



Design Report for Belly Pan Jack

Prepared for: Gibbs Construction

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Dear Mr. Gibbs

Team 56 of the Saluki Engineering Company would like to thank you for the opportunity to design and build the belly pan jack. The following design report contains all the information for the design and the prototype of the belly pan jack.

The main objective of this project is to design a safe and efficient tool to be used to remove and install belly pans. In order to achieve this, a number of different subsystems have been incorporated into the design. The design incorporates the use of a top that will contact the belly pan and has the ability to tilt in two directions in order to adapt to the numerous shapes of belly pans. The design also has an air over hydraulic pump for ease of use since an air supply will readily available in the client's shop. The belly pan jack is easily moved thanks to the large six inch diameter steel caster wheels. The belly pan jack also incorporates a velocity fuse and a hydraulic flow regulator as the safety mechanism. Another important safety feature of the jack is that it can be operated remotely allowing the mechanic to be out of the way.

The cost to build the prototype was **\$1,110.09**. If you have any questions, comments, or concerns feel free to contact Alex Gibbs at (618) 527 – 8673, or email gbg@dishmail.net. Thank you again for allowing us to design the belly pan jack.

Sincerely,

Alex Gibbs (Project Manager)
Team 56-Bellypan Jack

Acknowledgments

There are several people that were of great help in designing the belly pan jack. Dr. Gary Butson was of great assistance when designing the lifting mechanism. Dr. Butson's knowledge of structures and force analysis helped determine the forces that were generated in each member which allowed us to determine the amount of force needed to be provided by the cylinder. Since the prototype of the belly pan jack was not contracted out, the machining was done in the MEEP machine shop and at Gibbs Construction's shop. Tim Attig's knowledge of machining tools and his willingness to allow us to work in his shop is greatly appreciated. Without the use of the MEEP machine shop and Tim's knowledge of setting up the machines the belly pan jack would not have been able to be built.

Team 56 would also like to thank Chuck Evans of DMS Welding and Machine, for supplying a large portion of the materials used in building the prototype. Chuck was able to sell the materials to Team 56 at his cost, which greatly reduced the total cost of the prototype. Chuck also helped in the design of the belly pan jack by making suggestions as to what materials should be used. The final "thanks" has to be given to Greg Gibbs, owner of Gibbs Construction for giving us the opportunity to design the belly pan jack.

When preparing this report, each team member was assigned specific sections to complete. Alex Gibbs was given the power subsystem, the end of project memo, and the job of reading the final report to ensure that each section fit together nicely as well as writing the user's and technical manual and appendices. Ross Heern was assigned the safety subsystem and the Appendix E which contains the equations used to determine the size of the velocity fuse. Jason Webber was assigned the lifting surface subsystem; Bradley M. Wilson was assigned the chassis subsystem and the job of putting all parts of the reports together and making the table of

contents. Matt Lane was given the job of making all the Autodesk Inventor drawings and the detailed part drawings throughout the report and in the appendices of the report. Blake Thurston was given the general section of the report, the lifting mechanism subsystem and Appendix C which contains the equations and spread sheet used in completing the force analysis of the lifting mechanism.

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1.0 Executive Summary

The Saluki Engineering Company (SEC) design team 56 constructed the prototype of a belly pan jack for Gibbs Construction. The purpose of this jack is to provide an efficient means of removing and installing belly pans on heavy equipment such as bulldozers. The final design is a direct representation of the design presented in the design proposal with only minor changes. This report is divided into sections that were given to the team members to write. To begin the report is a general section which contains an introduction to the project and why it is needed, an overview of the project, a cost break down of the design, and a timeline for implementation. After the general section, the subsystem section of the report is presented, and it contains the five major subsystems of the design. This is followed by a User's Guide/Technical Manual and the final parts of the report are the Appendices.

In comparison to other lifting devices such as lift tables or transmission jacks, the designed belly pan jack is superior due to its performance specifications and its ability to adapt to numerous applications. Unlike most other lifting devices on the market, the designed belly pan jack has several safety devices to protect the operator. The first safety device utilized is a remote controlled pump which allows the operator to be away from the jack when raising or lowering the belly pans. Another safety device incorporated into the design is a velocity fuse on the pump which only allows a certain amount of oil flow before the fuse closes and no oil is allowed to flow, which will ensure if the hydraulics fail the jack will not fall. Another advantage of the designed belly pan jack is the lifting surface's ability to tilt to two directions, allowing it to accommodate various sizes and shapes of belly pans.

In considering the project as a schedule, we began designing the belly pan jack in September 2010 and completed the prototype in April 2011. The total cost for the prototype was **\$1,110.09**. However, many parts were made of materials on hand and the labor was free of charge.

2.0 Project Description

2.1 General Description

In the heavy machinery industry, equipment needs to be serviced on a regular basis. When purchasing equipment one looks at: the value, cost, dependability, ease of operation, and ease of maintenance of the machine. In many cases the maintenance of the machinery is among the most important. Many areas of maintenance involve the removal of protective plates from beneath the machine; these protective plates are often referred to as belly pans. Belly pans are large, bulky, difficult, and dangerous to remove and return beneath the machine. Methods of

removing belly pans have consisted of using a crane to apply a force to a strap from one side of the machine, anchored to the opposite side of the machine, and put tension on the strap to support the belly pan. Obviously a major problem with this is safety, as well as effectiveness, not to mention the availability of a crane. Other methods involve using several different jacks in conjunction with blocks to lift the belly pan. Safety and effectiveness are concerns with this method as well. There are a number of transmission jacks and lift tables that may work, but safety and effectiveness are still a major concern, because the manufacturer did not design the device for such conditions.

Among safety and effectiveness; dependability, ease of operation, ease of maintenance, maneuverability, and cost were considered when designing the belly pan jack. The designed belly pan jack will: provide a safe and effective way of removing and replacing the belly pan, be easily maneuvered, have fully integrated controls, be easy to work around while in the open shop as well as under the machine, and be cost effective. The subsystems which the belly pan jack consists of are: a safety mechanism, main lifting mechanism, power system, chassis, and platform/lifting surface. The belly pan jack will be easily situated beneath the machine, the wheels locked, connected to the shop air supply, raised to the belly pan, the belly pan unbolted, the jack will then be lowered, and the belly pan taken to be cleaned and service on the machine can be done easily. The innovative, user friendly design of the belly pan jack makes it an excellent choice for the service of large machinery.

2.2 Subsystem Interaction

There are five major subsystems of the design belly pan jack. The subsystems are: the chassis, the lifting mechanism, power, safety, and the lifting surface. The chassis of the belly pan

jack provides good stability when in operation as well as good mobility once the pan has been removed from the machine and needs to be relocated to be cleaned and for the machine to be serviced. Attached to the top of the chassis are the lifting mechanism and power subsystems. These two subsystems combine to provide the functionality of the jack. The lifting mechanism provides the lifting surface with stability as well as a direction of travel, while the power subsystem provides the lifting mechanism with the force needed to lift the belly pan. Incorporated into the power subsystem is the safety subsystem which allows the operator to confidently use the belly pan jack. Attached to the lifting mechanism is the lifting surface which allows the jack to be used for various sizes and shapes of belly pans. A block diagram shown in Figure 1 shows the relationships between the subsystems of the belly pan jack.

