EME 185

# “Final Report”


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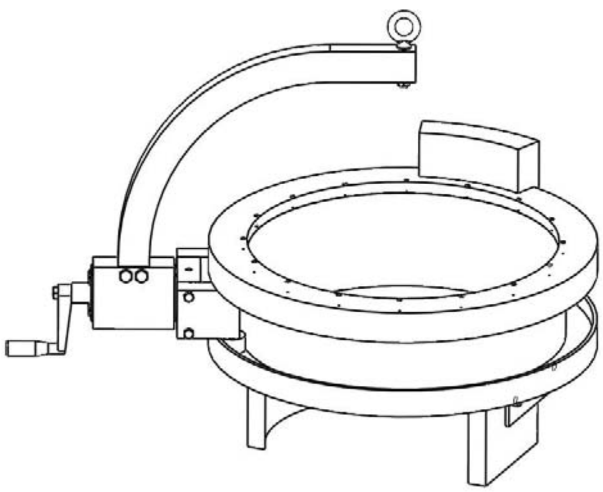

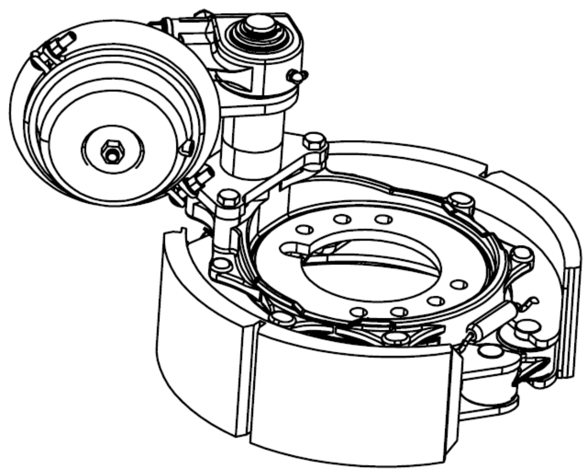

# Drum Brake Manipulator

## Executive Summary

In today's economic climate, lean manufacturing has become increasingly important for automotive manufacturers. This group sought to eliminate wasted time created in waiting, transporting, and physically moving and lifting a heavy duty truck brake drum assembly using a winch mounted crane hook. Our optimized design which clamps, lifts, tilts, and rotates the brake drum assembly, will increase safety, ergonomics, and productivity of the manufacturing operation while reducing cost and delivery time.

The design utilizes a combination of off the shelf parts and hardware as well as machined subcomponents that facilitate trouble-free assembly and maintenance. By splitting our project into four subsystems; clamping, lifting, tilting and rotation, we were able to evaluate each one independent of that other and determine that the rotating subsystem was the most critical subsystem. This subsystem is responsible for properly aligning the brake drum to the axle by facilitating 360 degrees of rotation about the center of the axle. Once this subsystem was determined, the other three were chosen to integrate accordingly.

The clamping system uses contoured pads that extend beneath the rotating assembly to grasp the brake drum assembly about the brake shoes. This allows the manipulator to clamp and securely lift the drum brake assembly while also permitting it to rotate about the center axis and have a range of motion of 360 degrees.

Tilting the assembly was achieved through the use of a shaft and two bearings that facilitate radial rotation with the use of a crank. This subsystem is mounted below a frame that connects to the rotational and clamping subsystems by the tilting subsystem shaft. In addition, an eyebolt is mounted to the upper portion of the frame to receive a connection from an electric wire hoist, which comprises our lifting system. The lifting system travels on a Knightbridge 7500 series overhead rail system via a low profile load trolley. CAD modeling was crucial to visualizing the integration of the four subsystems and identifying critical areas of stress.

Once the subsystems were fully designed through several iterative processes of stress calculations, material choices, and manufacturing processes, we were able to select the final configuration of the design. This yielded a device with an infinite life of $10^6$ cycles while maintaining a safety factor greater than 2. By use of off the shelf parts, material costs have been kept to very reasonable price of $2341.51. Each subsystem selection process and calculation will be discussed in detail throughout the report.

In summary, our design sought to eliminate wasted time created in waiting, transporting, and physically moving and lifting the brake drum assembly as well as improving ergonomics by doing away with an unsafe winch mounted crane hook. We have accomplished this by employing an optimized system, that utilizes a combination of clamping, lifting, tilting, and rotating subsystems, to ensure increased safety, ergonomics, and productivity of the manufacturing operation while reducing cost and delivery time.

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# I. Definition of Task:

A mechanical manipulator arm, utilizing electric or pneumatic power, will be designed for a pick and place operation. The manipulator will pick up the drum brake from the gravity roller conveyor, then orientate, align, and place it onto the axle for a worker to fasten in place. The manipulator is to be operated by a single operator with a total time of assembly of approximately one and a half minutes. Ultimately, the aim of this manipulator arm is to improve the ergonomics of the process as well as to increase productivity and safety in the assembly of the brake drums to the axles.

# II. Subsystems:

## 1. Lifting

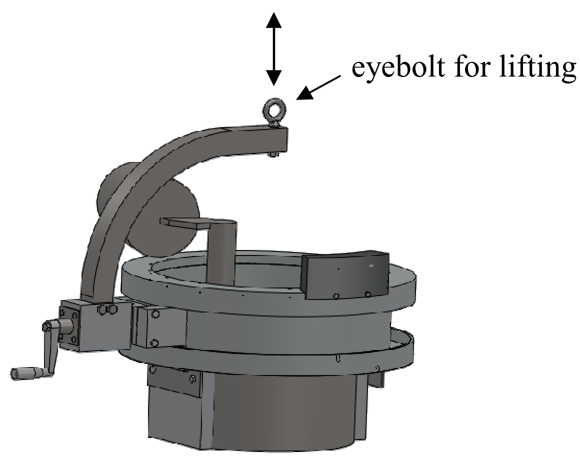
The primary purpose of the lifting subsystem is to lift the brake drum manipulator from the height of the gravity roller conveyor to the height of the center of the axle on the main axle assembly line. This subsystem must also meet two other requirements: to reliably hold the manipulator while being transported from the gravity roller conveyer to the axle and to support the brake drum for fastening to the axle. In addition, the customer has also specified that this lifting subsystem integrate with the existing 7500 Knightbridge overhead rail system and be rigid enough to prevent excessive swaying while moving.

Among the final parameters for the lifting device was its range of motion, lifting capacity, and cost. The lifting device must have a range of motion of at least 20 inches because the gravity roller conveyor sits 24 inches off the ground and the center of the axle assembly sits 44 inches off the ground. We chose an electric hoist with a maximum carrying capacity of 500 pounds because the brake drum weighs 110 pounds and the manipulator frame about 90 pounds. This leaves the hoist with a factor of safety of 2 with respect to its carrying capacity. This factor of safety can be taken into account for a worst case scenario where an average sized worker hangs off of the manipulator with the brake drum assembly fully clamped. Finally, the total cost of the lifting device had to be reasonable, so the model specified is on the lower end of hoists on the market. In general though, it was found that the more expensive hoists were due to having a higher lifting capacity.

The lifting device specified is a Coffing electric wire hoist, model EMW-500B (see appendix A). This hoist was chosen as it meet the desired specifications, integrated well with both the overhead rail system and manipulator frame, and was cost efficient. The Coffing electric hoist is rated to lift 500 lbs as specified by the customer and has a range of motion of up to 10 ft, which is more than enough to cover the 20 inches required. The hoist is rated to lift at 16 fpm, which equates to roughly 7 seconds to raise the brake drum assembly from the gravity roller conveyor to the center of the axle. This is slow enough to prevent possible injury during lifting, yet fast enough to keep the assembly line moving efficiently.

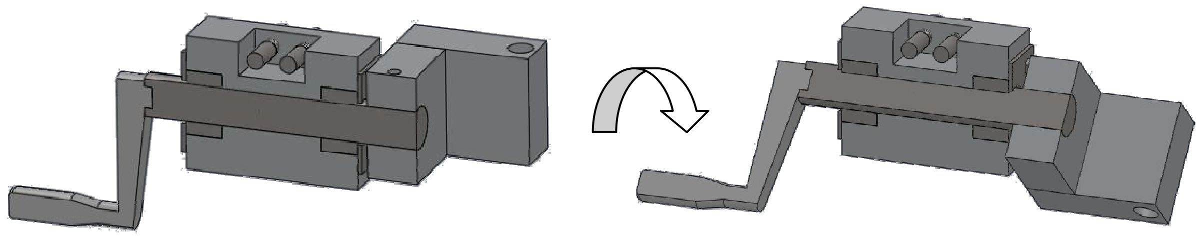
The Coffing hoist's hook mounts allow for easy integration with the Knightbridge overhead rail system and brake drum manipulator. For securing to the overhead rail system, we specified a Knightbridge load trolley, model MRTA7787 (see appendix A), as this particular model has an eye hook for connection between the overhead rail system and Coffing hoist upper hook mount. For integration with the brake drum manipulator, we selected an eye bolt large enough to interface with the lower Coffing hoist hook mount and a body long enough to install in the brake drum manipulator frame as this allows for an easy off-the-shelf solution. Finally, the Coffing hoist, at $748 dollars, is one of the cheapest electric hoists on the market as similarly specified units are priced two to three times as much.


There are two issues with the Coffing electric wire hoist however. The first is that the Coffing hoist is not rigid. To counteract and possible movements, the center of gravity of the manipulator is directly below the wires, therefore, greatly reducing any tendency of manipulator to sway while moving down the overhead rail system. Second, a transformer must be purchased because the power supply available onsite is 240V 3 phase and the Coffing hoist runs on 115V single phase.

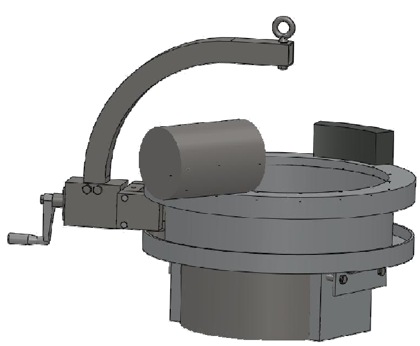


## 2. Tilting

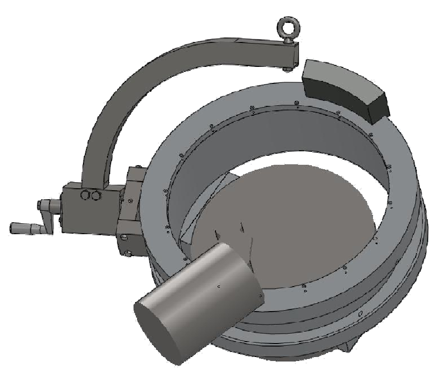
The brake drums are delivered to the assembly plant on pallets and positioned upright onto the gravity roller conveyor where air rollers are installed. For the brake drum to be properly bolted to the axle, the brake drum needs to be tilted 90 degrees and oriented such that the air cylinder will be inboard of the axle. The tilting subsystem should be designed to effectively integrate with the two subsystems it follows: rotating and clamping. With this in mind, a cassette was designed to house two bearings and an axle connecting the tilting handle to the clamping and rotating system. Here is a cross-section of how the handle turns the track.



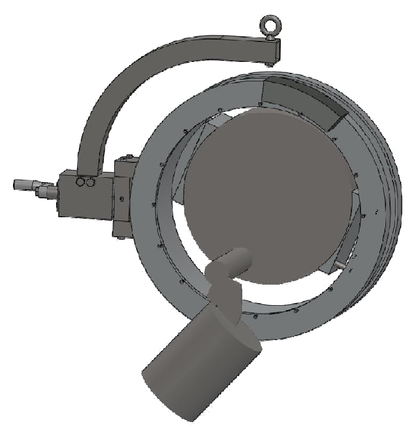
The following three images track show how the manipulator as a whole tilts.



-Not tilted-



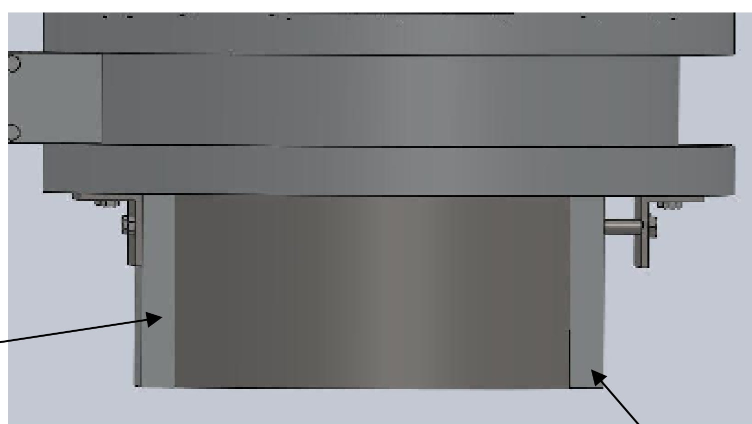
-Half tilted-



-Fully titled-

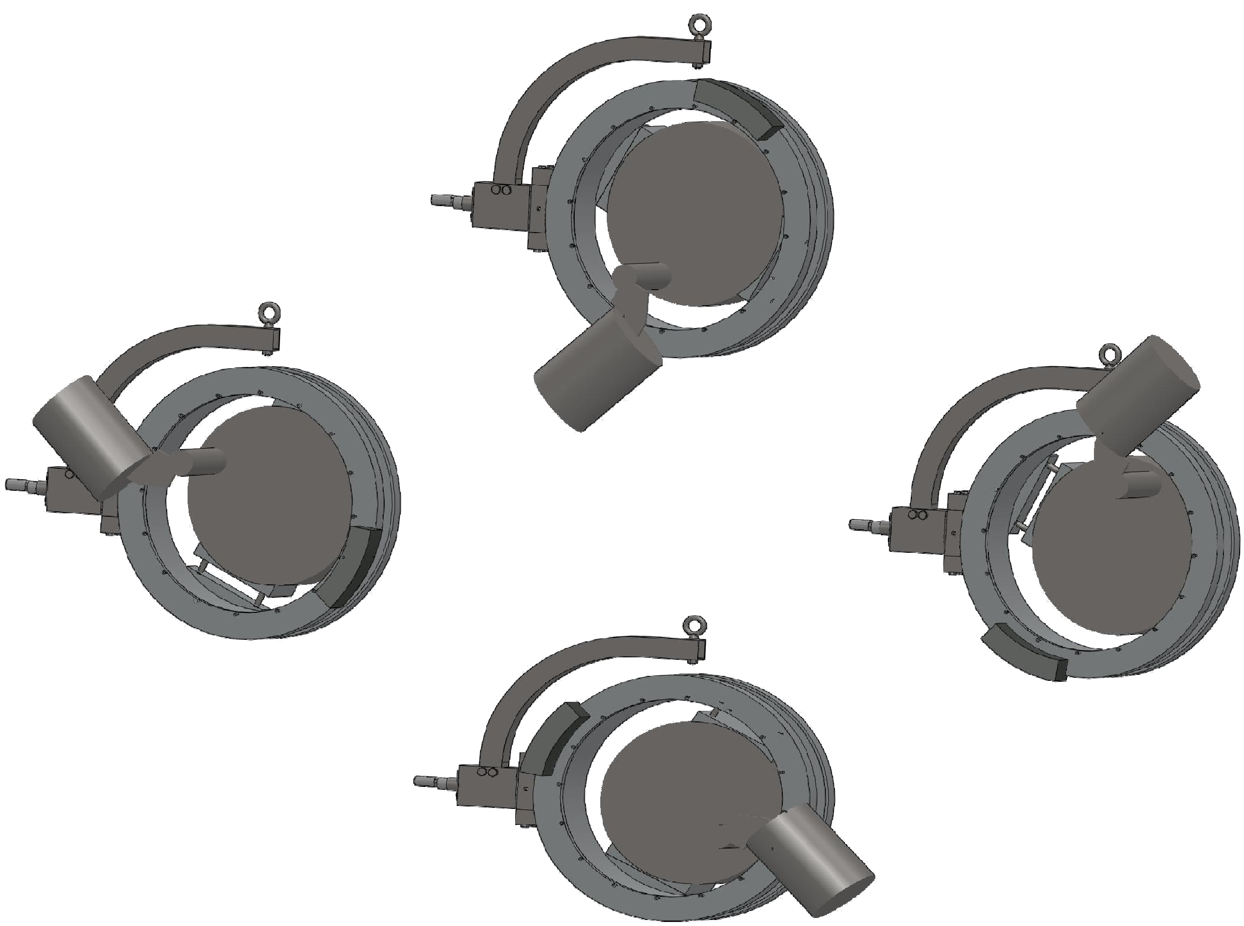
## 3. Clamping

The clamping subsystem was the one system which initially featured the most flexibility and options of the four subsystems. The primary goal of this subsystem is to secularly clamp or grasp the brake drum, preferably, in a manner which is quick, easy, reversible, and repeatable. Because the clamping system was dependent upon the rotating system, the group's options quickly narrowed to one clear design choice. The clamping system will clamp the brake drum on the outside of the two braking pads with two custom manufactured pads made out of Aluminum Alloy 6061, T6, fitting the outside curvature of the brake shoes. This will ensure that the manipulator will rotate the brake drum about its central axis, the limiting design constraint for the whole manipulator. These pads will torque the brake drum down to a calculated pressure ensuring that the manipulator pads will not let the brake assembly slip through. This process is simple and reversible through the use of a torque wrench set to a determined torque number, thereby guaranteeing that the brake drum will not have too much or too little torque applied. Two bolts will be used to secure the non-adjusting pad, allowing for more stability and reducing the stress on each bolt and mounting hole. One bolt will be used for the adjustable pad, reducing the amount of time and effort needed to tighten the brake drum. The thickness of the adjustable pad may need to be adjusted if the bolt goes through the middle of the pad because the middle of the pad currently has the thinnest cross-sectional thickness. The goal of the adjustable pad is that it must be allowed to move inward and outward to clamp and release the brake drum. This one bolt must be allowed to rotate independently of the pad so that the clamping pad does not spin while moving laterally. This design goal was met by force fitting a small bearing into the adjustable pad, which will then have a machined end of the bolt force fitted into the bearing. The bolts are threaded through tapped holes on the L-Bracket, ensuring the adjustable pad can move laterally and apply the proper pressure against the brake shoes.



