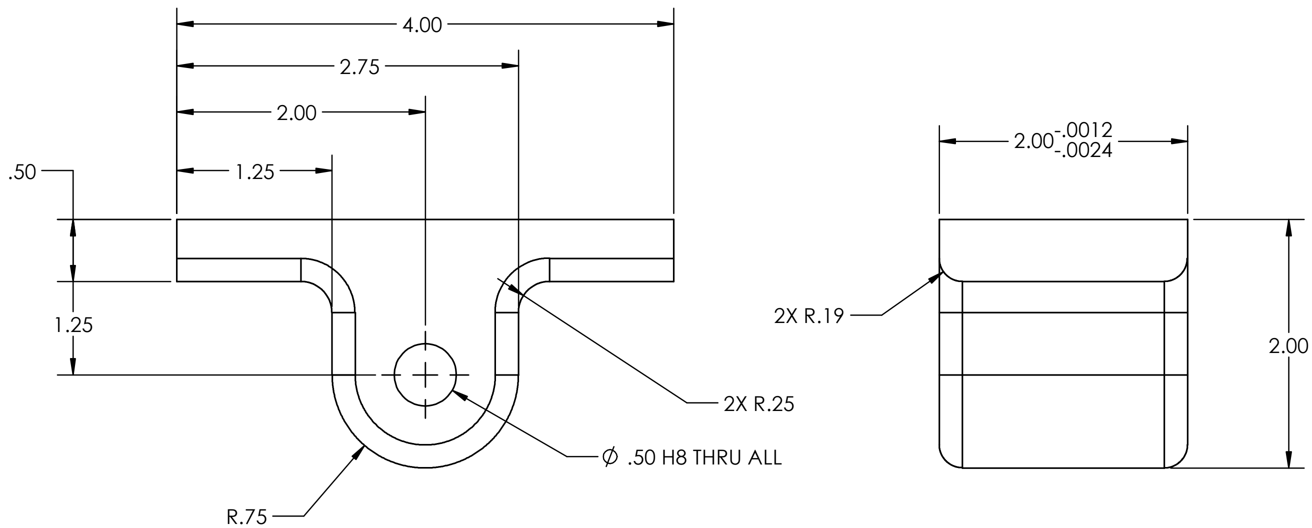
TITLE: **PIVOT CONNECTION MEMBER**
TEAM 3

SIZE: **B** | DWG. NO. **PIVOT CONNECTION MEMBER** | REV 0

DO NOT SCALE DRAWING

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

REV 0
DWG. NO. **PIVOT CONNECTION MEMBER**



REV 0

DWG. NO. PCM - MALE PIVOT BRACKET

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH

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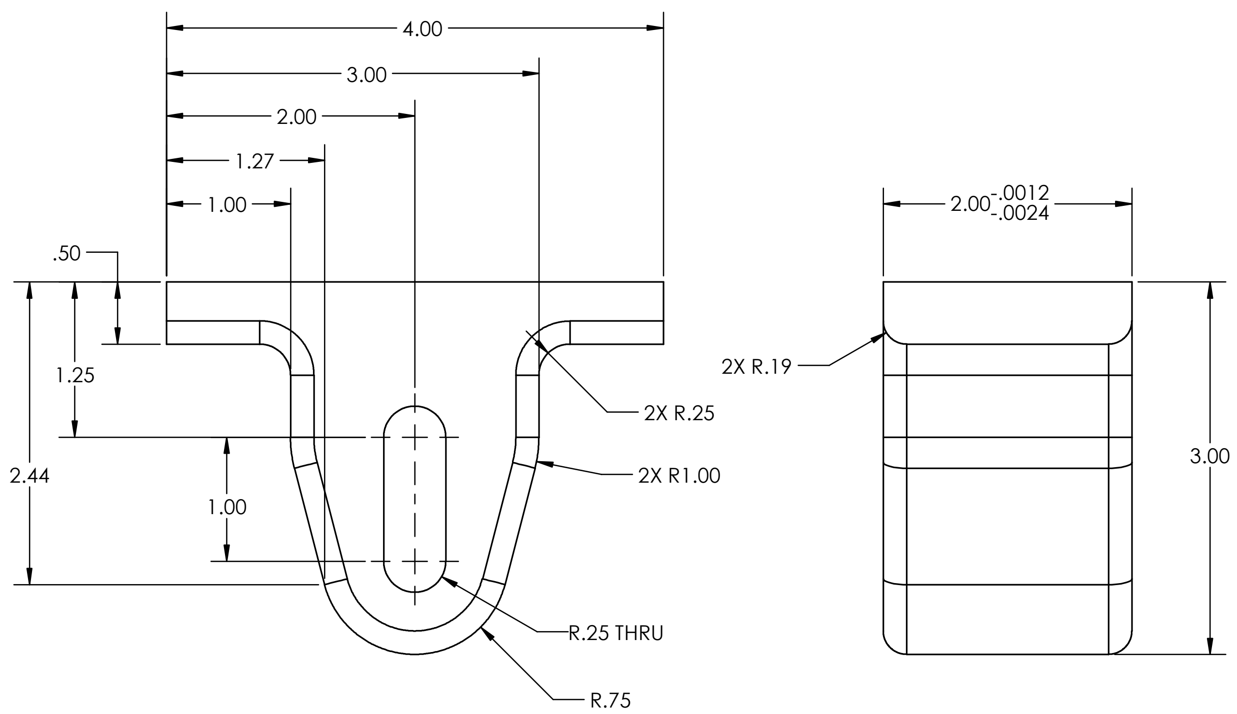
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
PCM - MALE PIVOT BRACKET
TEAM 3

SIZE **B** | DWG. NO. **PCM - MALE PIVOT BRACKET** | REV 0

SCALE: 1:1 | WEIGHT: 0.74LBS | SHEET 1 OF 1



REV 0
DWG. NO. PCM - MALE SLIDING PIVOT

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH
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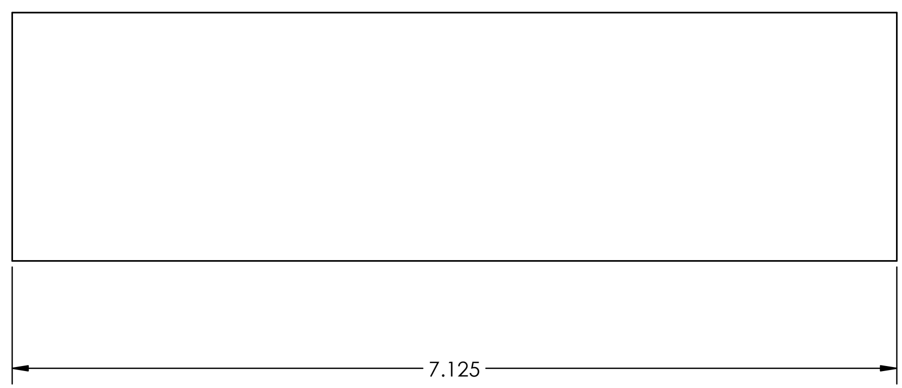
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
PCM - MALE SLIDING PIVOT
TEAM 3

SIZE **B** | DWG. NO. **PCM - MALE SLIDING PIVOT** | REV 0

SCALE: 1:1 | WEIGHT: 1.07LBS | SHEET 1 OF 1



DWG. NO. PCM - 4X2X0.15 C CHANNEL REV 0

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN NAME # / CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
4X2X0.15 6061-T6
ALUMINUM C-CHANNEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
PCM - 4X2X0.15 C CHANNEL
TEAM 3

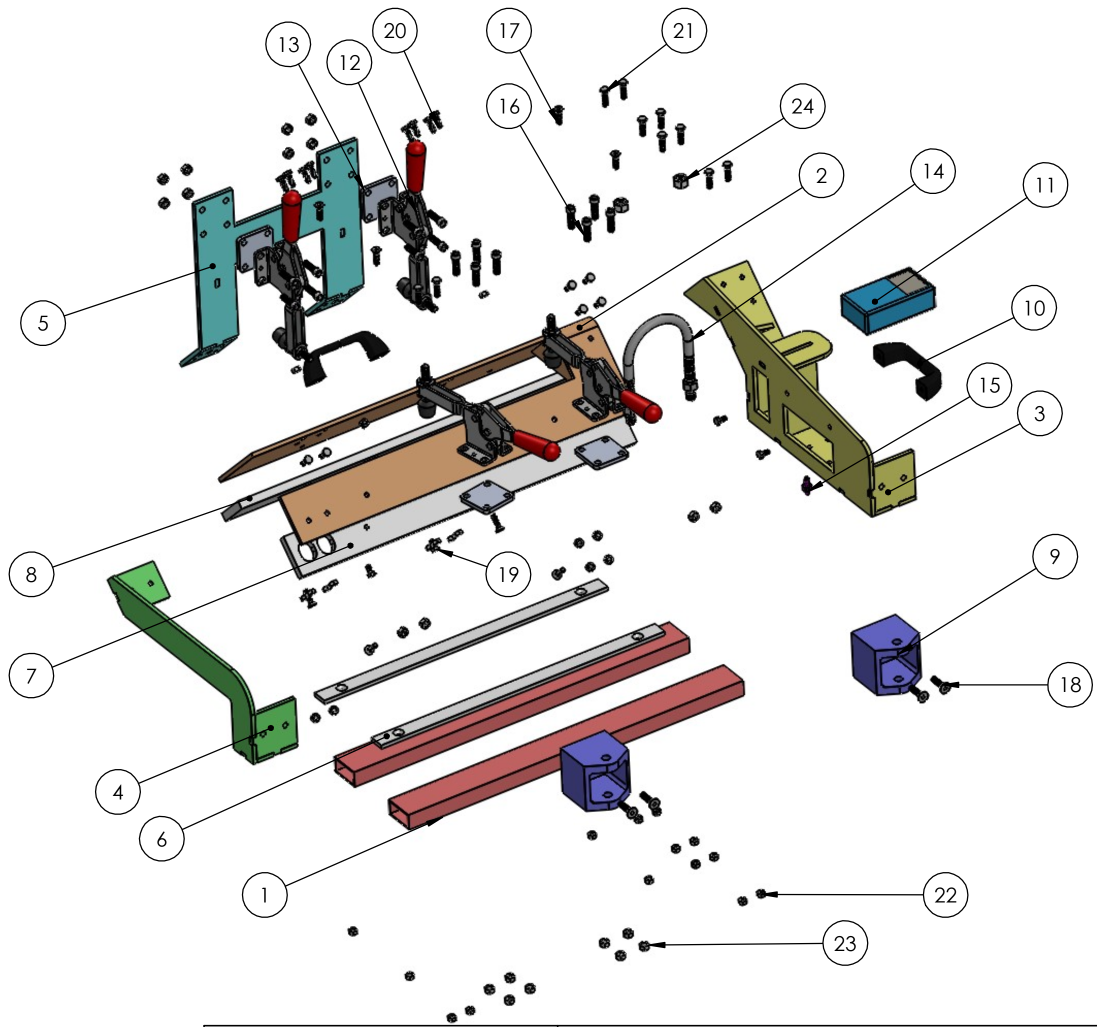
SIZE **B**

DWG. NO. **PCM - 4X2X0.15 C CHANNEL**

REV 0

SCALE: 1:1 | WEIGHT: 0.81LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Main Support Plate - RS		1
2	Angle Support RS		1
3	Main Connection Bracket - RS		1
4	Support Bracket - RS		1
5	Vertical Gusset Support		1
6	PTFE Strip - Below Gusset		2
7	PTFE Strip 1 - Below AS		1
8	PTFE Strip 2 - Below AS		1
9	Female Sliding Pivot		2
10	1661A4		2
11	Bosch Measurement Device		1
12	5091A610_LOW-PROFILE HOLD-DOWN TOGGLE CLAMP		4
13	Clamp Spacer		4
14	29605T47		1
15	91185A917		1
16	92196A584		16
17	92210A542		8
18	92210A585		4
19	92240A537		4
20	92240A540		14
21	92240A542		10
22	95462A029		32
23	95462A030		20
24	95462A033		2



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN SM / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

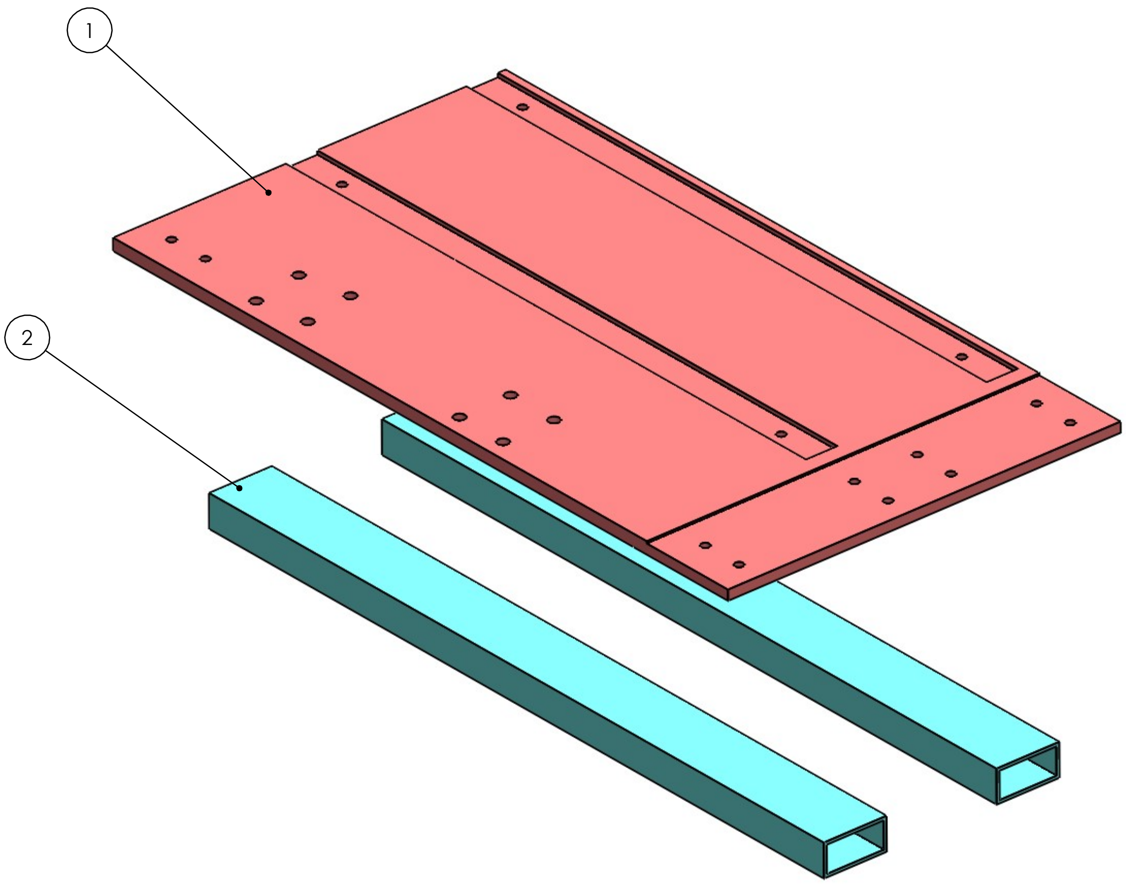
TITLE:
GUSSET LOCATOR - RIGHT SIDE
TEAM 3

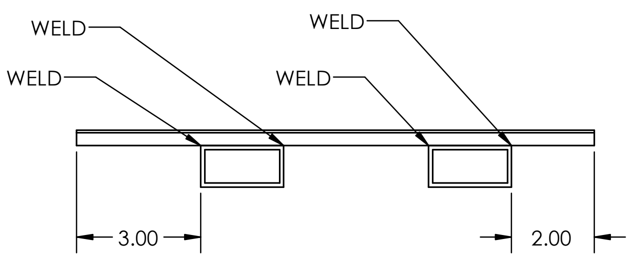
SIZE: B | DWG. NO. GUSSET LOCATOR - RIGHT SIDE | REV 0

SCALE: 1:7 | WEIGHT: | SHEET 1 OF 1

DWG. NO. GUSSET LOCATOR - RIGHT SIDE | REV 0

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	MSP - Machined Plate RS		1
2	MSP - 1x2 Rectangular Tube		2





REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN SM	
			CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

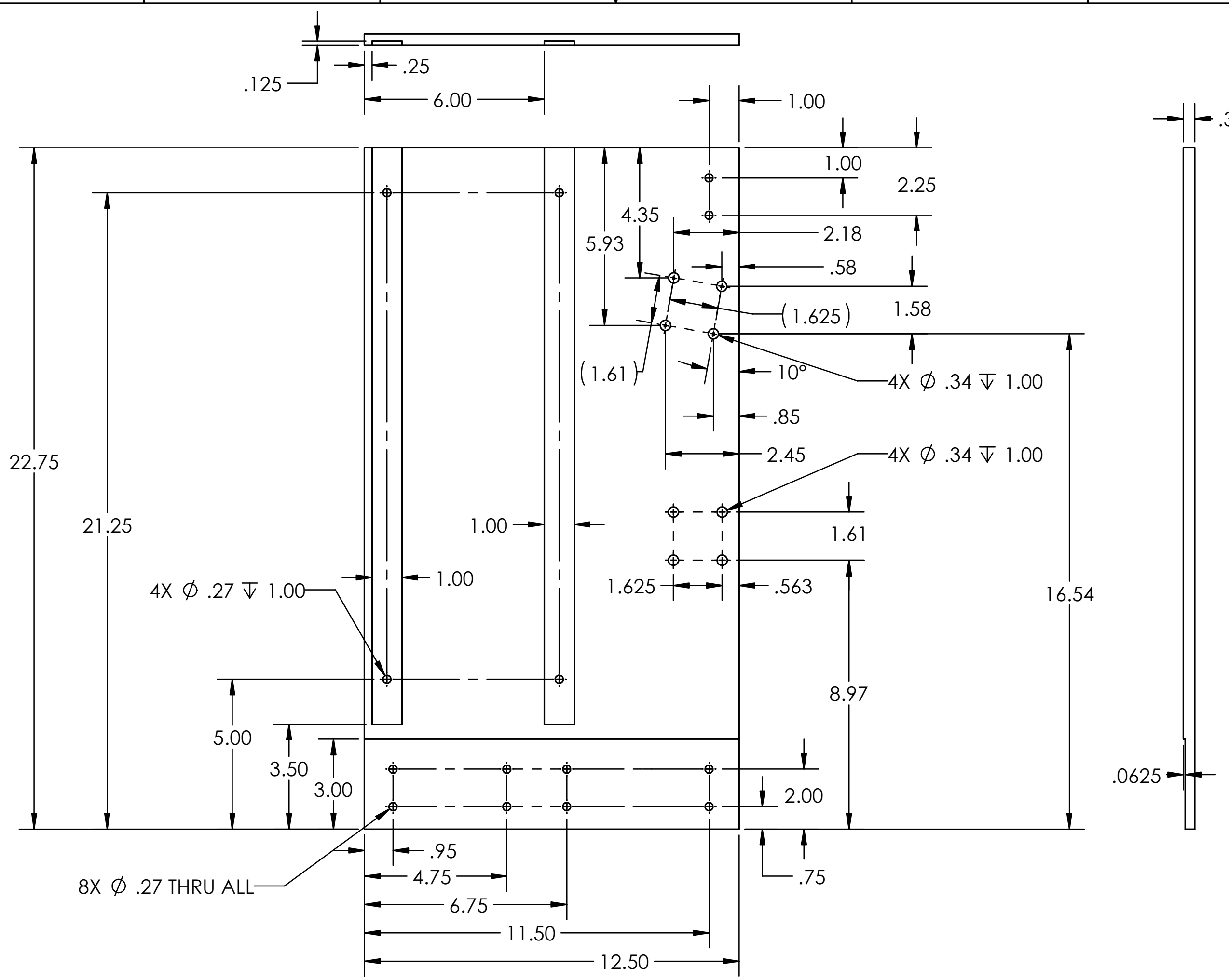
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
MAIN SUPPORT PLATE - RS
TEAM 3

SIZE: **B** | DWG. NO. **MAIN SUPPORT PLATE - RS** | REV 0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **MAIN SUPPORT PLATE - RS** | REV 0



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

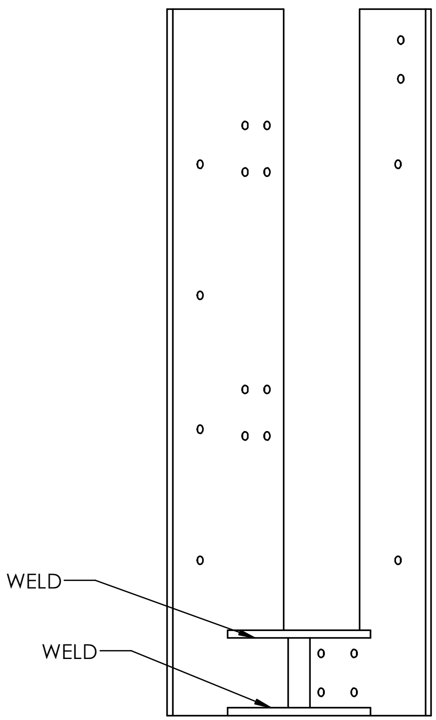
TITLE:
MSP - MACHINED PLATE RS
TEAM 3

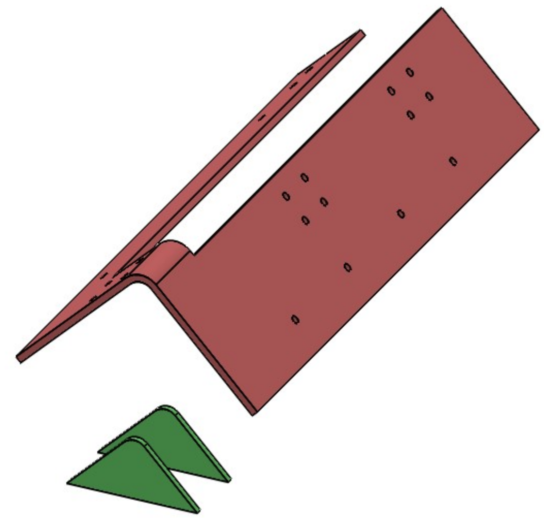
SIZE	DWG. NO.	REV
B	**MSP - MACHINED PLATE RS**	0

SCALE: 1:4 | WEIGHT: 9.655LBS | SHEET 1 OF 1

REV 0
DWG. NO. MSP - MACHINED PLATE RS

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	AS - Bent Plate RS		1
2	AS - Plate		2





REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN SM / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

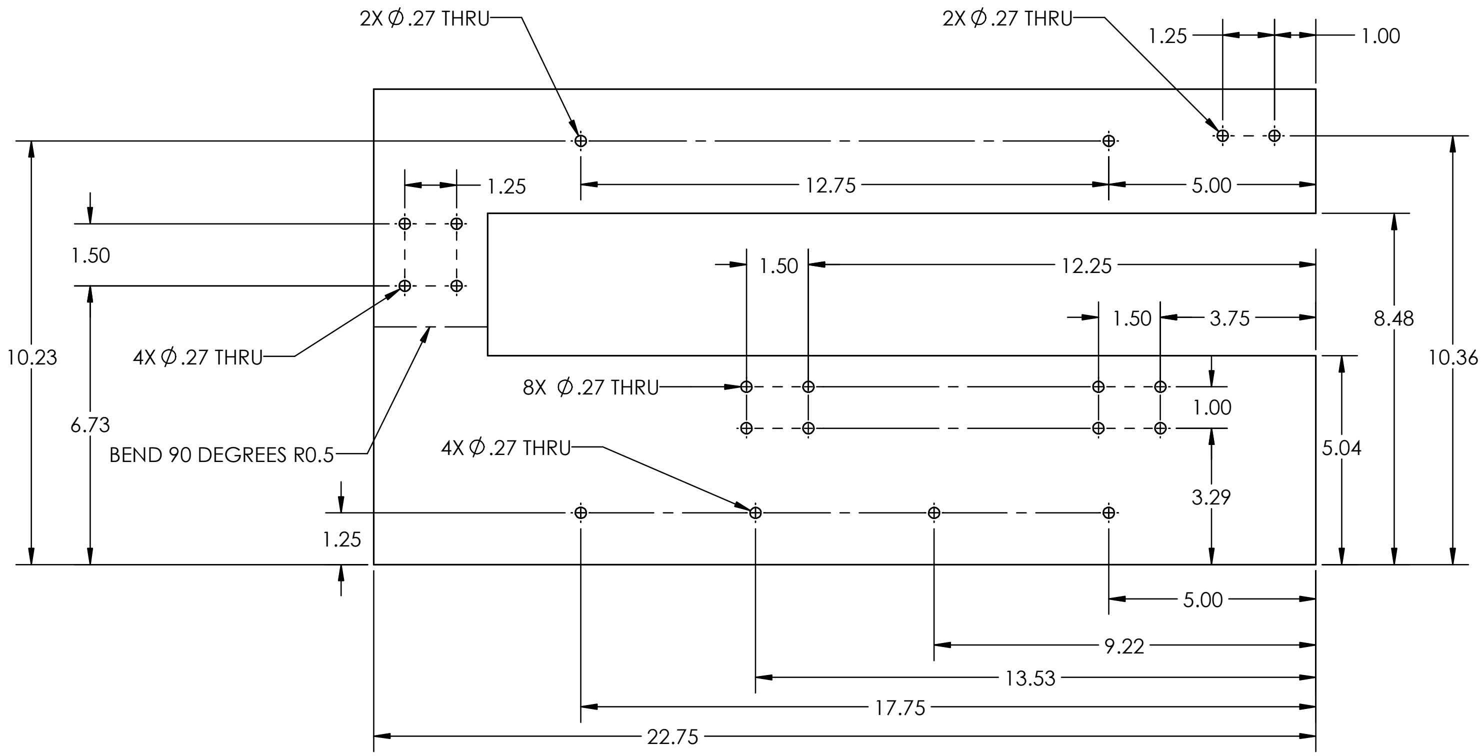
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
ANGLE SUPPORT RS
TEAM 3

SIZE **B** | DWG. NO. **ANGLE SUPPORT RS** | REV 0

SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

REV 0
ANGLE SUPPORT RS
DWG. NO.