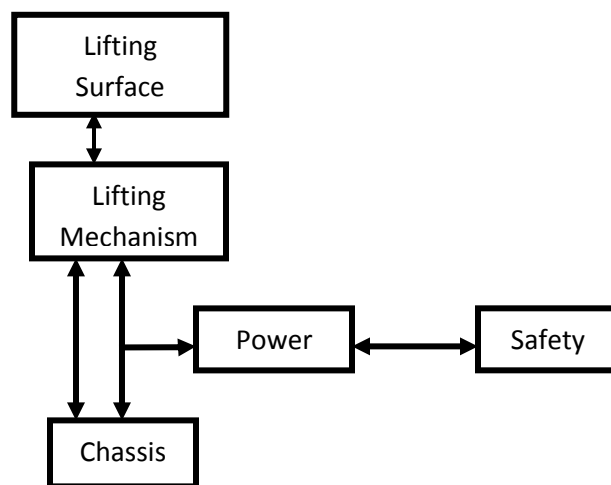


Figure 1: Block Diagram

2.3 Design Considerations

The chassis subsystem was the simplest to design of all the subsystems, because the function of the chassis is simple, provides support to the lifting mechanism, has the stability to the jack as a whole, and can be easily maneuvered. The support and stability was easily achieved by designing the chassis to have a good sturdy frame and having large heavy duty caster wheels. These large heavy duty 6 inch steel caster wheels along with a handle provide the jack with the ability to be easily maneuvered when fully loaded with a belly pan.

Several considerations went into designing the power subsystem. Different actuators such as air bags, screw actuators, and hydraulic cylinders were considered in the design process. The hydraulic cylinder was eventually decided upon because of the ease of operating the cylinder. The cylinder could be operated with a hydraulic pump, where as an air bag uses air as the working fluid which is not as simple to work with as hydraulic fluid; a screw actuator would have needed a means of turning the screw to move the lifting mechanism. Once the actuator had been selected the air over hydraulic pump was selected to supply the hydraulic fluid to the cylinder. This pneumatically controlled pump was selected, because the air supply is readily available in places where the jack will be used.

Three main considerations were taken into account when the lifting mechanism was being designed. The design considerations were that the mechanism had to collapse (fold down) to an overall height of 18 inches to accommodate machinery with low ground clearances, extend to a height of 55 inches to accommodate machinery with high ground clearances, and the

direction of travel of the lifting surface that the mechanism would provide. The scissors type of lifting mechanism was eventually chosen, because it met all of these needs. Like the lifting mechanism, only a couple of considerations were taken into account when it was being designed. The main design consideration was that the lifting surface be able to accommodate machines with various shapes and sizes of belly pans. This was accomplished by designing the lifting surface to be able to tilt in two directions.

Once all other subsystems had been designed the safety subsystem was designed. The main design consideration for the safety subsystem was to keep the jack from suddenly collapsing if the power system were to fail. This consideration was met by connecting a velocity fuse to the cylinder. In the event that the hose were to rupture, the velocity fuse would close, shutting off flow, because the flow rate of fluid from the cylinder would be high enough to trip the fuse.

3.0 Subsystem Description

3.1 Subsystems Introduction

There are five major subsystems of the design belly pan jack. The subsystems are: the chassis, the lifting mechanism, power system, safety system, and the lifting surface. Each subsystem is equally important in the operation of the belly pan jack. This section will explain in detail how each subsection works, and give a detailed description of the individual pieces of the subsystems.

3.2 Chassis



Figure 2: BPJ-2000 Chassis

3.2.1 Technical Description

To make the belly pan jack easy to move while loaded, four 6 inch locking steel caster wheels were chosen for their low rolling resistance and long life. These wheels are mounted snugly to the chassis and allow the chassis to sit very close to the ground which enhances the stability of the entire jack. Along with the wheels, the chassis has a pivoting handle to use while moving the belly pan jack. The handle is four feet long which allows for the operator to pull the belly pan out from under the machine without crawling under it. The handle also has a hitch at the end for towing the belly pan jack with a forklift or other small implement when it is fully loaded. The handle also has two hooks to be used as a storage device for the leads that go to the power system's remote control. At the base of the handle is the power system containment box, which securely houses the hydraulic pump. The frame of the chassis is constructed from 1x2x0.1875 inch rectangular tubing. The steel tubing is welded into a rectangle of 27x40 inches with

steel plates welded along the interior of the 40 inch members which provide a surface for the lifting system mounts to be welded to as well as a surface for the sliders to slide on. The areas of highest stress were located using FEA. Then gussets were added until the stress in the chassis was within satisfactory levels.

3.2.2 Design Process

The chassis subsystem, Figure 2, is the foundation support of the belly pan jack. It not only supports the lifting system, but it also contains the power system and facilitates mobility by allowing the belly pan jack to roll freely via the large steel caster wheels. The chassis design allows for a low profile and contributes to the belly pan jacks overall low clearance capabilities. The chassis also houses the hydraulic pump and reservoir as well as the lower mount point for the lifting cylinder. Along with contributing to the ease of mobility and connecting the power system to the lifting system the chassis supports the load of the lifting system.

3.2.3 Fault Analysis

Like the lifting system the most likely cause of failure to the chassis of the belly pan jack is due to over loading. If the belly pan jack was loaded beyond its capacity it is possible that the chassis could fail in three modes. The first would be bending in the frame, which is the least catastrophic of the three possible failures. If the frame were to fail, the chassis would simply contact the ground, which would then interfere with the sliders and possibly cause binding in the lifting system. The second is in severe over loading the lifting ram mounting point could break and allow the load to be dropped, however, the chassis was designed so that in this mode of

failure there is substantial bracing behind the mount point which would keep the ram from completely escaping the chassis and not allow the load to completely drop. The third mode of failure would be if a wheel failed to support the load. This would make the belly pan jack unstable and unable to be moved because of the low ground clearance the chassis will settle to the ground before the center of gravity moves outside of the footprint of the chassis. The immobility of the belly pan jack will not cause a hazard, and the jack should be able to be unloaded and repaired safely.

3.2.4 Parts List

Table 1 is a parts list of the chassis of the BPJ 2000, a complete parts list with detailed drawings is located in Appendix.

Table 1: BPJ-2000 Chassis Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	C-2	Narrow chassis
2	2	C-3	Side chassis
3	2	C-4	Plate
4	4	C-5	Tab
5	4	C-6	Caster mount outside
6	4	C-7	Caster Top plate
7	4	C-8	Caster Wheel
8	2	C-9	Cylinder Bracket bottom
9	4	C-10	Caster mount inside
10	1	C-11	Handle support
11	2	C-12	Pump box side plate
12	1	C-13	Pump box bottom plate
13	1	C-14	Pump box back plate
14	2	C-15	bottom support
15	2	C-16	Handle Mount
16	2	C-17	Side Yoke
17	1	C-18	Top Yoke
18	1	C-19	Handle Pipe
19	1	C-20	Tow Ring
20	1	C-21	Handle Bolt
21	1	C-22	Handle nut
22	1	C-23	Handle Grip