### 4. Rotating

The manipulator must be able to rotate about its central axis in order to align the mounting holes on the brake assembly to the axle. The preferred amount of rotation for the assembly is 360 degrees, allowing the unhindered alignment of the assembly. These two goals were the primary constraint to the whole brake drum manipulator. All the other subsystems had to incorporate rotation about the brake drum's central axis and allow for 360 degrees of rotation. In order to meet these goals, the group designed a track with two sets of track rollers, which would also double as the housing for the clamping subsystem. The track is comprised of two sections, a top and a bottom, both being a smooth ring with flanges. The flanges on the ring ensure that the rollers remain in the track and support the load of two rollers in the vertical position. The track rollers are stock parts, as well as all the nuts and bolts and screws securing the top and bottom tracks. The top and bottom tracks however will need to be custom manufactured using a CNC mill out of Aluminum Alloy 6061, T6. Critical load bearing members for the rotating subsystem are the shaft of the roller and the flange on the bottom track. The calculations for these components can be found in the calculations section.



## III. Calculations / Analysis

### Clamping System:

The analysis of the clamping system begins with calculating the amount of lateral force needed to firmly clamp the brake assembly with the manipulator pads. The amount of force needed to clamp the brake assembly is 275 pounds. This number is dependent upon the coefficient of friction between the outside of the brake shoes and the inside of the clamping pad. The group did research the possibility of increasing the coefficient of friction between the two surfaces by applying a spray-on material to the inside of the clamping pad. This option is one possible optimization choice that can be considered. This force will then be applied through one bolt pushing against the adjustable pad on the outside of the brake shoes. The required minimum theoretical torque on the bolt was calculated to be about 30 lbf in. One should physically test this number to find out if it is actually a realistic torque for clamping and holding the brake drum. Intuitively, this number seems pretty low, but the calculations confirm this result.

The next step was to test whether the L-brackets, which support the clamping bolts, are held securely to the bottom of the track. As long as the individual screws can hold 242.5 psi, the L-brackets (carrying the clamping pads and brake drum) will be firmly fastened to the bottom of the track.

### Lifting System:

There are three areas which are critical in the lifting system. Two of them are on the ends of the frame column, and the third is the actual frame itself. At the top of the frame, the eye bolt needs to support 500 pounds, worst case scenario. We specified a half inch diameter eye bolt to satisfy this need. On bottom of the frame column, the two bolts need to be strong enough against bending and shearing. Finally, optimizing the frame with respect to geometry and dimensions should be done to ensure that not too much or too little material is being used. Our initial choice was using a square hollow tube, but really, it could be in any cross-sectional shape and either solid or hollow. So depending on the manufacturing of the frame, circular or square or even triangular tubing could be selected. For our calculations with the hollow square tubing, the stress in the frame is only 26.8 ksi. With this calculated stress level, one could use either Aluminum or steel, but the factor of safety with steel would be easily greater than 2, meaning that further optimization should be considered.

### Tilting System:

There are a of couple calculations critical to the tilting system. The primary component is the axle which runs through the cassette, joining the handle and the clamping and rotating systems. The primary stress is bending. Our bending stress with an axle diameter of 1.25 inch is about 40 ksi. The axle is made out of steel, so the factor of safety with this specification is 1.3. Once this axle diameter is specified, the inside diameter of the two bearings can be specified. After looking at the radial static load limits on bearings (49,350 lbs), the load on our bearings did not even come close to the radial load limit. The radial load on the two bearings was 2500 pounds on the inner most bearing and 2000 pounds on the outer bearing.

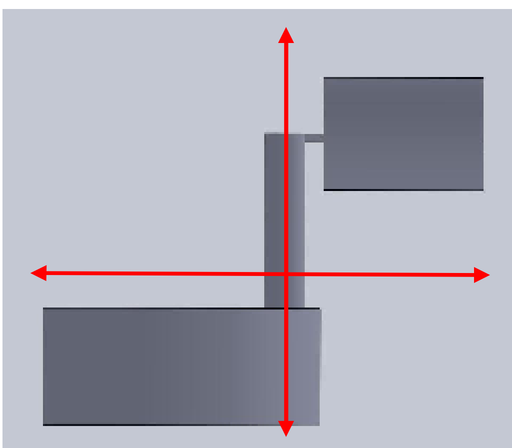
**Rotating System:**

Calculations pertinent to the rotating system are the shaft of the roller and the lip calculations when the manipulator is tilted. With a track roller shaft diameter of ¾ of an inch, these rollers have a factory of safety of almost 2. The lip calculations show that the lip is more than strong enough to hold the brake drum. Finally, the hoop stress of the track was also considered and was found out to be more than acceptable. There will be no chance of the top or bottom track deforming.

## IV. CG Diagrams (Mass Distribution)

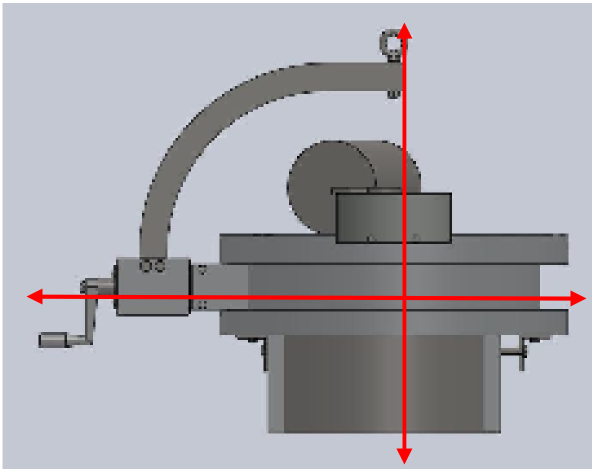
One of features of the manipulator is that the CG is consistently found in the same location when going through the installation motions. As the following pictures show below, the design of the brake drum and manipulator attempts to align the vertical CG as close to the lifting eyebolt and the horizontal CG with the axis which the brake drum is tilted upon. The end result is a feeling of near weightlessness when working with the brake drum, dramatically improving the ergonomics. These CG lines have a tolerance of a half inch.

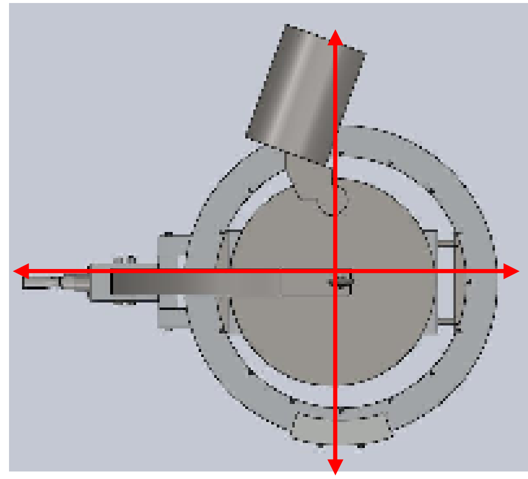
The CG of the brake drum in CAD



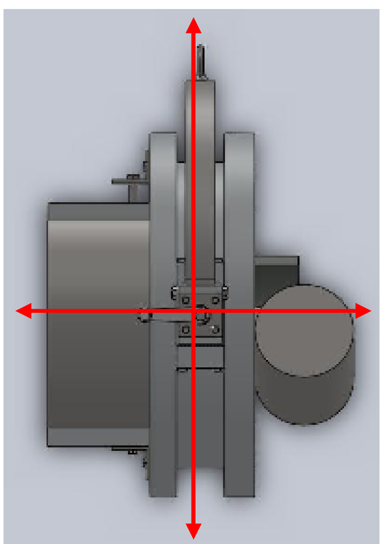
Included in the Appendix are pictures showing the experimental procedures of finding the CG of the brake drum.

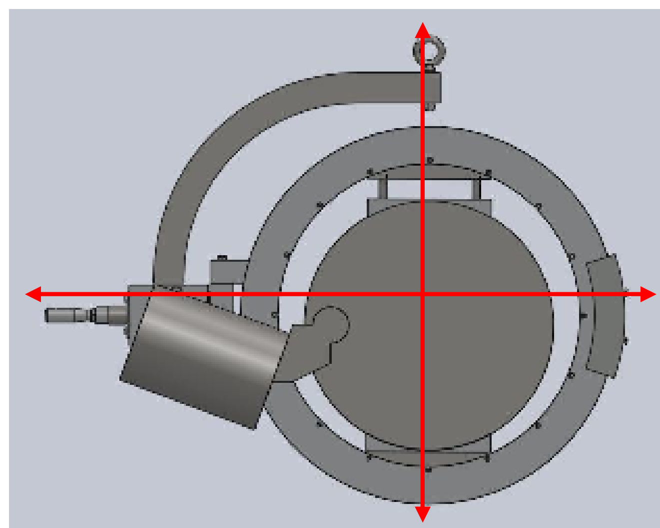
Here is the CG of the manipulator with the Brake Drum not tilted, i.e., as it is orientated on the gravity roller conveyor.





Here is the CG of the manipulator with the Brake Drum tilted.





## V. Production and General Maintenance

Maintainability:

Maintenance of the brake drum manipulator is almost zero, as it has been designed for infinite life. The components that may need future servicing and maintenance are the electric hoist, bearings, and track rollers. A Coffing service technician will handle all repairs on the electric hoist, as this unit requires specialized maintenance and service. For the bearings and track rollers, lubrication is probably not required for the life of the part as they are run on a very low number of cycles. However, if needed, the bearings have a removable plate that facilitates access for lubrication and the track rollers have lubricating holes.

Material Selection:

The materials we have selected for the brake drum manipulator are Al alloy 6061-T6 (wrought) which is typically used in transportation equipment and heavy duty structures and Carbon steel AISI 1020 (normalized) which is used in general mechanical engineering applications. Both of these materials are readily available from various suppliers and since they are widely used in the manufacturing world they help keep machining time to a minimum. Aluminum Alloy 6061-T6 will comprise a large number of our fabricated components while steel will comprise more of our high stress parts (see Appendix). Both materials offer excellent mechanical properties at relatively cheap cost.

Manufacturability:

From the beginning, the design of the brake drum manipulator has been drafted for easy manufacturability with many off the shelf parts. All of the components have been designed to mate with the use of hardware, instead of welds, for easy installation and removal by semi-skilled workers if repair or maintenance is required. All machined parts have been designed so that fabrication would only require a basic combination of machine tools consisting of a band saw, drill press, and end mill. The only exception is the track, which will require a CNC mill and CAM programming to machine correctly. However, since the track was split in two, the lower and upper piece, machining time is cut down and ease of fabrication and assembly are possible.

Design Shortcomings and Recommendations:

Pertinent issues remaining are manufacturing issues of the different parts. As mentioned before, the track requires advanced machining by a CNC mill and this process produces excessive scrap chips. In an optimized design, the track could possibly be split up into quad sections to save on material costs and ease of machining, but then the difficulty lies in combining the four sections smoothly. Additionally, the frame of the manipulator has been designed with square tubing. Although the square tubing permits easy installation of hardware with flat surfaces at the ends, the square tubing might become twisted around the center after passing through a mandrel bender. It is probably easier in this case to approach this problem from the other direction and consider the manufacturing aspect first. There are lots of everyday examples of pipes being bent with all different kinds of cross-sections. Cross-section's such as circular, hexagonal, rectangular, or square would all be fine as long as they can be manufactured without too many problems. Once a desired cross section is selected which can be manufactured from a specified process, stress calculations will need to be checked to ensure part can withstand the stresses and strains of the manipulator and drum brake.

## IV. Material Properties

As previously mentioned, the two materials chosen were aluminum and steel. This table below shows the pertinent mechanical properties and current cost of the two materials.

| Al alloy: 6061-T6 (wrought) | | | | |
|---|---|---|---|---|
| Density | 0.0965 | - | 0.0986 | lb/in^3 |
| Price | 0.868 | - | 1.4 | USD/lb |
| | | | | |
| **Mechanical properties** | | | | |
| Young's modulus | 9.86 | - | 10.7 | 10^6 psi |
| Shear modulus | 3.63 | - | 3.92 | 10^6 psi |
| Poisson's ratio | 0.325 | - | 0.335 | |
| Yield strength (elastic limit) | 28 | - | 42.1 | ksi |
| Tensile strength | 35 | - | 46.4 | ksi |

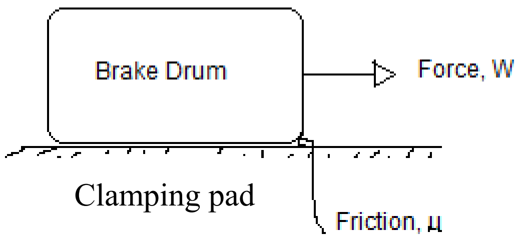
| Carbon steel: AISI 1020 (normalized) | | | | |
|---|---|---|---|---|
| Density | 0.282 | - | 0.285 | lb/in^3 |
| Price | 0.363 | - | 0.4 | USD/lb |
| | | | | |
| **Mechanical properties** | | | | |
| Young's modulus | 29.7 | - | 31.2 | 10^6 psi |
| Shear modulus | 11.5 | - | 12.2 | 10^6 psi |
| Poisson's ratio | 0.285 | - | 0.295 | |
| Yield strength (elastic limit) | 45 | - | 50.8 | ksi |
| Tensile strength | 57.3 | - | 71.1 | ksi |