REV	DATE Y/M/D	DESCRIPTION	
0	18/11/28	DRAWING CREATED	DWN / CKD

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

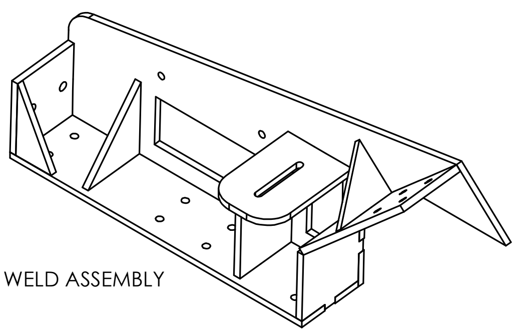
TITLE:
AS - BENT PLATE RS
TEAM 3

SIZE **B** | DWG. NO. **AS - BENT PLATE RS** | REV 0

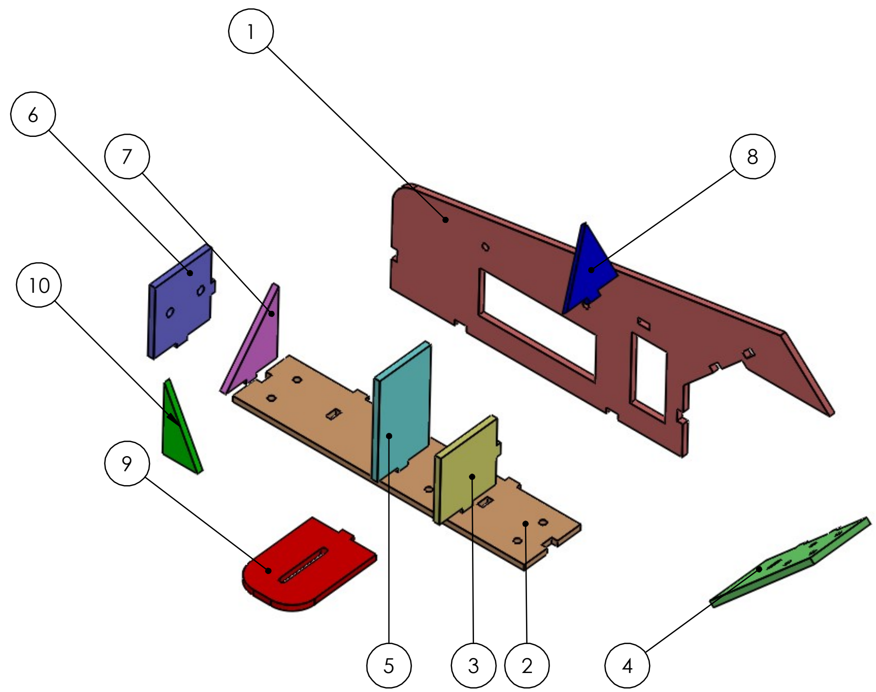
SCALE: 1:3 | WEIGHT: 4.67LBS | SHEET 1 OF 1

DWG. NO. **AS - BENT PLATE RS** REV 0

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	MCB - Plate 1		1
2	MCB - Plate 2		1
3	MCB - Plate 3		1
4	MCB - Plate 4		1
5	MCB - Plate 5		1
6	MCB - Plate 6		1
7	MCB - Rib 1		1
8	MCB - Rib 2		1
9	MCB - Laser Mount		1
10	MCB - Rib 3		1



WELD ASSEMBLY



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN SM / CKD	

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DIMENSIONAL UNIT: INCHES

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

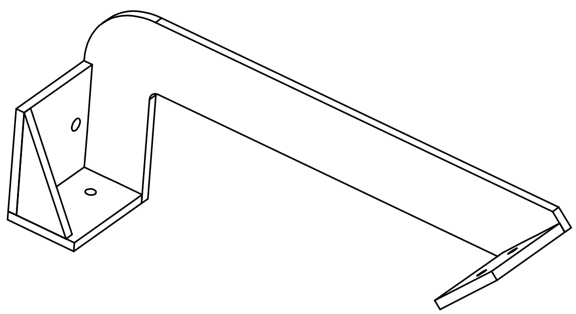
TITLE: **MAIN CONNECTION BRACKET - RS**
TEAM 3

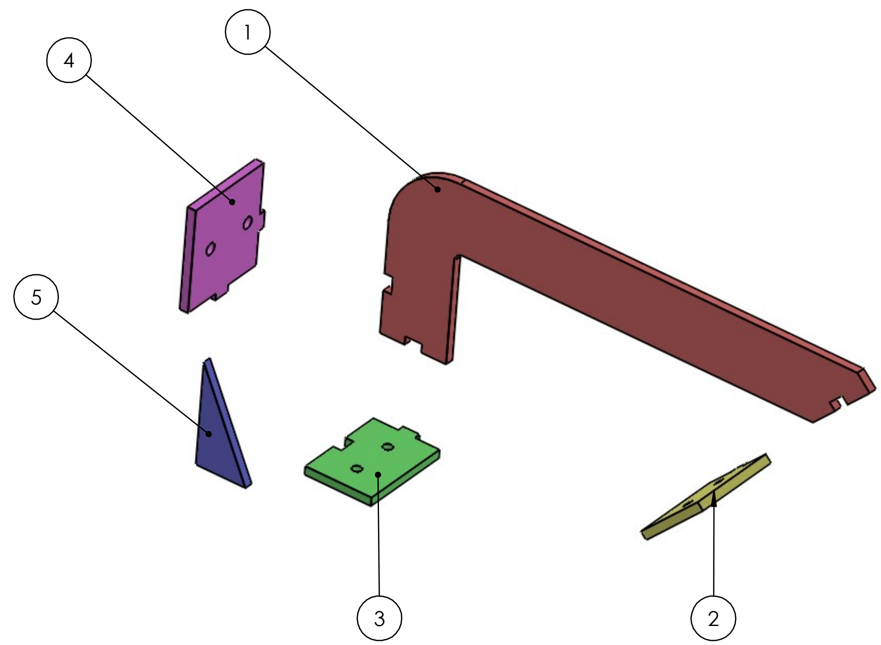
SIZE: **B** | DWG. NO. **MAIN CONNECTION BRACKET - RS** | REV 0

DO NOT SCALE DRAWING | SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

REV 0
DWG. NO. MAIN CONNECTION BRACKET - RS

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SB - Plate 1		1
2	SB - Plate 2		1
3	SB - Plate 3		1
4	MCB - Plate 6		1
5	MCB - Rib 3		1





REV	DATE Y/M/D	DESCRIPTION		
			DWN NAME # / CKD NAME #	
			DWN NAME # / CKD NAME #	
			DWN NAME # / CKD NAME #	
			DWN NAME # / CKD NAME #	
0	18/11/28	DRAWING CREATED	DWN NAME SM / CKD NAME #	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

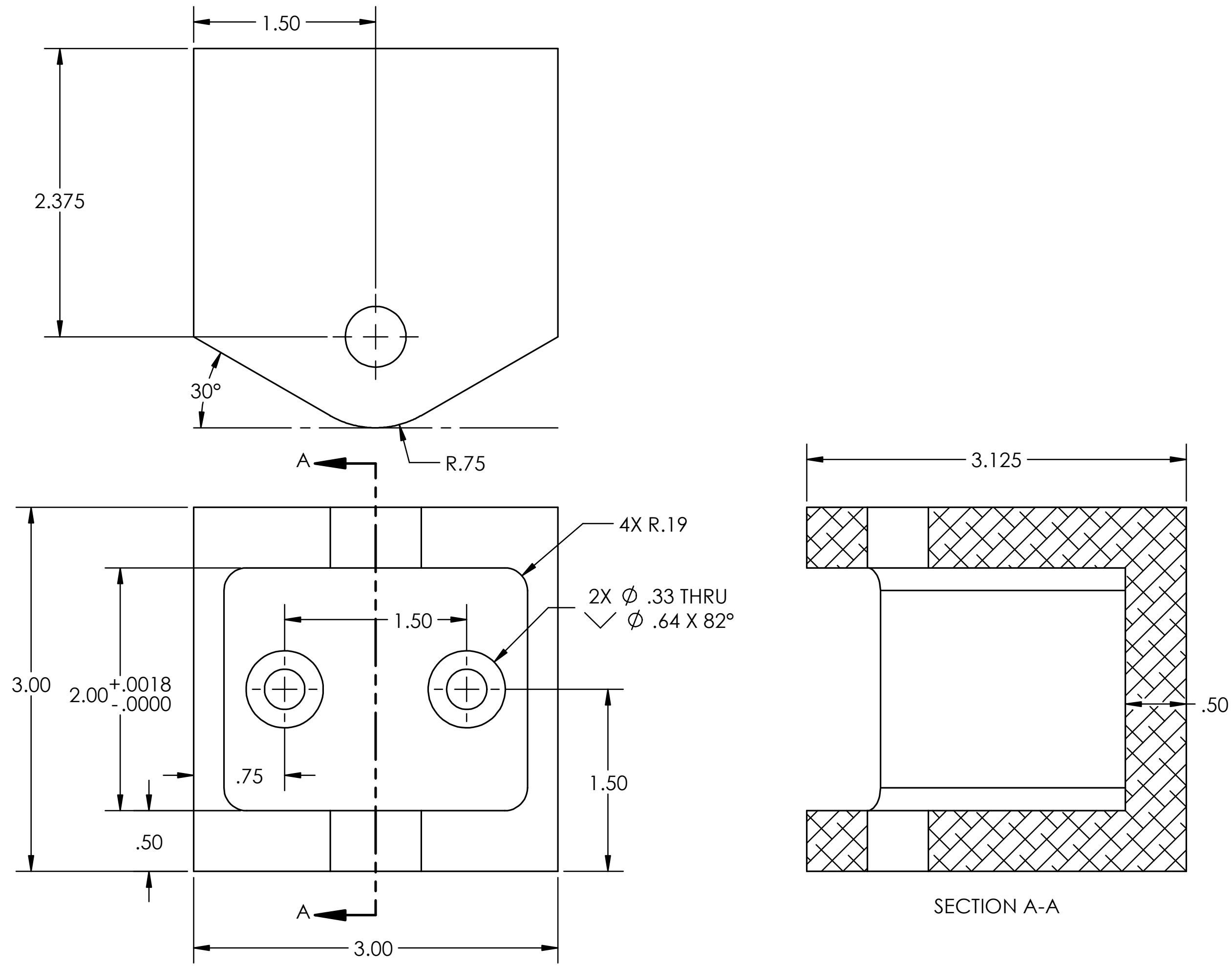
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
SUPPORT BRACKET - RS
TEAM 3

SIZE **B** | DWG. NO. **SUPPORT BRACKET - RS** | REV 0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **SUPPORT BRACKET - RS** REV 0



REV 0

DWG. NO. FEMALE SLIDING PIVOT

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
6061-T6

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

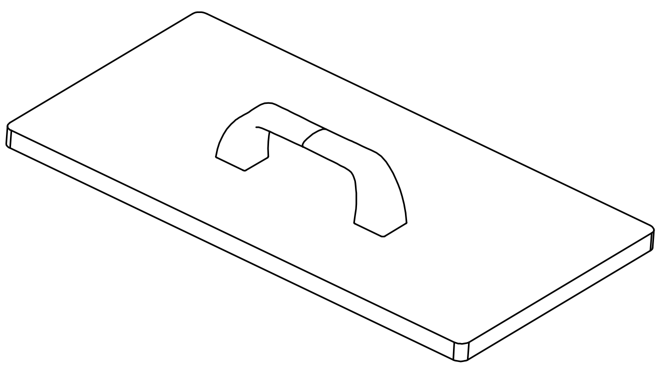
MECH 4860 ENGINEERING DESIGN

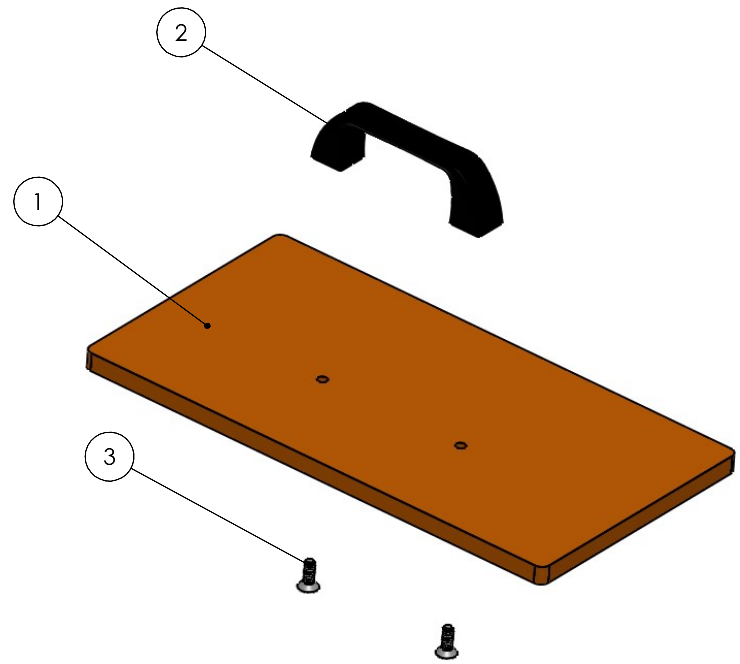
TITLE:
FEMALE SLIDING PIVOT
TEAM 3

SIZE **B** | DWG. NO. **FEMALE SLIDING PIVOT** | REV 0

SCALE: 1:1 | WEIGHT: 1.28LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Spacer Plate 1		1
2	1661A4		1
3	92210A540		2





REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN SM / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

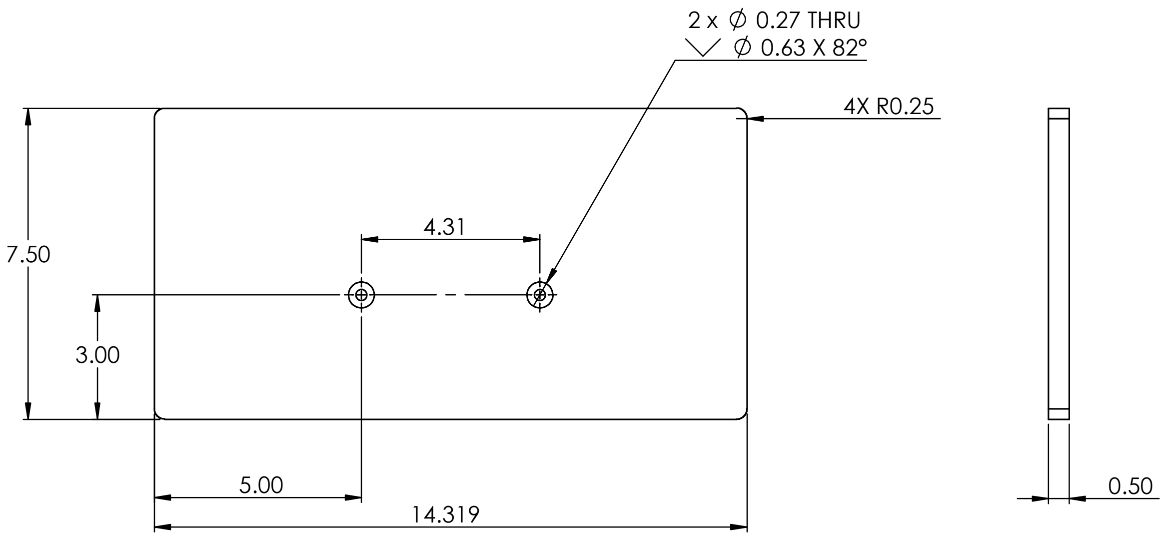
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
SPACER 1
TEAM 3

SIZE: **B** | DWG. NO. **SPACER 1** | REV 0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **SPACER 1** REV 0



REV 0

DWG. NO. SPACER PLATE 1

REV	DATE Y/M/D	DESCRIPTION	
0	18/11/28	DRAWING CREATED	DWN / CKD

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

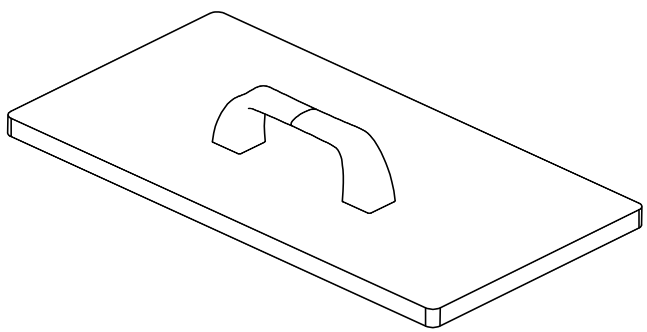
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

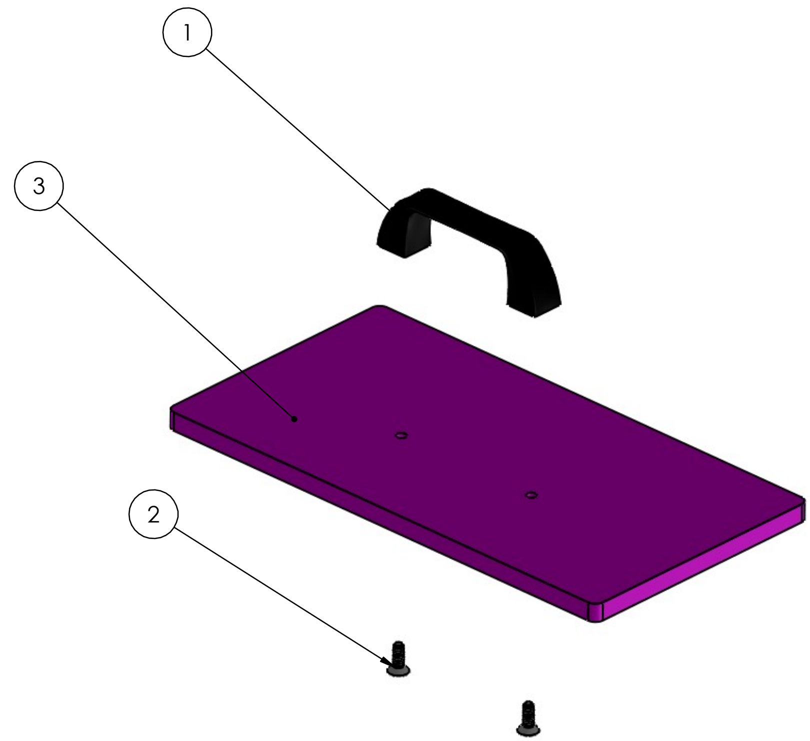
TITLE: **SPACE PLATE 1**
TEAM 3

SIZE	DWG. NO.	REV
B	**SPACER PLATE 1**	0

SCALE: 1:3 | WEIGHT: 5.23LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1661A4		1
2	92210A540		2
3	Spacer Plate 2		1





REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN SM	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

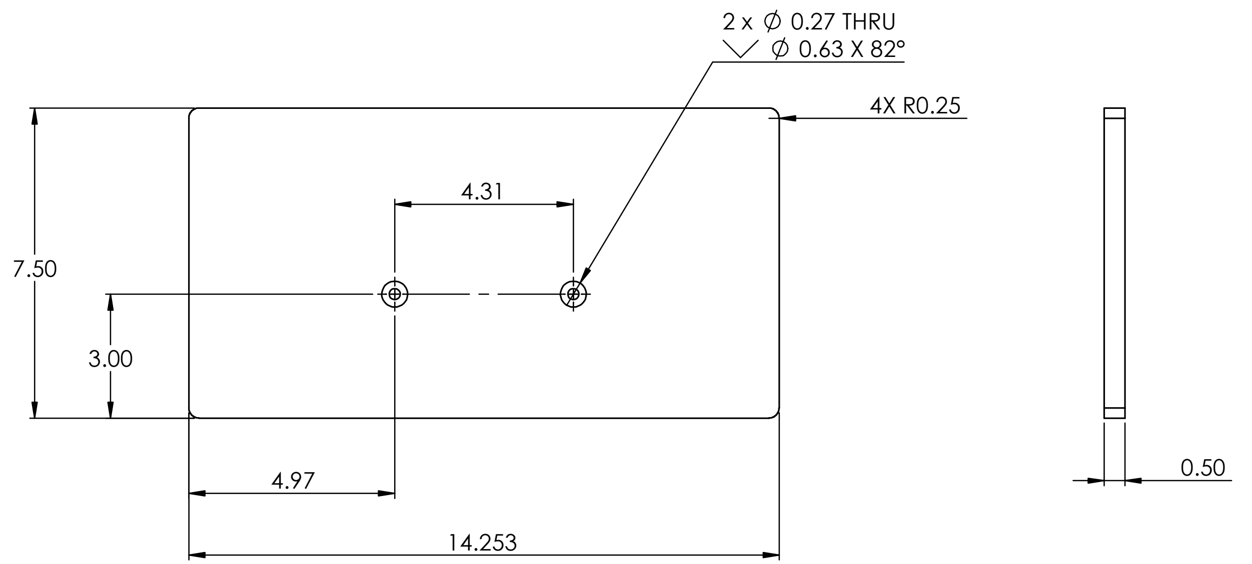
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
SPACER 2
TEAM 3

SIZE	DWG. NO.	REV
B	SPACER 2	0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

REV 0 — SPACER 2 — DWG. NO.



DWG. NO. SPACER PLATE 2

REV

REV	DATE Y/M/D	DESCRIPTION	
0	18/11/28	DRAWING CREATED	DWN / CKD

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

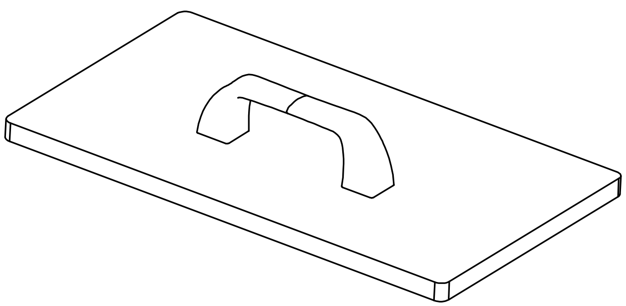
MECH 4860 ENGINEERING DESIGN

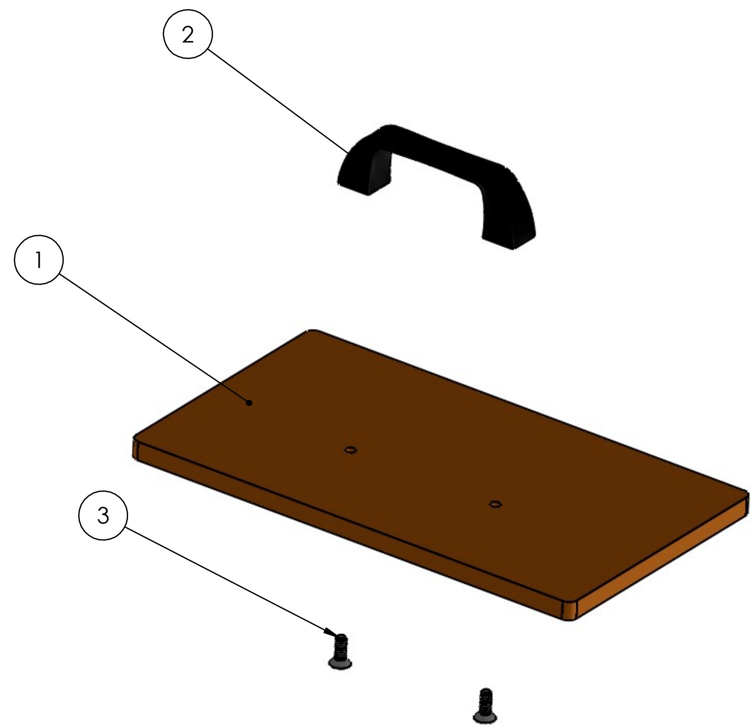
TITLE:
SPACER PLATE 2
TEAM 3

SIZE	DWG. NO.	REV
B	**SPACER PLATE 2**	

SCALE: 1:3 | WEIGHT: 5.20 | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Spacer Plate 3		1
2	1661A4		1
3	92210A540		2





REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN SM	CKD

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DIMENSIONAL UNIT: INCHES

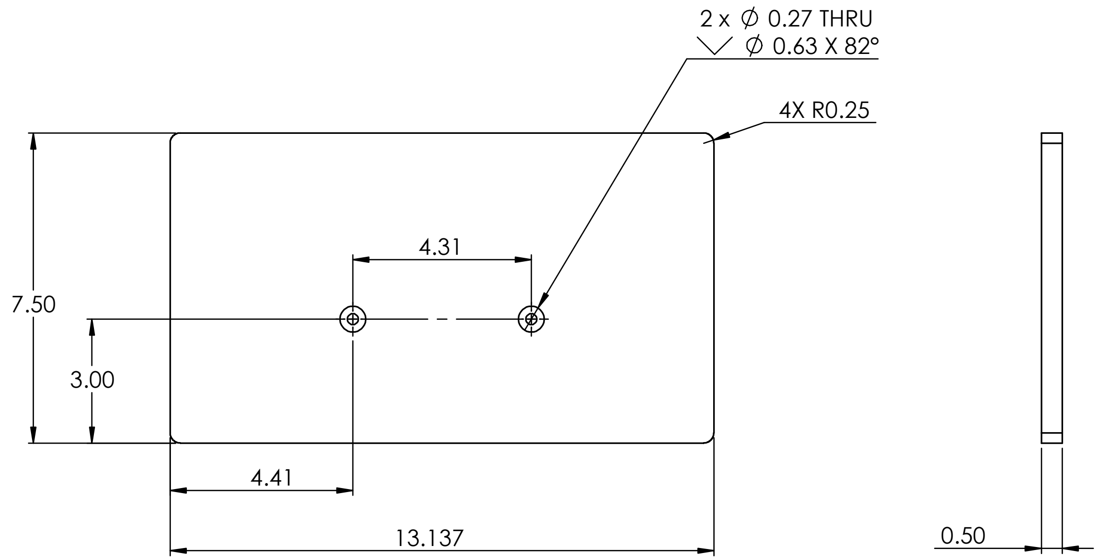
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **SPACER 3**
TEAM 3

SIZE: B | DWG. NO. SPACER 3 | REV 0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1



REV 0

DWG. NO. SPACER PLATE 3

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

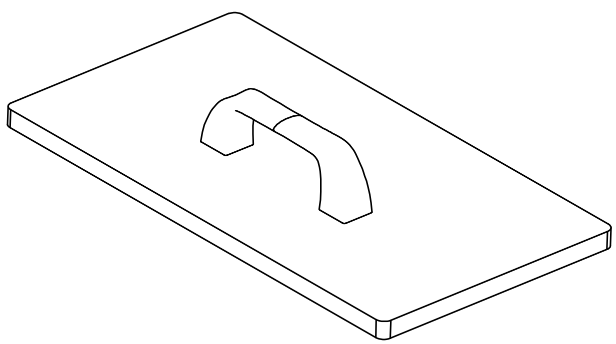
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

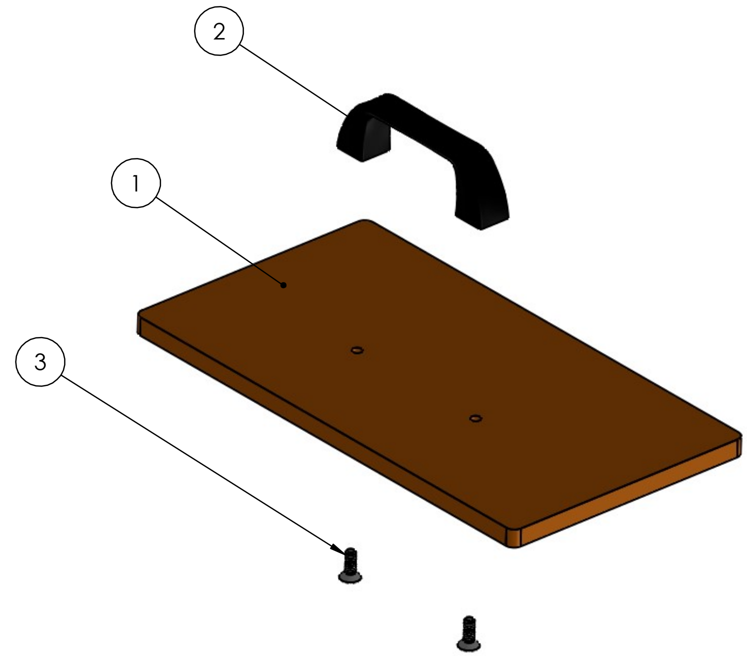
TITLE:
SPACER PLATE
TEAM 3

SIZE	DWG. NO.	REV
B	**SPACER PLATE 3**	0

SCALE: 1:3 | WEIGHT: 4.79LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Spacer Plate 4		1
2	1661A4		1
3	92210A540		2





			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN SM / CKD	
REV	DATE Y/M/D	DESCRIPTION		

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

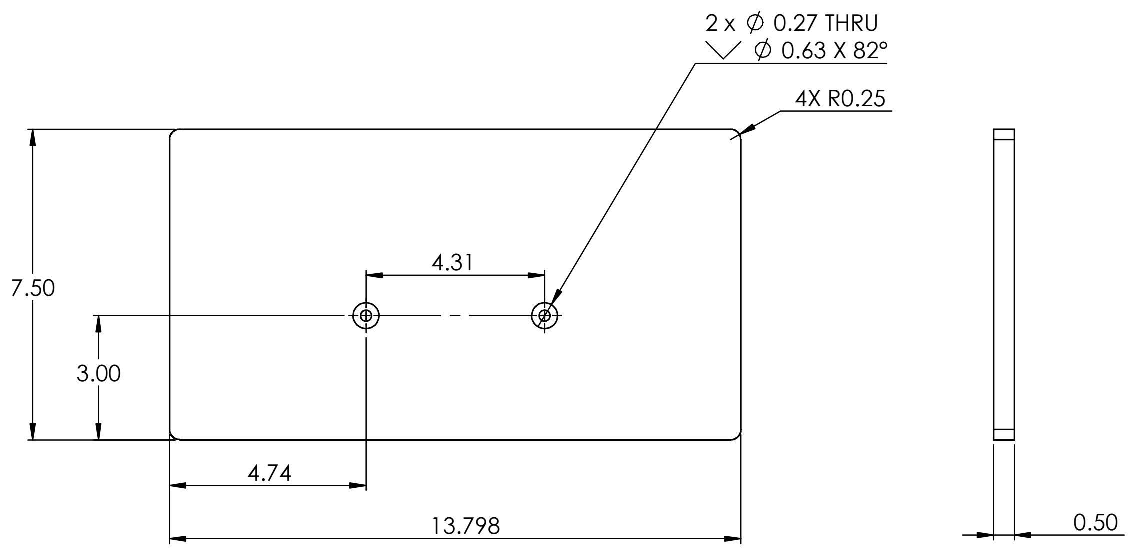
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
SPACER 4
TEAM 3

SIZE	DWG. NO.	REV
B	**SPACER 4**	0

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

REV 0 — SPACER 4 — DWG. NO.