3.3 Lifting Mechanism

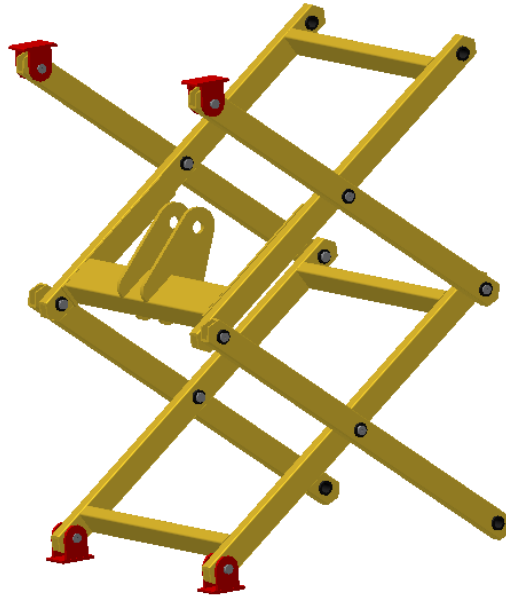


Figure 3: BPJ-2000 Lifting Mechanism Subsystem

3.3.1 Technical Description

The main parts of the lifting mechanism are the lifting members. There are a total of eight lifting members which have an overall length of 33 inches each. The lifting members were made of ASTM A500 steel, which is a structural steel, to withstand the forces generated at the joints of the mechanism. The only difference in the eight members is that, two of the members which the cylinder mounts to have an extra steel plate welded to them to increase their strength to accommodate the large force that is applied there. Three holes were drilled in each member to allow the members to be connected to each other as well as the other subsystems. Bushings/sleeves were then machined from cold rolled stock and welded into the holes.

To connect the members to each other and the other subsystems sixteen pins were machined from stress proof pin stock. Eight of these pins were made to 3.125 inches long to connect the members to each other, and the other eight pins were made to a length of 2.25 inches to connect the members to the sliders of other subsystems. The pins were machined to incorporate a grease fitting so the joints of the lifting

mechanism could be greased to provide smooth operation. From the grease fitting, the grease flowed through small cavities that were machined in the pins. To insure the pins would not come out of the joints, the pins were fitted with a standard 0.3125 inch hard flat washer on one end with the grease fitting, and a standard 0.75 inch external snap ring on the other end.

The lifting mechanism was attached to the chassis by mounting brackets that were made from AISI-1040 Steel. There were a total of eight mounting brackets that were made from the steel plate, four were welded to the chassis subsystem and four are welded on the lifting surface subsystems. The other ends of the lifting mechanism are attached to sliders, which allow the ends of the members to slide along the tracks made on the chassis subsystem and the lifting surface subsystem. The sliders were made of the same material as the mounting brackets. The tracks of the sliders are able to be greased allowing the sliders to move through the range of motion easily. The ends of the lifting mechanisms which are attached to the sliders have two steel stabilizers attached between the top and bottom sliders. These braces keep the top and bottom sliders in the same position which keeps the lifting mechanism from getting in a bind where it will not want to operate smoothly. The braces are bolted to a small steel block, the block separates the stabilizers so one brace is on top of the track and one brace is beneath the track keeping the sliders from coming off of the track in case the belly pan jack was loaded improperly.

The final parts of the lifting mechanism that were assembled are the mounting brackets for the cylinder. The cross member of the lifting mechanism which carries all the force from the cylinder is made of AISI-1040 rectangular steel tubing. Welded to this cross member are mounting brackets for the cylinder.

3.3.2 Design Process

The lifting mechanism, Figure 3, is the core of the belly pan jack, as it provides the lifting support and determines the motion of travel for the lifting surface. The lifting mechanism is connected to the

chassis subsystem and the lifting surface subsystem, with the power subsystem integrated into it to provide power for lifting. A considerable amount of time and effort went into designing the lifting mechanism. During the design process several design parameters were considered, these design parameters are: the lifting surface must travel only in the vertical direction, the mechanism must collapse (fold down) to a height of 18 inches to be able to accommodate machines with low ground clearances as well as reach a height of 55 inches when fully extended to accommodate tall machines as well. Several different designs were considered and the scissors type of lifting mechanism shown in Figure 3 was chosen because it best suited the design parameters.

Once the type of lifting mechanism had been decided upon, a complete force analysis was done on the lifting members. The equations used and the matrix that was constructed, can be seen in Appendix B. A force analysis was done to determine the amount of force is generated at the joints of the members, as well as to determine the lifting force required by the power subsystem to lift the load. The lifting mechanism was design to safely lift a weight of 2000 lbs. This incorporates a factor of safety of 2.5 so the maximum load is quite adequate to accommodate the weight of most belly pans.

3.3.3 Fault Analysis

The most likely cause of failure in the lifting mechanism is by over loading the belly pan jack. If the belly pan jack were over loaded the cylinder or cylinder mount would fail first. The cylinder mounts are transmitting a considerable amount of force from the cylinder to the lifting mechanism. The cylinder mounts are also made of mild strength steel where the lifting members are made of high strength steel. However the cylinder mounts were design to fail first because, the mounts would be a simpler or quicker fix than if one of the members failed by bending or fracturing.

The second most likely source of failure would occur in the shearing of a pin which connects the members together. At the points of the lifting mechanism where the members are joined together the pins

are only in single shear. Increasing the probability of the pins to shear is the grease cavity where material was taken out of the center of the pin. However, through proper maintenance and by not exceeding the recommended lifting capacity the jack will operate smoothly.

3.3.4 Part List

Table 2: Parts list of BPJ 2000 Lifting Mechanism

Part #	Part Description	Quantity
L-2	Scissors members	8
L-3	Bushings/Sleeves	24
L-4	Slider Base	4
L-5	Slider Tab	8
L-6	Long Pin	8
L-7	Cylinder Support for Members	2
L-8	Short Pin	8
L-9	Cylinder Cross Member	1
L-10	Cylinder Bracket	2
L-11	Bottom Slider Stabilizer	2
L-12	Top Slider Stabilizer	2
L-13	Stabilizer Spacer	4

3.4 Power Subsection

3.4.1 Technical description

The power system on the belly pan jack consists of a hydraulic cylinder, hydraulic motor, and an air over hydraulic pump. One double acting, hydraulic cylinder will be used; however, the cylinder will be plugged on one end so it acts as a single acting cylinder. The maximum hydraulic pressure input is 3500 psi. The maximum load rating for cylinder is 20 000 lbs. The hydraulic cylinder will extend from the bottom of the chassis to the mounting point on the scissor arms. The cylinder must also be able to support the maximum load on the jack while maintaining a factor of safety of 2.5.

The air over hydraulic pump will power the hydraulic cylinder. A compressed air supply is used to cycle a piston. As the piston is compressed by air, it will pump hydraulic fluid into the system. Once fully compressed, a one-way hydraulic valve will close, and a spring returns the piston back to initial stage to start the cycle over. The pump is capable of producing a hydraulic pressure 3200 psi with an input air pressure of 120 psi. Controls will be fully integrated for easy operation of the jack. The control for the system is a remote air valve. The valve has one button for raising the cylinder and one button for lowering the cylinder. The cylinder will be raised by the hydraulic pressure produced by the pump. Since the double acting cylinder is plugged, the weight of the table will provide the force to lower the jack when the lowering button is pushed to open the valve.