# Cost Report

| Part | Description | Retailor | Number Needed | Cost | Further Machining Required | Futher Notes | Website |
|---|---|---|---|---|---|---|---|
| Load Trolley | Low profile load trolley with eye hook (MRTA4393) | Knight Industries | 1x | | No | | http://www.knight-ind.com/mrta7787.htm |
| Wire Winch | Electric powered 2 part wire winch (EMW-500B) | L.K. Goodwin Co. | 1x | $748/ea | No | | http://www.lkgoodwin.com/more_info/emc_and_emw_models/emc_and_emw_models.shtml |
| Eye Bolt | Steel Eyebolt with Shoulder for Lifting 1/2"-20 Thread, 2600# Wll, 2-1/2" Thread Length (3014T263) | McMaster-Carr | 1x | $11.09/ea | No | | http://www.mcmaster.com/#3014t263/=101fwe |
| Frame Column | Low-Carbon Steel Square Tube 2" X 2", .120" Wall Thickness, 6' Length (6527K33) | McMaster-Carr | 1x | $52.64/ea | Yes | Cut and bend to size | http://www.mcmaster.com/#6527k33/=tifnp |
| Frame Hardware | Grade 5 Zinc-Plated Steel Hex Head Cap Screw 1/2"-20 Thread, 3 1/2" Length (91247A362) | McMaster-Carr | 2x | $7.49/Pack of 10 | No | | http://www.mcmaster.com/#91247a362/=x2i6g |
| | Plain Grade 5 Steel Hex Nut 1/2"-20 Thread Size, 3/4" Width, 7/18" Heigth (95505A615) | McMaster-Carr | 2x | $10.96/Pack of 100 | No | | http:///www.mcmaster.com/#95505a615 |
| Bearing Cassette | Multipurpose Aluminum (Alloy 6061) 3" Thick X 6" Width X 6" Length (To be machined from Upper Track Aluminum block) | Corus Aluminum | 1x | | Yes | Machine to size from Upper Track Chassis Aluminum Block | http://www.corusgroup.com/en/products/ |
| Bearing Plate Hardware | Zinc-Plated Steel Cap Screw 1/4" - 28 Thread, 7/8" length, (92620A565) | McMaster-Carr | 8x | $7.84/Pack of 100 | No | | http://www.mcmaster.com/#92620a565/=x2ow7 |
| Bearing Plate | 4142 Steel Hardened Tight-Tolerance Flat Stock 1/8" Thick, 3" Width, 1-1/2' Length (8892K218) | McMaster-Carr | 2x | $38.16/ea | Yes | Machine to size | http://www.mcmaster.com/#8892k218/=x2vub |
| Bearings | Wide standard radial bearing, 440 Stainless Wall, 174 Stainless Heat Treated Race (RWCR-20-1) | Radial Bearing Corporation | 2x | $125.00/ea | No | | http://www.radialbearing.com/widess.html |
| Shaft | 4130 Alloy Steel Aircraft-Grade Rod 1-1/4" Diameter, 1' Length (6673T291) | McMaster-Carr | 1x | $25.04/ea | Yes | Cut to size | http://www.mcmaster.com/#6673t291/=tibxv |
| Shaft Handle | Aluminum Crank Handle 1/2" Unthreaded Through Hole, Fold-Away, 4.28" Hndl (6473K91) | McMaster-Carr | 1x | $54.75/ea | No | | http://www.mcmaster.com/#6473k91/=x31s8 |
| Shaft Set screw | Alloy Stl Self-Lock Cup Point Sckt Set Screw 3/8"-16 Thread, 3/4" Length (91385A622) | McMaster-Carr | 1x | $11.89/Pack of 25 | No | | http://www.mcmaster.com/#91385a622/=x3e2u |
| Fork Base | Multipurpose Oversize Aluminum (Alloy 6061) 1-1/2" Thick, 4-1/4" X 3-1/4" (To be machined from Upper Track Aluminum block) | Corus Aluminum | 1x | | Yes | Machine to size from Upper Track Chassis Aluminum Block | http://www.corusgroup.com/en/products/ |
| Fork Tine | Multipurpose Aluminum (Alloy 6061) 1-1/2" Thick X 4" Width X 3-1/4" Length (To be machined from Upper Track Aluminum block) | Corus Aluminum | 2x | | Yes | Both forks can be machined Upper Track Chassis Aluminum Block | http://www.corusgroup.com/en/products/ |
| Fork Hardware | Grade 5 Zinc-Plated Steel Hex Head Cap Screw 3/8"-24 Thread, 2" Length (91247A223) | McMaster-Carr | 4x | $7.85/Pack of 25 | No | | http://www.mcmaster.com/#91247a223/=x34xi |
| Track Rollers | Extended-Life Track Rollers (1420T14) | McMaster-Carr | 4x | $22.98/ea | No | | http://www.mcmaster.com/#track-rollers/=thj3b |
| Upper Track Chassis | Multipurpose Aluminum (Alloy 6061) 25" x 25" x 7" block | Corus Aluminum | 1x | $603.93 | Yes | Machine to size | http://www.corusgroup.com/en/products/ |
| Lower Track Chassis | Multipurpose Aluminum (Alloy 6061) 25" x 25" x 2" block | Corus Aluminum | 1x | $172.55 | Yes | Machine to size | http://www.corusgroup.com/en/products/ |
| Track Hardware | Alloy Steel Flat Head Socket Cap Screw #8-32 Thread, 1-1/8" Length, Black Oxide (91771A200) | McMaster-Carr | 16x | $7.72/Pack of 50 | No | | http://www.mcmaster.com/#91253a544/=tgmq2 |
| Pad Bracket | Galvanized Low-Carbon Steel 90 Degree Angle Plain, 1/4" Thick, 3" X 3" Legs, 3' Length (8968K643) | McMaster-Carr | 2x | $58.61/ea | Yes | Both pads can be machined from one piece | http://www.mcmaster.com/#8968k643/=tgnai |
| Pad Bracket Hardware (Fixed) | Grade 5 Zinc-Plated Steel Hex Head Cap Screw 3/8"-24 Thread, 1/2" Long, Fully Threaded (92865A211) | McMaster-Carr | 6x | $9.41/Pack of 50 | No | | http://www.mcmaster.com/#92865a211/=x37zh |
| Pad Bracket Hardware (Adjustable) | Grade 5 Zinc-Plated Steel Hex Head Cap Screw 1/2"-20 Thread, 3 1/2" Length (91247A362) | McMaster-Carr | 2x | | No | Same Hardware as used in Frame | http://www.mcmaster.com/#91247a362/=x2i6g |
| Pads | Multipurpose Aluminum (Alloy 6061) 1-1/4" Thick, 7" X 8-1/4" (To be machined from Aluminum block) | Corus Aluminum | 2x | | Yes | Machine to size from Upper Track Chassis Aluminum Block, Adjustable Pad Will need additional machining step see drawing | http://www.corusgroup.com/en/products/ |
| Counter Weight | Lead (6% Antimony, cold rolled) shot for 4" x 4" x 6" block | Williams Advanced Materials Inc. | 1x | $74.89 | Yes | Machine to size | http://www.williams-adv.com |
| | | | | | | | |
| Total | | | 66 | $2,341.51 | | | |

**Lateral Force and Torque to clamp and hold brake drum:**

Notes:
Coefficient of Friction of Brake Material vs Aluminum.
$\mu \cong 0.36 - 0.82$ (spray-on material?)
$\mu = 0.4$ (more of a conservative estimate)




The FBD above is if you were to look at the brake drum on its side, sliding down the pad.

Given: $\mu$, W
Find: $F_{lat}$

$$\boxed{F_{lat}\mu \geq W}$$

$$F_{lat}(0.4) \geq 110 lbs$$

$$F_{lat} \geq 110/0.4$$

$\mathbf{F_{lat} \geq 275}$ **lbs (force)**

Given: K (torque coefficient), $F_i$, d
Find: $\tau$

$$\boxed{\tau = K \cdot F_i \cdot d}$$

$$\tau = (0.20)\,(275)\text{lbf} \cdot (0.5)\text{in}$$

$\boldsymbol{\tau}$ **=27.5 lbf in**

The needed torque to apply lateral force.

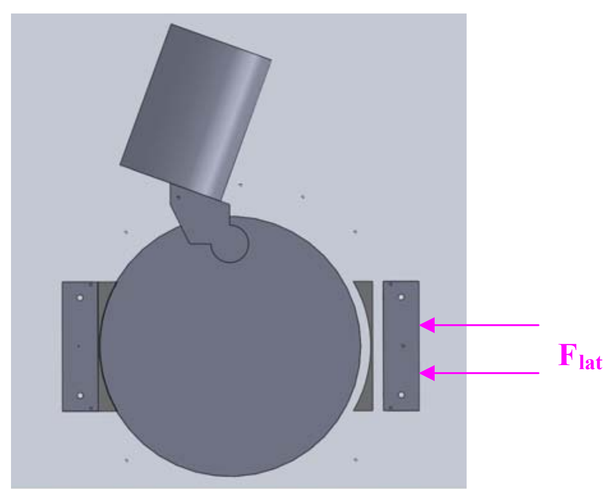
Check that the bending stress on the bolts are okay.
(Magnitude of transverse shear stress << bending, torsional stresses typically)

$$\boxed{\sigma_{bending} = \frac{Mc}{I}}$$

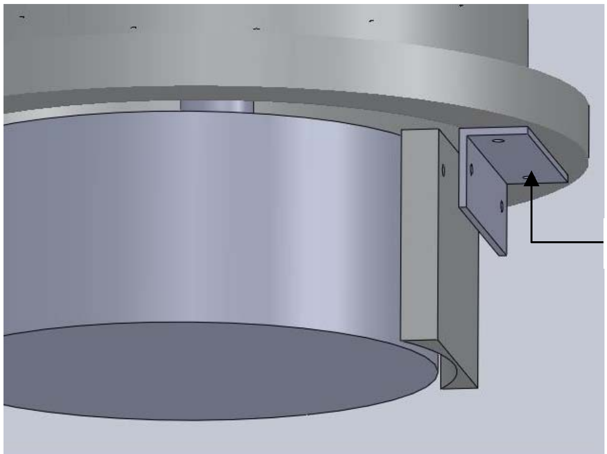
$$\sigma_{bending} = \frac{[(P/2)(l)](r_{bolt})}{(\frac{\pi}{64})d^4}$$

$$\sigma_{bending} = \frac{[(110/2)(3")](0.25")lbs \cdot in^2}{(\frac{\pi}{64})(0.5)^4 in^4}$$

$\boldsymbol{\sigma_{bending}}$ **= 13.445 ksi**



**Axial Stress on L-Brackets connecting the clamping pads to the manipulator track.**




Given: P, $A_{bolt}$
Find: $\sigma_{xx}$

Assumptions / Notes:

The weight of the brake drum is supported equally by 4 screws.

$$\boxed{\sigma_{xx} = \frac{P}{A_{bolt}}}$$

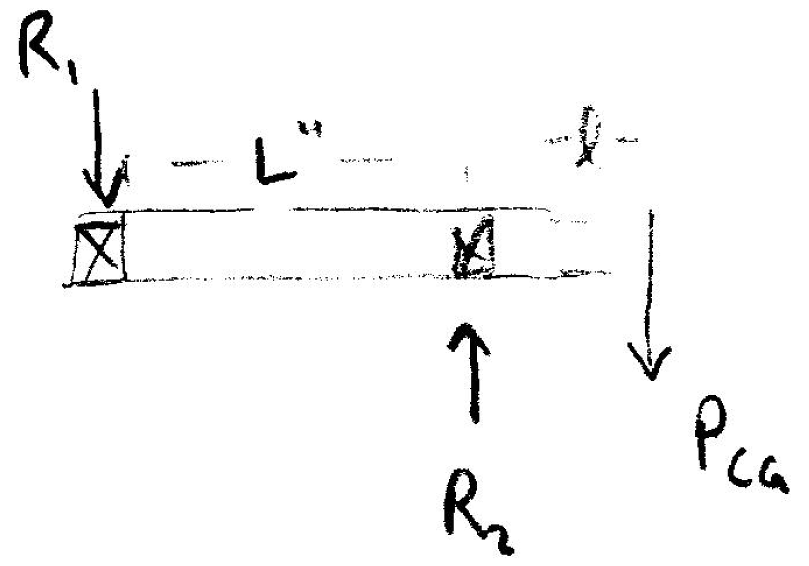
$$\sigma_{xx} = \frac{(P/4)}{\pi \cdot r^2}$$

$$\sigma_{xx} = \frac{(110/4)lbs}{\pi \cdot (0.19^2)in^2}$$

**$\sigma_{xx}$ = 242.5 psi**

As long as an individual screw can hold 242.5 psi, the L-brackets (carrying the clamping pads and brake drum) will be firmly fastened to the bottom of the track.

# Forces on the Bearings




$L = 3"$
$l = 12"$

$$\Sigma F_y = -R_1 + R_2 - P_{ca} = 0$$

$$R_2 - R_1 = P_{ca}$$

$$R_2 - R_1 = 500$$

$$\Sigma M_A = 0$$

$$R_2(L) - P_{ca}(L+l) = 0$$

$$R_2 = \frac{P_{ca}(L+l)}{L} = \frac{500(3+12)}{3} = 2500 \text{ lbs}$$

$$\boxed{R_2 = 2500 \text{ lbs}}$$

$$R_1 = R_2 - 500$$

$$\boxed{R_1 = 2000 \text{ lbs}}$$

**Bending for the shaft**

$$\boxed{\sigma_{bending} = \frac{M \cdot y}{I}}$$

$$\sigma_{xx} = \frac{(15''\cdot 500)\cdot(0.625'')}{\frac{\pi}{64}\cdot(1.25^4)}$$

$$\sigma_{xx} = 39.15ksi$$

**Rollers (in tilted position)**

Given: P = $m_{brake}$
$W_{track}$

$$\boxed{\sigma_{bending} = \frac{M \cdot r}{I}}$$

$$\sigma_{bending} = \frac{[(P/2)+(W_{track}/2)](y)\cdot r}{(\pi/4)(r^4)}$$

$$\sigma_{bending} = \frac{[(110/2)+(50/2)](12)\cdot 0.375}{(\pi/4)(0.375^4)}$$

**$\sigma_{bending}$ = 23.178 ksi**

**Lifting Frame Column Calculations:**

Edge shearing was initially thought to be a concern, but after considering the thickness of the cassette and the bolt diameters, this was found to be a non-issue. As a rule of thumb, bolted connections usually are spaced at a minimum of 1.5 times the diameter of the bolt from the edge in consideration. This type of failure may usually be neglected though.

Edge Shearing of a member

$$\boxed{\tau = \frac{F}{4at} = \frac{0.577(S_y)_{mem}}{n_d}}$$

$$F = \frac{4at \cdot 0.577 \cdot (S_y)_{mem}}{n_d}$$

$$F = \frac{4(0.5")(0.25") \cdot 0.577 \cdot (54kpsi)}{1.5}$$

**F = 10.386 kip**

Frame – Top (eye bolt)
Eye bolt = ½" bolt

$$\boxed{\sigma_{xx} = \frac{P}{A_{bolt}}}$$

$$\sigma_{xx} = \frac{P}{\pi \cdot r^2}$$

$$\sigma_{xx} = \frac{500lbs}{\pi \cdot (0.25^2)in^2}$$

**$\sigma_{xx}$ = 2.55 ksi**

Frame – Bottom

$$\boxed{\sigma_{bending} = \frac{Mc}{I}}$$

$$\sigma_{bending} = \frac{(P \cdot l)(s/2)}{(1/12)(bh_0^3 - bh_i^3)}$$

$$\sigma_{bending} = \frac{(500 \cdot 10)(2/2)}{(1/12)(2^4 - 1.76^4)}$$

**$\sigma_{bending}$ = 9.367 ksi**

Bottom Frame Bolts

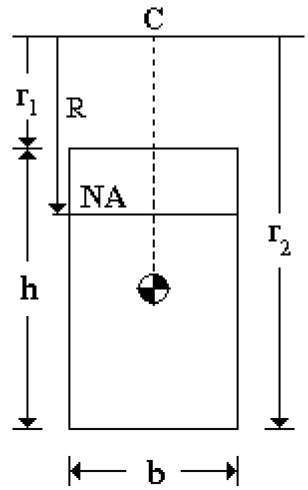
$$\boxed{\sigma_{bending} = \frac{Mc}{I}}$$

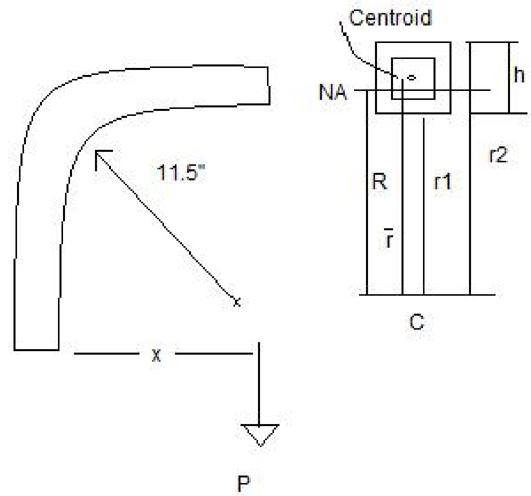
$$\sigma_{bending} = \frac{(P/2 \cdot l)(d/2)}{(\pi/64)(d^4)}$$

$$\sigma_{bending} = \frac{(500/2 \cdot 18)(0.5/2)}{(\pi/64)(0.5^4)}$$

**$\sigma_{bending}$ = 367.0 ksi**

## Curved Beam Calculations




$$R = \frac{h}{\ln \frac{r_2}{r_1}} \qquad R = \frac{2}{\ln \frac{13.5}{11.5}} \qquad \mathbf{R = 12.4733}$$

**Bending Stress, $\sigma_x$**

- a positive stress will increase the curvature
- a negative stress will decrease or flatten the curved beam out

P = 500 lb
x = 17 in
r1 = 11.5 in
r2 = 13.5 in (the maximum stress can be expected)
C = Center of Curvature
$\bar{r}$ = radius of curvature from C to the centroid of the cross-section.
A = area of cross-section
M = bending moment
R = location of the Neutral Axis
y = point where bending stress is being measured

$$\boxed{\sigma_x = \frac{M \cdot y}{Ae(r - y)}} \qquad e = \bar{r} - R$$

e = 12.5 – 12.4733

$$\sigma_x = \frac{M(r - R)}{Aer} \qquad \text{e = 0.0267}$$

$$\sigma_x = \frac{(500 \cdot 17)(13.5 - 12.4733)}{(0.9024)(0.0267)(13.5)}$$

**$\sigma_x$ = +26.829 ksi**

# Low Profile Load Trolley with Eye Hook

## MRTA7787

**APPLICATION**

- Travels inside RAD7510 Series Rail.
- Suspends fixtures, hoists, spring balancers, etc.
- Transfers loads along horizontal axis
- Up to 2500lbs. [1134kg.] Maximum Capacity
- 1.25in [32mm] Eye Hook Diameter
- 0.72in. [18mm] throat opening
- Low profile design reduces stack-up heights by 1.89in. [48mm]

**ENGINEERING DATA**

- Trolleys are manufactured from commercial grade pickled and oiled hot rolled steel with a tensile strength of ± 49 ksi and a yield point of ± 30 ksi.
- Fiberglass filled High Impact Plastic Wheels
- Side guide rollers and trolley wheels double-shielded bearings keep dirt out and do not require any lubrication.
- The use of double-shielded bearings within the guide rollers prevents drag on the load trolley.
- Max. temp at 100% load -20 degs. F to 248 degs. F.