REV 0

DWG. NO. SPACER PLATE 4

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

UNIVERSITY of MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
SPACER PLATE 4
TEAM 3

SIZE	DWG. NO.	REV
B	**SPACER PLATE 4**	0

SCALE: 1:3 | WEIGHT: 5.03LBS | SHEET 1 OF 1

Appendices E – Trunnion Preliminary Drawings

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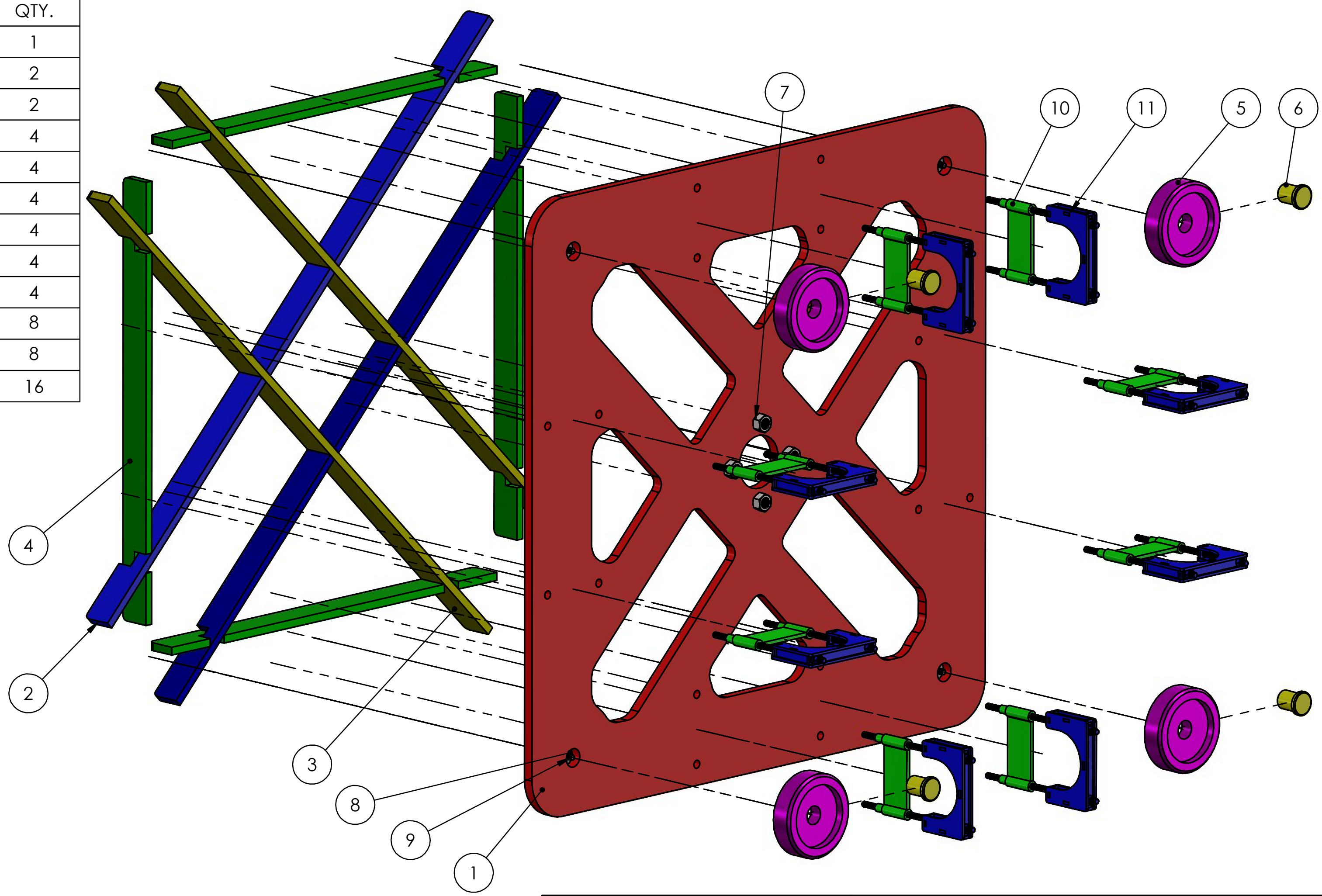
ITEM NO.	PART NUMBER	QTY.
1	TMB Plate	1
2	TMB Brace 1	2
3	TMB Brace 2	2
4	TMB Brace 3	4
5	TMB Locator	4
6	BMB Pin	4
7	94895A038	4
8	91090A118	4
9	92620A744	4
10	TMB Rod Spacer	8
11	OEC Assembly	8
12	94895A825	16



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TOP MOUNTING BRACKET
TEAM 3

SIZE **B**

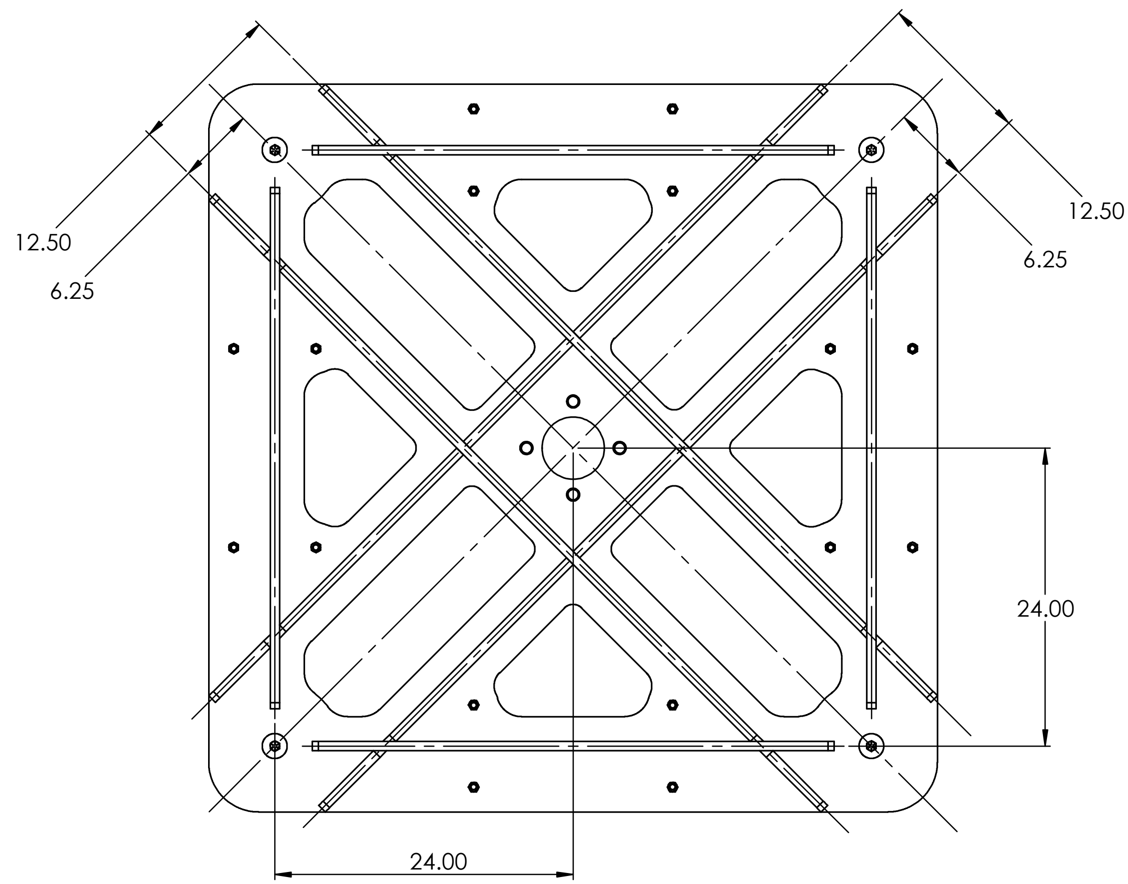
DWG. NO. **TOP MOUNTING BRACKET EXPLODED**

REV

SCALE: 1:10 | WEIGHT: | SHEET 1 OF 1

REV

DWG. NO. **TOP MOUNTING BRACKET EXPLODED**



REV	DATE Y/M/D	DESCRIPTION		
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
0	18/11/28	DRAWING CREATED	DWN NAME #	
			CKD NAME #	

EDUCATIONAL AND PROPRIETARY MATERIALS
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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

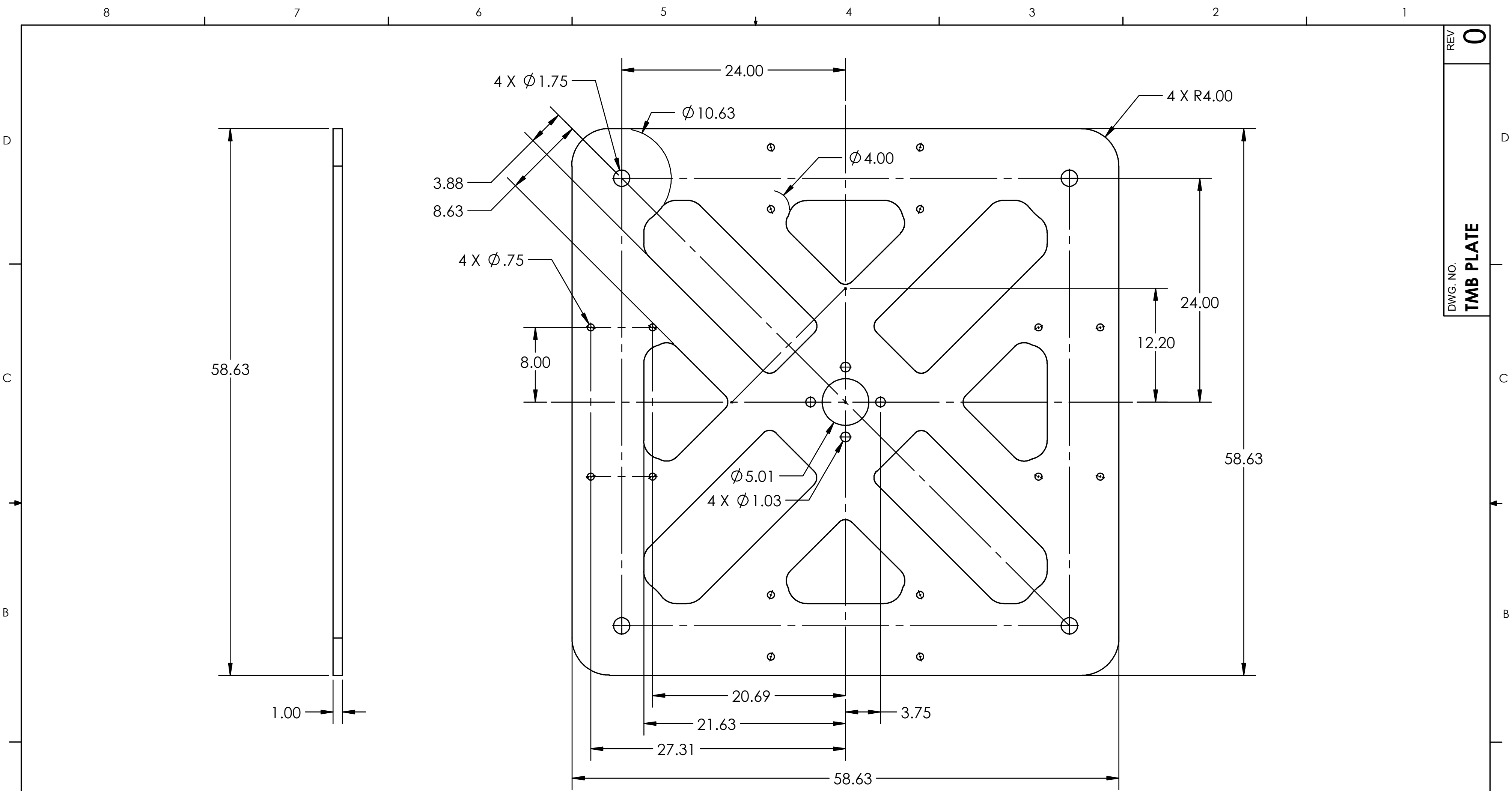
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
TOP MOUNTING BRACKET
TEAM 3

SIZE	DWG. NO.	REV
B	**TOP MOUNTING BRACKET**	0

SCALE: 1:10 | WEIGHT: | SHEET 1 OF 1

REV 0 — DWG. NO. **TOP MOUNTING BRACKET**



			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	
REV	DATE Y/M/D	DESCRIPTION		

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE
±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

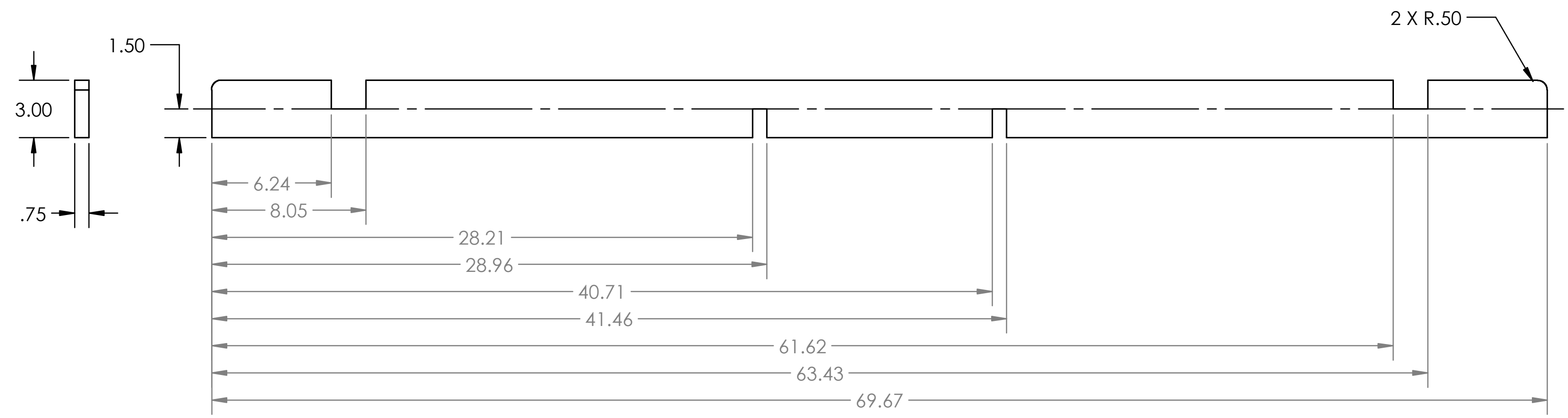
UNIVERSITY OF MANITOBA
MECH 4860 ENGINEERING DESIGN

TITLE:
TMB PLATE
TEAM 3

SIZE **B** | DWG. NO. **TMB PLATE** | REV 0

SCALE: 1:10 | WEIGHT: 238.37 LBS | SHEET 1 OF 1

REV 0
DWG. NO. **TMB PLATE**



REV 0
DWG. NO. TMB BRACE 1

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6 ALUMINUM

FINISH ✓

DO NOT SCALE DRAWING

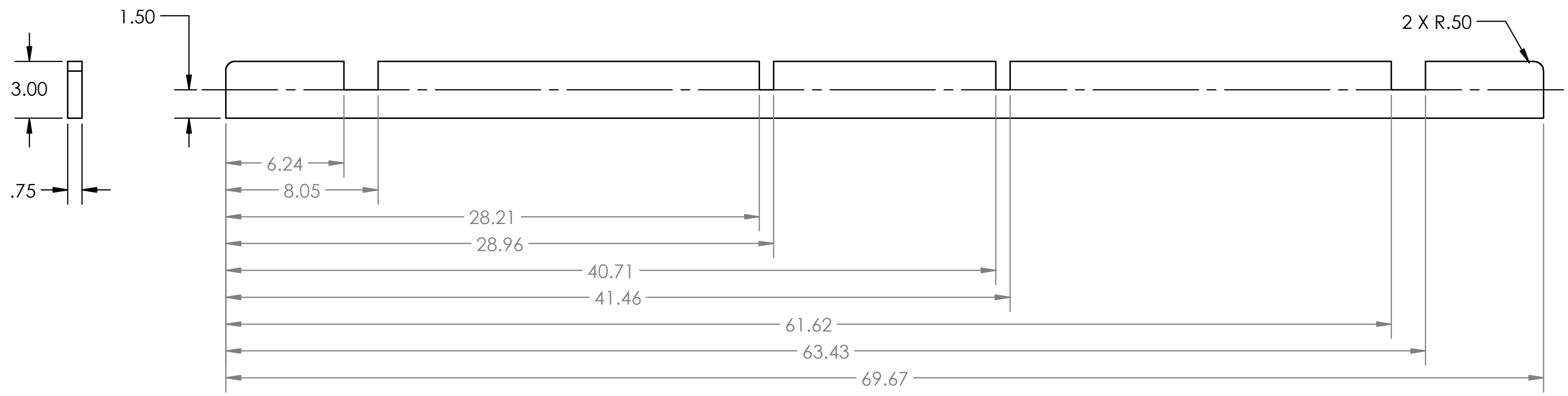
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TMB BRACE 1
TEAM 3

SIZE **B** | DWG. NO. **TMB BRACE 1** | REV 0

SCALE: 1:6 | WEIGHT: 14.72 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 6061-T6 ALUMINIUM

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE: **TMB BRACE 2**

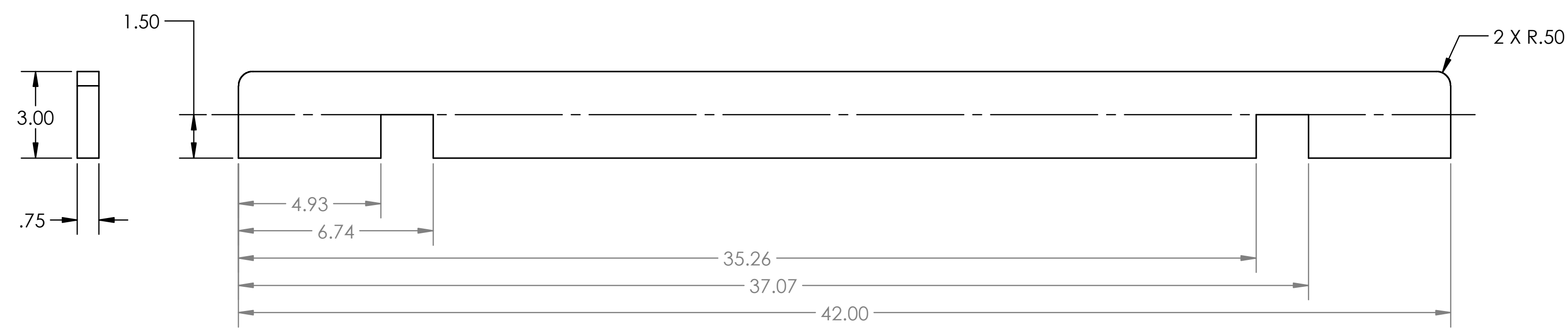
TEAM 3

SIZE: **B** | DWG. NO.: **TMB BRACE 2** | REV: 0

SCALE: 1:6 | WEIGHT: 14.72 LBS | SHEET 1 OF 1

REV 0

DWG. NO. **TMB BRACE 2**



REV 0

DWG. NO. TMB BRACE 3

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

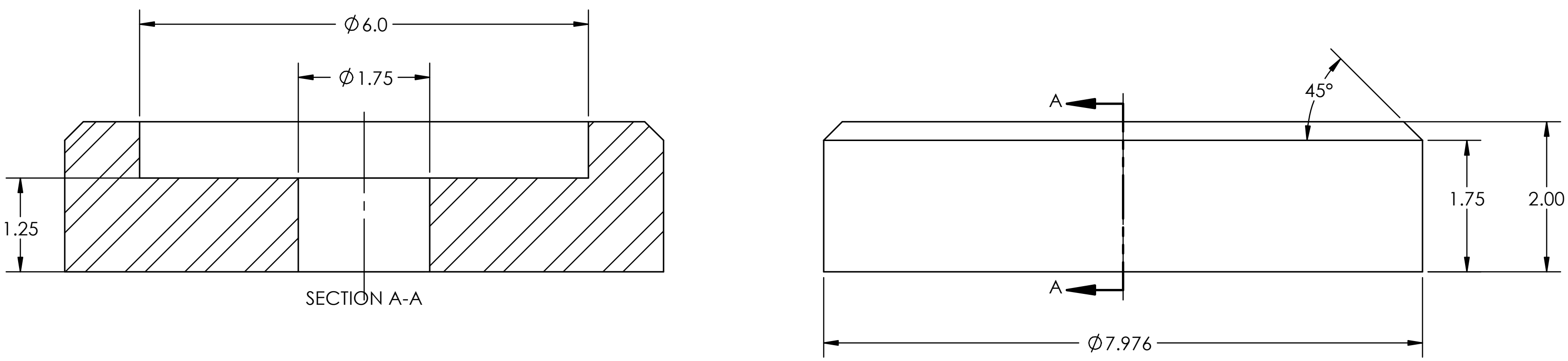
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TMB BRACE 3
TEAM 3

SIZE	DWG. NO.	REV
B	**TMB BRACE 3**	0

SCALE: 1:4 | WEIGHT: 8.81 LBS | SHEET 1 OF 1



REV 0

DWG. NO. TMB LOCATOR

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

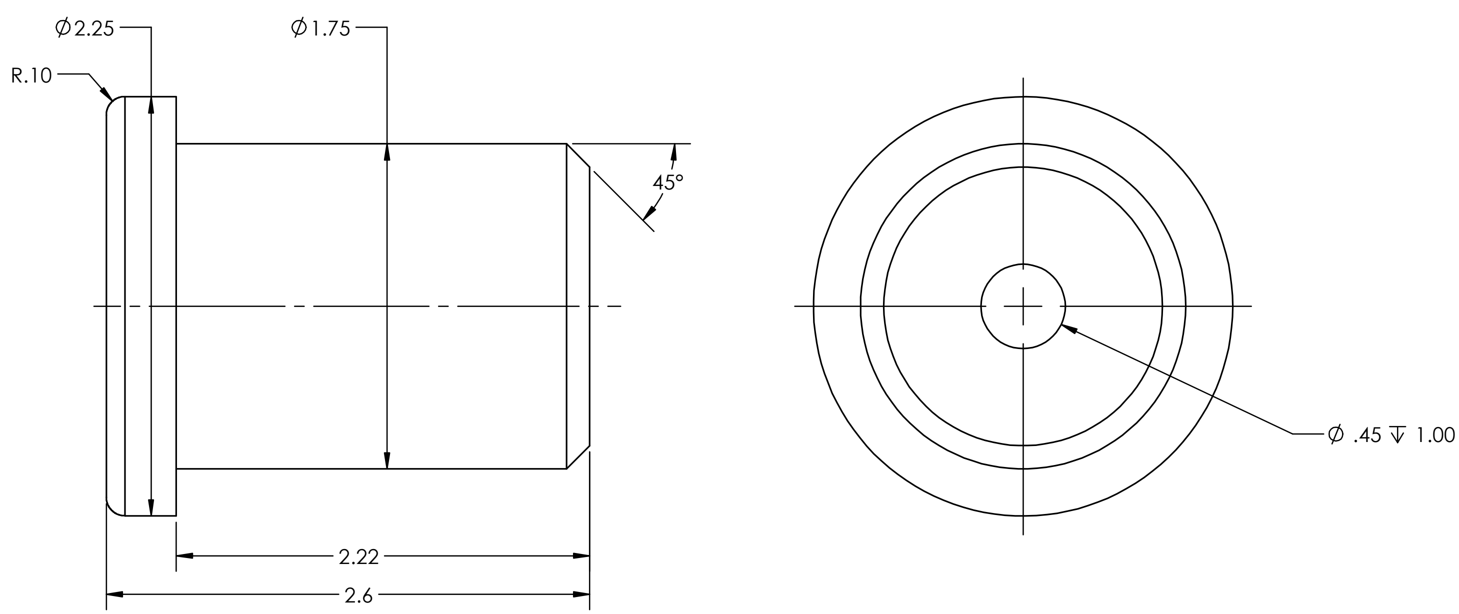
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK BASE
TEAM 3

SIZE **B** | DWG. NO. **TMB LOCATOR** | REV 0

SCALE: 1:1.5 | WEIGHT: 15.46 LBS | SHEET 1 OF 1



REV 0

DWG. NO. BMB PIN

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

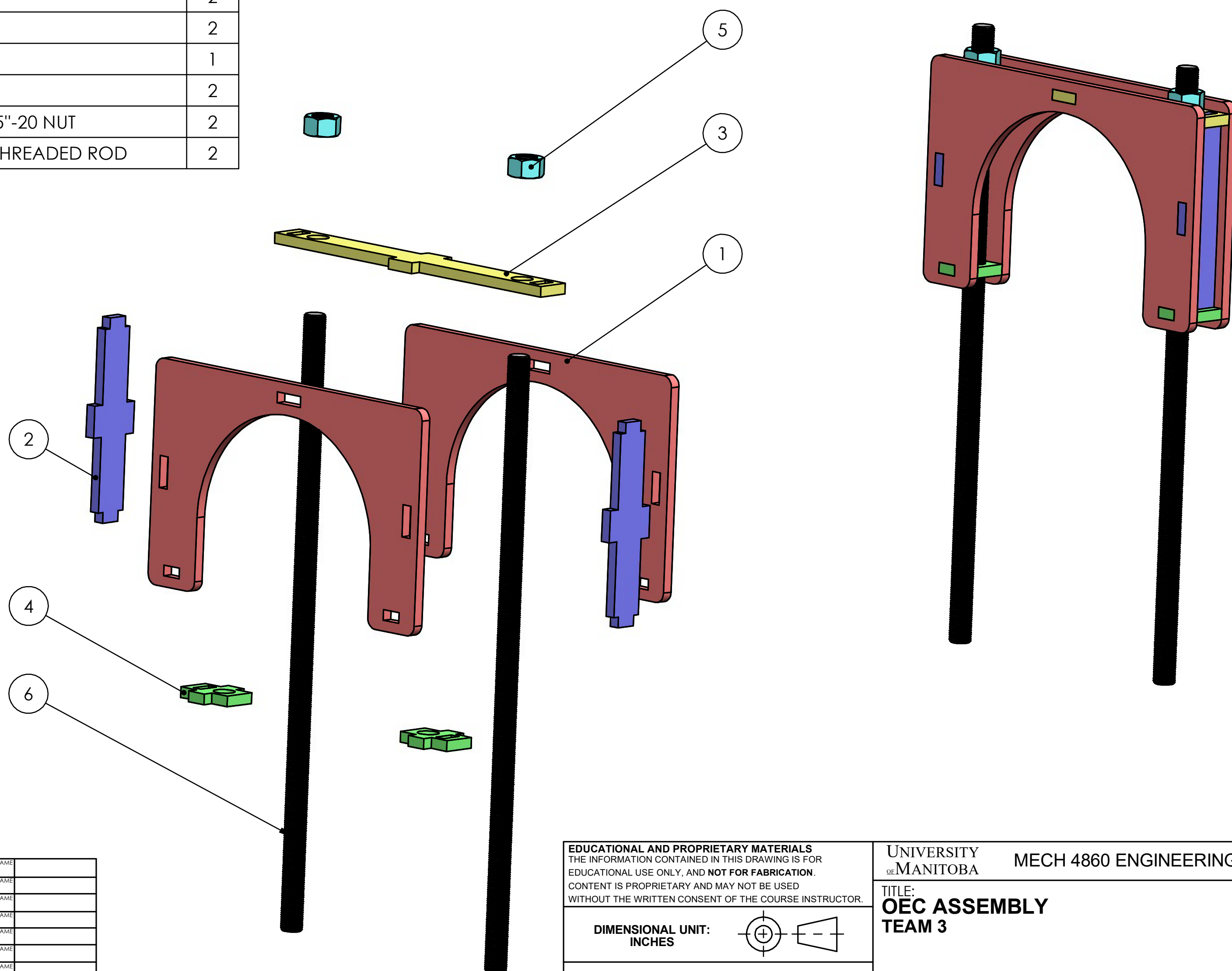
MECH 4860 ENGINEERING DESIGN

TITLE:
BMB PIN
TEAM 3

SIZE **B** | DWG. NO. **BMB PIN** | REV 0

SCALE: 1.5:1 | WEIGHT: 1.85 LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	OEC1		2
2	OEC3		2
3	OEC2		1
4	OEC4		2
5	94895A825	0.5"-20 NUT	2
6	90322A168	0.5"-20 THREADED ROD	2



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

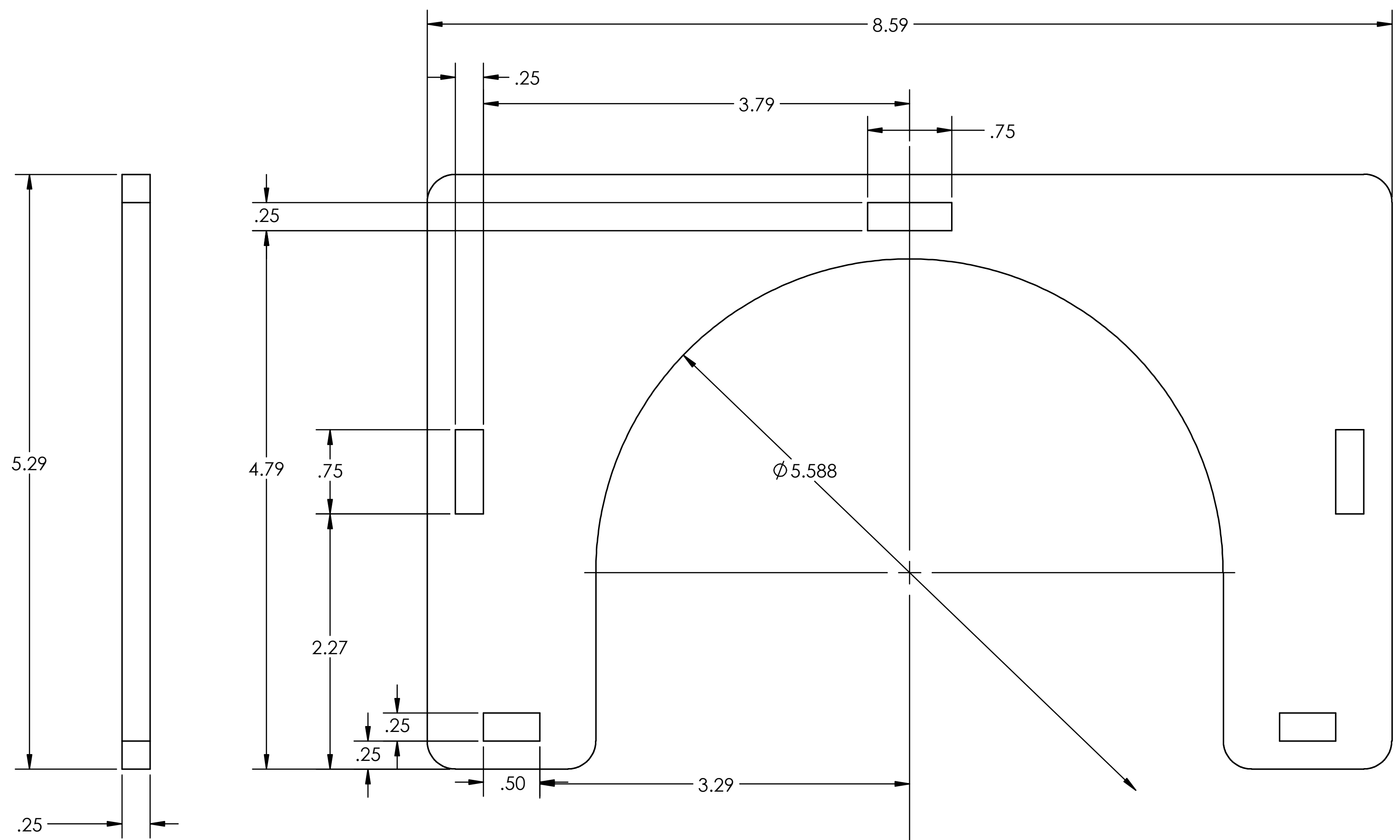
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
OEC ASSEMBLY
TEAM 3

SIZE **B** | DWG. NO. **OEC ASSEMBLY** | REV 0

SCALE: 1:2.5 | WEIGHT: | SHEET 1 OF 1

REV 0 — OEC ASSEMBLY — DWG. NO.



UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

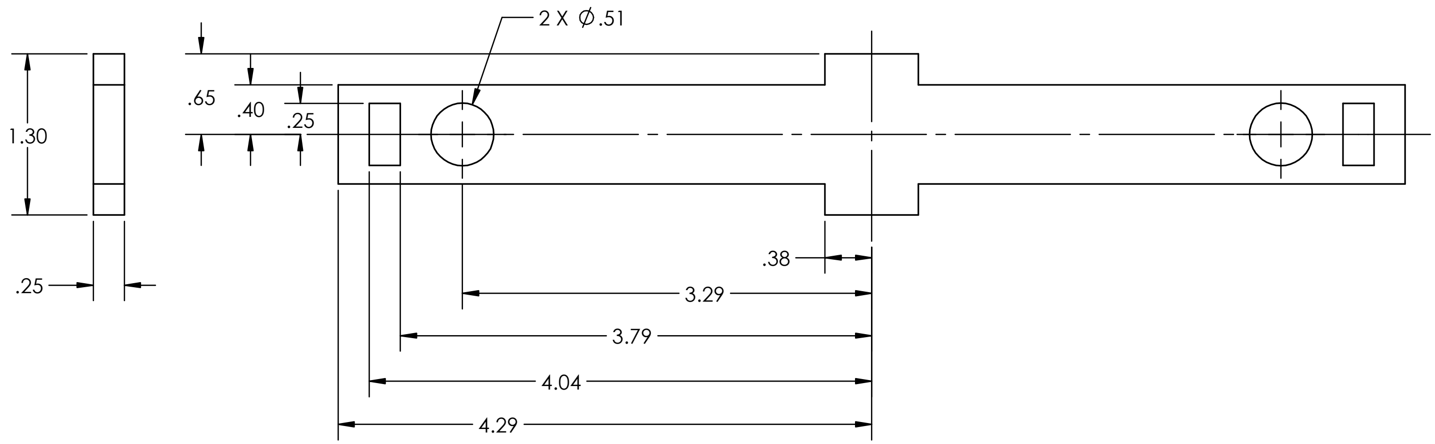
TITLE:
OEC1
TEAM 3

SIZE: B | DWG. NO.: OEC1 | REV: 0

SCALE: 1:1 | WEIGHT: 0.55 LBS | SHEET 1 OF 1

REV 0

DWG. NO. OEC2



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

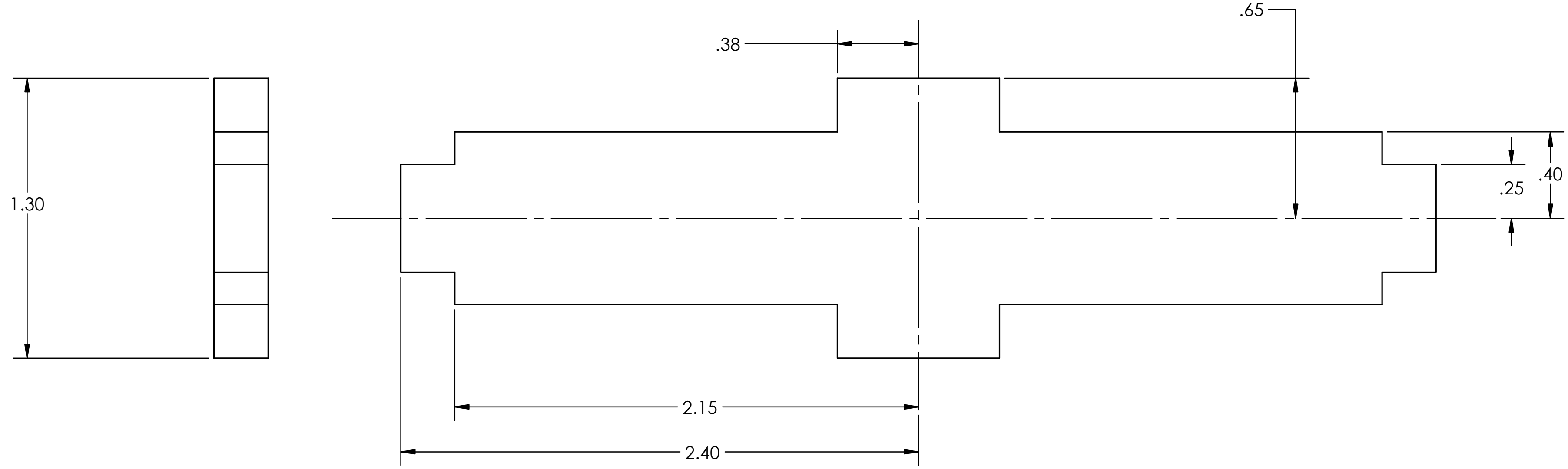
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
OEC 2
TEAM 3

SIZE	DWG. NO.	REV
B	**OEC2**	0

SCALE: 1:1 | WEIGHT: 0.16 LBS | SHEET 1 OF 1



REV 0

DWG. NO. OEC3

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH ✓

DO NOT SCALE DRAWING

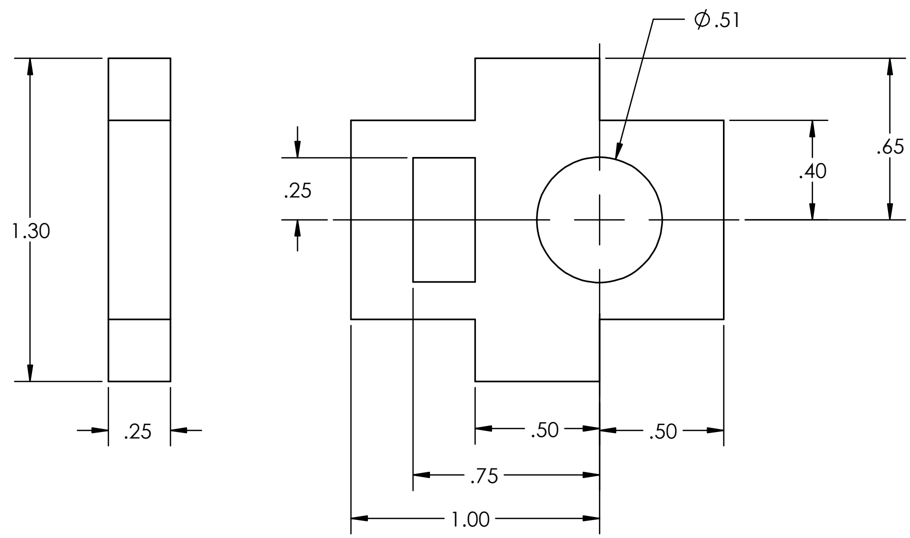
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
OEC 3
TEAM 3

SIZE **B** | DWG. NO. **OEC3** | REV 0

SCALE: 2:1 | WEIGHT: 0.55 LBS | SHEET 1 OF 1



REV 0

DWG. NO. OEC4

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

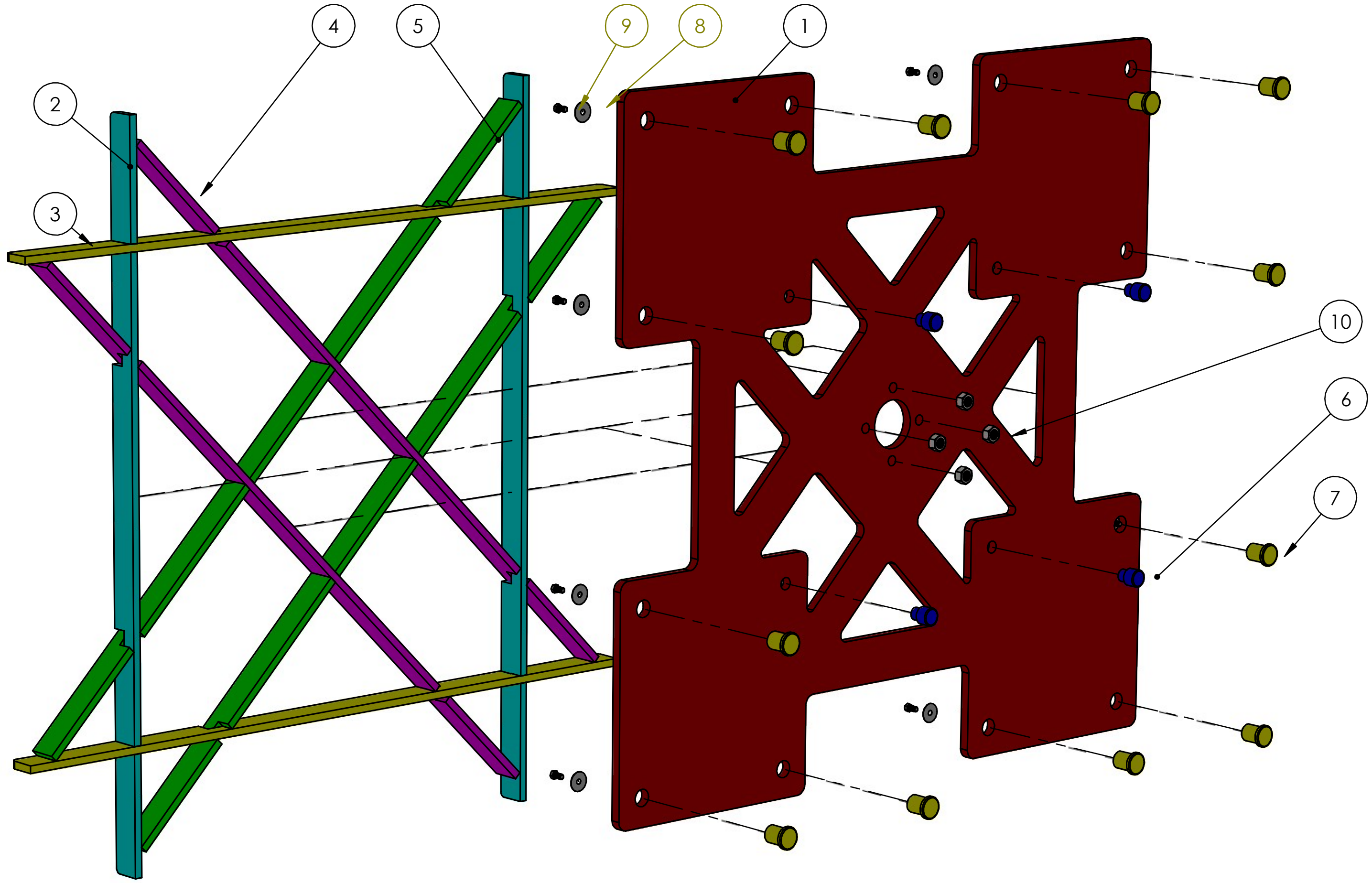
MECH 4860 ENGINEERING DESIGN

TITLE:
OEC 4
TEAM 3

SIZE **B** | DWG. NO. **OEC4** | REV 0

SCALE: 2:1 | WEIGHT: 0.03 LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	QTY.
1	BMB Plate	1
2	BMB Brace 1	2
3	BMB Brace 2	2
4	BMB Brace 3	2
5	BMB Brace 4	2
6	BMB Locator	4
7	BMB Pin	12
8	91090A118	12
9	92620A744	12
10	94895A038	4



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

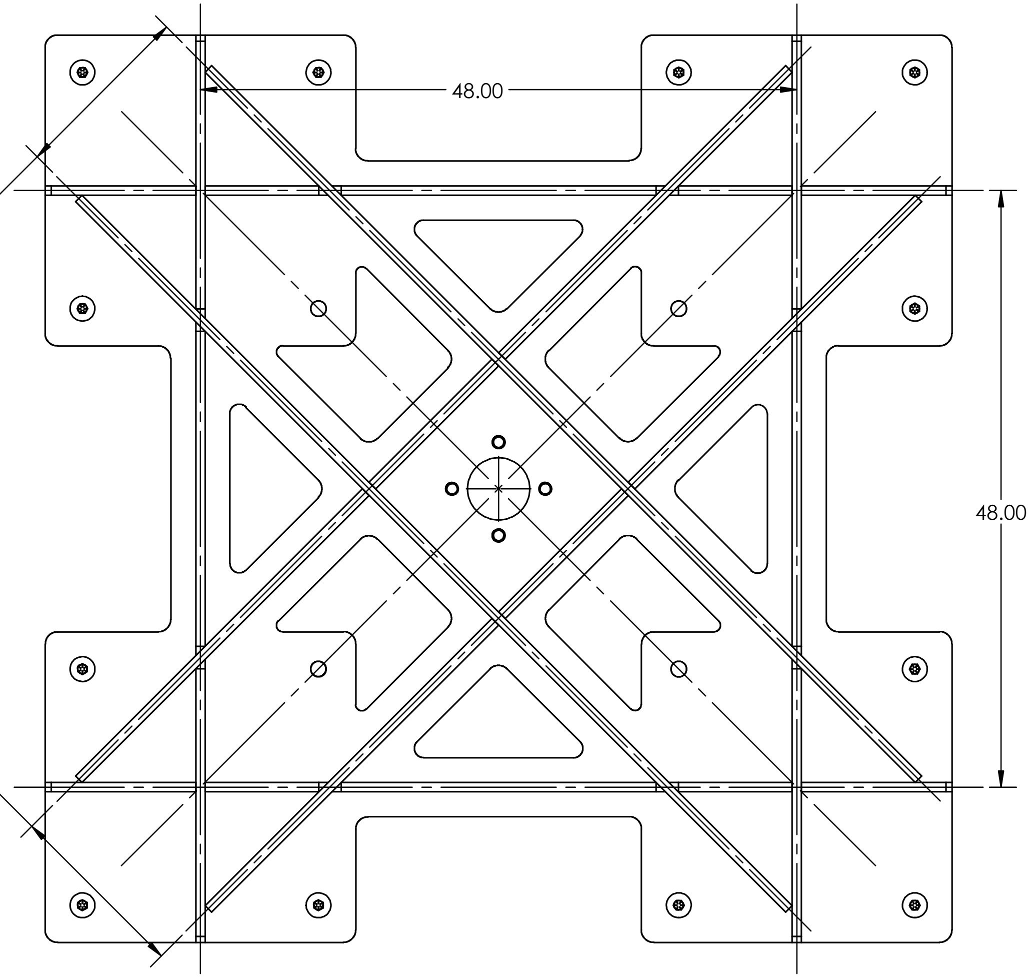
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
BOTTOM MOUNTING BRACKET
TEAM 3

SIZE: **B** | DWG. NO. **BOTTOM MOUNTING BRACKET** | REV 0

SCALE: 1:10 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **BOTTOM MOUNTING BRACKET** | REV **0**



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

EDUCATIONAL AND PROPRIETARY MATERIALS
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DIMENSIONAL UNIT: INCHES

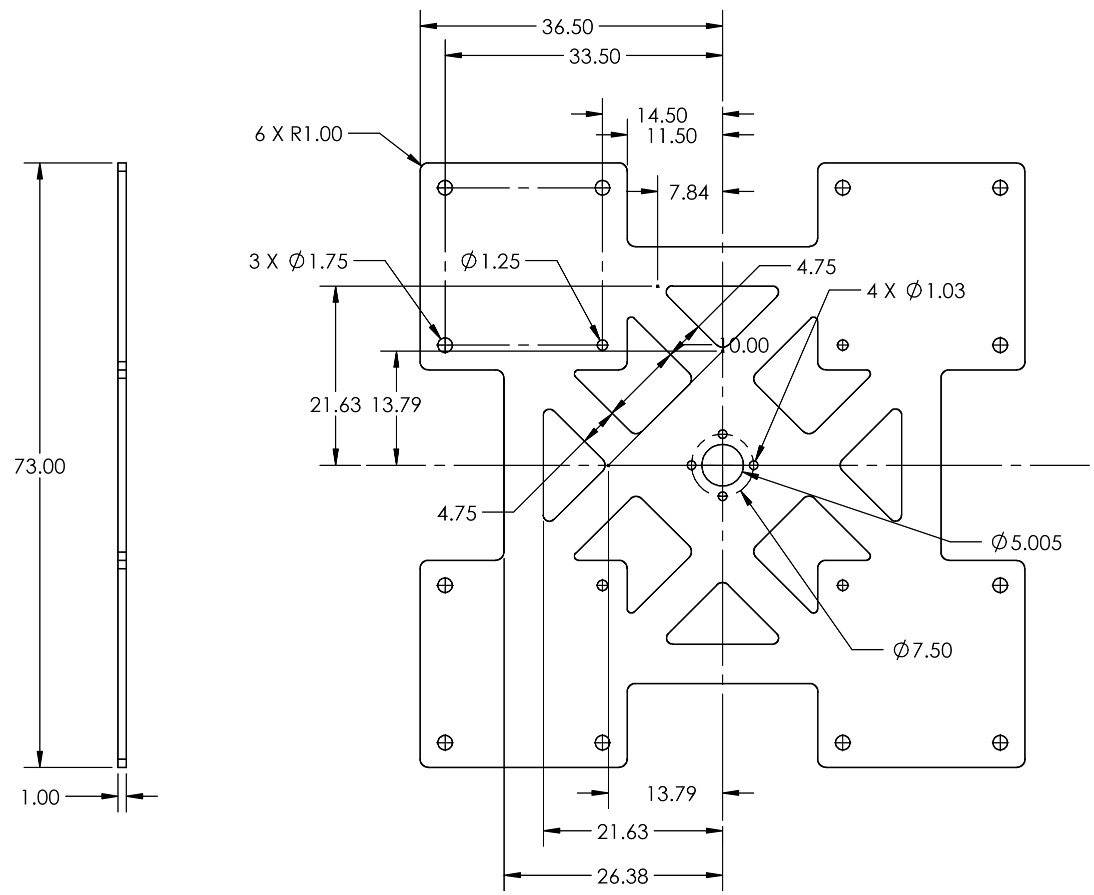
University of Manitoba — MECH 4860 ENGINEERING DESIGN

TITLE: **BOTTOM MOUNTING BRACKET TEAM 3**

SIZE: B | DWG. NO. **BOTTOM MOUNTING BRACKET LAYOUT** | REV 0

DO NOT SCALE DRAWING | SCALE: 1:10 | WEIGHT: | SHEET 1 OF 1

REV 0
DWG. NO. BOTTOM MOUNTING BRACKET LAYOUT



UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

REV	DATE Y/M/D	DESCRIPTION	
0	18/11/28	DRAWING CREATED	DWN / CKD

MATERIAL
6061-T6 ALUMINIUM

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

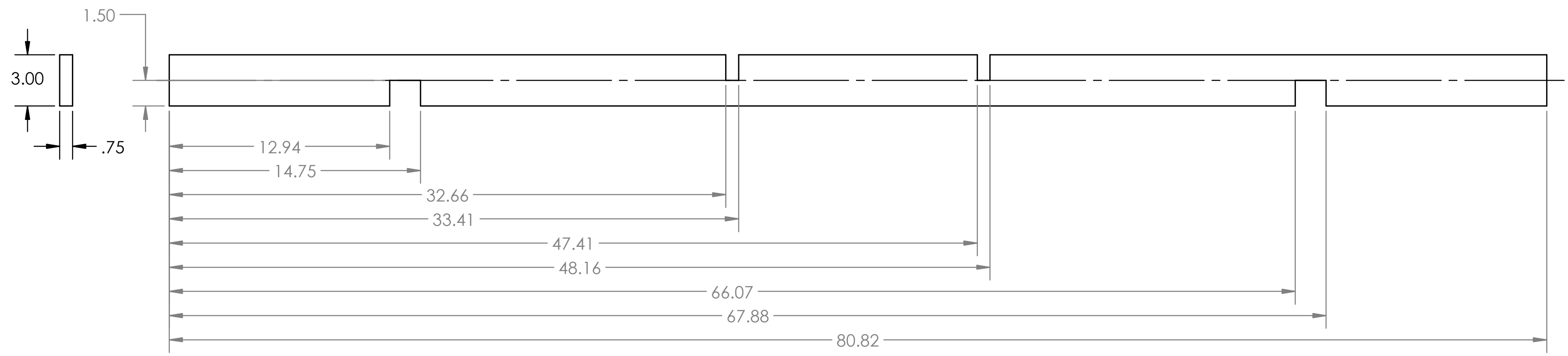
MECH 4860 ENGINEERING DESIGN

TITLE:
BMB PLATE
TEAM 3

SIZE B | DWG. NO. **BMB PLATE** | REV 0

SCALE: 1:15 | WEIGHT: 365.15 LBS | SHEET 1 OF 1

REV 0
DWG. NO. **BMB PLATE**



REV 0

DWG. NO. BMB BRACE 1

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

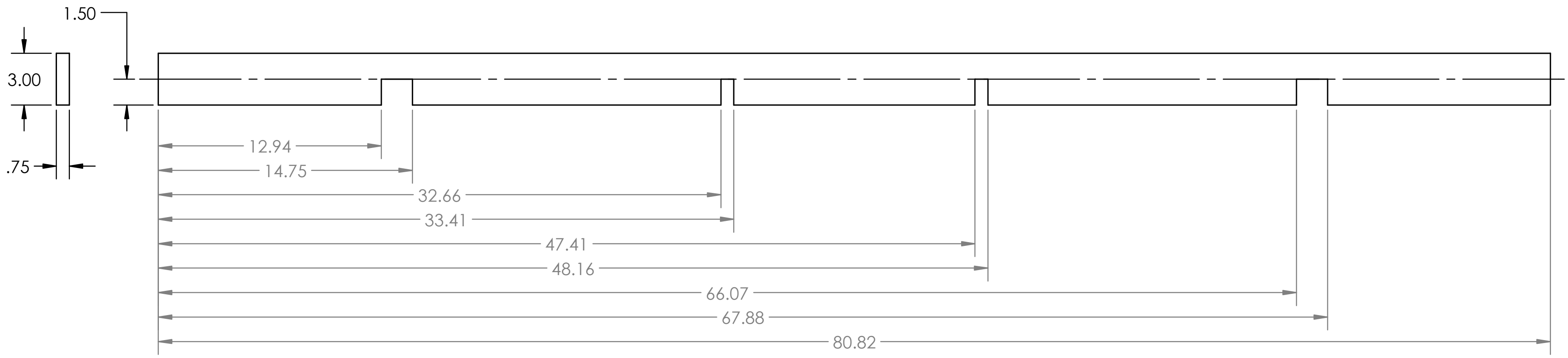
UNIVERSITY of MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
BMB BRACE 1
TEAM 3

SIZE **B** | DWG. NO. **BMB BRACE 1** | REV 0

SCALE: 1:6 | WEIGHT: 17.18 LBS | SHEET 1 OF 1



REV 0

DWG. NO. BMB BRACE 2

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

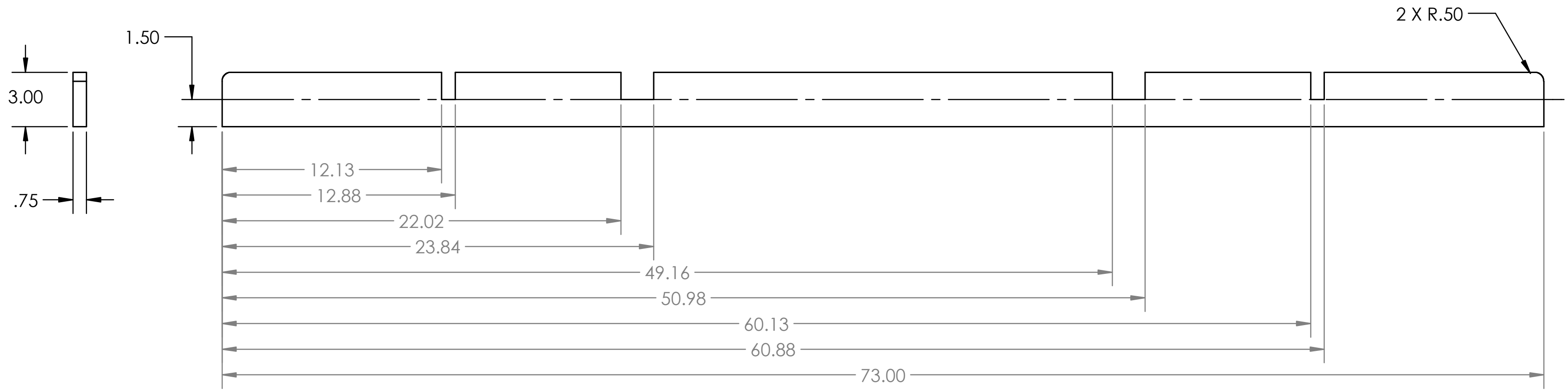
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
BMB BRACE 2
TEAM 3

SIZE **B** | DWG. NO. **BMB BRACE 2** | REV 0

SCALE: 1:6 | WEIGHT: 17.18 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE
±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

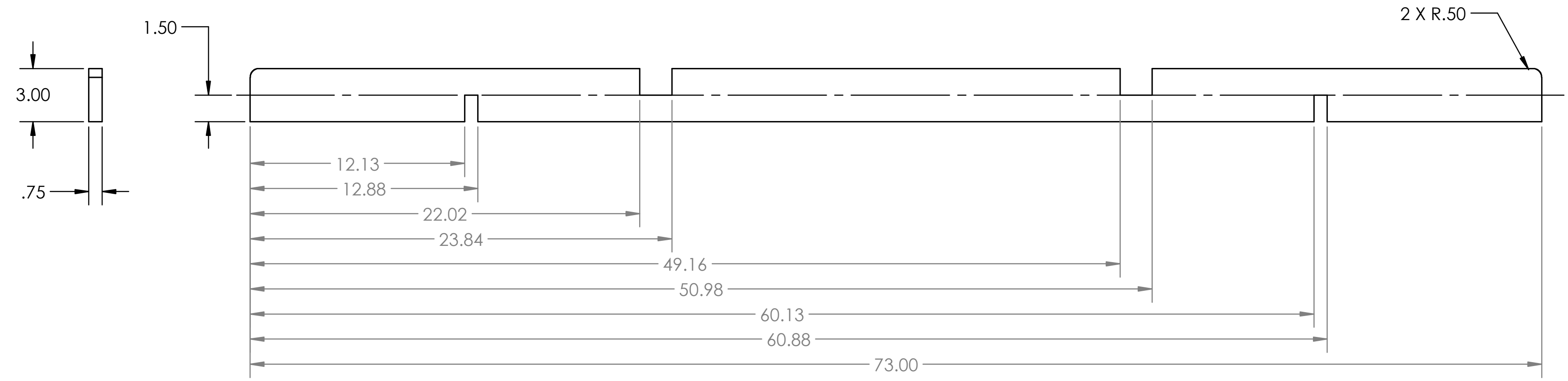
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
BMB BRACE 3
TEAM 3

SIZE **B** | DWG. NO. **BMB BRACE 3** | REV 0

SCALE: 1:6 | WEIGHT: 15.45 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
6061-T6 ALUMINUM

FINISH

DO NOT SCALE DRAWING

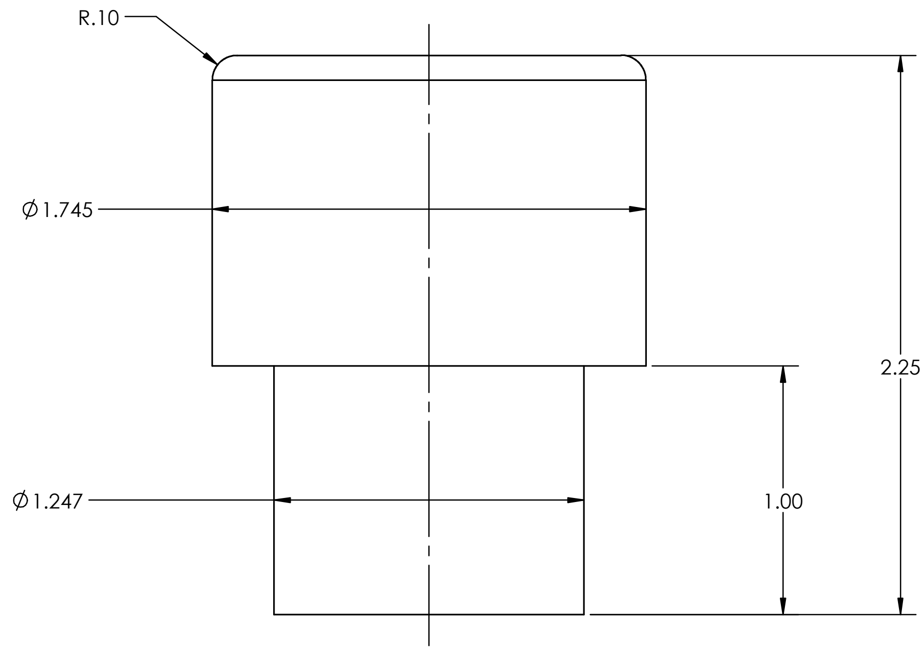
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
BMB BRACE 4
TEAM 3