3.4.2 Design Process

The hydraulic cylinder was chosen so that the maximum lifting capacity of the belly pan jack could be safely supported. The parameters that were considered when choosing the hydraulic cylinder were the bore, rod diameter, max load, and maximum pushing force. Since the cylinder is not required to pull it will be plugged at the top end so that it acts as a single acting cylinder.

An air over hydraulic pump was chosen so that the jack could be used in a variety of places without the need of electricity. The parameters that were considered when choosing the pump were the maximum air pressure supported, maximum oil pressure created, reservoir size, and ease of use.

3.4.3 Fault Analysis

The power system is most likely to fail when a maximum load is present and the scissor members are in a position producing maximum force on the hydraulic cylinder. Figure 4 shows

the maximum force with respect to scissor position occurs when the jack is fully lowered. The load position on the platform may also affect the load. A load that is off center by more than the recommend 25% of the total length or width may produce loads greater than designed for. A load higher than designed for may cause a failure of the hydraulic cylinder, hydraulic lines, or hydraulic pump.

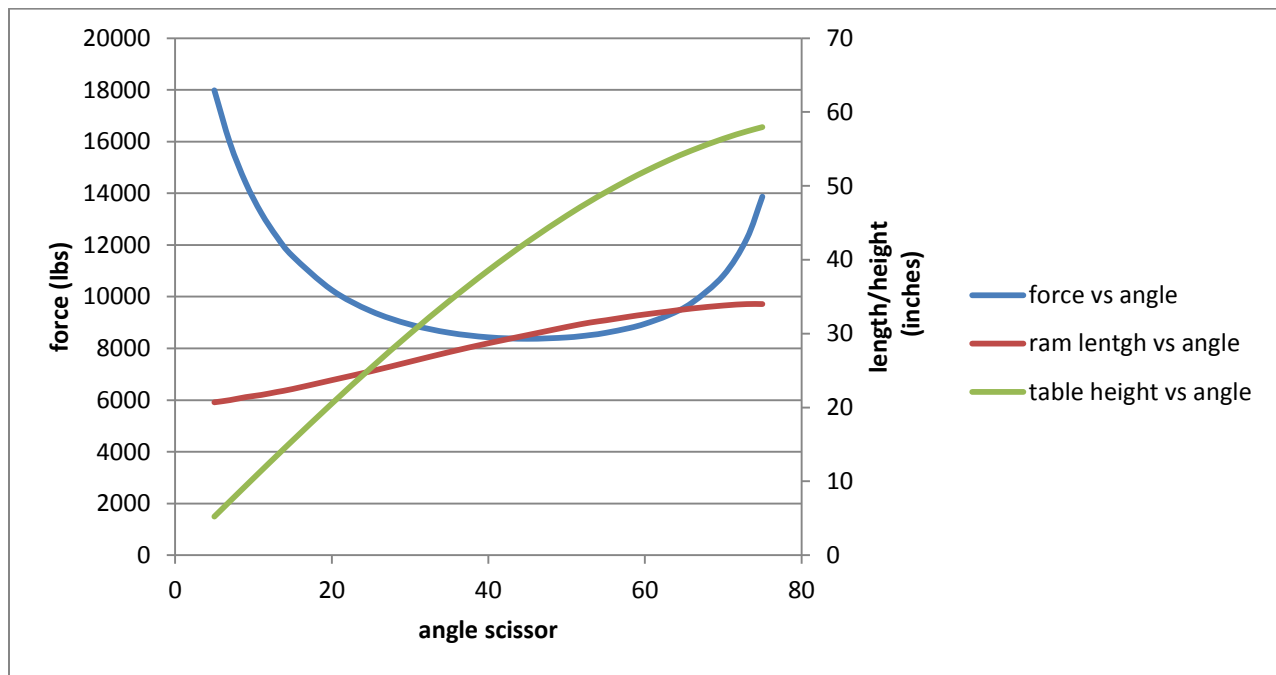


Figure 4: Cylinder Force, Ram Length, Table Height vs. Scissor Angle

3.5 Safety

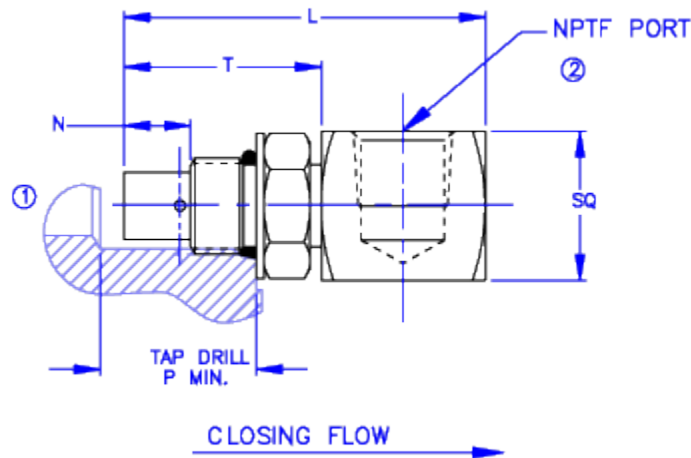


Figure 5: BPJ 2000 Safety Velocity Fuse [2]

3.5.1 Technical Description

Several considerations had to be met when designing the safety of the belly pan jack. The following are considerations: allowing the operator to be able to operate the belly pan jack from a safe distance if needed, full control of the jack must be maintained by the operator, and the operator must be protected in the event of a loss of pressure causing the jack to collapse.

To achieve these, several items had to be used in conjunction with each other. A velocity fuse to prevent the jack from collapse in the event of sudden loss of hydraulic pressure; a flow regulator to provide more control to the downward motion of the jack (to prevent the belly pan jack from dropping rapidly while loaded); the control for the pump is a remote with a twelve foot long hose to keep the operator clear of the belly pan jack.

The velocity fuse, Figure 5, is an in line 90° elbow swivel with an NPTF outlet port that provides full line shut off in the event of line failure resulting in sudden loss of pressure. The velocity fuse acts like an electrical fuse in that it is set at a predetermined flow rate, for which the fuse will trip if that flow rate is met or exceeded. After the fuse is tripped, it holds the hydraulic

fluid in the hydraulic cylinder until the fuse can be reset by applying pressure to the fuse to decrease the pressure differential to 50 psi: simulating the ruptured hydraulic line being replaced and operated to raise the belly pan jack decreasing the pressure differential eventually reaching equilibrium and resetting the velocity fuse. Exact dimensions and drawings can be found in Appendix E.

The flow regulator, Figure 6, is an in line hydraulic flow regulator with an NPTF outlet that regulates the flow of fluid into the pump, and it occurs when the jack is being lowered. In this way the flow regulator provides the operator with added control, preventing the belly pan jack from being lowered too quickly while loaded. Exact dimensions and drawings can be found in Appendix E.

The remote control for the pump is fully integrated into the pump itself. The remote is twelve feet long and allows the jack to be controlled from a distance of twelve feet and keeps the operator clear of the jack while lifting and lowering. In this way it greatly decreases the chance of injury to the operator [2].