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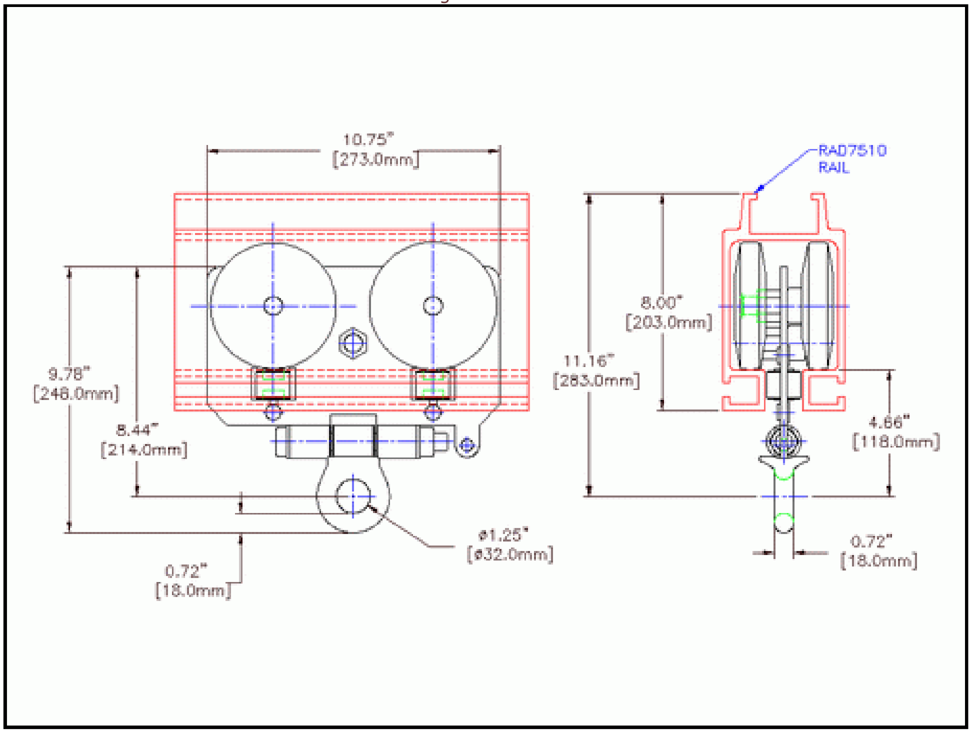
Print Brochure

| Rail Series | Part Number | Weight |
|---|---|---|
| RAD7510 | MRTA7787 | 9.5lbs. / 4.31kg. |
| RAD4110 Equivalent = MRTA4393 | | |

## MRTA7787

Click on Images Below for Full Size



# EMC and EMW Models

## The Solutions for Light Duty Applications


300 & 500 lb.


500 lb.

**EMC & EMW Models** - Compact chain and wire rope hoists designed for a variety of light duty applications. These models feature thermally protected motors.

**CAPACITIES & LIFT** - Rated loads 300 and 500 pounds. 10-foot lift with 6-foot push button cord standard.

**VOLTAGES** - 115V, single phase motors only.

**SUSPENSION** - Swivel top and bottom hooks with safety latches standard.

**POWER CORD** - Provided with grounded 3-prong plug for easy installation in any standard 115V outlet.

**ALUMINUM HOUSING** - Lightweight and compact to provide strength and portability. Weighs less than 25 lb.

**LIMIT SWITCHES** - Upper and lower limit switches on chain models and upper paddle limit switch on wire rope model regulates load travel.

**ELECTROMAGNETIC BRAKE** - Quick acting for positive load control.

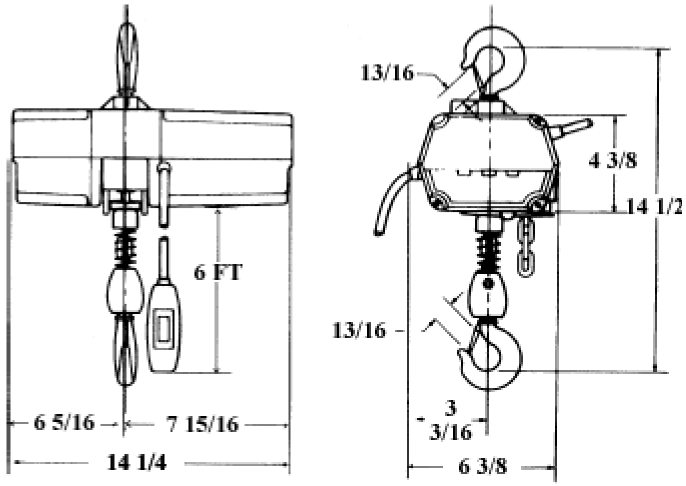
**THERMAL MOTOR PROTECTION** - Standard to prevent overheating

**LIGHT DUTY OPERATION** - Rated for intermittent duty applications (10-minute run time per hour maximum).

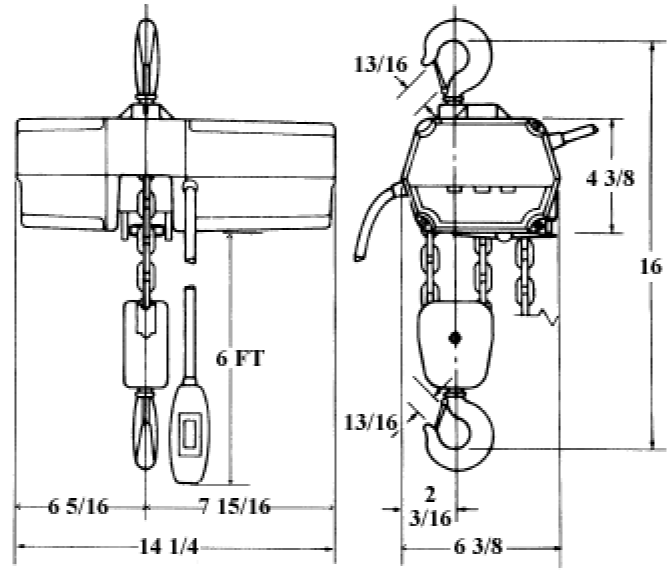
**ACCESSORIES** - LCC-05 chain container (shown) available for EMC models.

**UL LISTED**
**LIFETIME WARRANTY**

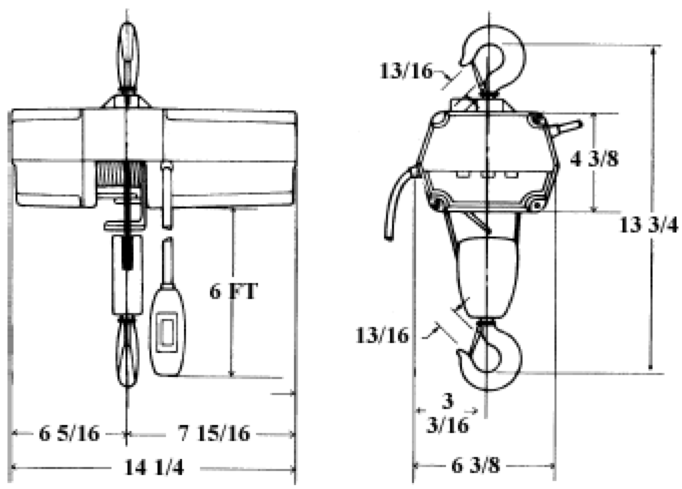
EMC and EMW (Hook Mount) 300 & 500 Lb. - EMC 500 Lb. - EMW



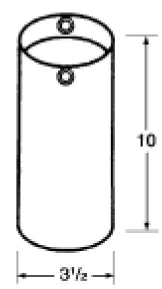
EMC-300B



EMC-500B



EMW-500B



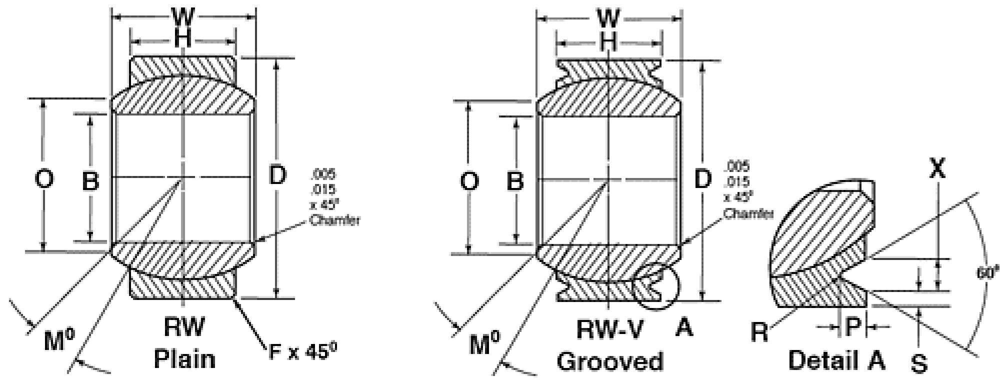

**Chain Container for EMC models**; vinyl-coated nylon fabric construction - order model no. LCC-05.

## PRICING - Light Duty Electric Hoists (10 ft. Lift only)

| Model No.* | Product Code | Rated Cap. (lbs.) | No. of Chains | Std. Lift (Feet) | Lifting Speed (FPM) | Motor H.P. | Voltage & Phase (AC) | A Dim. | Housing Dim. (in.) H x W x L | Shipping Weight (Lbs.) | Price |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **EMC300B** | **07627W** | 300 | 1 | 10 | 16 | 1/6 | 115V. 1 PH | 14 1/2 | 4 3/8 x 6 3/8 x 14 1/4 | 21 | **$748** |
| **EMC500B** | **07632W** | 500 | 2 | 10 | 8 | 1/6 | 115V. 1 pH | 16 | 4 3/8 x 6 3/8 x 14 1/4 | 24 | **$748** |
| **EMW-500B**** | **07612W** | 500 | 2-part wire rope | 10 | 10 | 1/6 | 115V. 1 pH | 13 3/4 | 4 3/8 x 6 3/8 x 14 1/4 | 19 | **$748** |

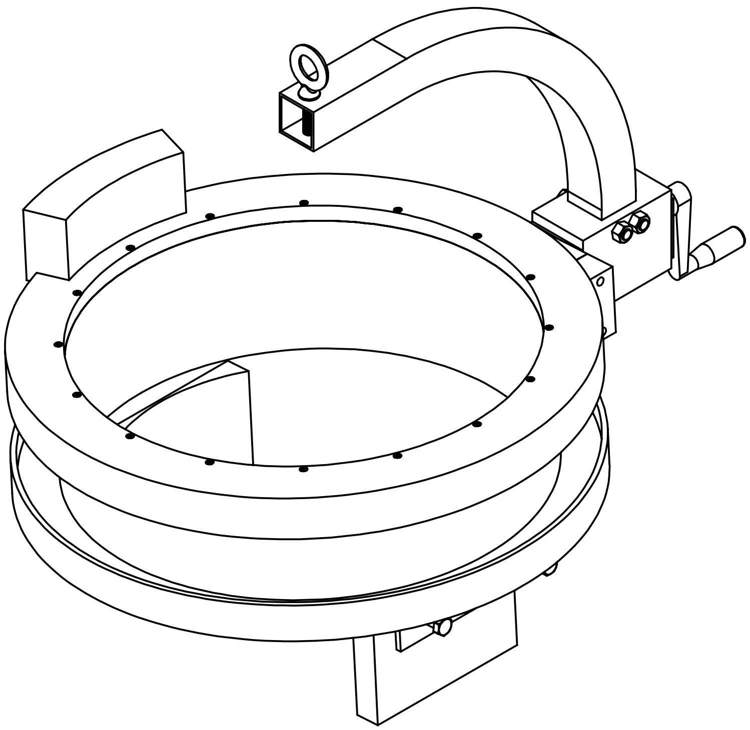
**Note:** These models meet UL, but NOT CSA.
* Equipped with 18” power cord and grounded 3-prong plug. Push-button drop is 4 Ft. less than lift. **** Wire Rope Model**

# Wide Standard Series Cont.




**RW/RW-V** **Teflon Liner Available

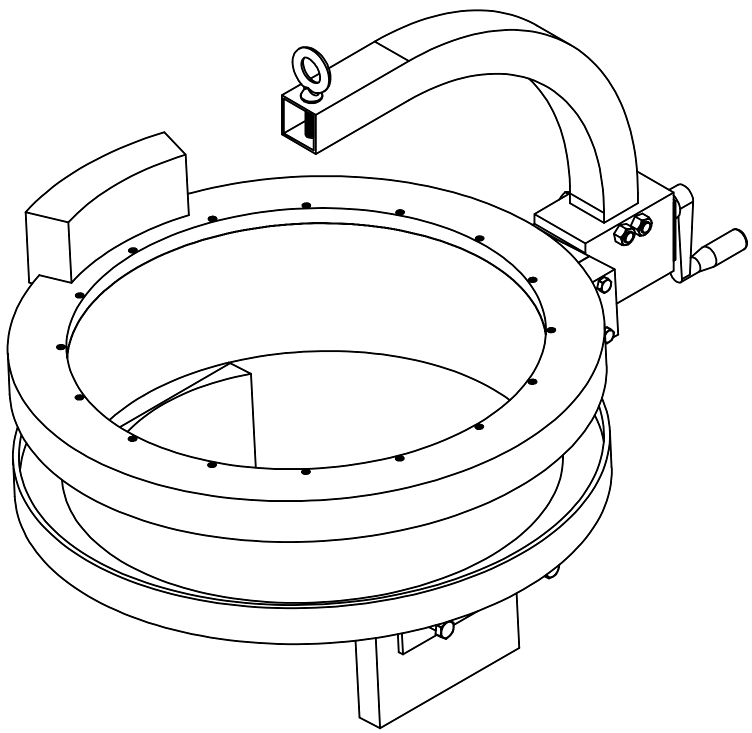
| Radial Part No. | | B | D | W | H | Ball Dia. | M° Mis-align angle | O | F | Recomm'd Housing Bore Dia. | Alum. Bronze Static Rad. Lim. Load (LBS) | Stainless Static Rad. Lim. Load (LBS) | Approx. Weight (LBS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plain | Grooved | +.0000<br>-.0005 | +.0000<br>-.0005 | +.000<br>-.005 | +.010<br>-.000 | (REF.) | ± | (REF.) | +.015<br>-.000 | +.0000<br>-.0005 | | | |
| **-3** | **-3V** | .1900 | .5000 | .359 | .281 | .437 | 15° | .249 | .010 | .5000 | 3300 | 8700 | .015 |
| **-3-1** | **-3-1V** | .1900 | .6250 | .437 | .322 | .531 | 18° | .301 | .010 | .6250 | 4700 | 12350 | .026 |
| **-4** | **-4V** | .2500 | .6250 | .437 | .322 | .531 | 18° | .301 | .010 | .6250 | 4700 | 12350 | .028 |
| **-5** | **-5V** | .3125 | .6875 | .437 | .312 | .593 | 15° | .401 | .010 | .6875 | 5150 | 13500 | .029 |
| **-6** | **-6V** | .3750 | .8125 | .500 | .401 | .687 | 10° | .471 | .010 | .8125 | 7750 | 20300 | .049 |
| **-7** | **-7V** | .4375 | .9375 | .562 | .437 | .781 | 11° | .542 | .010 | .9375 | 9750 | 25450 | .072 |
| **-8** | **-8V** | .5000 | 1.0000 | .625 | .500 | .875 | 10° | .612 | .020 | 1.0000 | 12500 | 32800 | .089 |
| **-9** | **-9V** | .5625 | 1.1250 | .687 | .531 | 1.000 | 11° | .726 | .020 | 1.1250 | 15350 | 40250 | .123 |
| **-10** | **-10V** | .6250 | 1.1875 | .750 | .562 | 1.062 | 12° | .752 | .020 | 1.1875 | 17300 | 45400 | .140 |
| **-12** | **-12V** | .7500 | 1.3750 | .875 | .625 | 1.250 | 14° | .892 | .020 | 1.3750 | 22900 | 60000 | .208 |
| **-14** | **-14V** | .8750 | 1.6250 | .875 | .750 | 1.375 | 6° | 1.061 | .020 | 1.6250 | 30150 | 79200 | .325 |
| **-15** | **-15V** | .9375 | 1.3750 | .450 | .350 | 1.188 | 5° | 1.099 | .010 | 1.3750 | 1200 | 31550 | .087 |
| **-16** | **-16V** | 1.0000 | 2.1250 | 1.375 | 1.000 | 1.875 | 14° | 1.275 | .020 | 2.1250 | 55500 | 145650 | .870 |
| **-20** | **-20V** | 1.2500 | 2.3750 | 1.500 | 1.125 | 2.093 | 13° | 1.464 | .020 | 2.3750 | 69900 | 183350 | 1.107 |
| **-20-1** | **-20-1V** | 1.2500 | 2.0000 | 1.093 | .937 | 1.781 | 6° | 1.408 | .020 | 2.0000 | 49350 | 129600 | .526 |
| **-22** | **-22V** | 1.3750 | 2.5625 | 1.687 | 1.218 | 2.218 | 15° | 1.539 | .020 | 2.5625 | 82600 | 216850 | 1.385 |
| **-24** | **-24V** | 1.5000 | 2.6875 | 1.687 | 1.218 | 2.390 | 14° | 1.697 | .030 | 2.6875 | 86950 | 228300 | 1.480 |
| **-28** | **-28V** | 1.7492<br>1.7500 | 2.9990<br>3.0000 | 1.812 | 1.312 | 2.672 | 13° | 1.966 | .030 | 2.9992<br>3.0000 | 105250 | 267300 | 1.905 |
| **-32** | **-32V** | 1.9992<br>2.0000 | 3.2490<br>3.2500 | 1.937 | 1.375 | 2.937 | 13° | 2.211 | .030 | 3.2492<br>3.2500 | 121850 | 319800 | 2.230 |
| **-36** | **-36V** | 2.2492<br>2.2500 | 3.6240<br>3.6250 | 2.000 | 1.406 | 3.156 | 12° | 2.444 | .030 | 3.6242<br>3.6250 | 134450 | 352850 | 2.775 |
| **-40** | **-40V** | 2.4990<br>2.5000 | 3.9362<br>3.9375 | 2.062 | 1.437 | 3.437 | 12° | 2.752 | .030 | 3.9365<br>3.9375 | 150300 | 394550 | 3.288 |
| **-44** | **-44V** | 2.7490<br>2.7500 | 4.1237<br>4.1250 | 2.187 | 1.500 | 3.687 | 12° | 2.971 | .030 | 4.1240<br>4.1250 | 168700 | 442900 | 3.536 |
| **-48** | **-48** | 2.9990<br>3.0000 | 4.3737<br>4.3750 | 2.312 | 1.562 | 3.937 | 12° | 3.190 | .030 | 4.3740<br>4.3750 | 188000 | 493550 | 3.957 |



| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | 1420T14 | Track Roller | 4 |
| 2 | 3014T263 | Eyebolt | 1 |
| 3 | 57155K378 | Pad - Bearing | 2 |
| 4 | 6473K91 | Handle | 1 |
| 5 | 91247A223 | Screw - Fork | 4 |
| 6 | 91247A362 | Bolt - Frame | 4 |
| 7 | 91385A622 | Set Screw | 1 |
| 8 | 91771A200 | Screw - Track | 16 |
| 9 | 92620A565 | Screw - Frame | 8 |
| 10 | 92865A211 | Screw - Pad | 6 |
| 11 | 95505A615 | Nut - Frame | 2 |
| 12 | P1T1 | Shaft | 1 |
| 13 | P1T2 | Pad - Fixed | 1 |
| 14 | P1T3 | Pad - Adjustable | 1 |
| 15 | P1T5 | Bracket - Adjustable | 2 |
| 16 | P1T6 | Counterweight | 1 |
| 17 | P2F1 | Cassette | 1 |
| 18 | P2F2 | Frame - Column | 1 |
| 19 | P2F3 | Bearing - Plate | 2 |
| 20 | P2R1 | Track - Top | 1 |
| 21 | P2R2 | Track - Bottom | 1 |
| 22 | P2R3 | Fork Base | 1 |
| 23 | P2R4 | Fork Tine | 2 |
| 24 | RWCR-20-1 | Frame - Bearing | 2 |

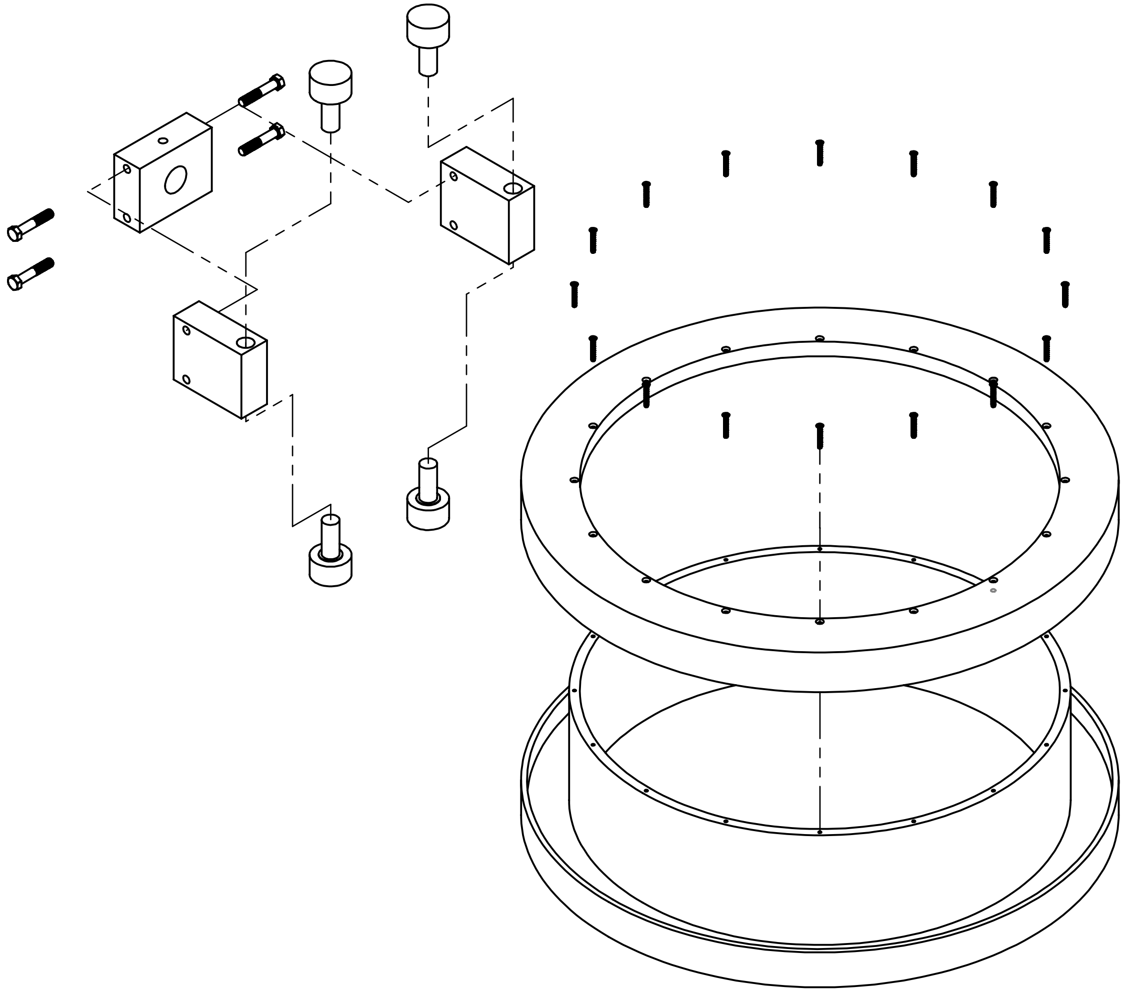
| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: N/A | Units: Inches | Drawing #: A1 | |
| Tolerance: ±.01 | Scale: 1:8 | Title: Brake Drum Manipulator | |
| Next Assy: N/A | Date: March 13, 2009 | Group: Adams and Team | |

| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | 57155K378 | Pad - Bearing | 2 |
| 2 | 6473K91 | Handle | 1 |
| 3 | 91247A362 | Bolt - Frame | 2 |
| 4 | 91385A622 | Set Screw | 1 |
| 5 | 92865A211 | Screw - Pad | 6 |
| 6 | A2F | Frame Assembly | 1 |
| 7 | A2T | Track Assembly | 1 |
| 8 | P1T1 | Shaft | 1 |
| 9 | P1T2 | Pad - Fixed | 1 |
| 10 | P1T3 | Pad - Adjustable | 1 |
| 11 | P1T5 | Bracket - Adjustable | 2 |
| 12 | P1T6 | Counterweight | 1 |

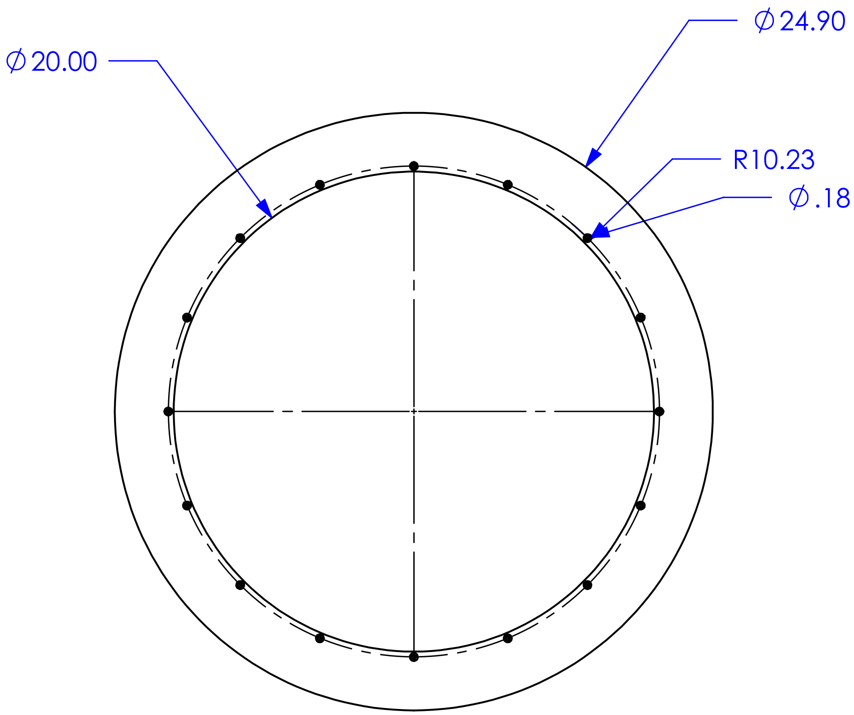


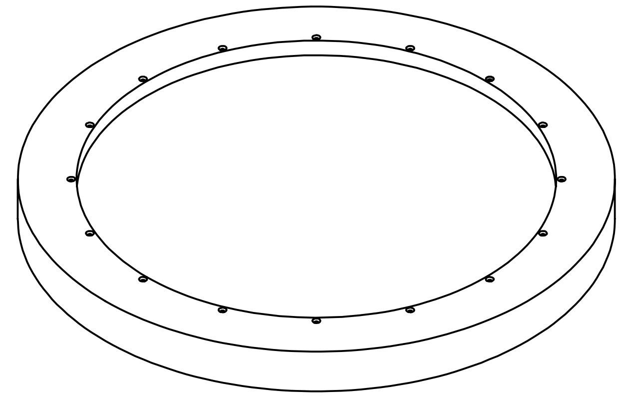
| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: N/A | Units: Inches | Drawing #: A1 | |
| Tolerance: ±.01 | Scale: 1:8 | Title: Brake Drum Manipulator | |
| Next Assy: N/A | Date: March 13, 2009 | Group: Adams and Team | |

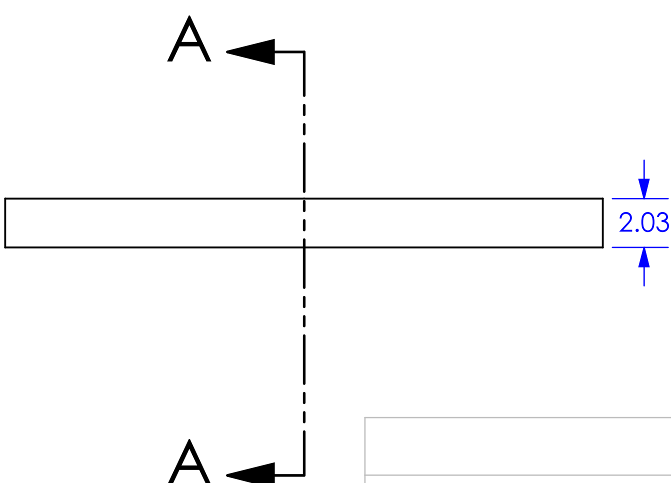
| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | 1420T14 | Track Roller | 4 |
| 2 | 91771A200 | Screw - Track | 16 |
| 3 | P2R1 | Track - Top | 1 |
| 4 | P2R2 | Track - Bottom | 1 |
| 5 | P2R3 | Fork Base | 1 |
| 6 | P2R4 | Fork Tine | 2 |
| 7 | 91247A223 | Screw - Fork | 4 |

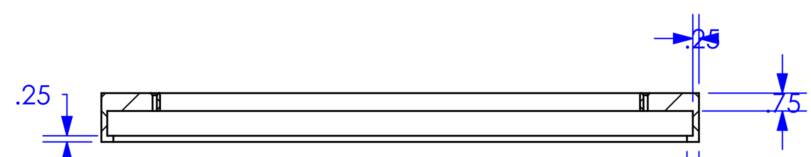


| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: N/A | Units: Inches | Drawing #: A2T | |
| Tolerance: ±.01 | Scale: 1:8 | Title: Track Assembly | |
| Next Assy: A1 | Date: March 13, 2009 | Group: Adams and Team | |



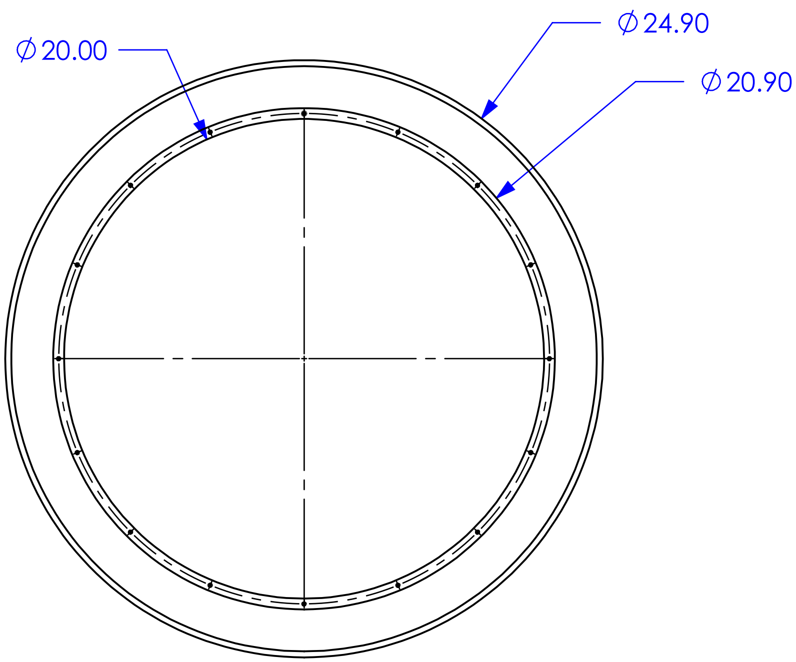



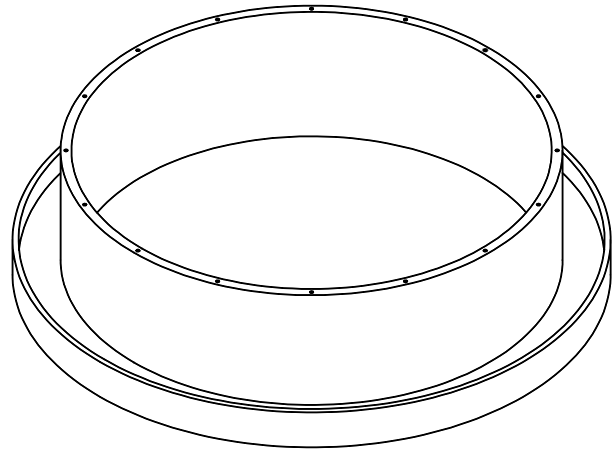


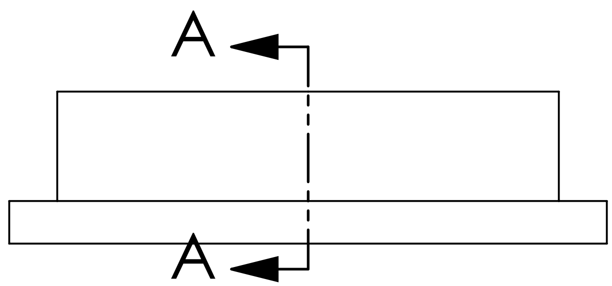



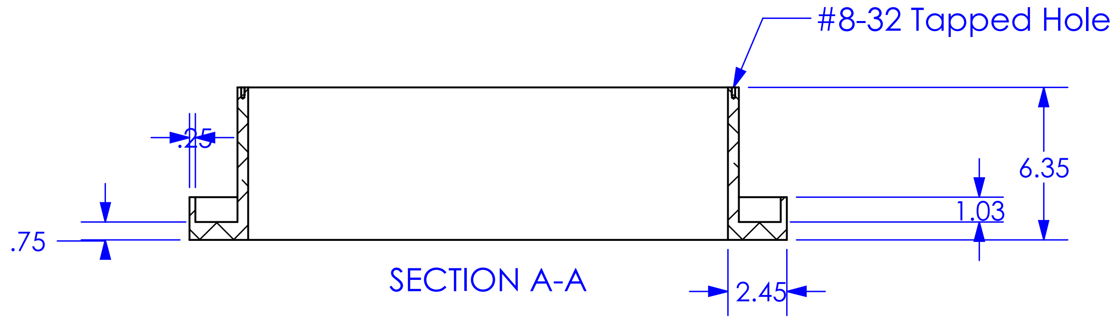

SECTION A-A

| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Alumninum 6061 | Units: Inches | Drawing #: P2R1 | |
| Tolerance: ±.01 | Scale: 1:8 | Title: Track - Top | |
| Next Assy: A2T | Date: February 18, 2009 | Group: Adams and Team | |