SIZE **B** | DWG. NO. **BMB BRACE 4** | REV 0

SCALE: 1:6 | WEIGHT: 15.45 LBS | SHEET 1 OF 1

REV 0 — DWG. NO. BMB BRACE 4



REV 0

DWG. NO. BMB LOCATOR

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
6061-T6 ALUMINUM

FINISH
√

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

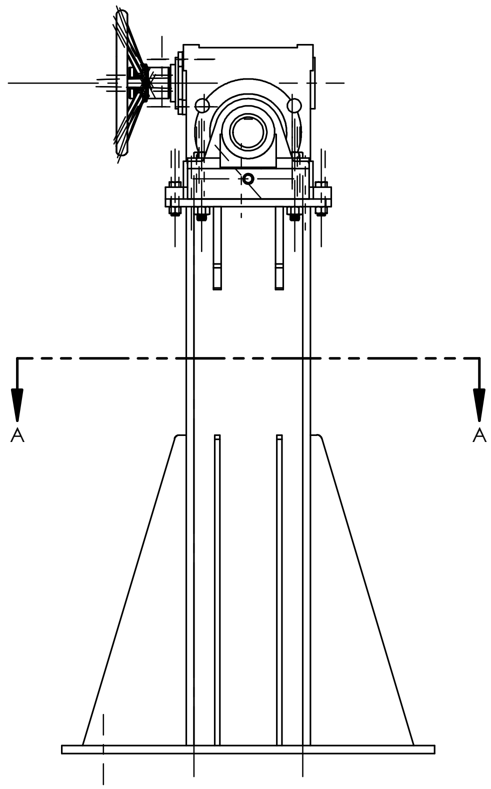
TITLE:
BMB LOCATOR
TEAM 3

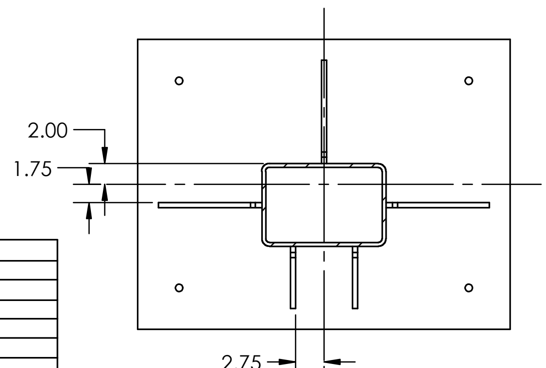
SIZE **B**

DWG. NO. **BMB LOCATOR**

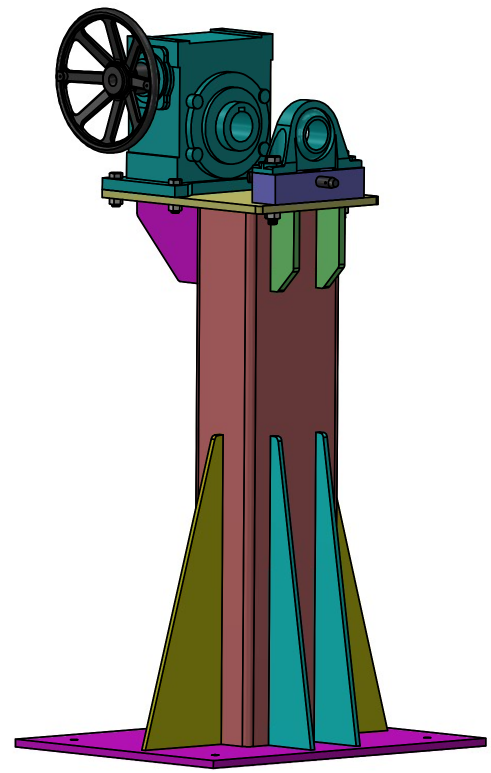
REV 0

SCALE: 2:1 | WEIGHT: 0.41 LBS | SHEET 1 OF 1





SECTION A-A



NOTE: COMPONENTS TO BE WELDED TOGETHER

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK ASSEMBLY
TEAM 3

SIZE **B**

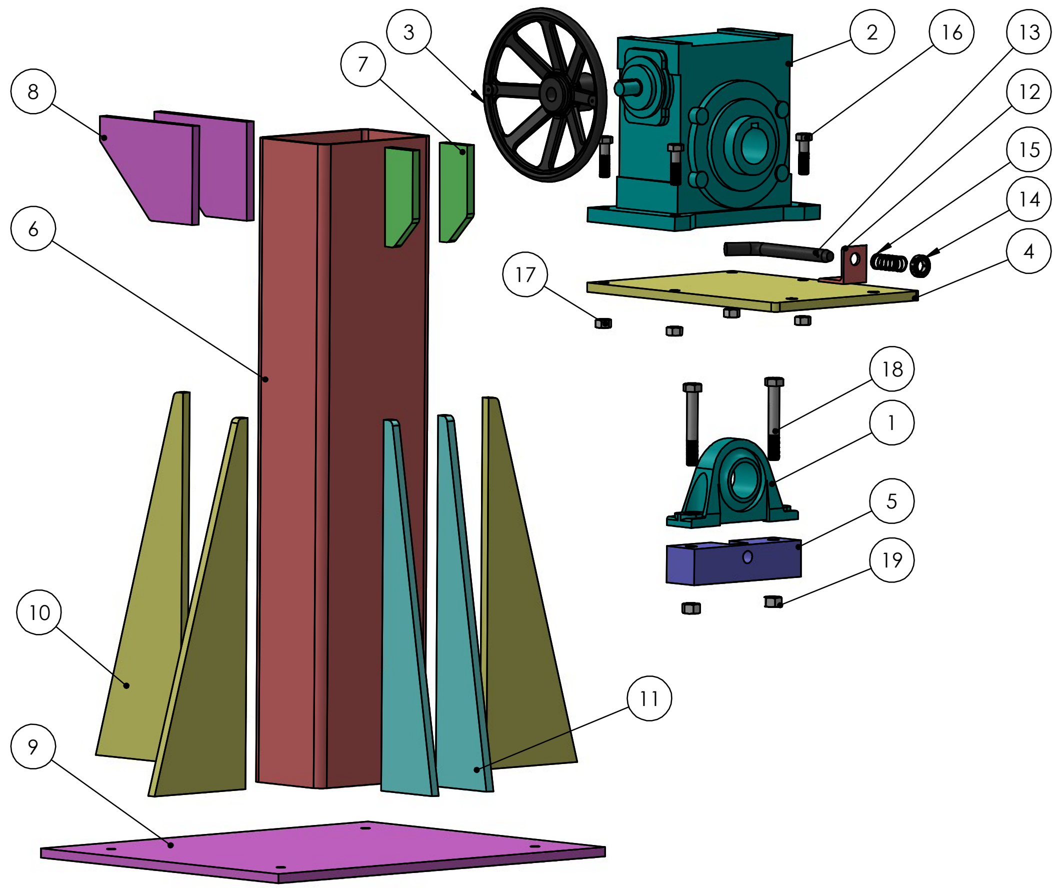
DWG. NO. **FIXED SUPPORT STRUCTURE**

REV

SCALE: 1:12 | WEIGHT: | SHEET 1 OF 1

REV
DWG. NO. **FIXED SUPPORT STRUCTURE**

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Bearing	PART-033688-DESC	1
2	47S30H18B Gearbox	PART-47S30H18B-DESC	1
3	Hand Wheel CARR_LANE		1
4	FSS Top Plate		1
5	FSS Bearing Support		1
6	FSS Support Beam		1
7	FSS Flange 3		2
8	FSS Flange 4		2
9	FSS Base Plate		1
10	FSS Flange 1		3
11	FSS Flange 2		2
12	FSS Angle Support		1
13	90146A233_ZINC-PLATED STEEL BENT-PULL HITCH PIN		1
14	6435K18	1" SHAFT COLLAR	1
15	9657K547	COMPRESSION SPRING	1
16	91257A876	0.75"-16 X 2.75" BOLT	4
17	94895A840	0.75"-16 NUT	4
18	91257A925	0.875"-9 X 6" BOLT	2
19	94895A842	0.875"-9 NUT	2



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

EDUCATIONAL AND PROPRIETARY MATERIALS
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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

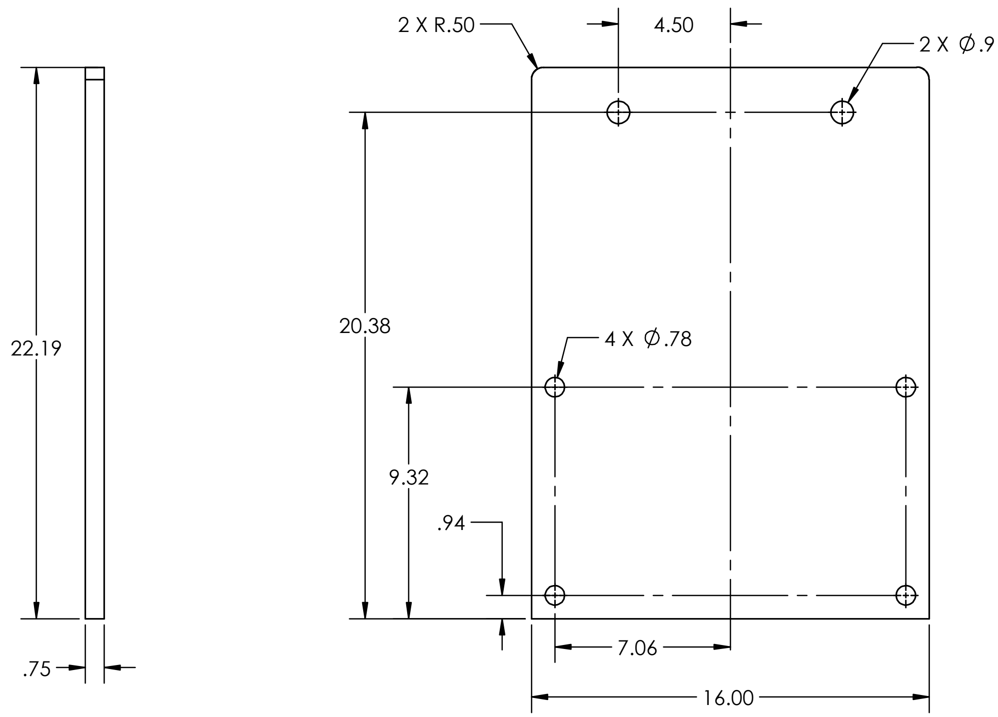
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
FIXED SUPPORT STRUCTURE
TEAM 3

SIZE: **B** | DWG. NO.: **FIXED SUPPORT STRUCTURE EXPLODED VIEW** | REV: 0

SCALE: 1:10 | WEIGHT: 963.54 LBS | SHEET 1 OF 1

REV 0 — DWG. NO. FIXED SUPPORT STRUCTURE EXPLODED VIEW



REV 0

DWG. NO. FSS TOP PLATE

REV	DATE Y/M/D	DESCRIPTION		
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
0	18/11/28	DRAWING CREATED	DWN NAME #	
			CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

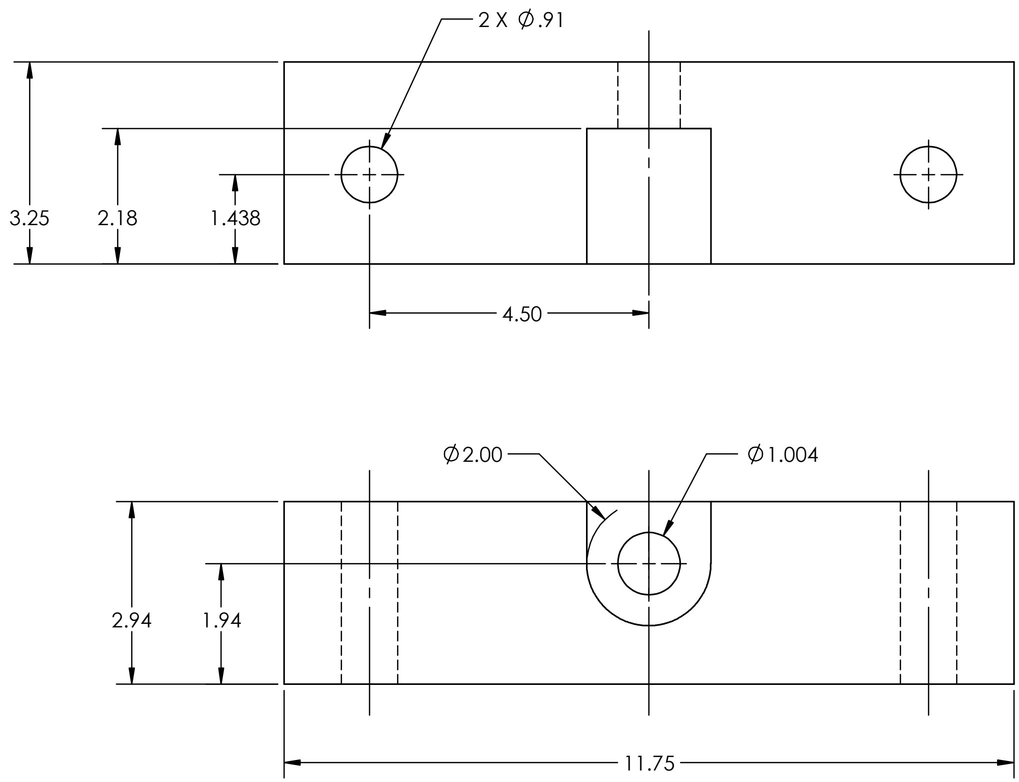
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
FSS TOP PLATE
TEAM 3

SIZE	DWG. NO.	REV
B	FSS TOP PLATE	0

SCALE: 1:5 | WEIGHT: 74.33 LBS | SHEET 1 OF 1



REV 0

DWG. NO. FSS BEARING SUPPORT

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY

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MATERIAL: CARBON STEEL

FINISH

DO NOT SCALE DRAWING

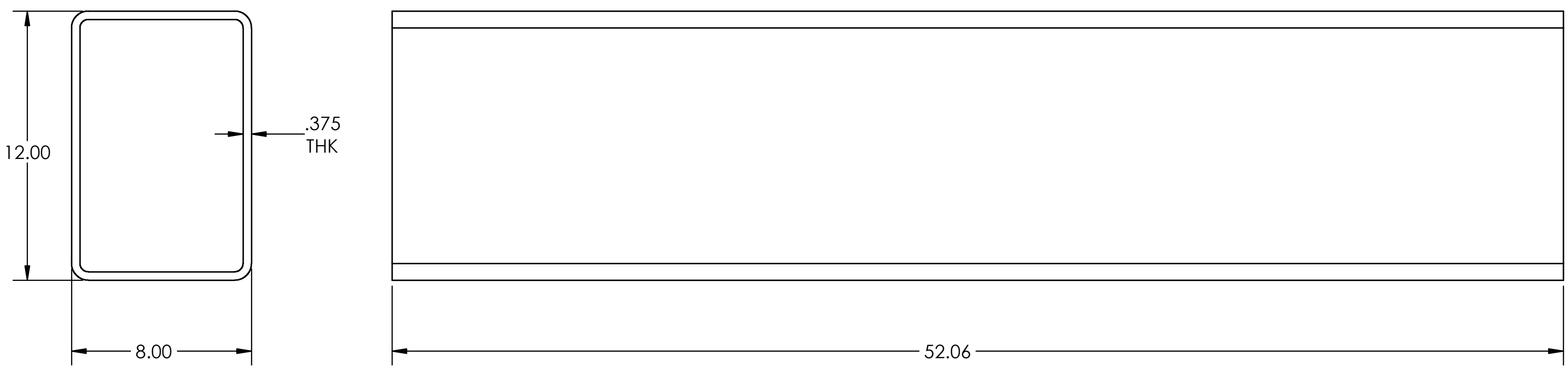
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **BEARING SUPPORT**

TEAM 3

SIZE: **B** | DWG. NO. **FSS BEARING SUPPORT** | REV 0

SCALE: 1:2 | WEIGHT: 28.14 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE ±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 8"X12" STEEL STOCK

FINISH

DO NOT SCALE DRAWING

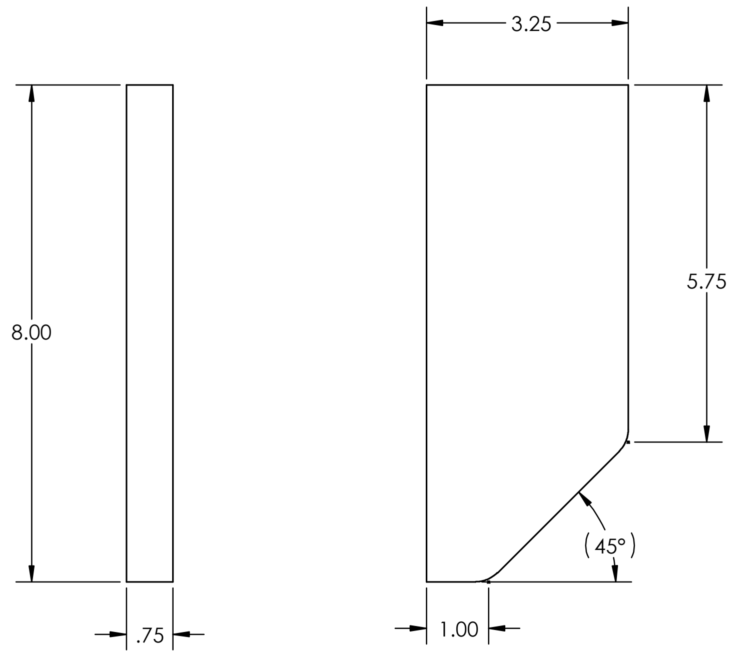
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **FSS SUPPORT BEAM**
TEAM 3

SIZE: **B** | DWG. NO. **FSS SUPPORT BEAM** | REV 0

SCALE: 1:5 | WEIGHT: 206.49 LBS | SHEET 1 OF 1

DWG. NO. **FSS SUPPORT BEAM** REV 0



0	18/11/28	DRAWING CREATED	DWN / CKD	
REV	DATE Y/M/D	DESCRIPTION		

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL: CARBON STEEL

FINISH: √

DO NOT SCALE DRAWING

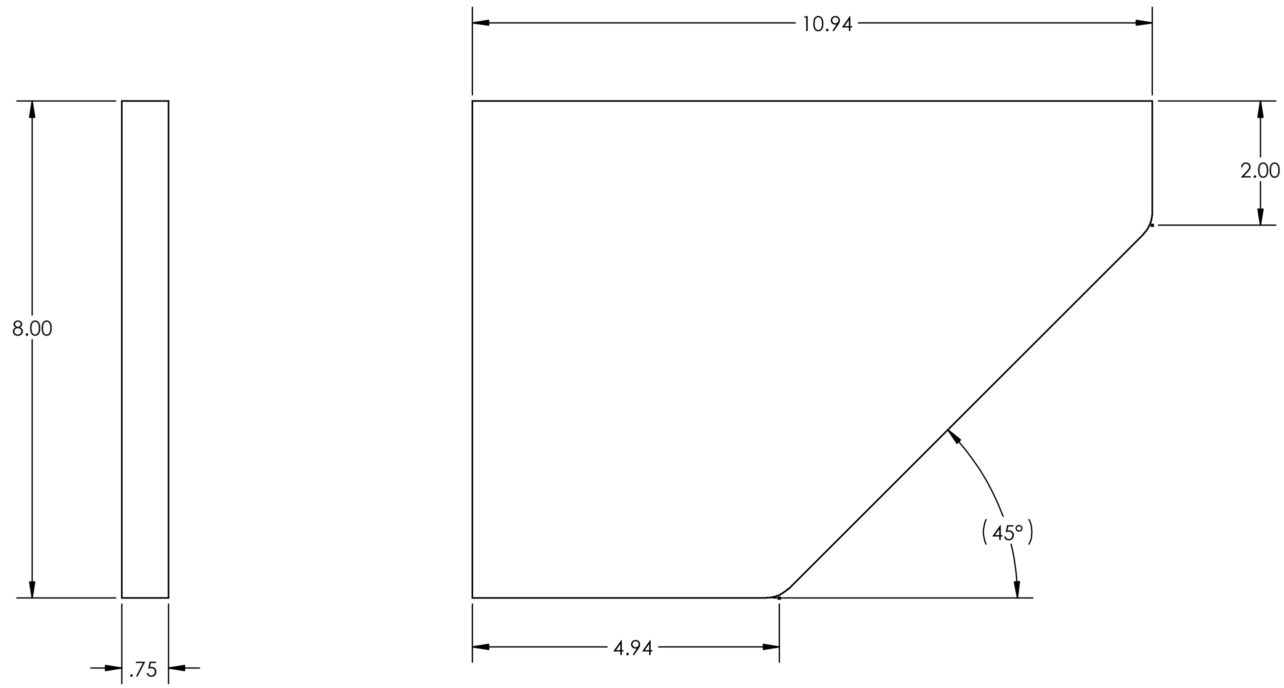
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **FSS FLANGE 3**
TEAM 3

SIZE: **B** | DWG. NO.: **FSS FLANGE 3** | REV: 0

SCALE: 1:2 | WEIGHT: 4.96 LBS | SHEET 1 OF 1

REV 0
DWG. NO. FSS FLANGE 3



			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	
REV	DATE Y/M/D	DESCRIPTION		

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

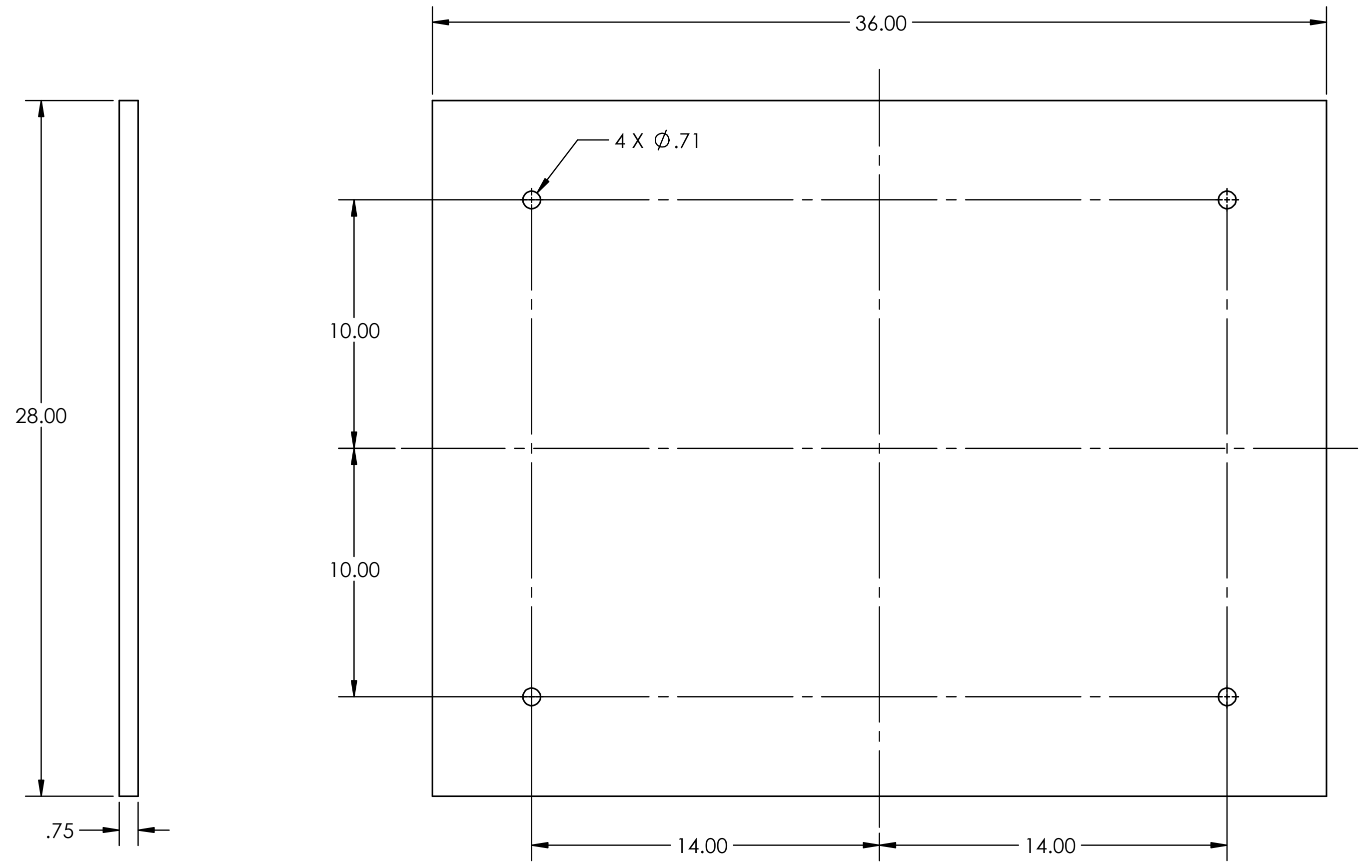
MECH 4860 ENGINEERING DESIGN

TITLE:
FSS FLANGE 4
TEAM 3

SIZE **B** | DWG. NO. **FSS FLANGE 4** | REV 0

SCALE: 1:2 | WEIGHT: 14.69 LBS | SHEET 1 OF 1

REV 0
DWG. NO. **FSS FLANGE 4**



REV 0

DWG. NO. FSS BASE PLATE

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

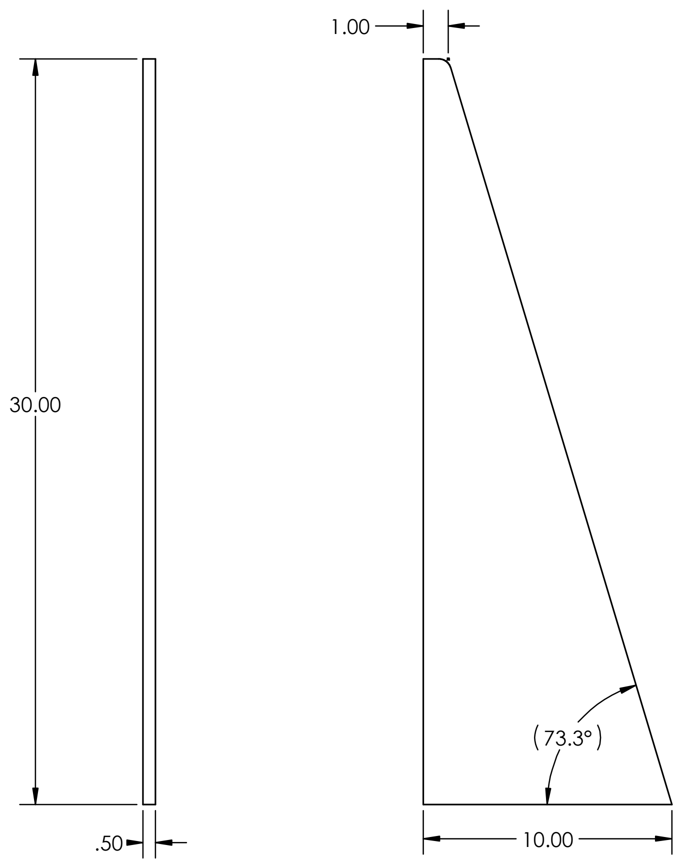
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
FSS BASE PLATE
TEAM 3

SIZE **B** | DWG. NO. **FSS BASE PLATE** | REV 0

SCALE: 1:5 | WEIGHT: 210.70 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY

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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY of MANITOBA

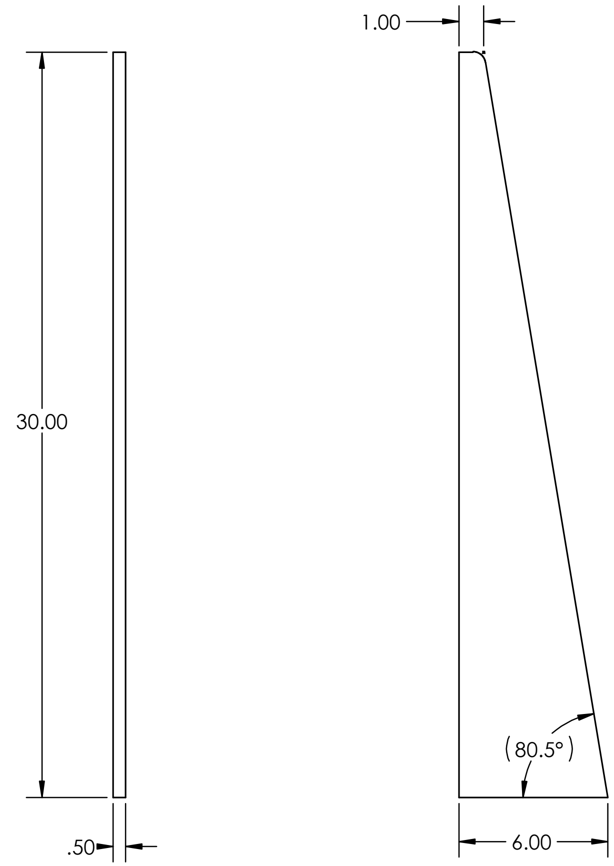
MECH 4860 ENGINEERING DESIGN

TITLE:
FSS FLANGE 1
TEAM 3

SIZE **B** | DWG. NO. **FSS FLANGE 1** | REV 0

SCALE: 1:5 | WEIGHT: 34.87 LBS | SHEET 1 OF 1

REV 0
DWG. NO. **FSS FLANGE 1**



REV 0

DWG. NO. FSS FLANGE 2

0	18/11/28	DRAWING CREATED	DWN / CKD	
REV	DATE Y/M/D	DESCRIPTION		

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

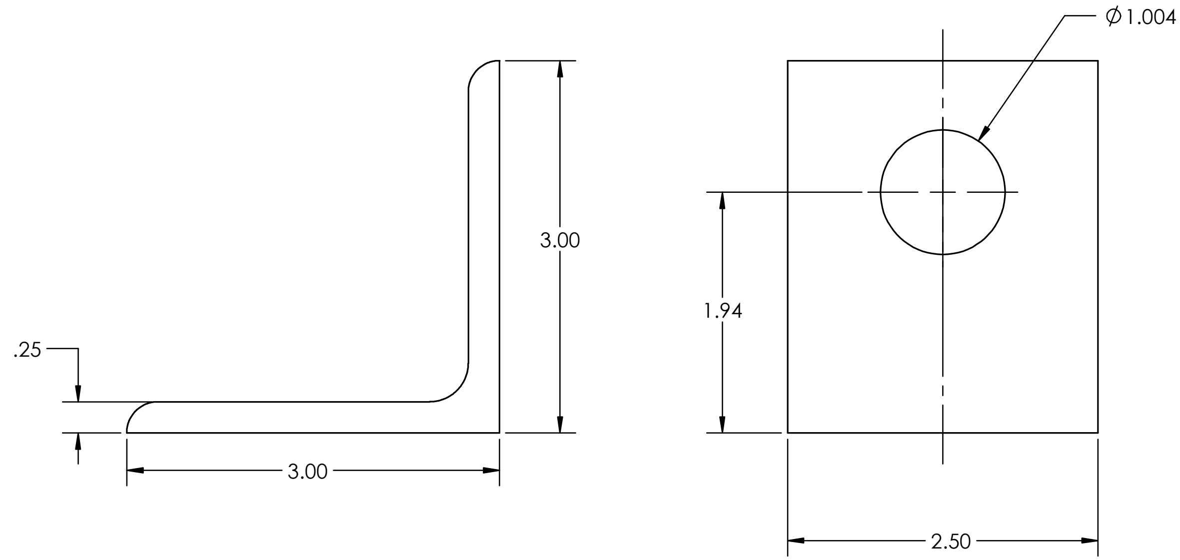
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
FSS FLANGE 2
TEAM 3