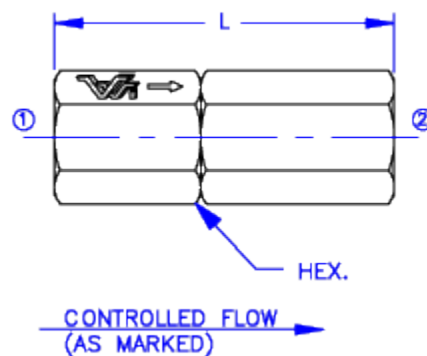


Figure 6: BPJ 2000 Safety Flow Regulator [2]

3.5.2 Design Process

Originally the safety mechanism was a mechanical mechanism integrated into the lifting mechanism which would lock the jack in place as it rose. This, however, was altered to a hydraulic safety valve known as a velocity fuse. The velocity fuse reduces the weight of the belly pan jack as well as lowering the cost and maintenance required for the belly pan jack. The velocity fuse allows uncontrolled flow in one direction, into the cylinder, and allows monitored flow the other direction, out of the cylinder. In order to monitor the flow, the fuse was set at a predetermined flow rate for which the fuse would close off flow out of the cylinder.

The velocity fuse was used in conjunction with a flow regulator. The flow regulator allows uncontrolled flow one direction, out of the pump, while controlling the flow in the other direction, into the pump which facilitates the jack being lowered. The flow regulator was also set at a predetermined flow which was achieved by the specs of the pump. Since the pump pumps a minimum of 28 cubic inches per minute at maximum pressure and a maximum of 108 cubic inches per minute at minimum pressure, the flow regulator was set to 58 cubic inches per minute, a value which allows the belly pan jack to be lowered at a controlled and efficient speed. The velocity fuse was set at a trip flow which was suggested to be 40% higher than the maximum flow rate in the controlled direction. This is to protect against surges on initial startup. Since the regulated flow was set to 58 cubic inches per minute, the velocity fuse was set to trip at 81 cubic inches per minute. This elevated flow rate will only be reached in the event of a ruptured line or fitting.

3.5.3 Fault Analysis

It is worth stating that the likelihood of failure of the safety subsection is unlikely but several sources of failure are mentioned. Possible failure of the safety subsection resides in the flow regulator and velocity fuse as well as the cylinder itself. Although the likelihood of failure of the velocity fuse and regulator is minimal, it is still worth noting that all devices have a limited life and can fail at any moment due to unforeseen circumstances. That said, the integrity of the flow regulator and velocity fuse are found to be sound and of top quality. Also a source of failure is the hydraulic cylinder itself. Since the velocity fuse is set to trip in the event of a ruptured line, the fuse uses the cylinder to stop the belly pan jack from dropping, the cylinder could possibly break. This is unlikely though, and generally steel lines and cylinders are considered a positive safety device with the source of failure is in the fluid itself. Taking these faults into account, the safety subsystem is a sound system and an adequate source of safety for the equipment, operator, and bystanders.

3.5.4 Parts List

Table 3: BPJ-2000 Safety Parts List

	Part Description	Part #	Quantity
1	Velocity Fuse	A1	1
2	Flow Regulator	A2	1
3	NPTF to o-ring adapter	A3	2

3.6 Platform Subsystem

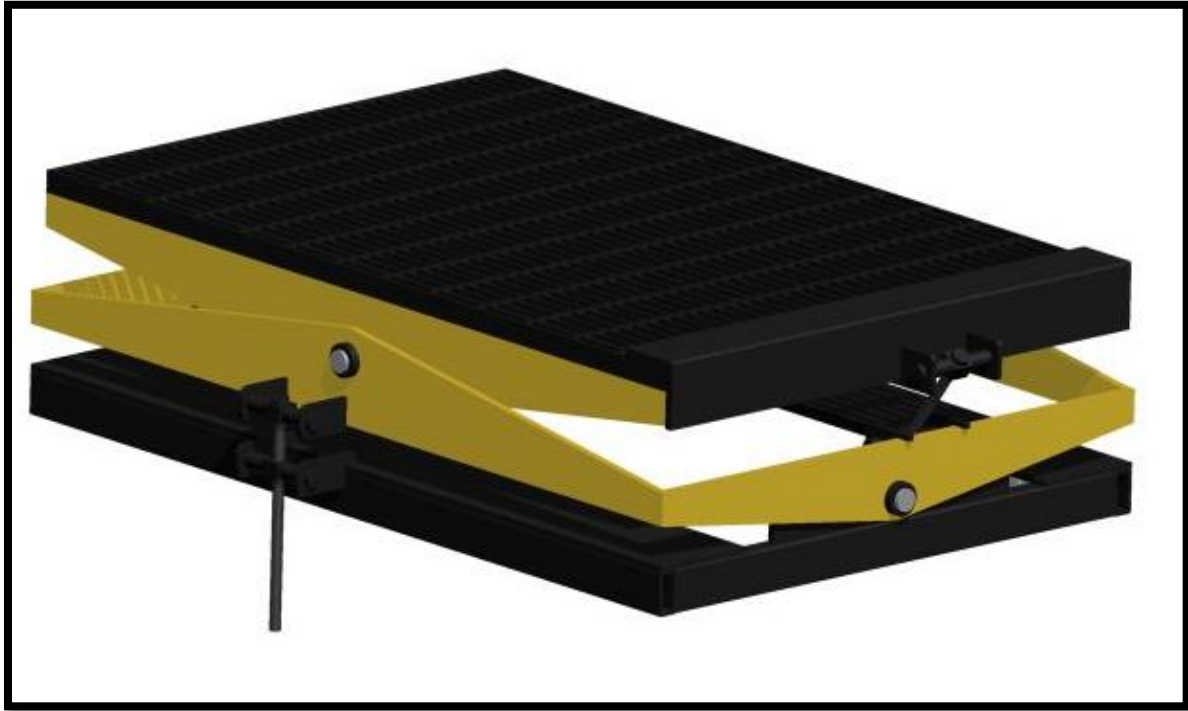


Figure 7: BPJ-2000 Platform Subsystem

3.6.1 Technical Description

The lifting mechanism is linked to the base of the platform with a threaded rod. The base of the platform is also linked to the top of the platform with a threaded rod. The threaded rods can be rotated to adjust the tilt in both dimensions. Both platforms are designed to tilt ± 8 degrees. The ability to tilt makes it possible to orient the platform at any angle. This makes positioning and aligning the lifted object into difficult mounting positions much easier and safer.

The lifting mechanism surface is made of a grating material. This will allow for easy attachment of any fixture. These would include both general manufactured fixtures and/or

custom made-to-fit fixtures. An example of the later would be a simple wood block cut to shape and then bolted to the surface. The grated top mounting system allows for much more mounting flexibility than a standard flat top.

Finally, the pins and threaded links were designed for easy removal. This was done to allow for a multitude of different mounting systems. For example, a low profile flat top could be mounted to the system for low clearance situations. Also, custom tops can be manufactured for applications in which the standard mounting system is inadequate.

3.6.2 Design Process

The platform subsystem is used to connect the lifting mechanism to the object to be supported. The objects to be supported will have varying shapes and sizes. This brings the need for a platform that is capable of fitting a wide variety of objects. To accomplish this, the base of the platform is connected to the lifting mechanism with two pins on each side. The base of the platform is also attached to the top of the platform with pins. The pin connections allow the platform to tilt in two dimensions. The pin holes had a sleeve welded onto them to increase surface area contact to reduce wear. The pins were also equipped with grease fittings to allow for greasing of the pins without removal.