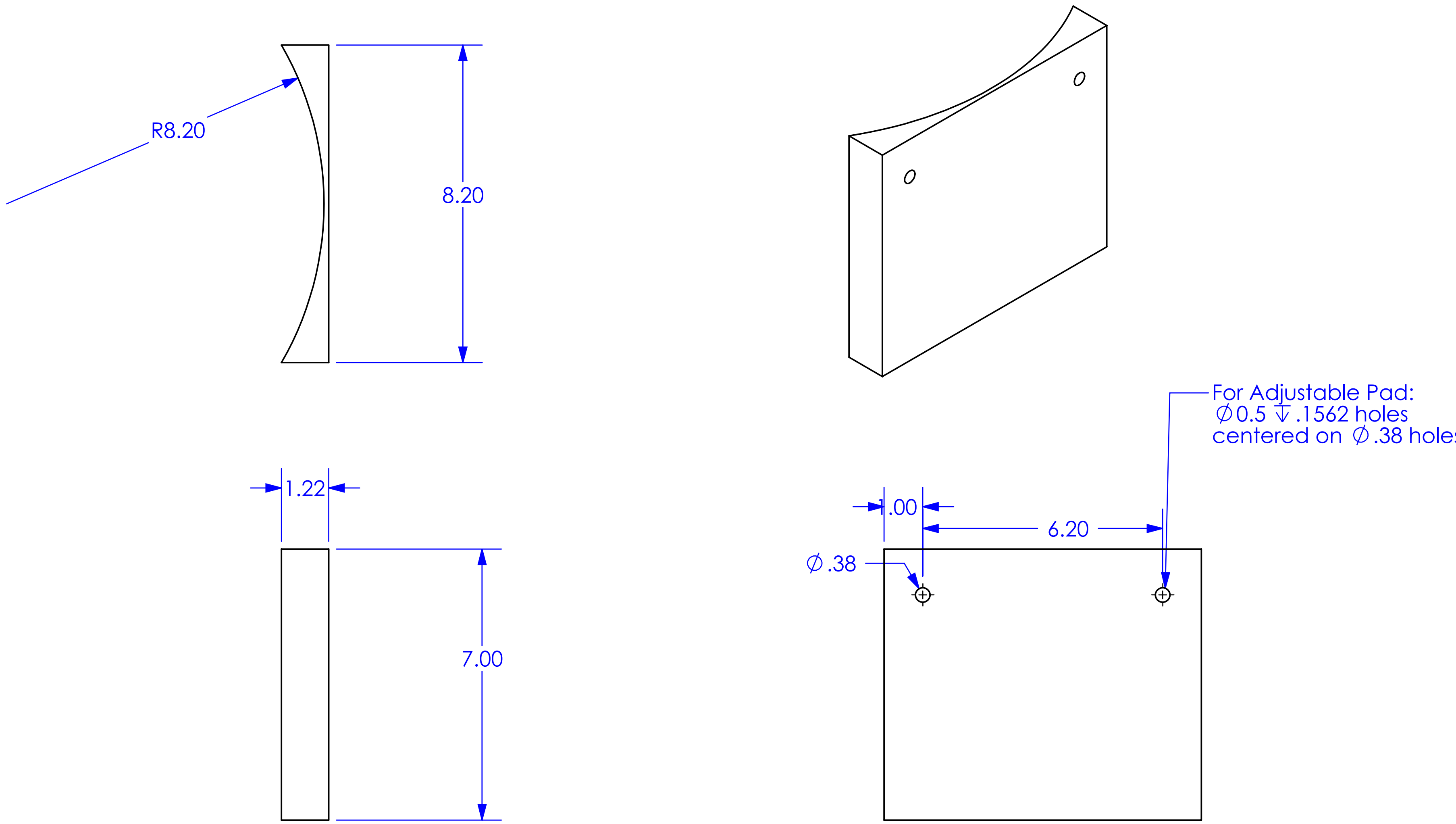





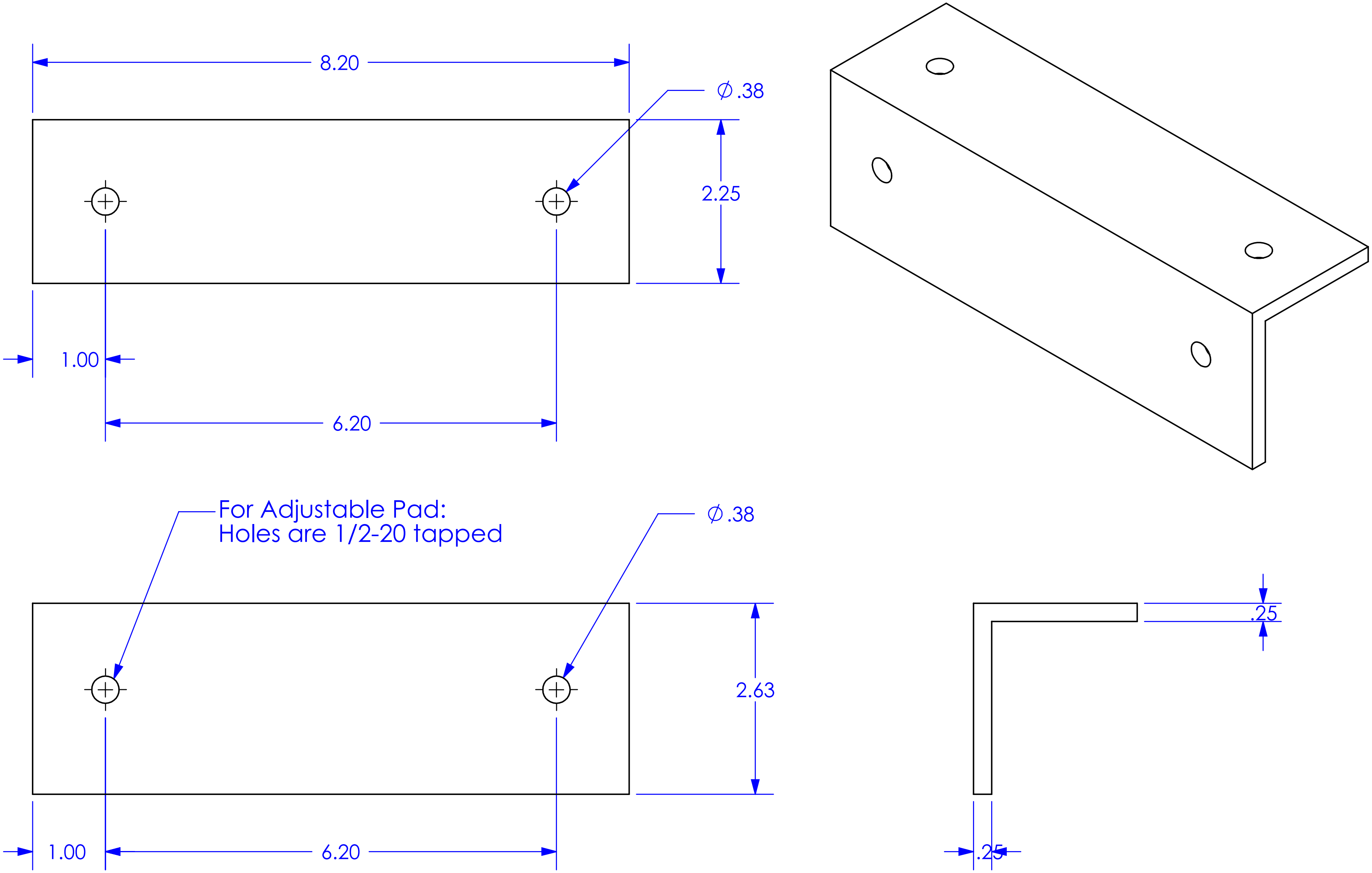




SECTION A-A

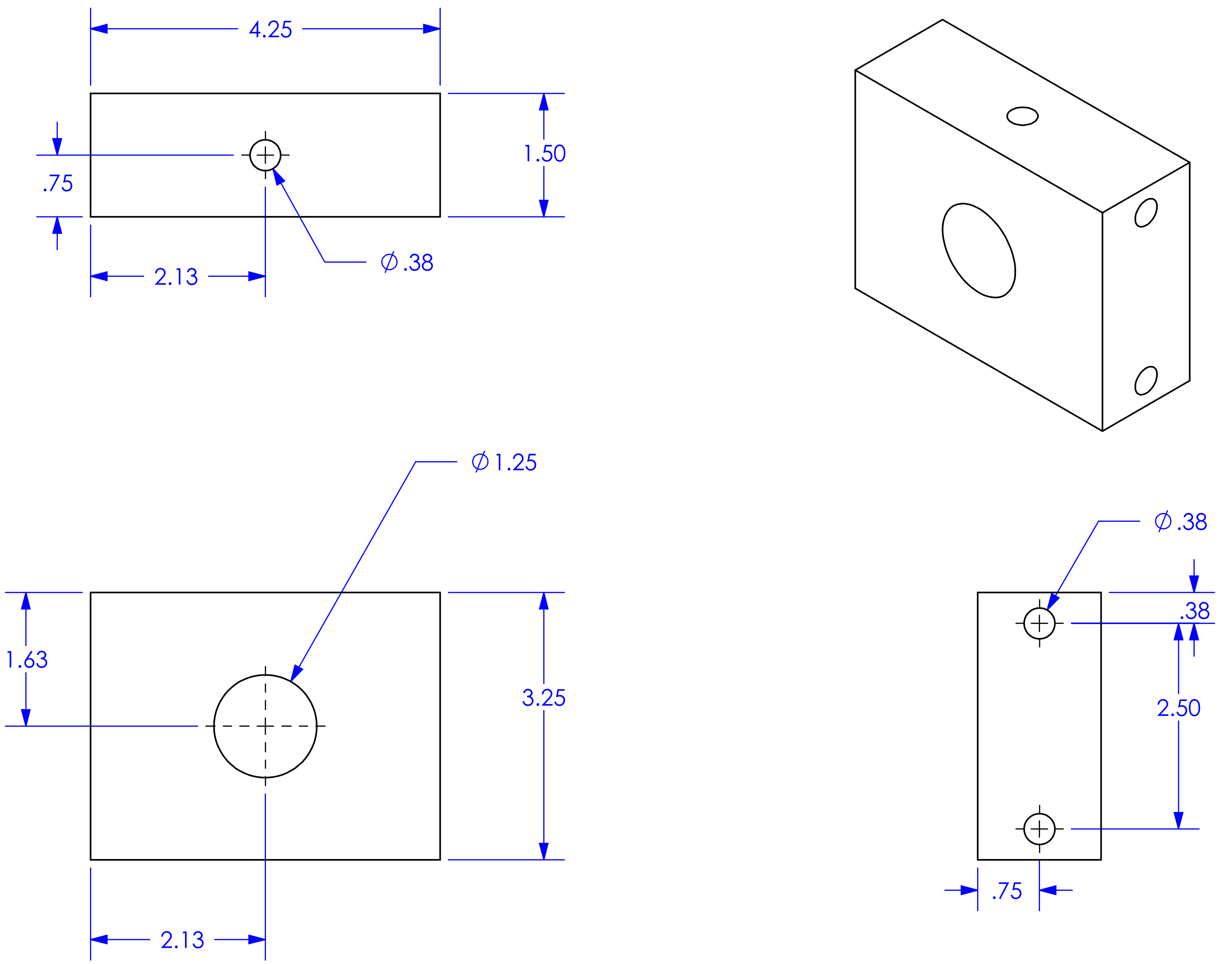
| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Aluminum 6061 | Units: Inches | Drawing #: P2R2 | |
| Tolerance: ±.01 | Scale: 1:8 | Title: Track - Bottom | |
| Next Assy: A2T | Date: March 13, 2009 | Group: Adams and Team | |



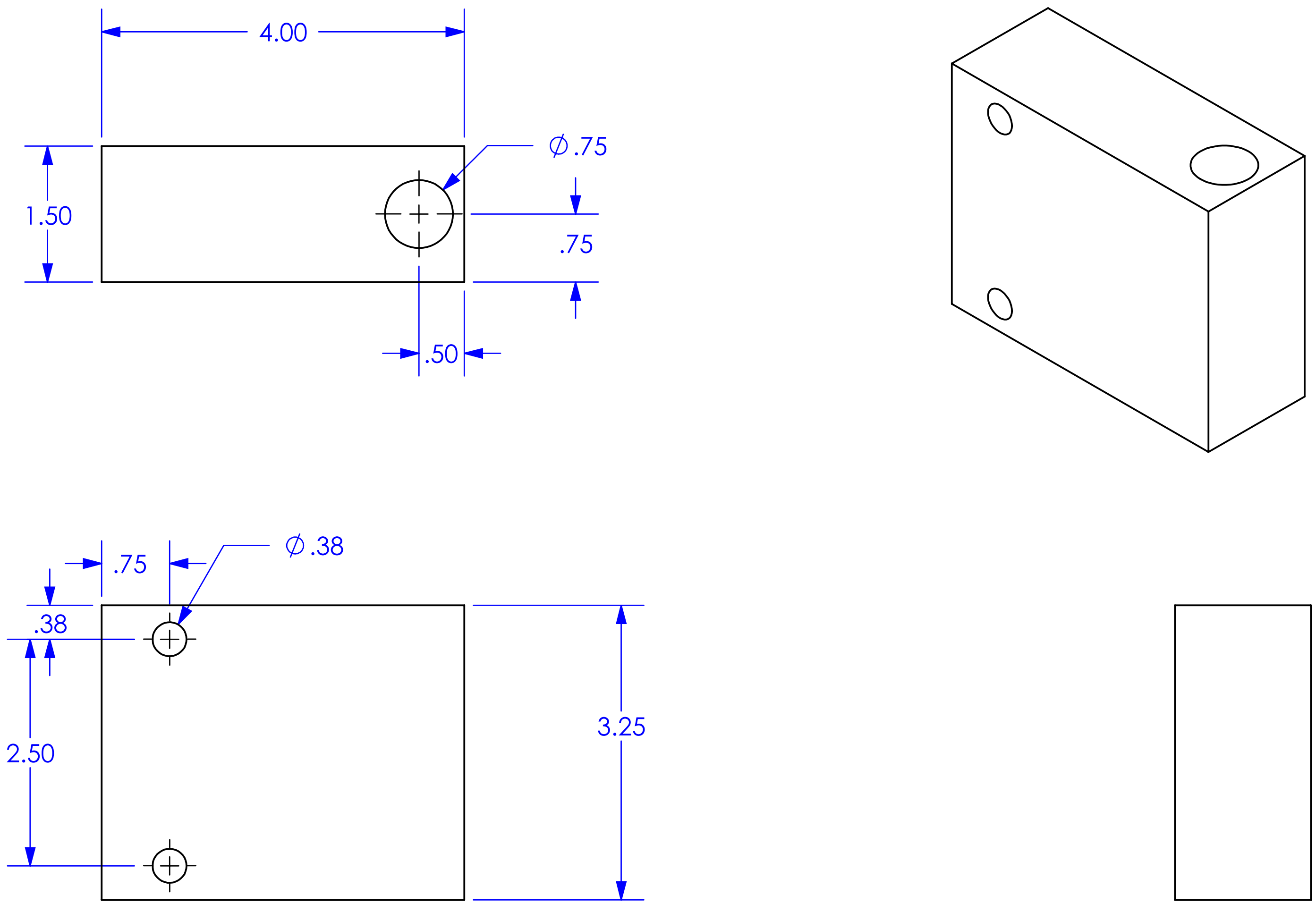

| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Aluminum 6061 | Units: Inches | Drawing #: P1T2/P1T3 | |
| Tolerance: ±.01 | Scale: 1:4 | Title: Pad - Fixed/Adjustable | |
| Next Assy: A1 | Date: March 13, 2009 | Group: Adams and Team | |