SIZE **B** | DWG. NO. **FSS FLANGE 2** | REV 0

SCALE: 1:5 | WEIGHT: 22.18 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
3" X 3" X 0.25" STEEL ANGLE

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

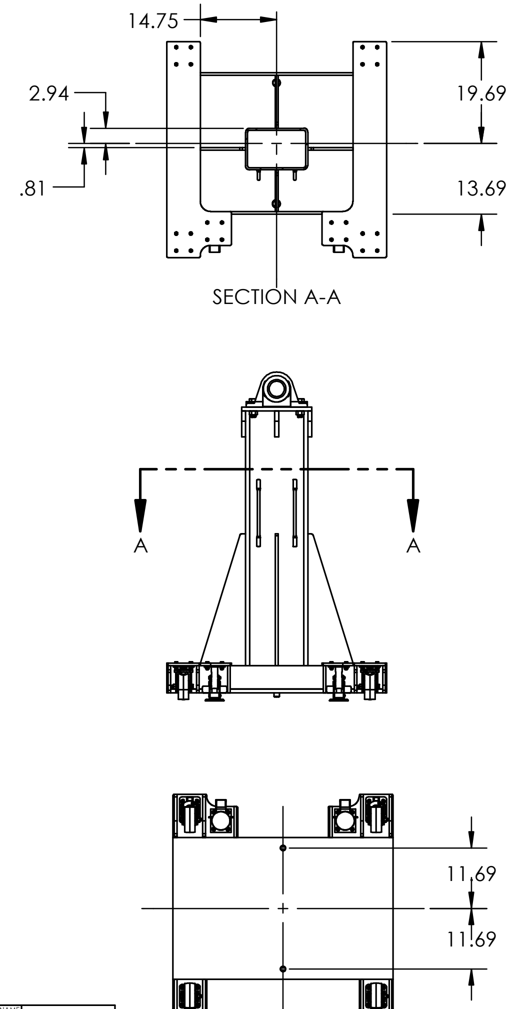
MECH 4860 ENGINEERING DESIGN

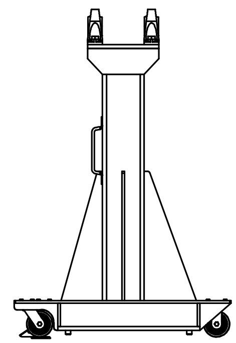
TITLE:
FSS ANGLE SUPPORT
TEAM 3

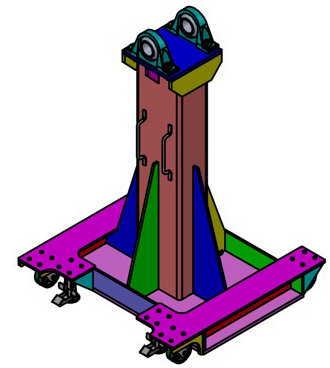
SIZE **B** | DWG. NO. **FSS ANGLE SUPPORT** | REV 0

SCALE: 1:1 | WEIGHT: 0.95 LBS | SHEET 1 OF 1

DWG. NO. FSS ANGLE SUPPORT
REV 0







NOTE: COMPONENTS TO BE WELDED TOGETHER

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

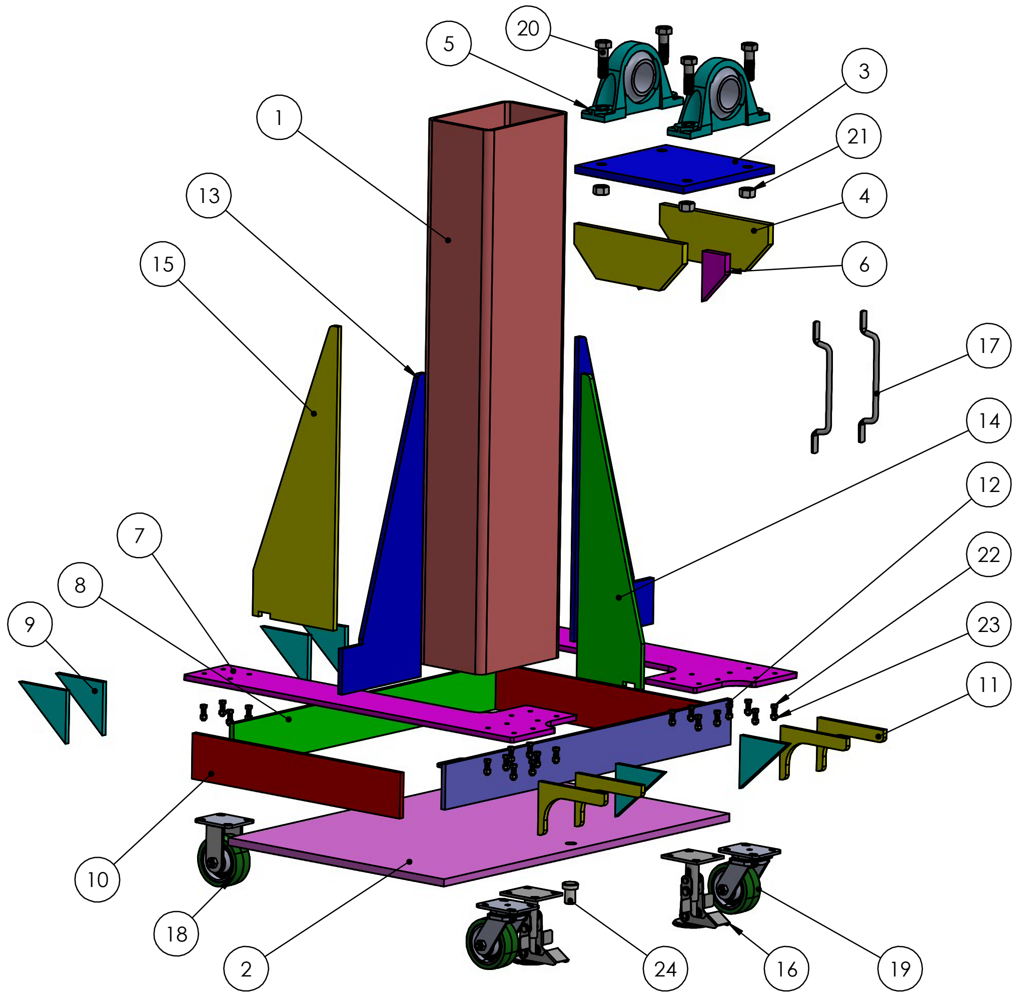
TITLE:
TRACK ASSEMBLY
TEAM 3

SIZE **B** | DWG. NO. **MOVING SUPPORT STRUCTURE** | REV

SCALE: 1:24 | WEIGHT: | SHEET 1 OF 1

REV
DWG. NO. **MOVING SUPPORT STRUCTURE**

ITEM NO.	PART NUMBER	QTY.
1	MSS Support Beam	1
2	MSS Base Plate	1
3	MSS Top Plate	1
4	MSS Brace 1	2
5	Bearing	2
6	MSS Brace 2	2
7	MSS Plate 2	2
8	MSS Plate 3	1
9	MSS Plate 4	6
10	MSS Plate 5	2
11	MSS Plate 6	4
12	MSS Plate 7	1
13	MSS Plate 8	2
14	MSS Plate 9	1
15	MSS Plate 10	1
16	2728T220_DUAL RELEASE ZINC-PLATED STEEL FLOOR LOCK	2
17	1871A69	2
18	R-WH-5DB	2
19	S-WH-5DB	2
20	91257A913	4
21	94895A842	4
22	92620A626	24
23	94895A031	24
24	MSS Pin	2



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

EDUCATIONAL AND PROPRIETARY MATERIALS
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DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

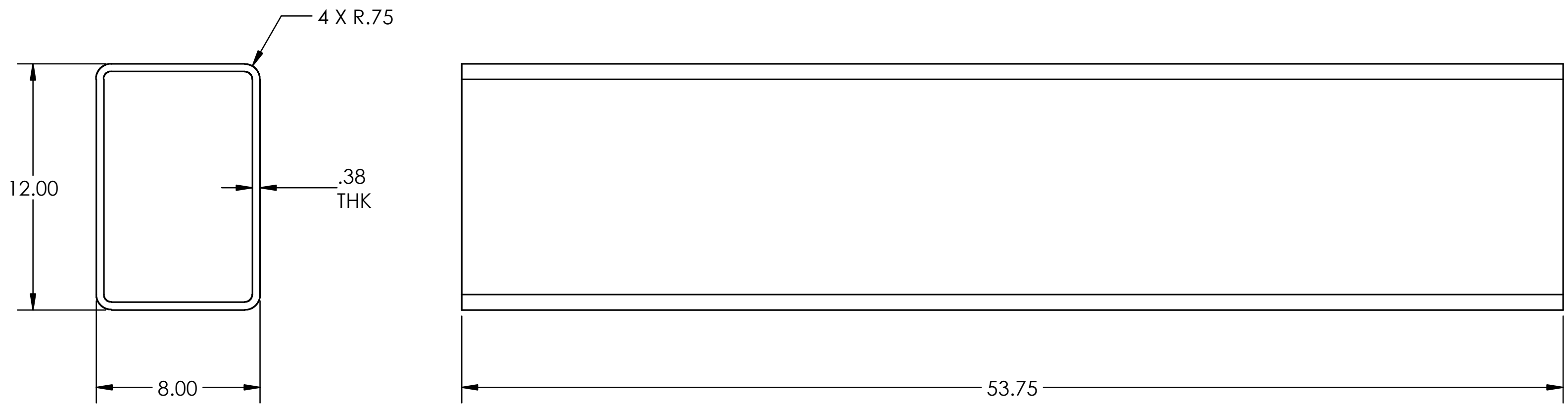
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **TRACK ASSEMBLY**
TEAM 3

SIZE: B | DWG. NO.: **MOVING SUPPORT STRUCTURE EXPLODED** | REV: 0

SCALE: 1:12 | WEIGHT: | SHEET 1 OF 1

DWG. NO. **MOVING SUPPORT STRUCTURE EXPLODED** REV 0



REV 0

DWG. NO. **MSS SUPPORT BEAM**

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL
8" X 12" X 0.375" STEEL STOCK

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

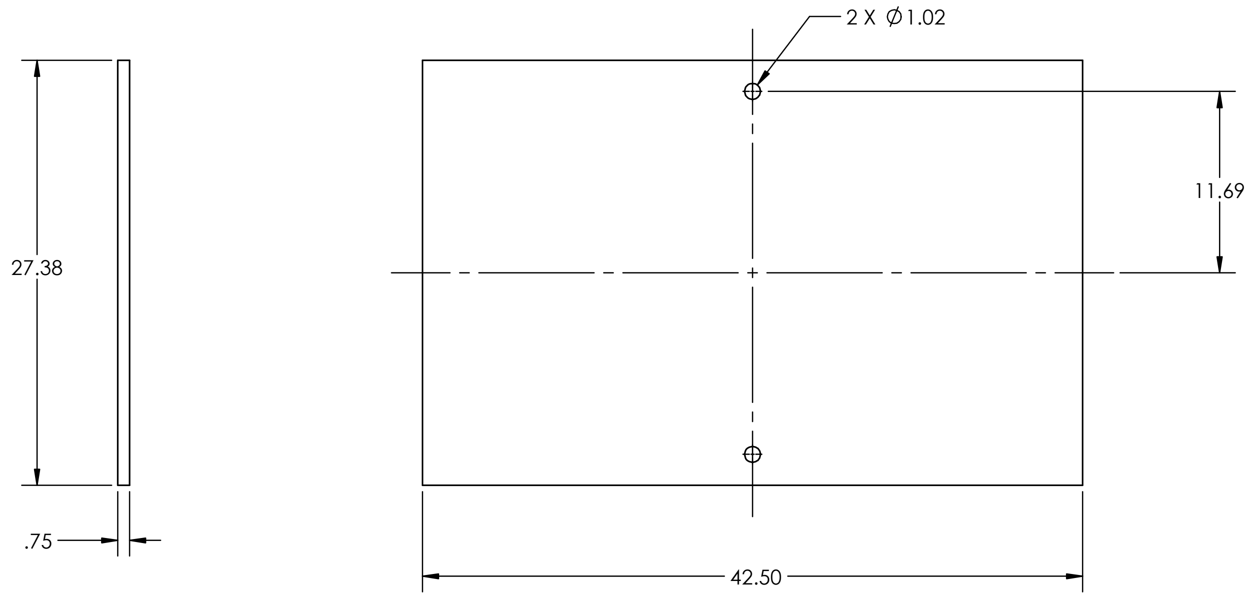
TITLE:
TRACK BASE
TEAM 3

SIZE **B**

DWG. NO. **MSS SUPPORT BEAM**

REV 0

SCALE: 1:6 | WEIGHT: 213.19 LBS | SHEET 1 OF 1



REV 0 — DWG. NO. MSS BASE PLATE

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN NAME # / CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY

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MATERIAL
CARBON STEEL

FINISH

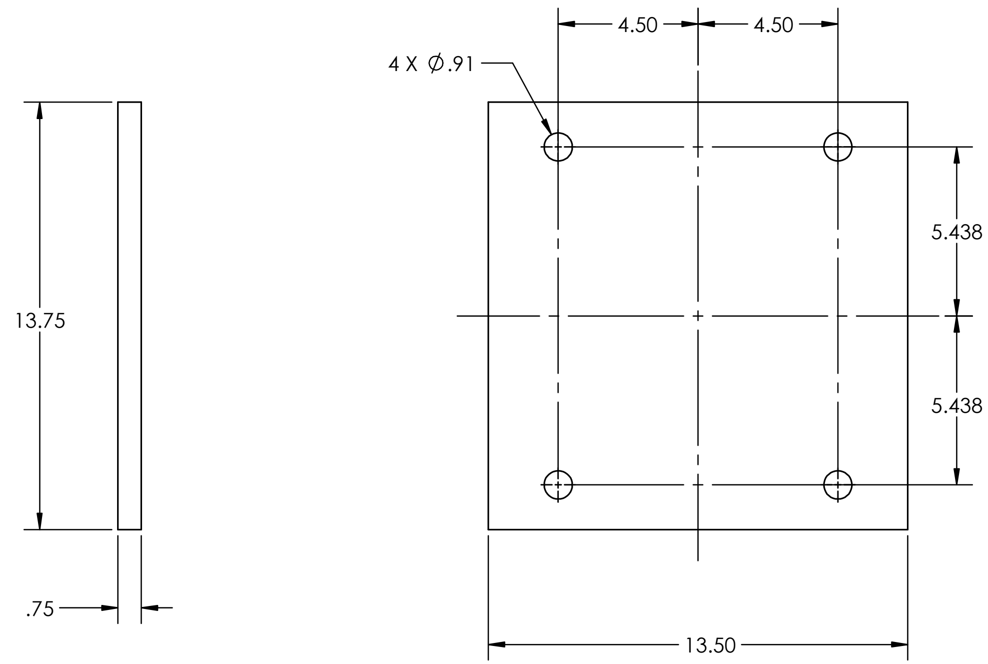
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
MSS BASE PLATE
TEAM 3

SIZE **B** | DWG. NO. **MSS BASE PLATE** | REV 0

SCALE: 1:8 | WEIGHT: 245.54 LBS | SHEET 1 OF 1



REV 0

DWG. NO. MSS TOP PLATE

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

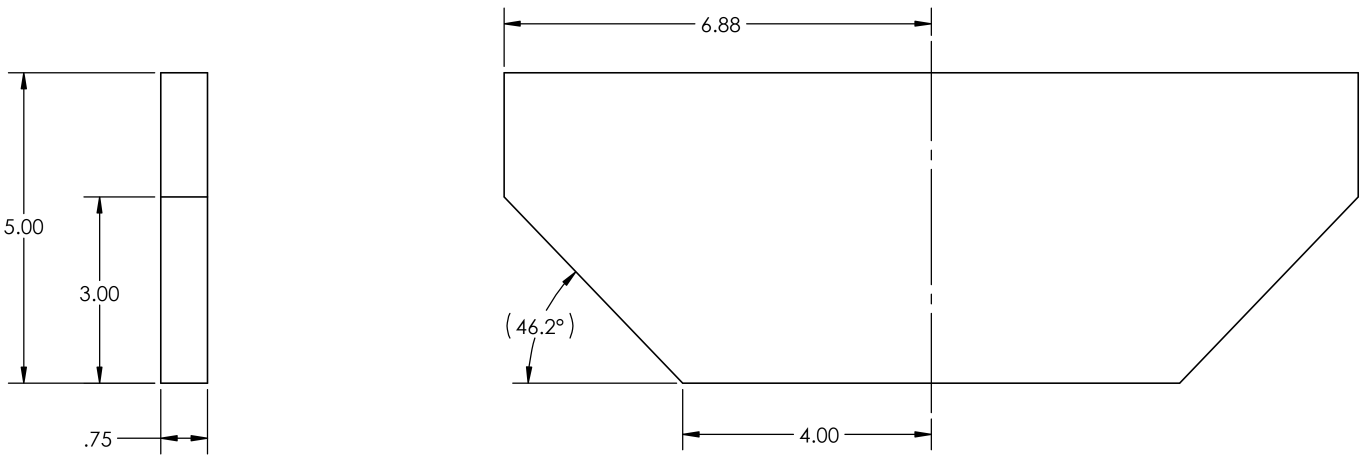
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MSS TOP PLATE
TEAM 3

SIZE **B** | DWG. NO. **MSS TOP PLATE** | REV 0

SCALE: 1:4 | WEIGHT: 38.69 LBS | SHEET 1 OF 1



REV 0

DWG. NO. **MSS BRACE 1**

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

MATERIAL: CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE: **MSS BRACE 1**

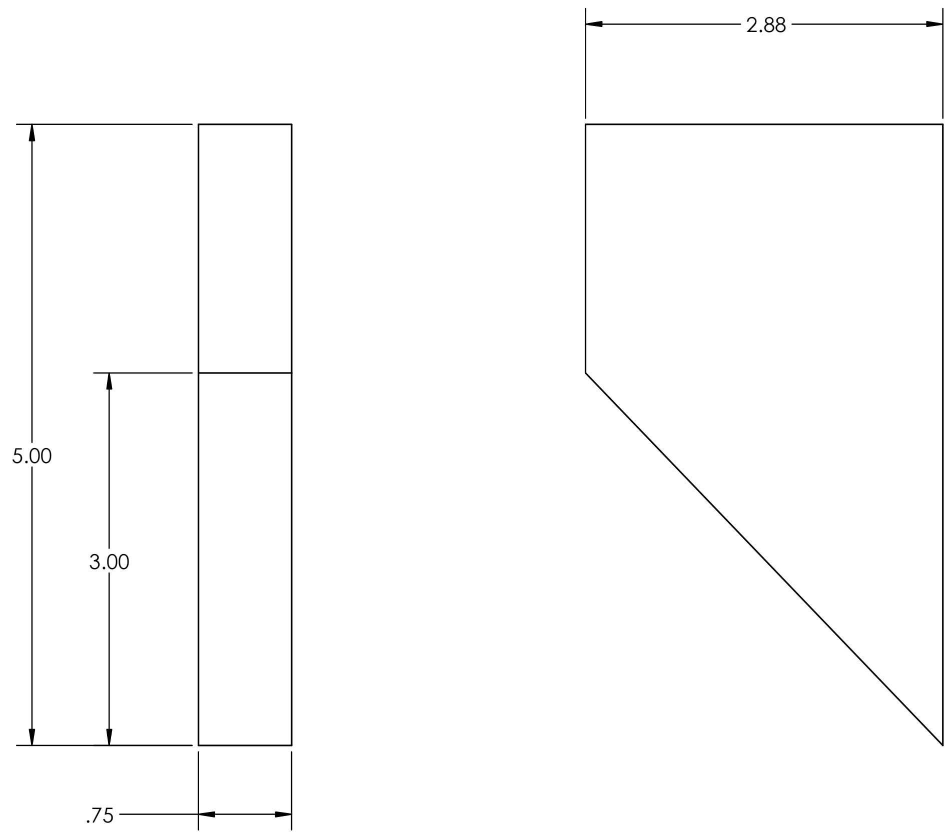
TEAM 3

SIZE: **B**

DWG. NO. **MSS BRACE 1**

REV 0

SCALE: 1:2 | WEIGHT: 12.71 LBS | SHEET 1 OF 1



REV 0
DWG. NO. MSS BRACE 2

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

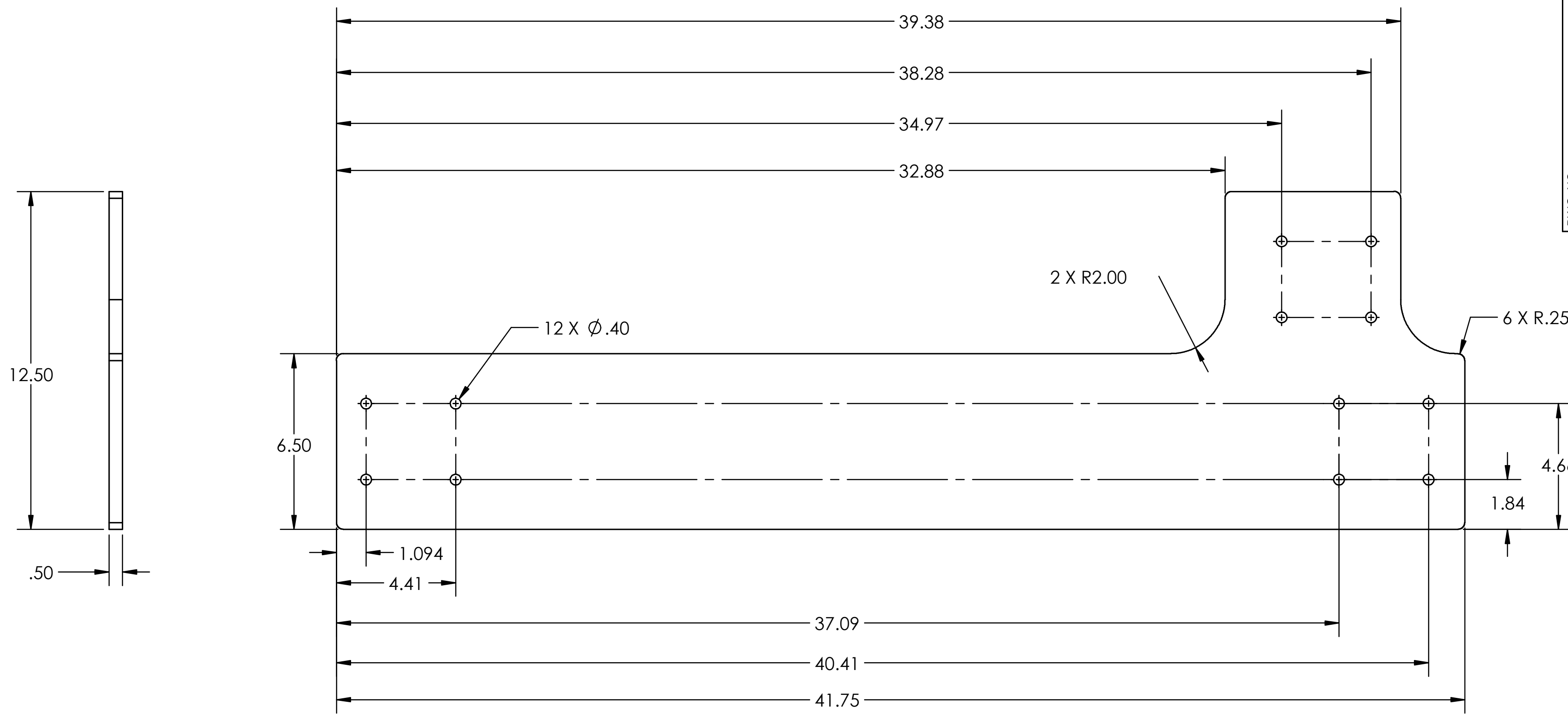
UNIVERSITY of MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MSS BRACE 2
TEAM 3

SIZE **B** | DWG. NO. **MSS BRACE 2** | REV 0

SCALE: 1:1 | WEIGHT: 2.13 LBS | SHEET 1 OF 1



REV 0

DWG. NO. MSS PLATE 2

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

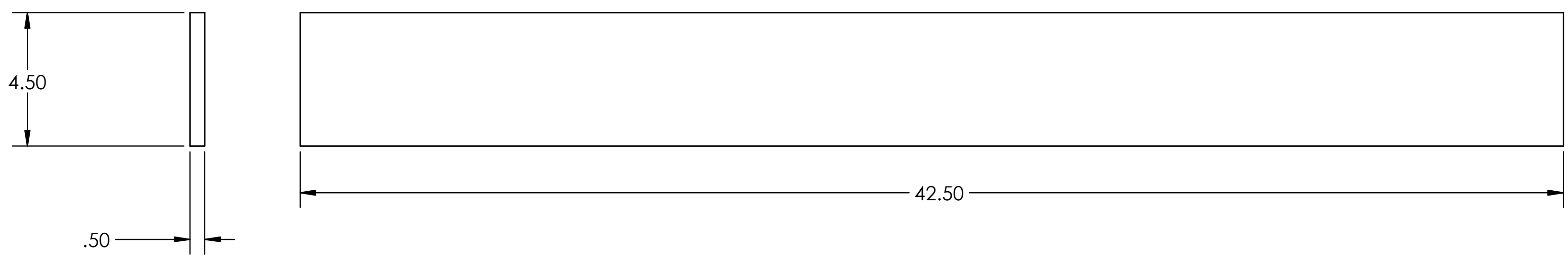
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MSS PLATE 2
TEAM 3

SIZE **B** | DWG. NO. **MSS PLATE 2** | REV 0

SCALE: 1:4 | WEIGHT: 43.75 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

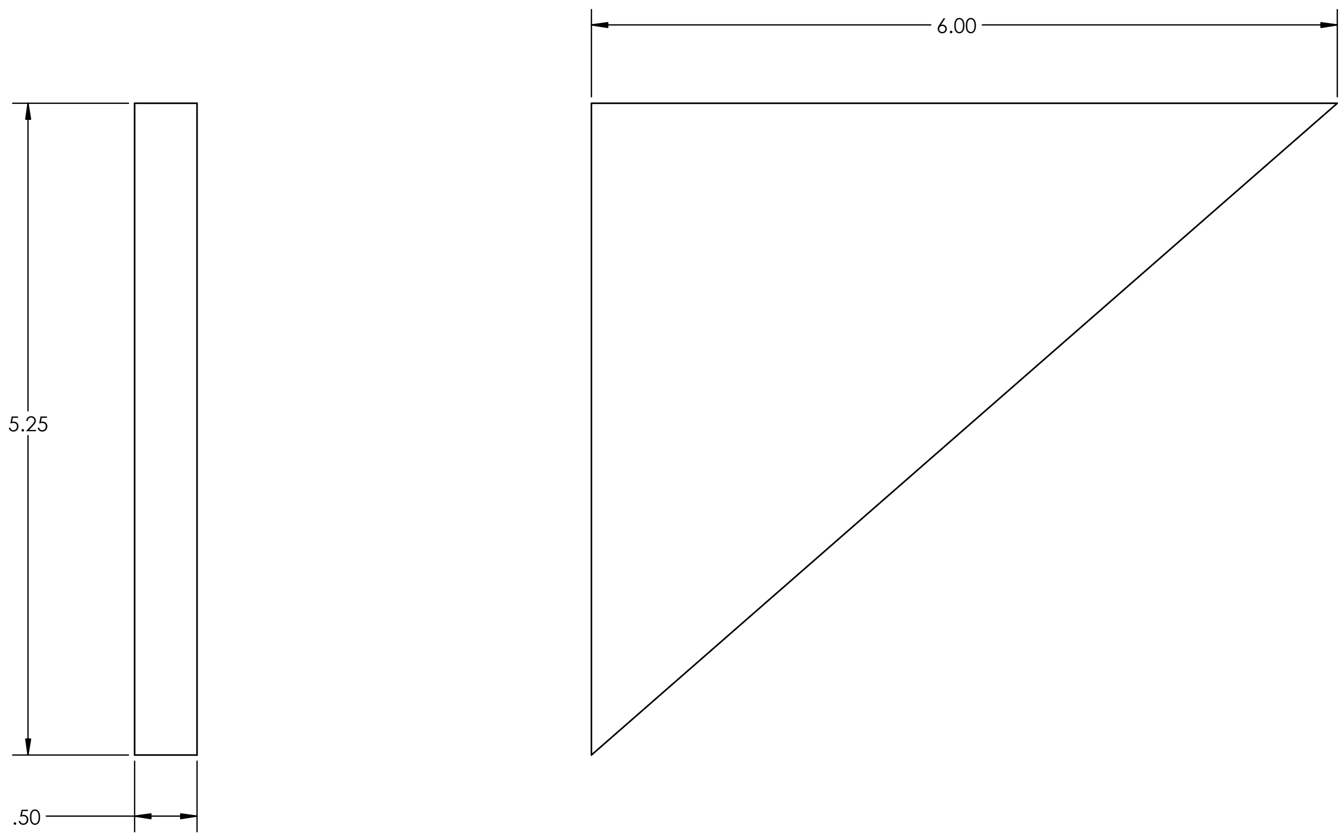
MECH 4860 ENGINEERING DESIGN

TITLE:
MSS PLATE 3
TEAM 3

SIZE **B** | DWG. NO. **MSS PLATE 3** | REV 0

SCALE: 1:4 | WEIGHT: 26.95 LBS | SHEET 1 OF 1

REV 0
DWG. NO. **MSS PLATE 3**



REV 0

DWG. NO. MSS PLATE 4

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±

X.X ±

X.XX ±0.06

X.XXX ±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

EDUCATIONAL AND PROPRIETARY

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MATERIAL

CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:

MSS PLATE 4

TEAM 3

SIZE **B**

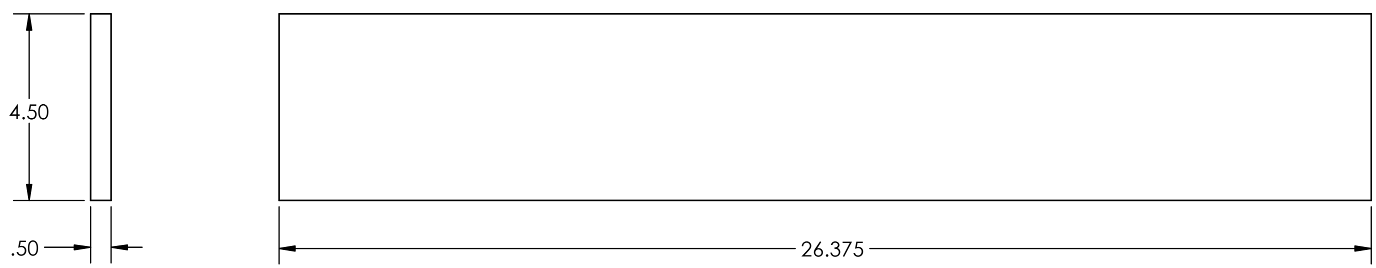
DWG. NO. **MSS PLATE 4**

REV 0

SCALE: 1:1

WEIGHT: 2.22 LBS

SHEET 1 OF 1



REV 0

DWG. NO. MSS PLATE 5

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

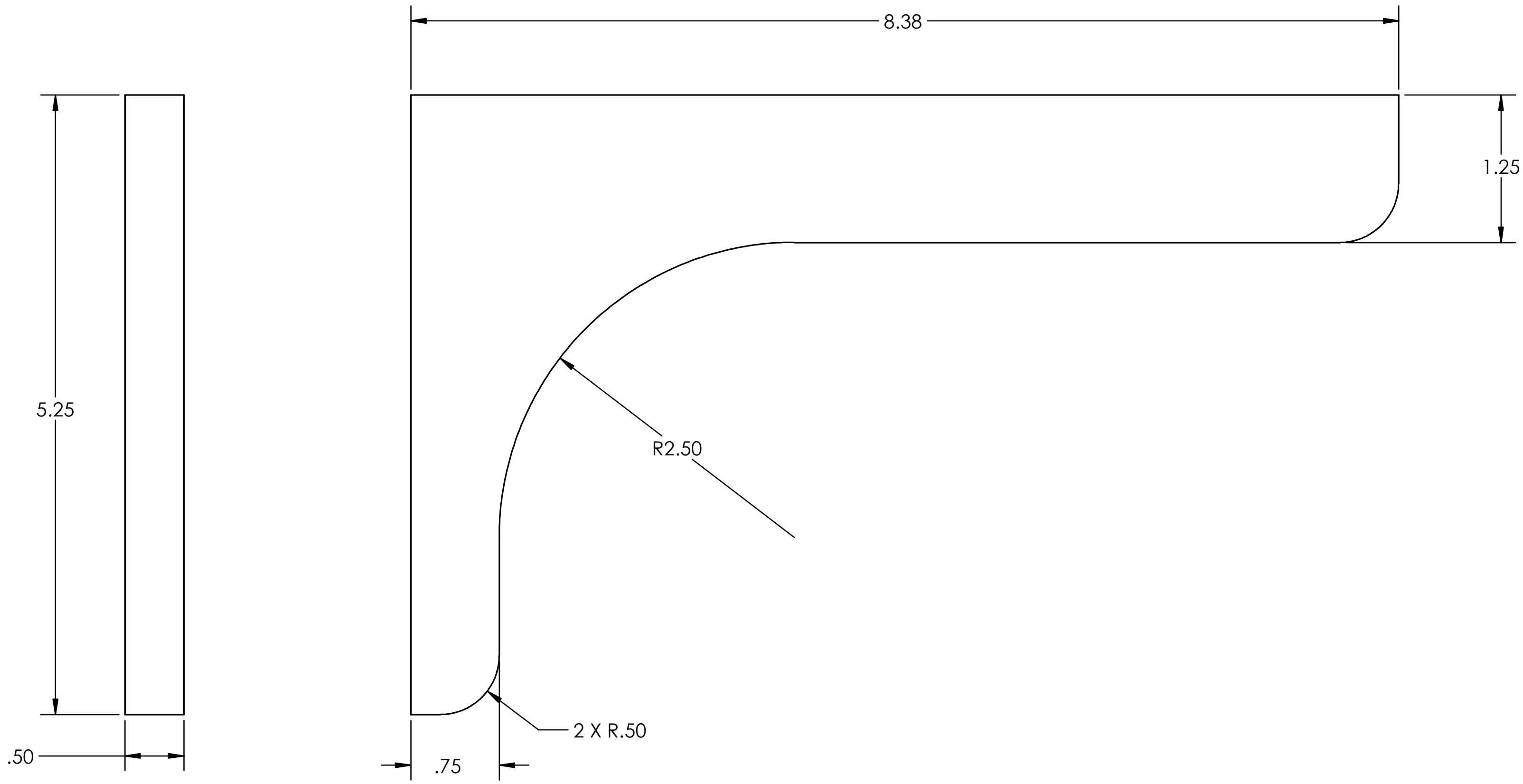
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MSS PLATE 5
TEAM 3

SIZE **B** | DWG. NO. **MSS PLATE 5** | REV 0

SCALE: 1:3 | WEIGHT: 16.72 LBS | SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY

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MATERIAL: CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE: **TRACK BASE**

TEAM 3

SIZE: **B**

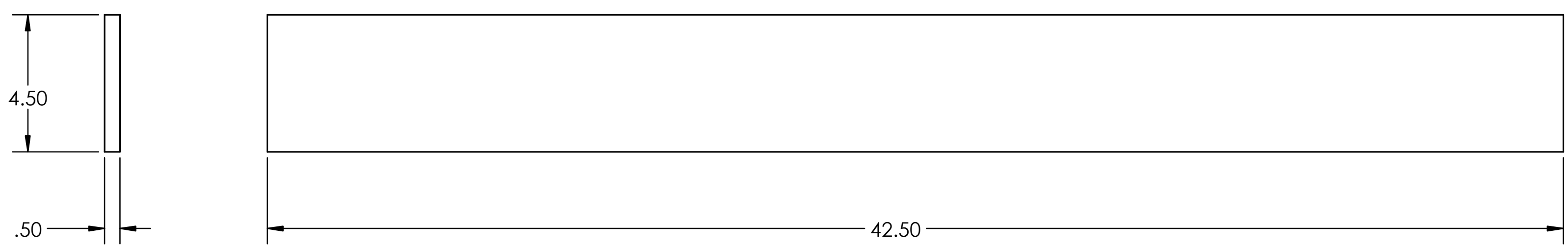
DWG. NO. **MSS PLATE 6**

REV 0

SCALE: 1:1 | WEIGHT: 15.46 LBS | SHEET 1 OF 1

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

REV 0 — DWG. NO. MSS PLATE 6



REV 0

DWG. NO. MSS PLATE 7

REV	DATE Y/M/D	DESCRIPTION		
			DWN NAME # / CKD NAME #	
			DWN NAME # / CKD NAME #	
			DWN NAME # / CKD NAME #	
			DWN NAME # / CKD NAME #	
0	18/11/28	DRAWING CREATED	DWN NAME # / CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MSS PLATE 7
TEAM 3

SIZE **B**

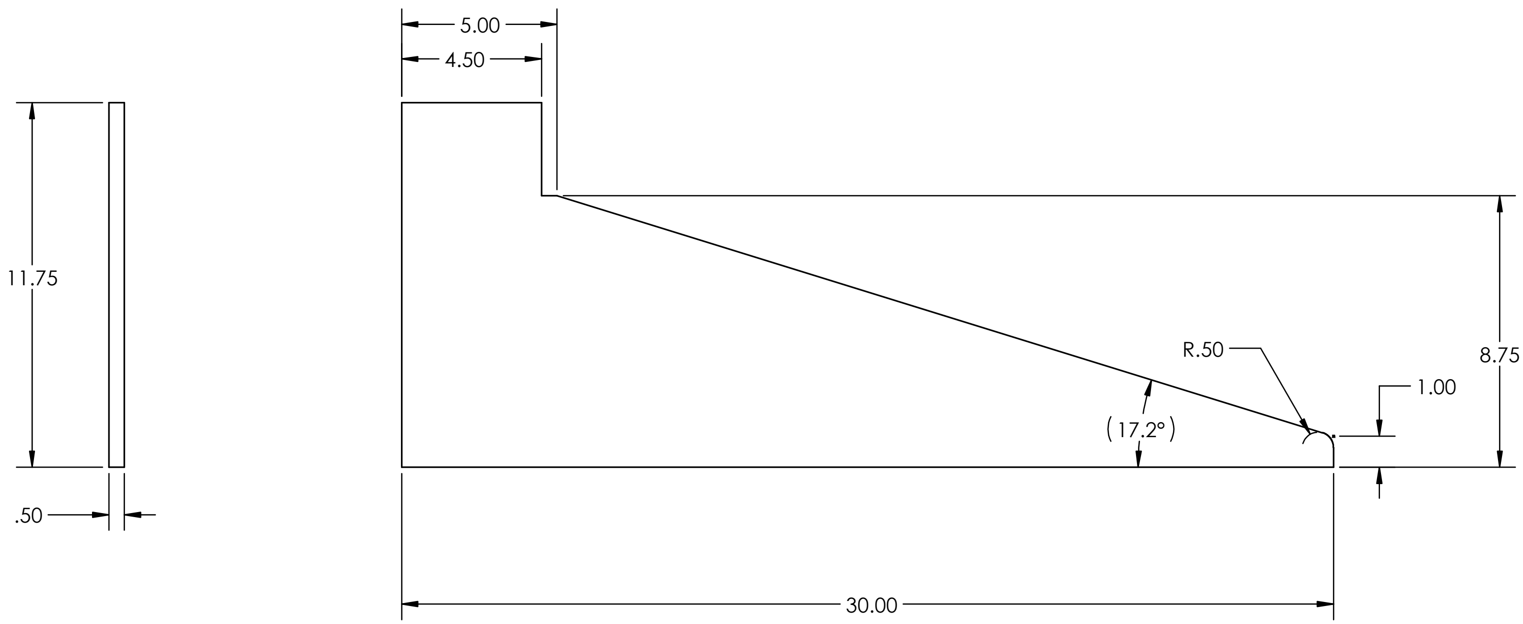
DWG. NO. **MSS PLATE 7**

REV 0

SCALE: 1:4

WEIGHT: 26.95 LBS

SHEET 1 OF 1



REV 0

DWG. NO. MSS PLATE 8

			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	
REV	DATE Y/M/D	DESCRIPTION		

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

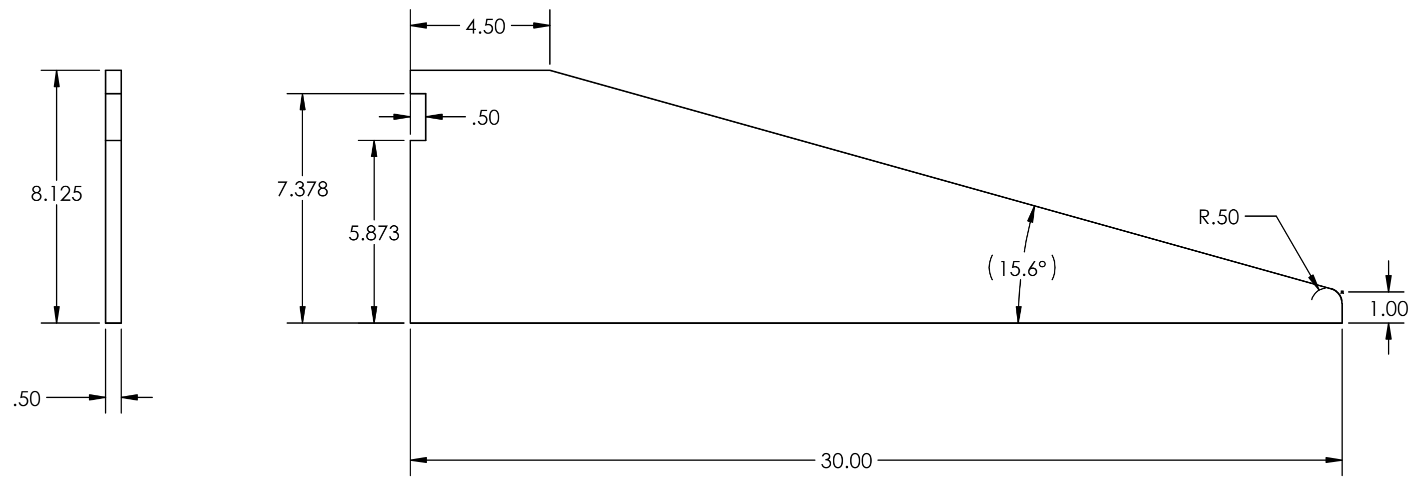
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
MSS PLATE 8
TEAM 3

SIZE **B** | DWG. NO. **MSS PLATE 8** | REV 0

SCALE: 1:4 | WEIGHT: 25.23 LBS | SHEET 1 OF 1



REV 0

DWG. NO. MSS PLATE 9

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE ±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL: CARBON STEEL

FINISH

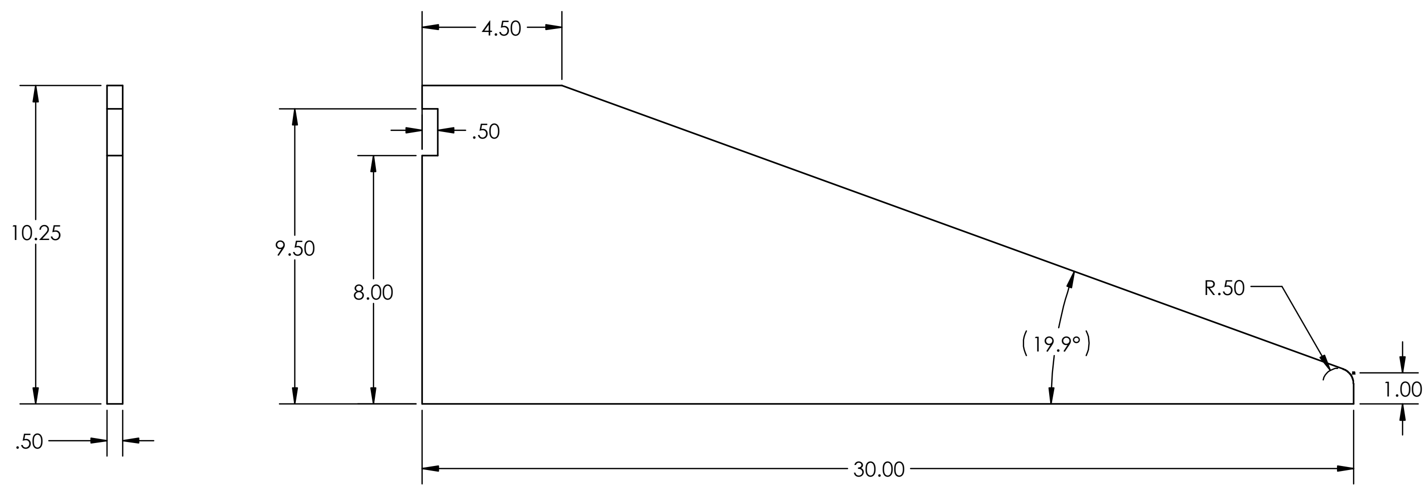
DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **MSS PLATE 9**
TEAM 3

SIZE: **B** | DWG. NO. **MSS PLATE 9** | REV 0

SCALE: 1:4 | WEIGHT: 21.43 LBS | SHEET 1 OF 1



REV 0

DWG. NO. MSS PLATE 10

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY

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MATERIAL: CARBON STEEL

FINISH: √

DO NOT SCALE DRAWING

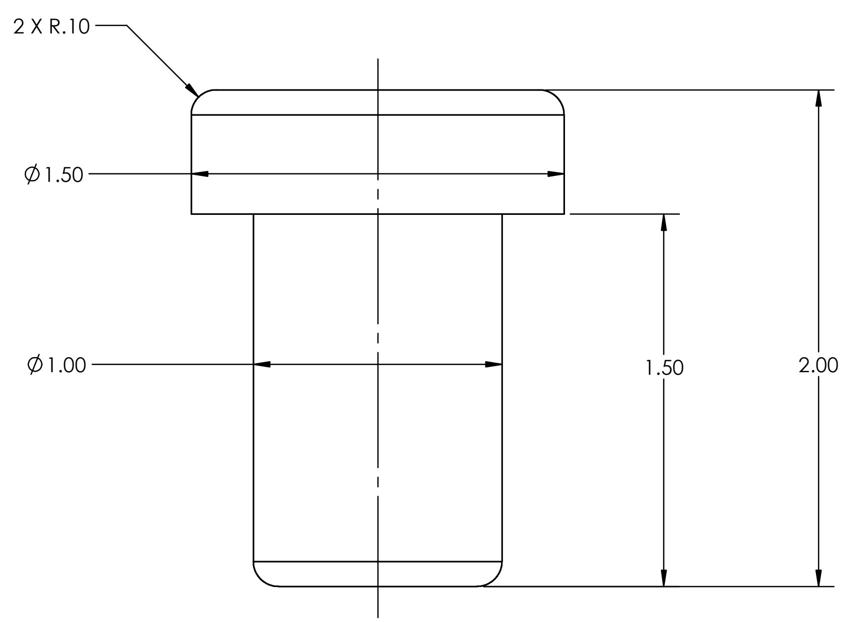
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK BASE
TEAM 3

SIZE: **B** | DWG. NO. **MSS PLATE 10** | REV 0

SCALE: 1:4 | WEIGHT: 15.46 LBS | SHEET 1 OF 1



DWG. NO. **MSS PIN**

REV 0

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH ✓

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

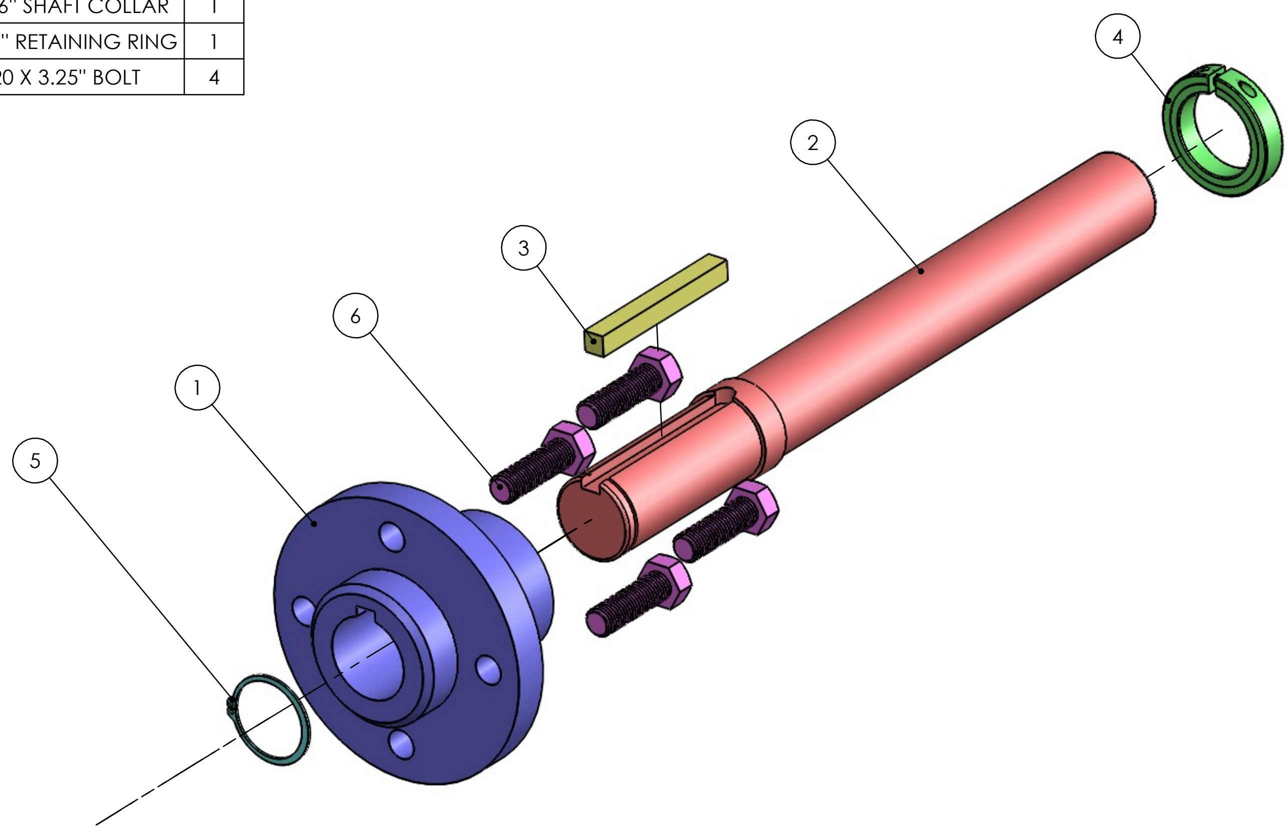
TITLE:
MSS PIN
TEAM 3

SIZE **B** | DWG. NO. **MSS PIN** | REV 0

SCALE: 2:1 | WEIGHT: 0.58 LBS | SHEET 1 OF 1

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Connection Bracket		1
2	Free Shaft		1
3	Free Shaft Key		1
4	6435K76	2-15/16" SHAFT COLLAR	1
5	97633A478	2-15/16" RETAINING RING	1
6	92620A959	1"-20 X 3.25" BOLT	4



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

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DIMENSIONAL UNIT: INCHES

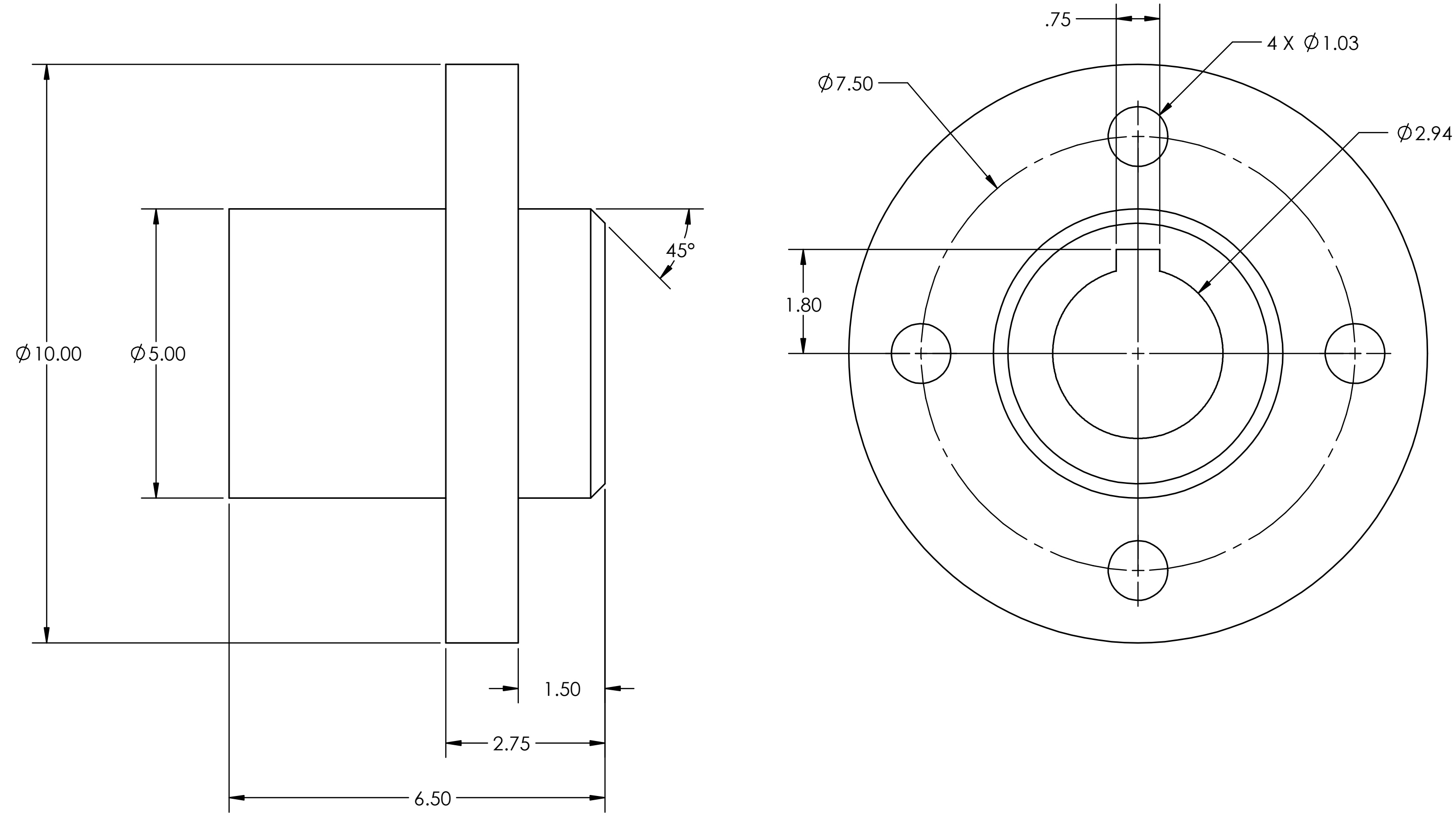
University of Manitoba — MECH 4860 ENGINEERING DESIGN

TITLE: **FREE SHAFT AND CONNECTIONS TEAM 3**

SIZE **B** | DWG. NO. **FREE SHAFT AND CONNECTIONS** | REV 0

DO NOT SCALE DRAWING | SCALE: 1:4 | WEIGHT: 97.28 LBS | SHEET 1 OF 1

DWG. NO. FREE SHAFT AND CONNECTIONS REV 0



REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL: CARBON STEEL

FINISH: ✓

DO NOT SCALE DRAWING

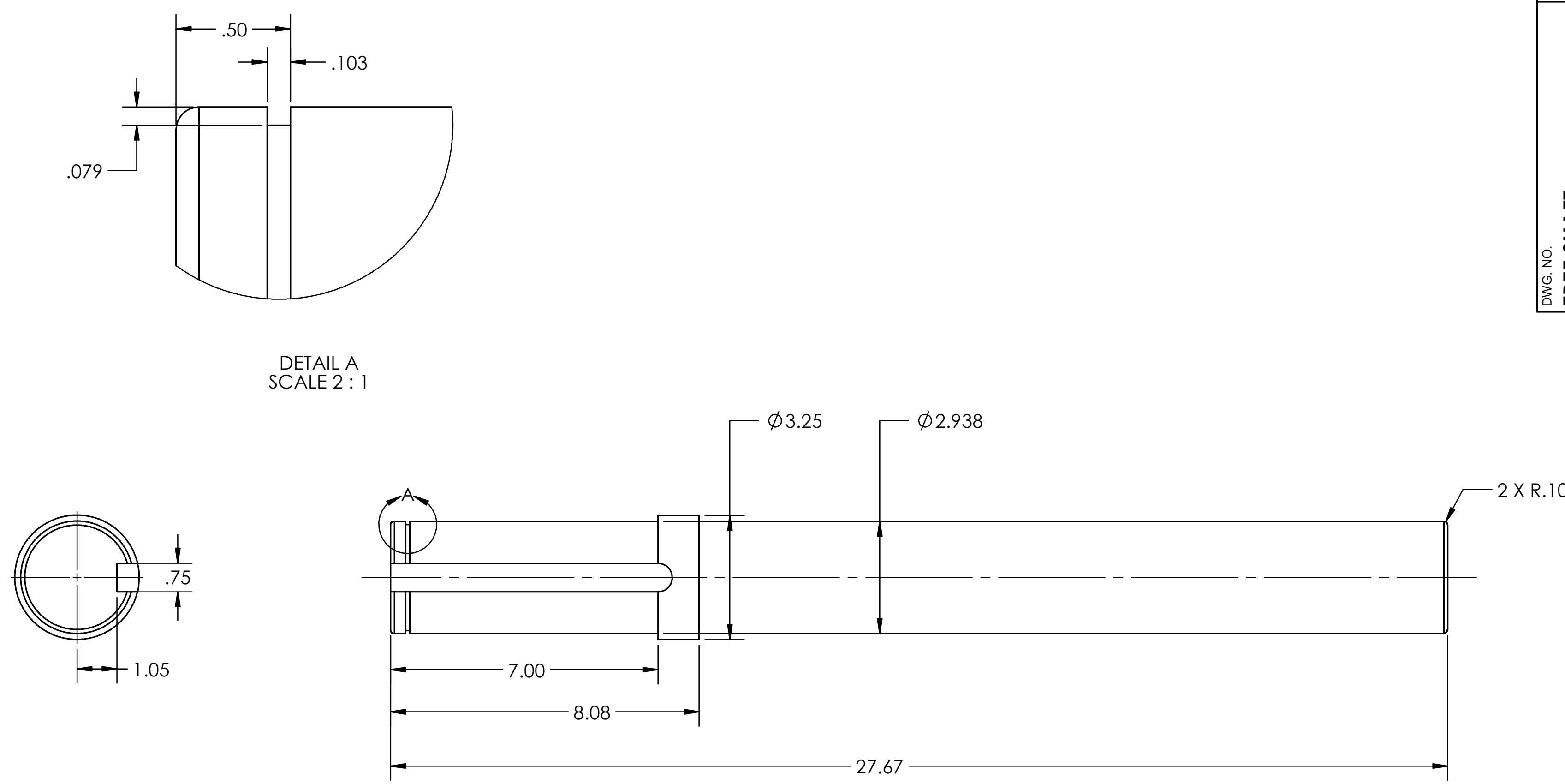
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **CONNECTION BRACKET**
TEAM 3