3.6.3 Fault Analysis

The platform system is most likely to fail in a situation where a maximum load is present. The maximum load the system is rated for is 2 000 pounds. The factor of safety the system is designed with is 2.5 meaning failure is possible with any loading above 5 000 pounds. However, the load rating is for a relatively centered load. The specifications require that the center of gravity of the load not move more than 25% of the total length from the center of the platform on

the long axis of the table and the center of gravity should not move more than 25% of the total width from the center on the shorter axis. A load scheme outside of this range does not necessarily mean a failure will occur; however, any loads placed outside of this range may significantly increase the strain on parts to levels above the factor safety and also cause permanent damage to the system.

3.6.4 Parts List

Table 4: BPJ-2000 Platform Parts List

PARTS LIST				
ITEM	QTY	PART NUMBER	DESCRIPTION	COMMENTS
1	2	T-2	Narrow Chassis	See Part C-2
2	2	T-3	Side Chassis	See Part C-3
3	2	T-4	Plate	See Part C-4
4	4	T-5	Tab	See Part C-5
5	2	T-6	Top Front/Back Top	
6	4	T-7	Top Side	
7	8	T-8	Top Sleeve	
8	4	T-9	Top Pin	
9	1	T-10	Top Grate	
10	1	T-11	Top Screw Mount	
11	2	T-12	Side Top Bracket for Screw Adjustment	
12	2	T-13	Side Bottom Bracket for Screw Adjustment	
13	4	T-14	Front Top Bracket for Screw Adjustment	
14	4	T-15	Screw Adjuster	
15	2	T-16	Thread Rod For Top Adjustment	
16	2	T-17	Top Front/Back Bottom	

4.0 Performance

Extensive testing was performed on the functionality of the belly pan jack in the application in which it was designed for. The belly pan jack was physically used under a bulldozer to ensure the design would do what it was supposed to do. The tilting top was also tested by setting different shaped belly pans on it, which it adapted to with ease. The remote control for the power system operates very well and allows the operator to be a good distance from the jack at all times. Due to the large caster wheels and the handle, the belly pan jack moves very easily across the shop floor even when fully loaded. The grease able pins that where precision machined allow the jack to raise and lower very smoothly, while maintaining a constant speed. Due to time restrictions, not much strain testing of the belly pan jack has been performed. However, one test that was performed on the belly pan jack was that the jack was tested to carry its designed load. The belly pan jack was loaded with 2000 lb., and the jack was easily able to raise and lower the load. Even though extensive actual strain testing has not been done on the belly pan jack yet, several simulations were made with the modeling software, Autodesk Inventor. Figure 8 shows the total displacement created in the various parts of the belly pan jack when loaded to with 2000 lbs. The maximum deformation occurred on the far right end of the lifting surface, with a value of 0.31 inches. This deformation is not much considering the overall height of the jack.

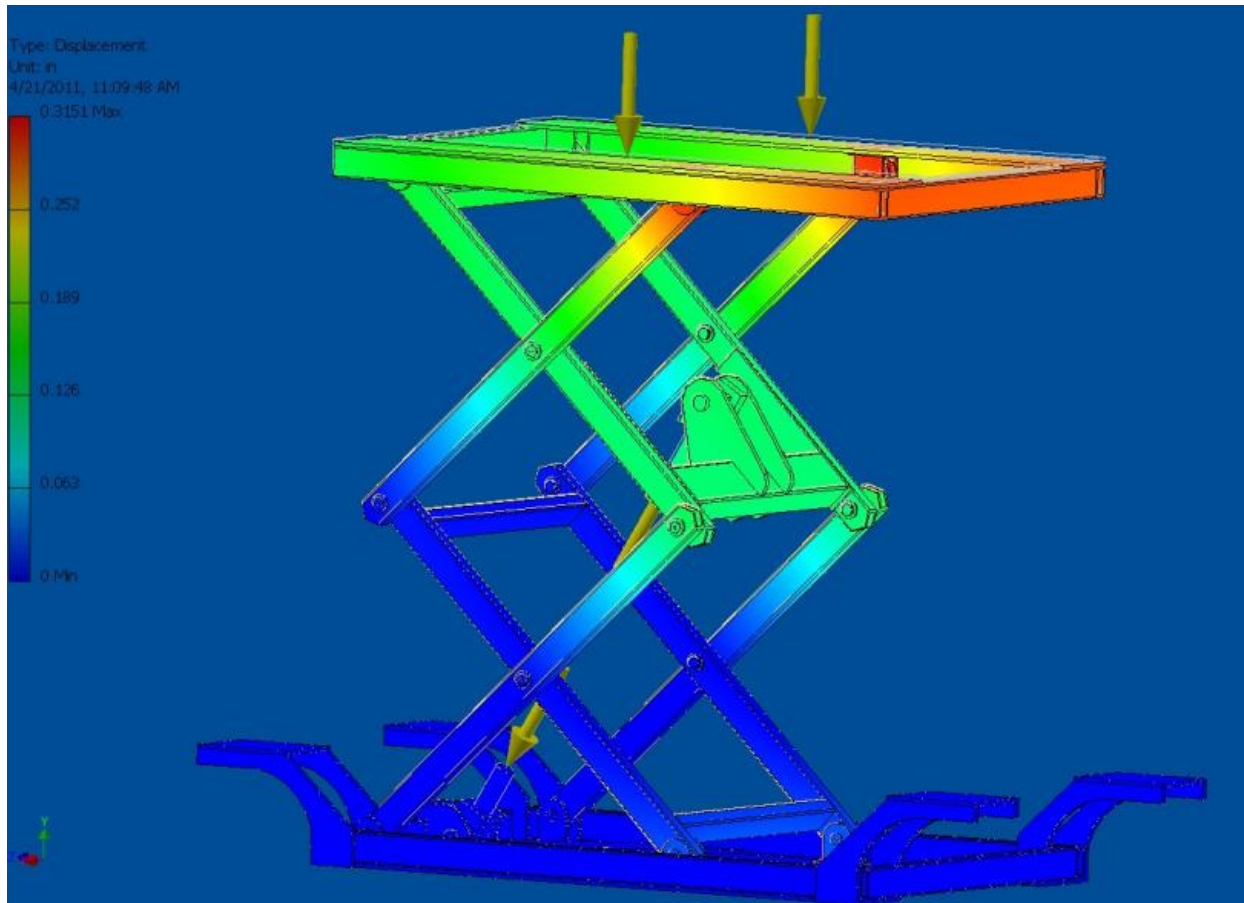


Figure 8: Total Displacement with 2000 lb Load

The next figure, Figure 9, shows the stress that was produced in the parts of the lifting mechanism, lifting surface and the chassis. From Figure 9, it can be seen that the stress in the members is very low and the maximum stress occurs in the pins and cylinder mounts where there are high stress concentrations.