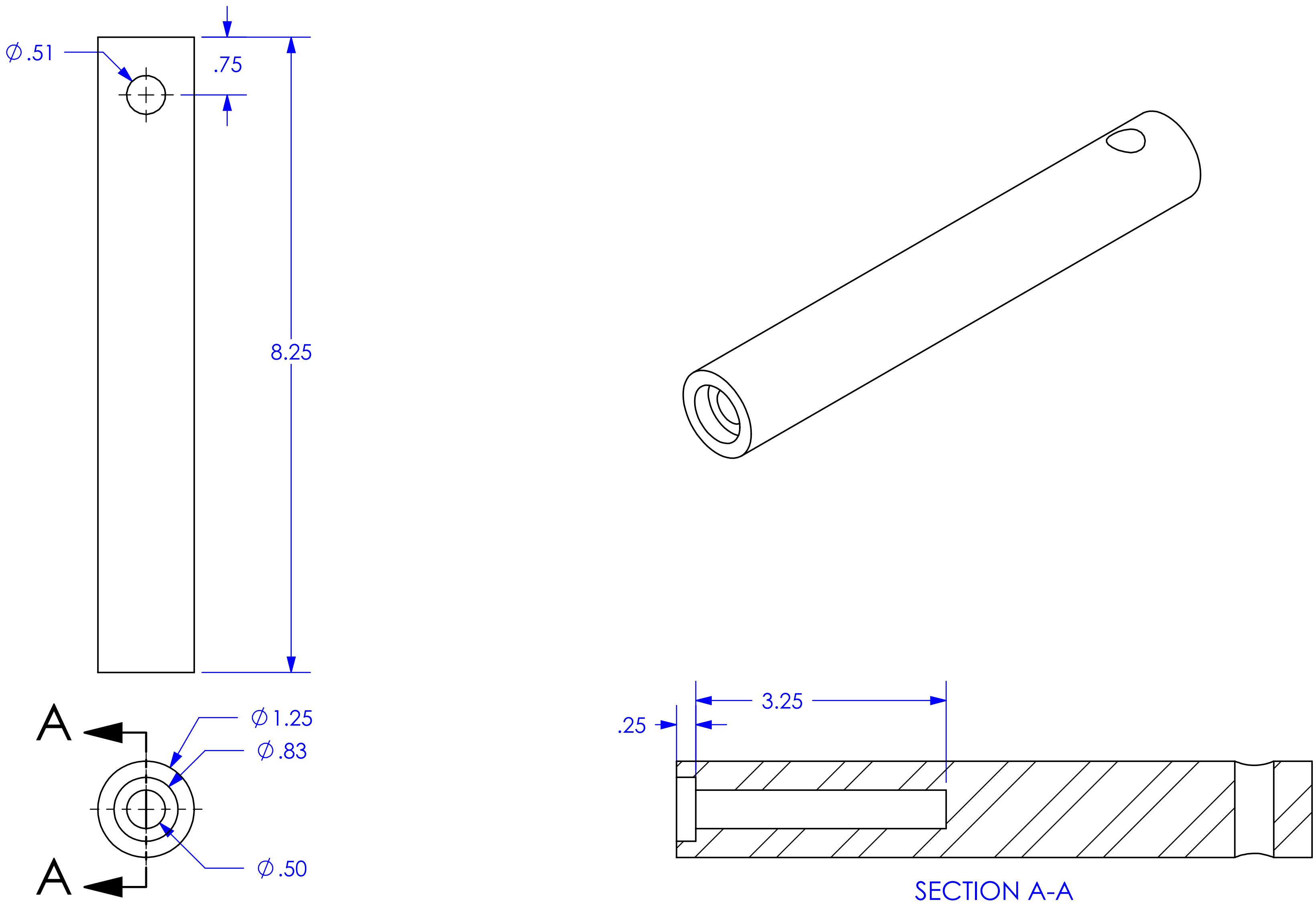

| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Steel AISI 1020 | Units: Inches | Drawing #: P1T4/P1T5 | |
| Tolerance: ±.01 | Scale: 1:2 | Title: Bracket - Fixed/Adjustable | |
| Next Assy: A1 | Date: March 13, 2009 | Group: Adams and Team | |



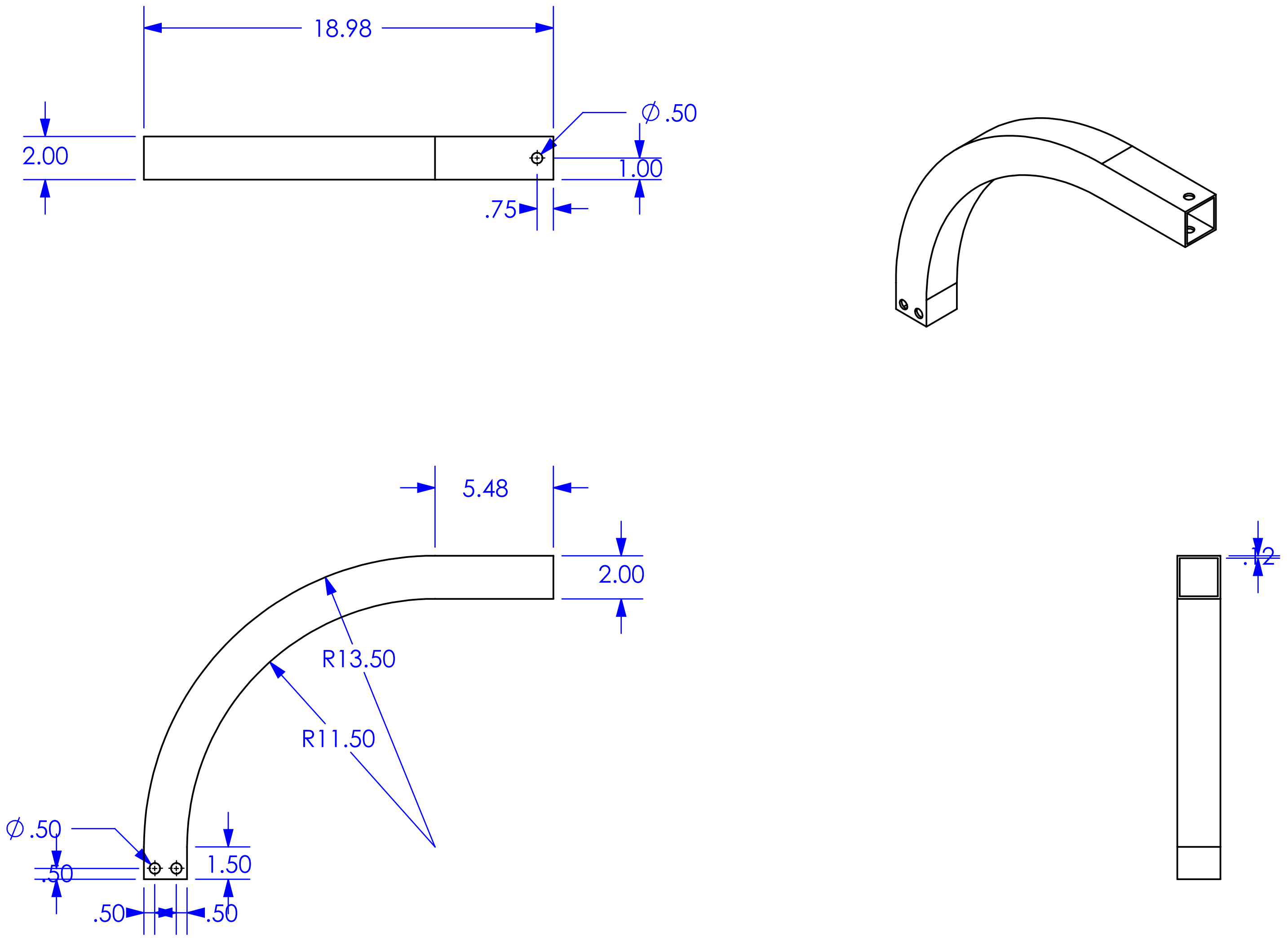

| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Aluminum 6061 | Units: Inches | Drawing #: P2R3 | |
| Tolerance: ±.01 | Scale: 1:2 | Title: Fork - Base | |
| Next Assy: A2F | Date: March 13, 2009 | Group: Adams and Team | |




| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Aluminum 6061 | Units: Inches | Drawing #: P2R4 | |
| Tolerance: ±.01 | Scale: 1:2 | Title: Fork - Tine | |
| Next Assy: A2T | Date: March 13, 2009 | Group: Adams and Team | |

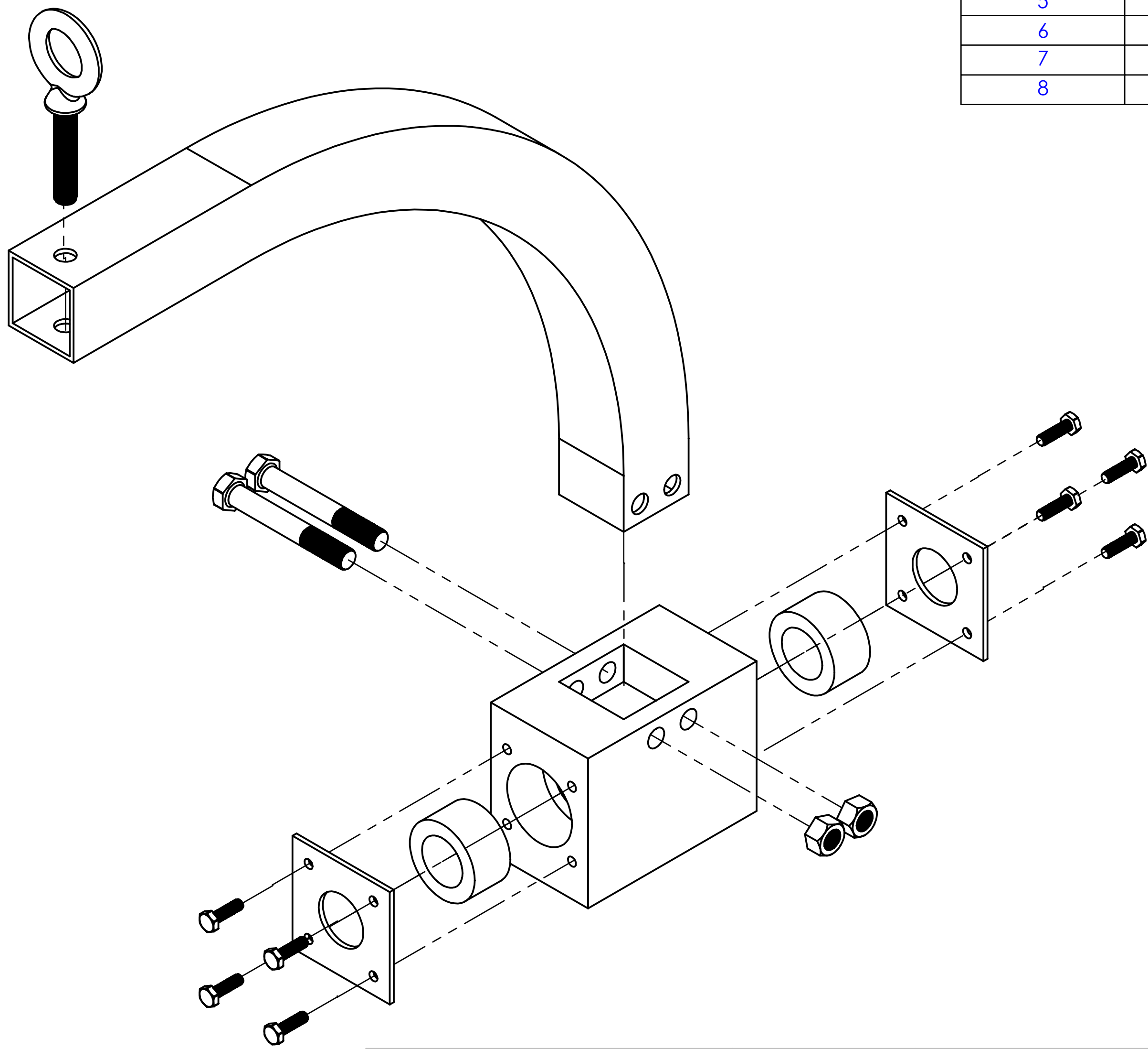



| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Steel AISI 1020 | Units: Inches | Drawing #: P1T1 | |
| Tolerance: ±.01 | Scale: 1:2 | Title: Shaft | |
| Next Assy: A1 | Date: March 13, 2009 | Group: Adams and Team | |

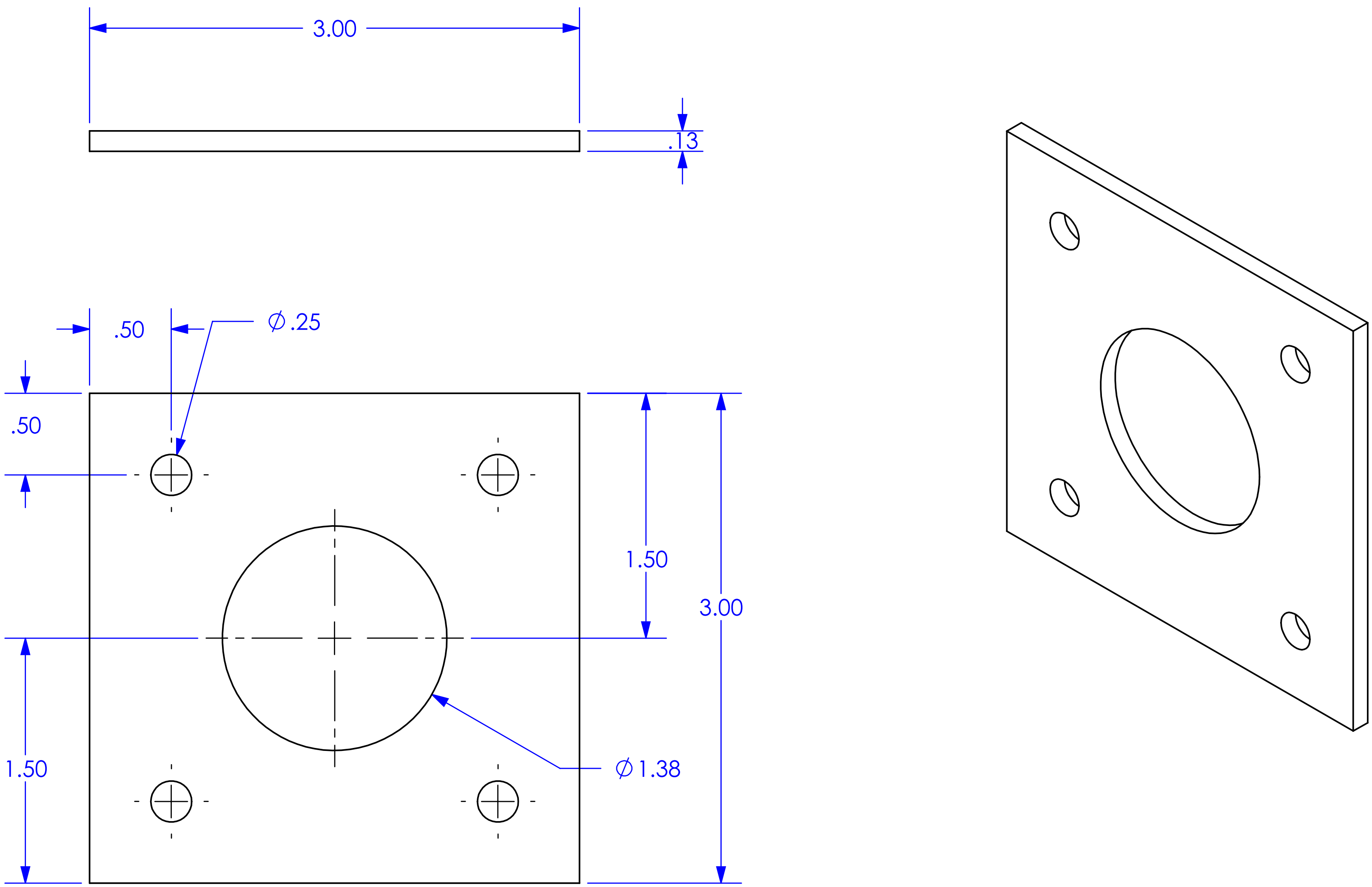



| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Steel AISI 1020 | Units: Inches | Drawing #: P2F2 | |
| Tolerance: ±.01 | Scale: 1:8 | Title: Frame - Column | |
| Next Assy: A2F | Date: March 13, 2009 | Group: Adams and Team | |