SIZE: **B** | DWG. NO. **CONNECTION BRACKET** | REV 0

SCALE: 1:2 | WEIGHT: 42.5 LBS | SHEET 1 OF 1

REV 0 — DWG. NO. **CONNECTION BRACKET**



REV 0

DWG. NO. FREE SHAFT

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
C1144 STEEL

FINISH
√

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK BASE
TEAM 3

SIZE **B**

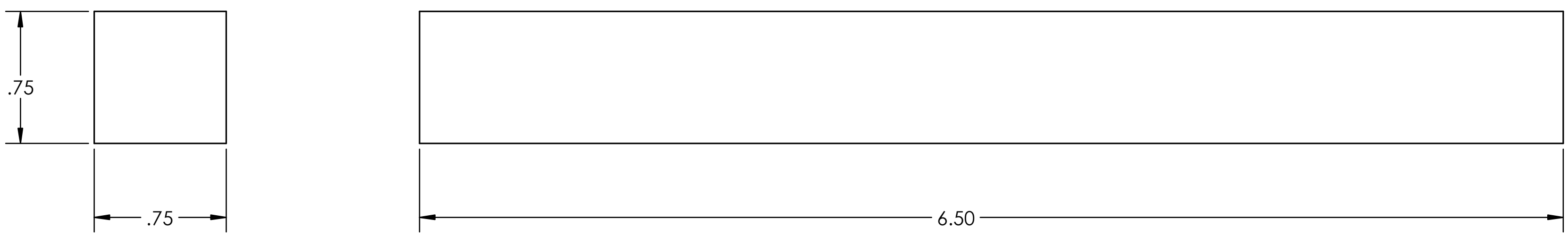
DWG. NO. **FREE SHAFT**

REV 0

SCALE: 1:3

WEIGHT: 15.46 LBS

SHEET 1 OF 1



REV 0

DWG. NO. FREE SHAFT KEY

REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

CHAMFERS

FILLETS

EDUCATIONAL AND PROPRIETARY
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MATERIAL
0.75"X0.75" KEY STOCK

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

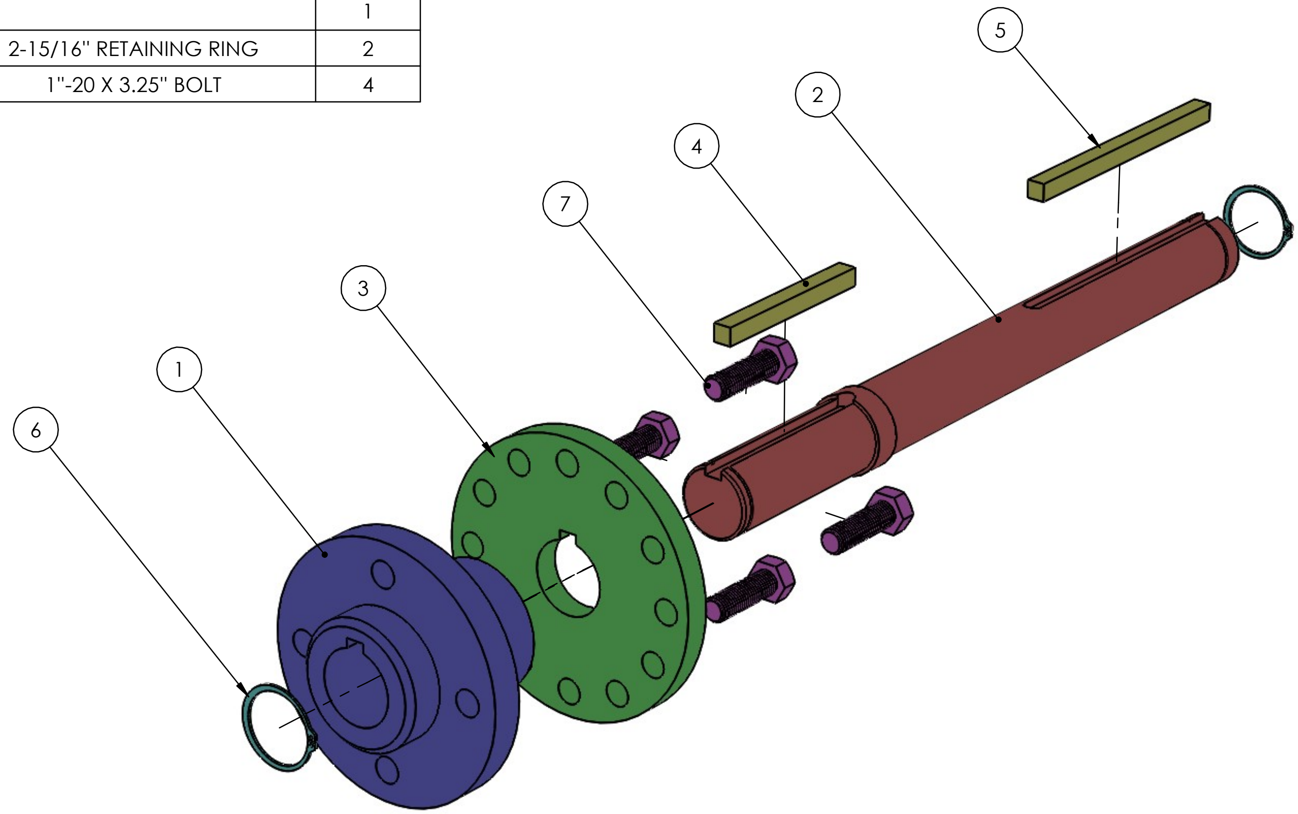
MECH 4860 ENGINEERING DESIGN

TITLE:
FREE SHAFT KEY
TEAM 3

SIZE **B** | DWG. NO. **FREE SHAFT KEY** | REV 0

SCALE: 1.5:1 | WEIGHT: 1.03 LBS | SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Connection Bracket		1
2	Drive Shaft		1
3	Drive Shaft Locking Plate		1
4	Drive Shaft Key		1
5	Gearbox Key		1
6	97633A478	2-15/16" RETAINING RING	2
7	92620A959	1"-20 X 3.25" BOLT	4



REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

DIMENSIONAL UNIT: INCHES

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
DRIVE SHAFT AND CONNECTIONS
TEAM 3

SIZE **B**

DWG. NO. **DRIVE SHAFT AND CONNECTIONS**

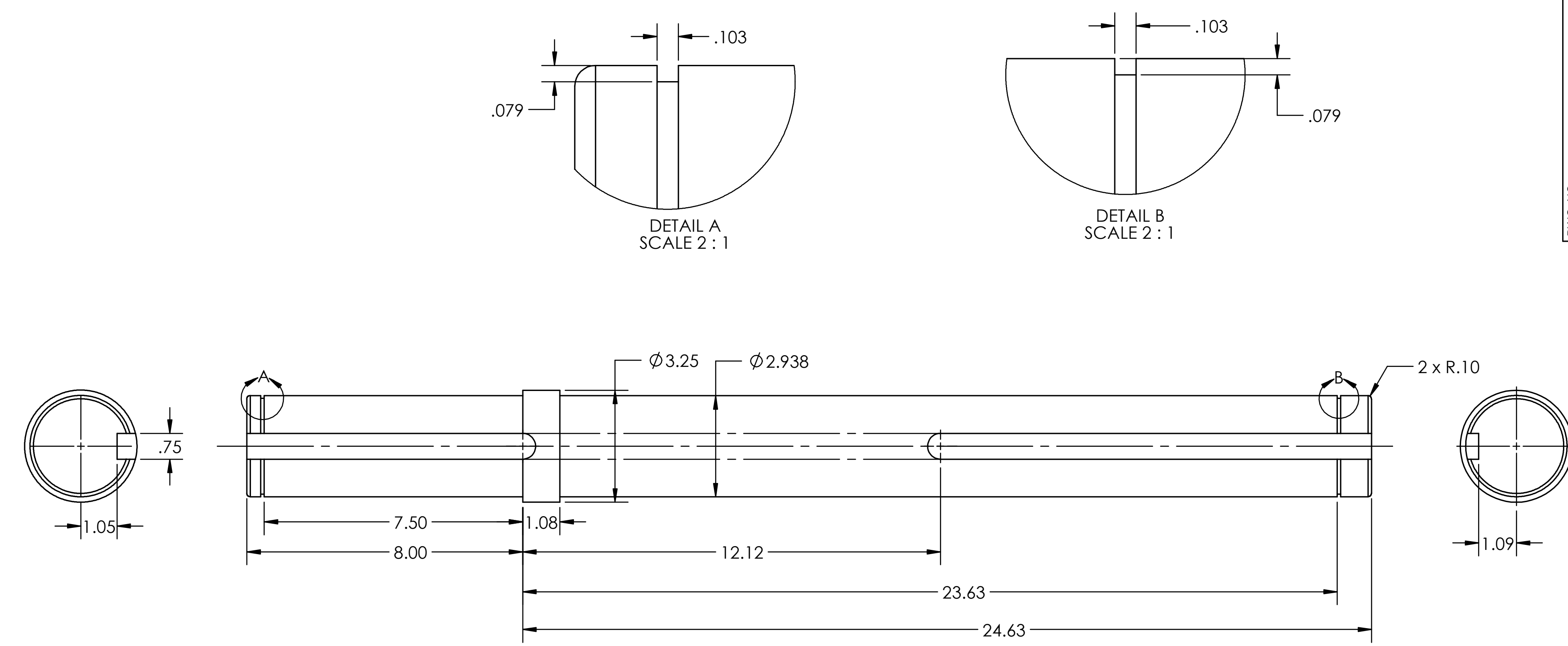
REV 0

SCALE: 1:4 | WEIGHT: 129.63 LBS | SHEET 1 OF 1

REV 0 DWG. NO. DRIVE SHAFT AND CONNECTIONS

REV 0

DWG. NO. DRIVE SHAFT



REV	DATE Y/M/D	DESCRIPTION		
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
			DWN NAME #	
			CKD NAME #	
0	18/11/28	DRAWING CREATED	DWN NAME #	
			CKD NAME #	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
C1144 STEEL

FINISH
√

DO NOT SCALE DRAWING

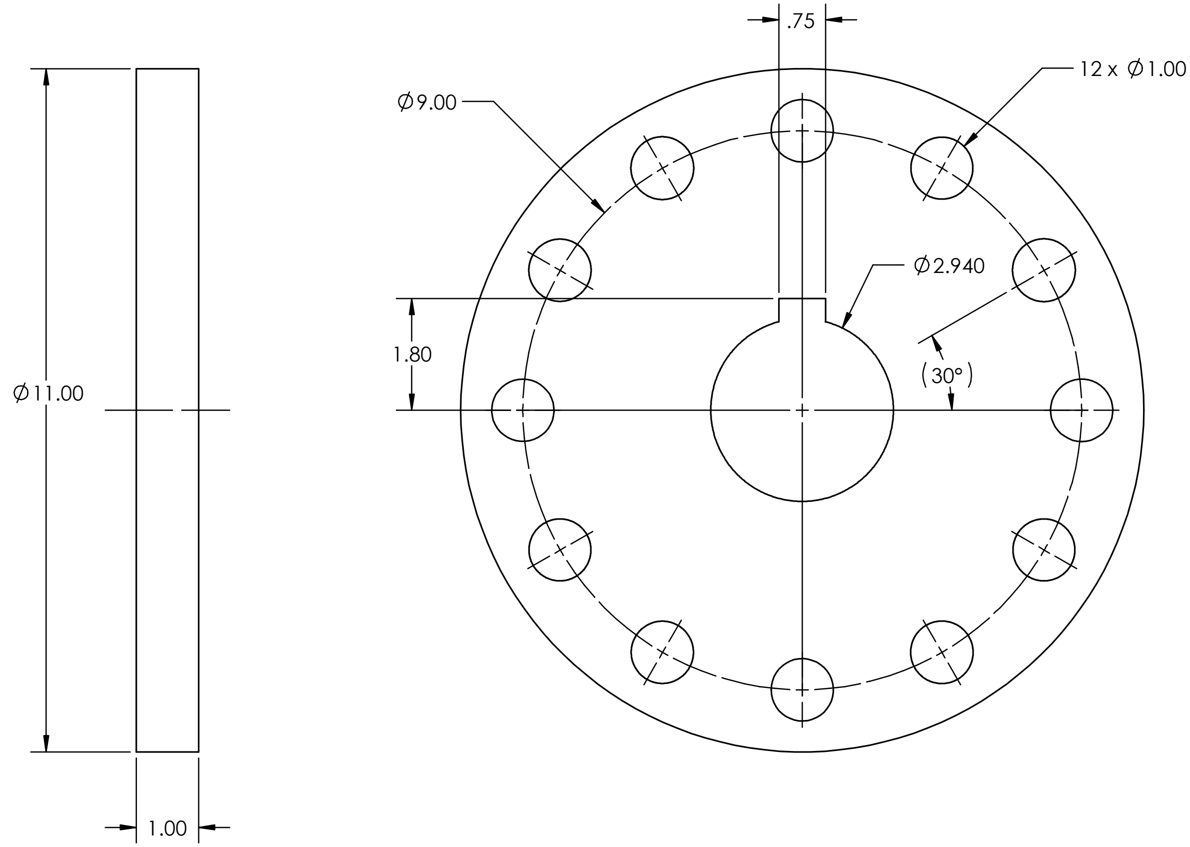
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
DRIVE SHAFT
TEAM 3

SIZE **B** | DWG. NO. **DRIVE SHAFT** | REV 0

SCALE: 1:3 | WEIGHT: 61.41 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL: CARBON STEEL

FINISH: ✓

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **DRIVE SHAFT LOCKING PLATE**
TEAM 3

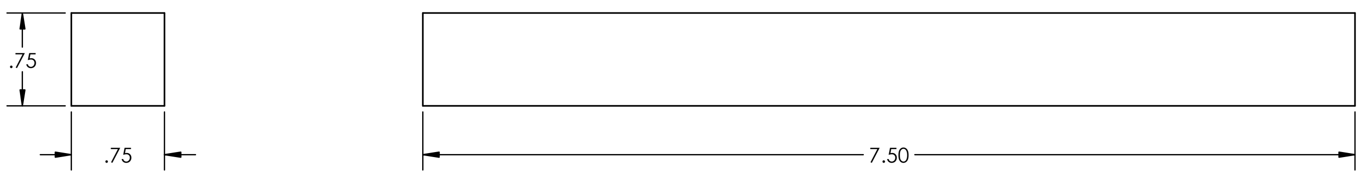
SIZE: **B** | DWG. NO. **DRIVE SHAFT LOCKING PLATE** | REV 0

SCALE: 1:2 | WEIGHT: 22.12 LBS | SHEET 1 OF 1

DWG. NO. DRIVE SHAFT LOCKING PLATE — REV 0

REV 0

DWG. NO. DRIVE SHAFT KEY



REV	DATE Y/M/D	DESCRIPTION		
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
			DWN / CKD	
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

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MATERIAL: 0.75" X 0.75" KEY STOCK

FINISH

DO NOT SCALE DRAWING

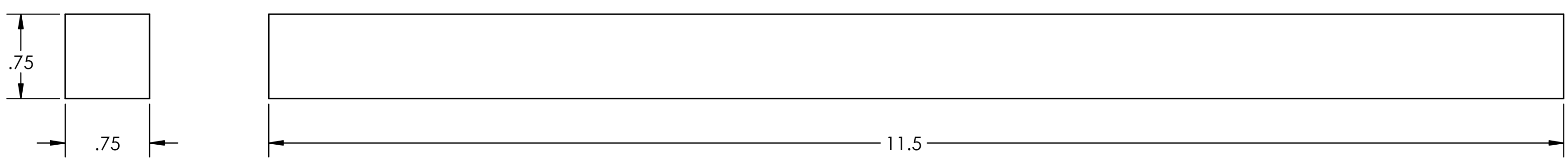
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **DRIVE SHAFT KEY**

TEAM 3

SIZE: **B** | DWG. NO. **DRIVE SHAFT KEY** | REV 0

SCALE: 1:1 | WEIGHT: 1.19 LBS | SHEET 1 OF 1



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
0.75" X 0.75" KEY STOCK

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

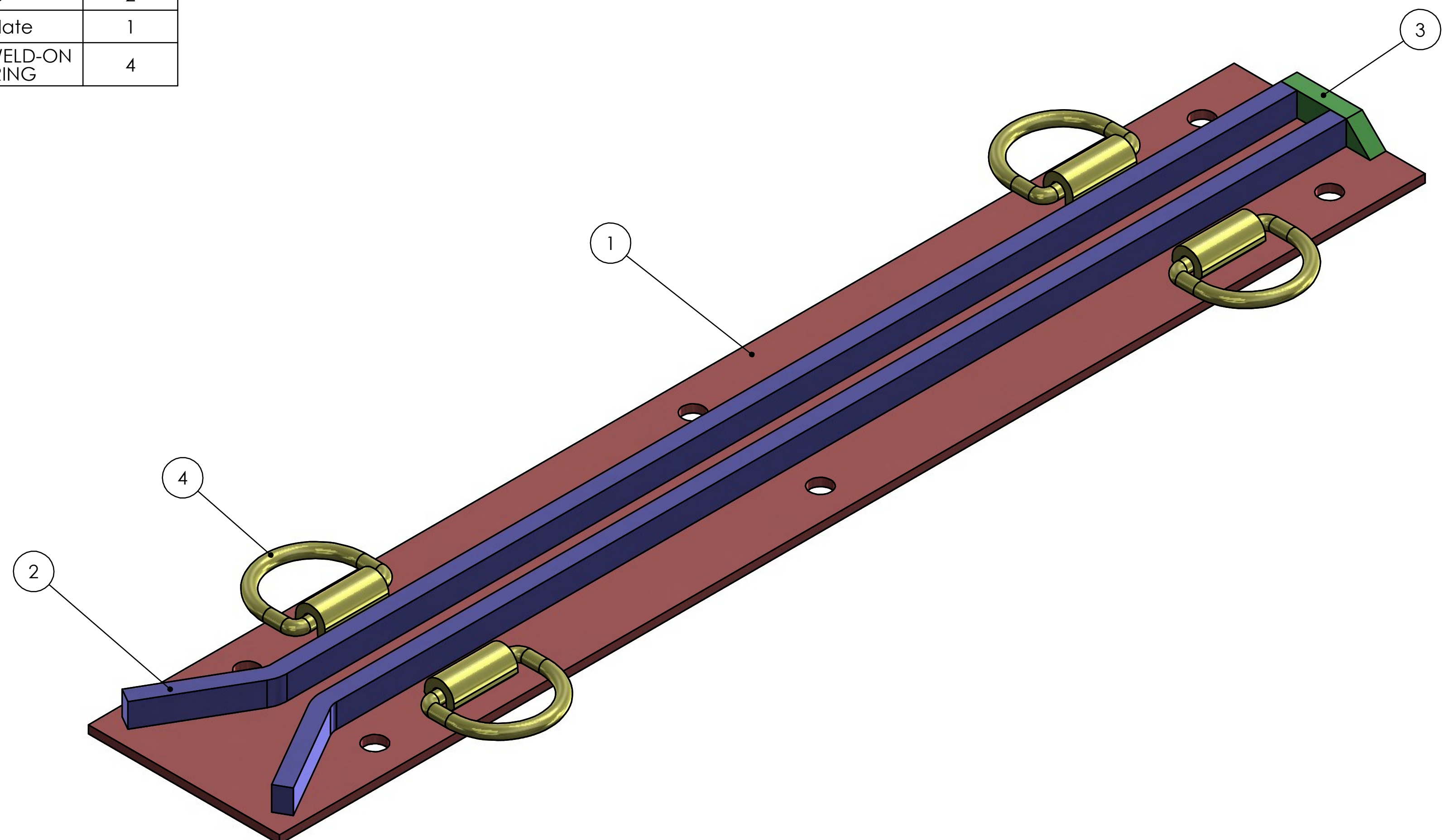
TITLE:
GEARBOX KEY
TEAM 3

SIZE **B** | DWG. NO. **GEARBOX KEY** | REV 0

SCALE: 1:1 | WEIGHT: 1.82 LBS | SHEET 1 OF 1

DWG. NO. **GEARBOX KEY** | REV 0

ITEM NO.	PART NUMBER	QTY.
1	Track Base	1
2	Track Guide	2
3	Track End Plate	1
4	3028T310_WELD-ON TIE-DOWN RING	4



REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

EDUCATIONAL AND PROPRIETARY MATERIALS
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DIMENSIONAL UNIT: INCHES

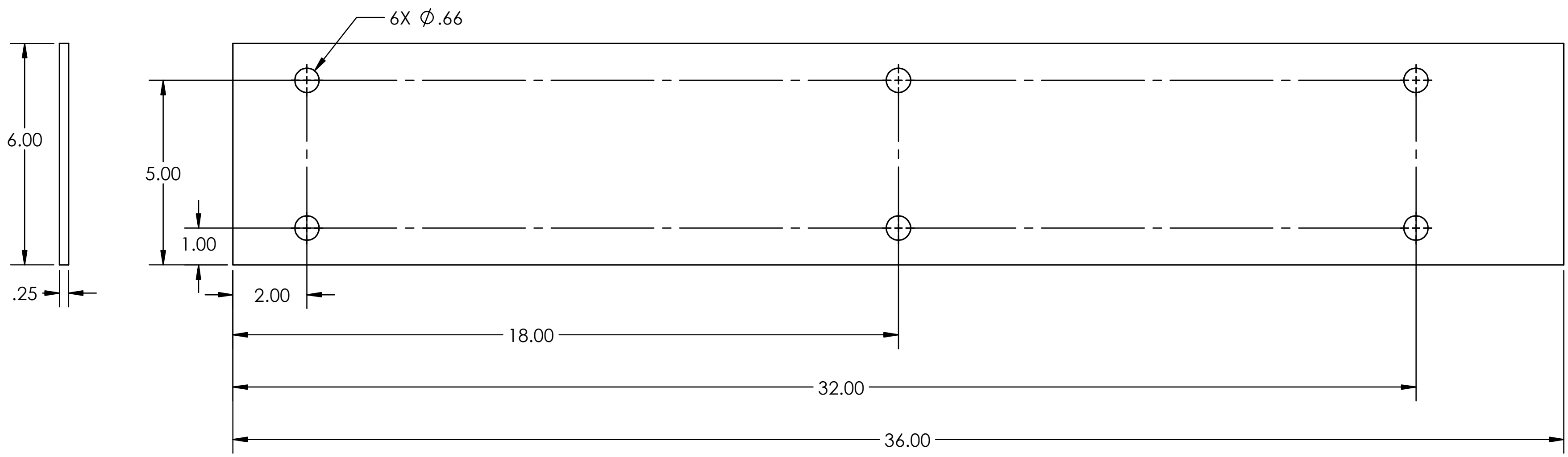
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK ASSEMBLY
TEAM 3

SIZE **B** | DWG. NO. **TRACK ASSEMBLY** | REV 0

DO NOT SCALE DRAWING | SCALE: 1:2.5 | WEIGHT: | SHEET 1 OF 1

REV 0 — TRACK ASSEMBLY — DWG. NO.



REV 0

DWG. NO. TRACK BASE

REV	DATE Y/M/D	DESCRIPTION		
0	18/11/28	DRAWING CREATED	DWN / CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X ±
X.X ±
X.XX ±0.06
X.XXX ±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY
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MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

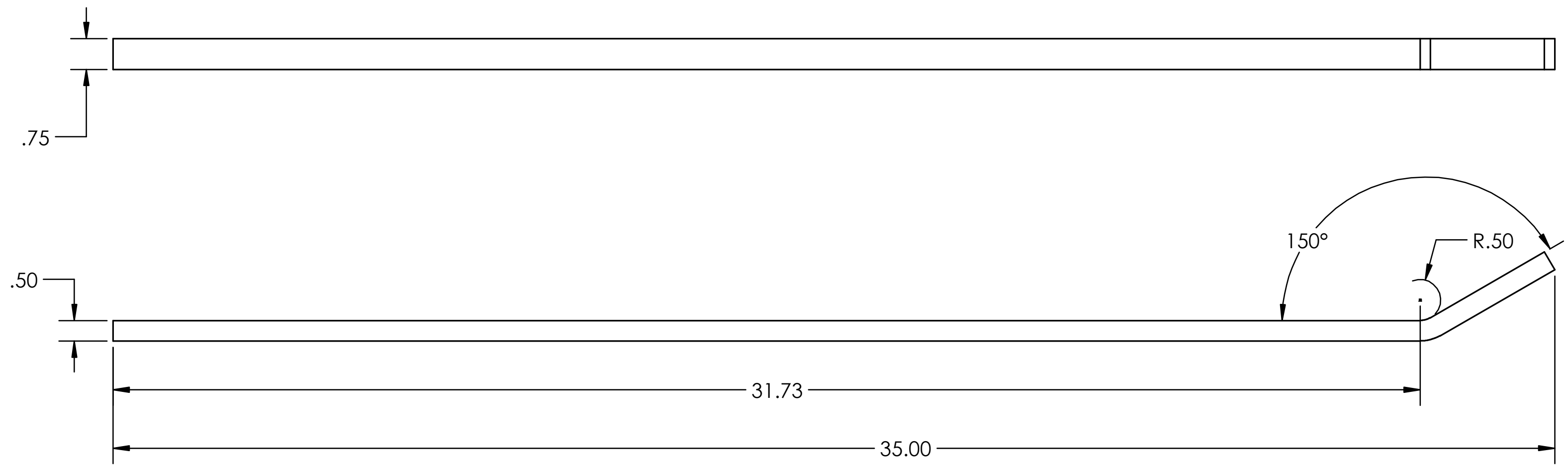
UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK BASE
TEAM 3

SIZE **B** | DWG. NO. **TRACK BASE** | REV 0

SCALE: 1:3 | WEIGHT: 15.46 LBS | SHEET 1 OF 1



REV 0

DWG. NO. TRACK GUIDE

REV	DATE Y/M/D	DESCRIPTION		
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

EDUCATIONAL AND PROPRIETARY

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MATERIAL: CARBON STEEL

FINISH

DO NOT SCALE DRAWING

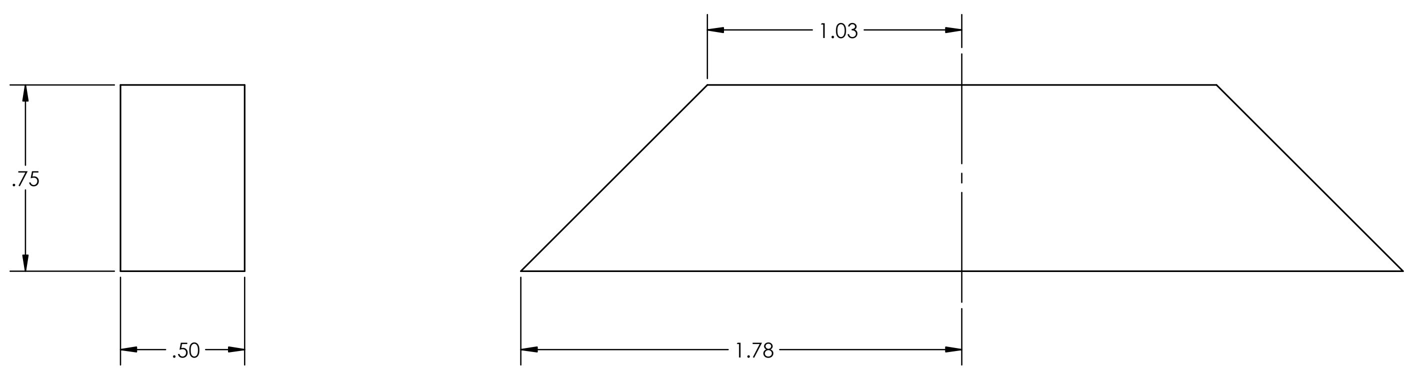
UNIVERSITY OF MANITOBA — MECH 4860 ENGINEERING DESIGN

TITLE: **TRACK GUIDE**

TEAM 3

SIZE: **B** | DWG. NO. **TRACK GUIDE** | REV 0

SCALE: 1:3 | WEIGHT: 3.83 LBS | SHEET 1 OF 1



			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
			DWN	
			CKD	
0	18/11/28	DRAWING CREATED	DWN	
			CKD	
REV	DATE Y/M/D	DESCRIPTION		

UNLESS OTHERWISE SPECIFIED

LINEAR TOLERANCES

X	±
X.X	±
X.XX	±0.06
X.XXX	±0.03

ANGULAR TOLERANCE

±1°

CHAMFERS

FILLETS

DIMENSIONAL UNIT: INCHES

N/A = NOT APPLICABLE

MATERIAL
CARBON STEEL

FINISH

DO NOT SCALE DRAWING

UNIVERSITY OF MANITOBA

MECH 4860 ENGINEERING DESIGN

TITLE:
TRACK END PLATE
TEAM 3

SIZE **B** | DWG. NO. **TRACK END PLATE** | REV 0

SCALE: 2:1 | WEIGHT: 0.30 LBS | SHEET 1 OF 1

REV 0
DWG. NO. TRACK END PLATE