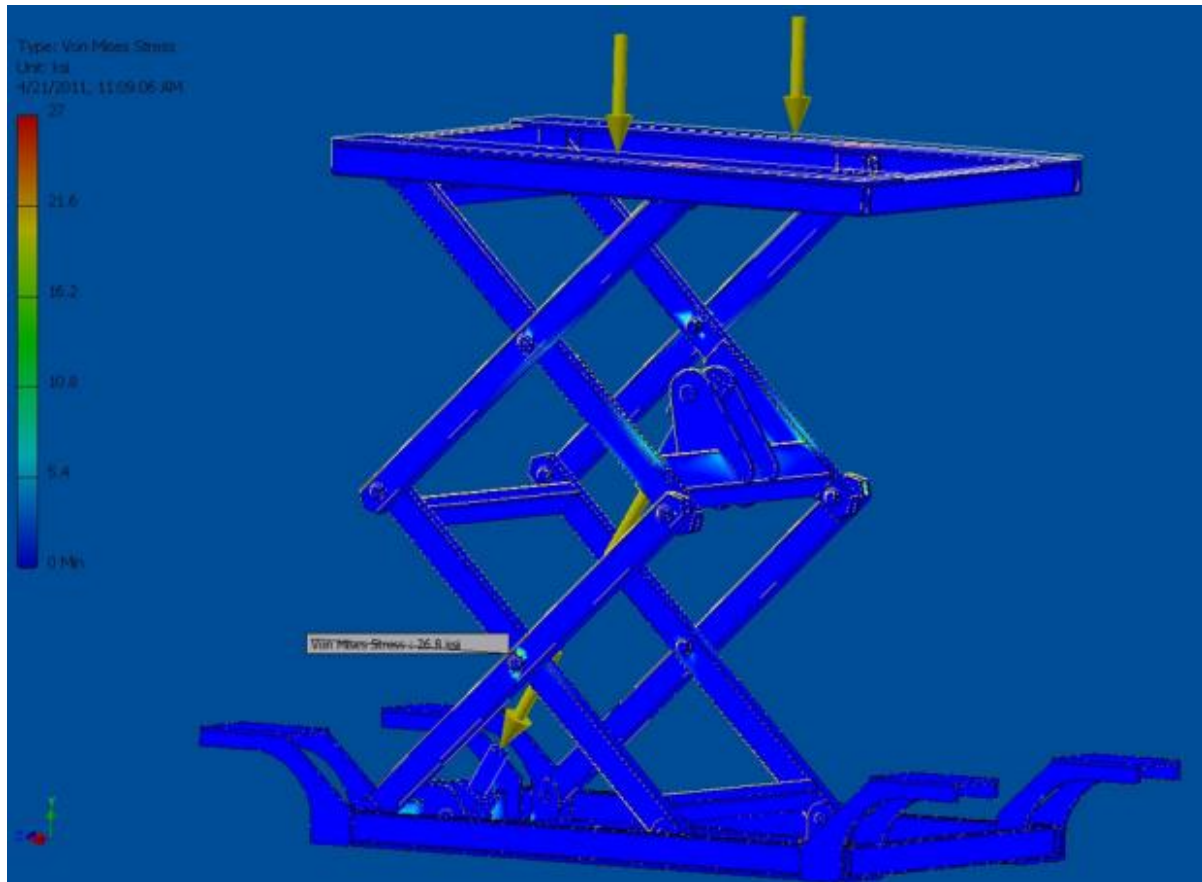


Figure 9: Stress with 2000 lb load

The next figure, Figure 10, shows the total displacement of the jack with a lateral force of 300 lbf. This lateral force was applied horizontally to simulate the event of the jack being bumped by another object or by hitting an object when the jack is being pulled across the floor. The results from this simulation show that the deformation only increases by a small amount from the deformation produced with only a load on the top.

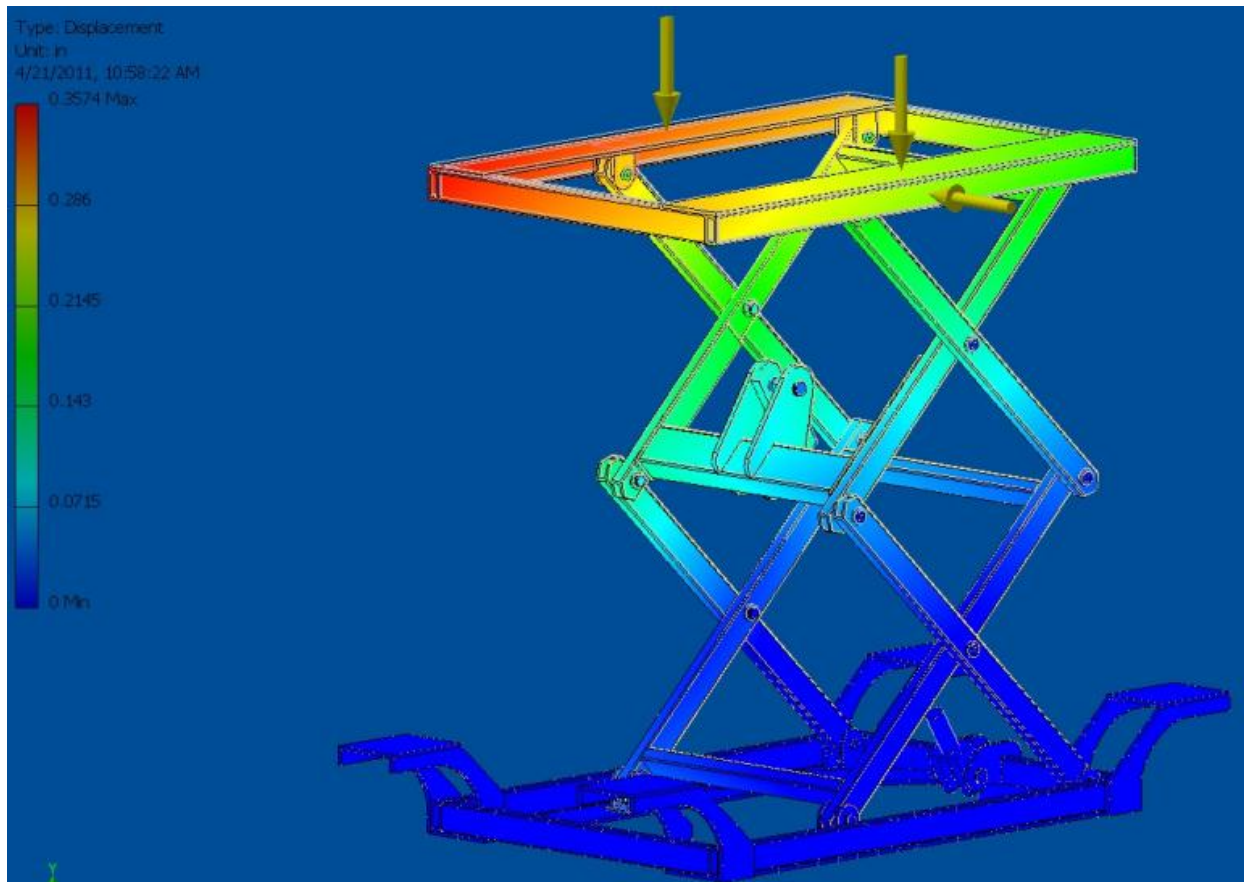


Figure 10: Total Deformation with 300 lb Lateral Load

Another area of concern is the bottom of the chassis that supports the cylinder. Figure 11 shows the maximum force that the cylinder would exert and where the stress concentrations are. As can be seen the design withstands the load. Figure 12 shows the factor of safety rendering of the chassis. With only the only low areas being where some pieces are welded, the overall design is very good.