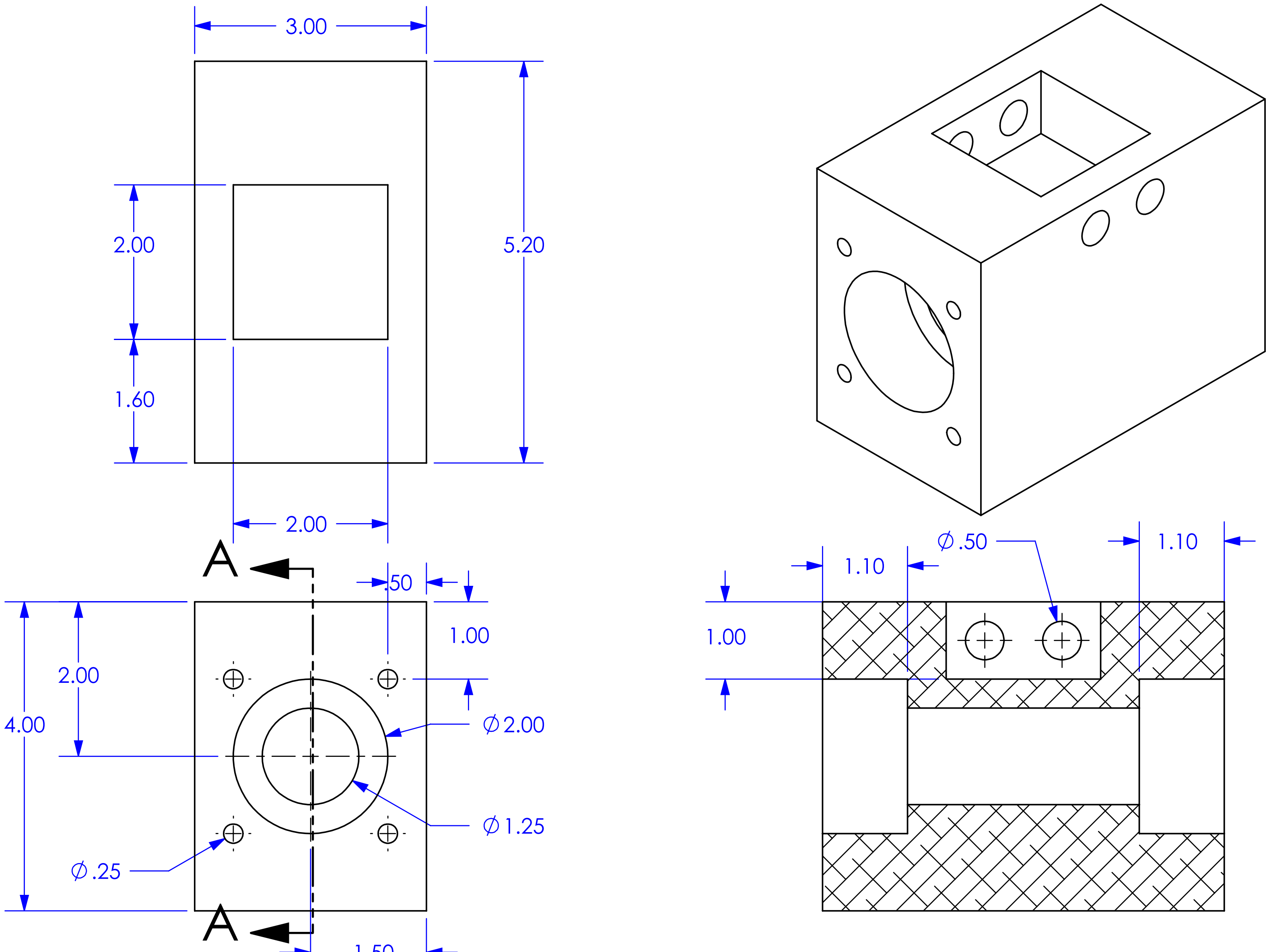
| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | 3014T263 | Eyebolt | 1 |
| 2 | 91247A362 | Bolt - Frame | 2 |
| 3 | 92620A565 | Screw - Frame | 8 |
| 4 | 95505A615 | Nut - Frame | 2 |
| 5 | P2F1 | Cassette | 1 |
| 6 | P2F2 | Frame - Column | 1 |
| 7 | P2F3 | Bearing - Plate | 2 |
| 8 | RWCR-20-1 | Frame - Bearing | 2 |



| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: N/A | Units: Inches | Drawing #: A2F | |
| Tolerance: ±.01 | Scale: 1:4 | Title: Frame | |
| Next Assy: A1 | Date: March 13, 2009 | Group: Adams and Team | |

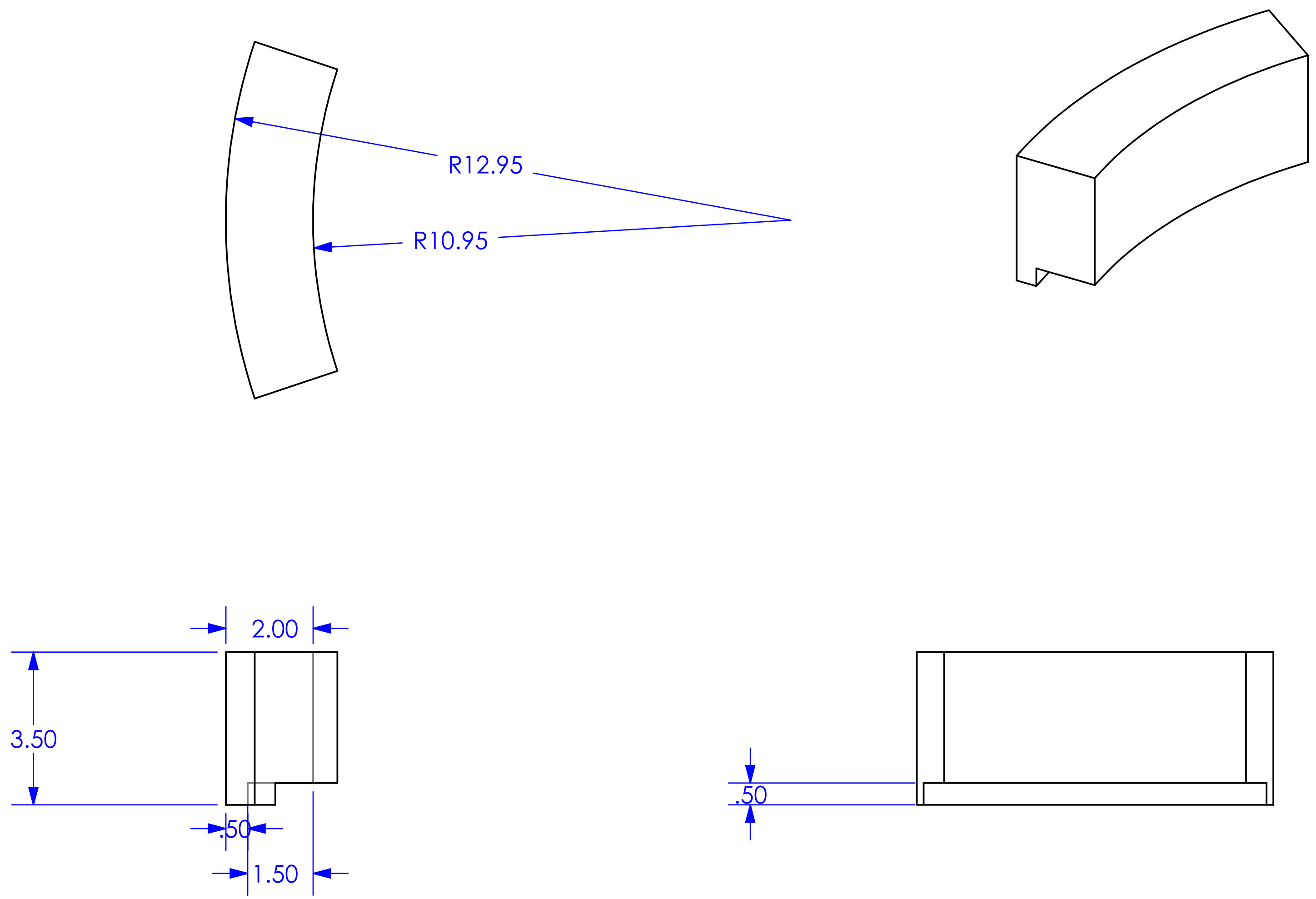



| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Steel AISI 1020 | Units: Inches | Drawing #: P2F3 | |
| Tolerance: ±.01 | Scale: 1:1 | Title: Bearing - Plate | |
| Next Assy: A2F | Date: March 13, 2009 | Group: Adams and Team | |




SECTION A-A

| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Aluminum 6061 | Units: Inches | Drawing #: P2F1 | |
| Tolerance: ±.01 | Scale: 1:2 | Title: Cassette | |
| Next Assy: A2F | Date: March 13, 2009 | Group: Adams and Team | |




*Dimensions in front view are for cross sectional area

| | | | |
|---|---|---|---|
| | | Drawing By: Christopher Adams | Init: |
| Material: Steel with Lead Shot | Units: Inches | Drawing #: P1T6 | |
| Tolerance: ±.01 | Scale: 1:4 | Title: Counterweight | |
| Next Assy: A1 | Date: March 13, 2009 | Group: Adams and Team | |

# OSHA Standards

OSHA is the governing board in charge of protecting American Workers. Its primary obligations are to

- Encourages employers and employees to reduce workplace hazards and to implement new safety and health programs or improve existing programs;
- Develops mandatory job safety and health standards and enforces them through work site inspections, employer assistance, and sometimes, by imposing citations or penalties or both;
- Establishes responsibilities and rights for employers and employees to achieve better safety and health conditions;
- Conducts research, either directly or through grants and contracts, to develop innovative ways of dealing with workplace hazards;
- Maintains a reporting and record keeping system to monitor job-related injures and illnesses;
- Establishes training programs to increase the competence of occupational safety and health personnel; and
- Develops analyzes, evaluates, and approves state occupational safety and health programs.
- Provides technical and compliance assistance, training and education, and cooperative programs and partnerships to help employers reduce worker accidents and injuries.

Since our design is to be used in a manufacturing environment, OSHA rules apply to the operations, installation and maintenance of our brake manipulator assembly. Therefore it is essential that the following guidelines be followed.

- Provide a workplace free from recognized hazards;
- Keep workers informed about OSHA and safety and health matters with which they are involved
- Comply in a responsible manner with standards, rules, and regulations issued under the *OSH Act*;
- Be familiar with mandatory OSHA standards;
- Make standards available to employees for review upon request;
- Evaluate workplace conditions;
- Minimize or eliminate potential hazards;
- Make sure employees have and use safe, properly maintained tools and equipment (including appropriate personal protective equipment);
- Warn employees of potential hazards;
- Establish or update operating procedures and communicate them to employees;
- Provide medical examinations when required;
- Provide training required by OSHA standards;

Since our manipulator involves the lifting and handling of both the brake drum assembly and the manipulator device, the manufacturing plant should follow the OSHA standards:

- 1910.9 (a) and (b)
- 1910.132(a)
- 1910.132(d)(1)
- 1910.132(d)(1)(i)
- 1910.132(d)(1)(ii)
- 1910.132(d)(1)(iii)
- 1910.132(f)
- 1910.132(f)(1)
- 1910.132(f)(1)(i)
- 1910.132(f)(1)(ii)
- 1910.132(f)(1)(iii)
- 1910.132(f)(1)(iv)
- 1910.132(f)(2)
- 1910.132(f)(3)
- 1910.132(f)(3)(i)
- 1910.132(f)(3)(ii)
- 1910.132(f)(3)(iii)
- 1910.132(f)(4)
- 1910.133(a)(1)
- 1910.133(a)(1)
- 1910.133(a)(2)
- 1910.133(a)(3)
- 1910.133(a)(4)
- 1910.135(a)
- 1910.135(a)(1)
- NIOSH Lifting Tasks

These standards deal with providing training or retraining, providing Personal Protective Equipment, or PPE, and set lifting guidelines to employees directly associated with the handling and use of the brake manipulator. PPE required for the safe operation of the manipulator should include gloves, safety glasses, and a impact resistant helmet that conforms to ANSI standard Z-89. Complete details for the specified OSHA standards are as follows.

**1910.9(a)**

Personal protective equipment. Standards in this part requiring the employer to provide personal protective equipment (PPE), including respirators and other types of PPE, because of hazards to employees impose a separate compliance duty with respect to each employee covered by the requirement. The employer must provide PPE to each employee required to use the PPE, and each failure to provide PPE to an employee may be considered a separate violation.

**1910.9(b)**
Training. Standards in this part requiring training on hazards and related matters, such as standards requiring that employees receive training or that the employer train employees, provide training to employees, or institute or implement a training program, impose a separate compliance duty with respect to each employee covered by the requirement. The employer must train each affected employee in the manner required by the standard, and each failure to train an employee may be considered a separate violation.

**1910.132(a)**
Application. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

**1910.132(d)(1)**
The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE). If such hazards are present, or likely to be present, the employer shall:

**1910.132(d)(1)(i)**
Select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment;

**1910.132(d)(1)(ii)**
Communicate selection decisions to each affected employee; and,

**1910.132(d)(1)(iii)**
Select PPE that properly fits each affected employee. Note: Non-mandatory Appendix B contains an example of procedures that would comply with the requirement for a hazard assessment.

**1910.132(f)**
Training.

**1910.132(f)(1)**
The employer shall provide training to each employee who is required by this section to use PPE. Each such employee shall be trained to know at least the following:

**1910.132(f)(1)(i)**
When PPE is necessary;

**1910.132(f)(1)(ii)**
What PPE is necessary;

**1910.132(f)(1)(iii)**
How to properly don, doff, adjust, and wear PPE;

**1910.132(f)(1)(iv)**
The limitations of the PPE; and,

**1910.132(f)(2)**
Each affected employee shall demonstrate an understanding of the training specified in paragraph (f)(1) of this section, and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE.

**1910.132(f)(3)**
When the employer has reason to believe that any affected employee who has already been trained does not have the understanding and skill required by paragraph (f)(2) of this section, the employer shall retrain each such employee. Circumstances where retraining is required include, but are not limited to, situations where:

**1910.132(f)(3)(i)**
Changes in the workplace render previous training obsolete; or

**1910.132(f)(3)(ii)**
Changes in the types of PPE to be used render previous training obsolete; or

**1910.132(f)(3)(iii)**
Inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill.

**1910.132(f)(4)**
The employer shall verify that each affected employee has received and understood the required training through a written certification that contains the name of each employee trained, the date(s) of training, and that identifies the subject of the certification.

**1910.133(a)**
General requirements.

**1910.133(a)(1)**
The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

**1910.133(a)(2)**
The employer shall ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g. clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.

**1910.133(a)(3)**
The employer shall ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design, or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.

**1910.133(a)(4)**
Eye and face PPE shall be distinctly marked to facilitate identification of the manufacturer.

**1910.135(a)**
General requirements.

**1910.135(a)(1)**
The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects.

Application of the NIOSH lifting tasks assumes the following:

- Lifting task is two-handed, smooth, in front of the body, hands are at the same height or level, moderate-width loads (i.e., they do not substantially exceed the body width of the lifter), and the load is evenly distributed between both hands.
- Manual handling activities other than lifting are minimal and do not require significant energy expenditure, especially when repetitive lifting tasks are performed (i.e., holding, pushing, pulling, carrying, walking or climbing).
- Temperatures (66-79°F) or humidity (35-50%) outside of the ranges may increase the risk of injury.
- One-handed lifts, lifting while seated or kneeling, lifting in a constrained or restricted work space, lifting unstable loads, wheelbarrows and shovels are not tasks designed to be covered by the lifting equation.
- The shoe sole to floor surface coupling should provide for firm footing.
- Lifting and lowering assumes the same level of risk for low back injuries.