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30.41 Max

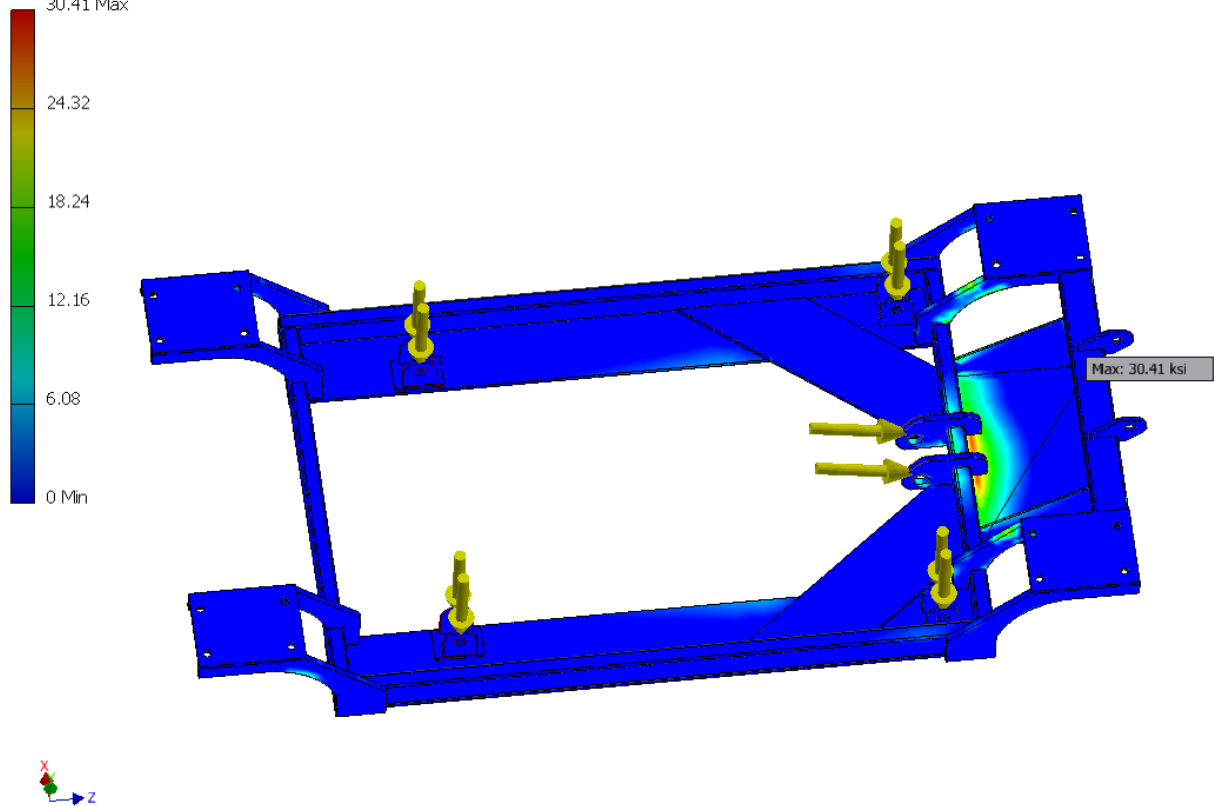


Figure 11 Chassis FEA

Type: Safety Factor
Unit: ul
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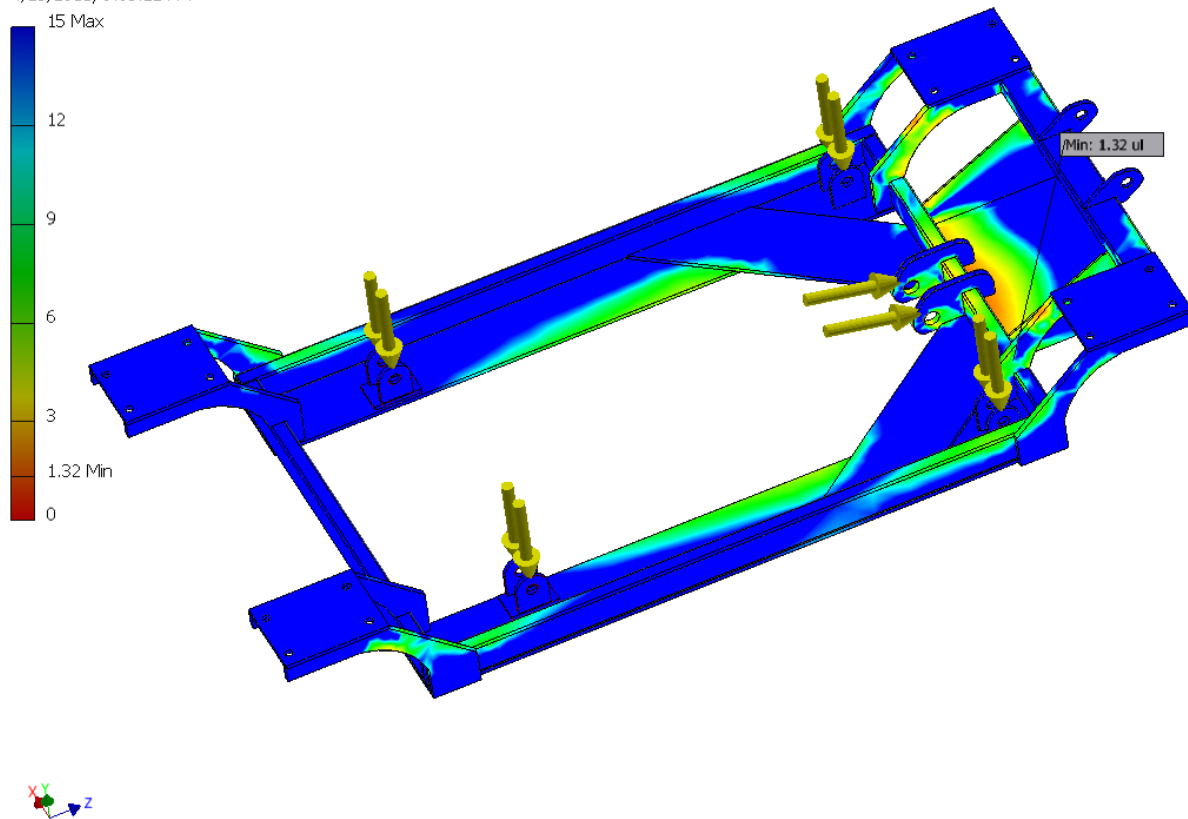


Figure 12 Chassis Factor of Safety

5.0 Construction Cost

An itemized cost list of the materials and parts needed to build the belly pan jack prototype. All of the steel needed for the different subsystems that the client did not already have was purchased from DMS Welding and Machine in Vergennes, Illinois by the client. Some of the hard ware needed for the jack like the grease fittings, washers, bolts, nuts, and cylinder pins were purchased from Rural King in Carbondale, Illinois; the hydraulic hose and fittings from Royal Brass and Hose in Benton, Illinois. Several parts were also purchased from the internet, like the pump which was purchased from EBay. Other parts were ordered from the internet. For example, the external snap rings were ordered from mcmaster.com, the velocity fuse and flow regulator from v6nberg.com, caster wheels from hamiltoncaster.com, and the cylinder from surpluscenter.com. The build of the prototype was not outsourced and the members of team 56 provided all the labor required labor. The special tooling needed such as a lathe, mill, band saw, belt sander, and drill press was provided by Tim Attig and the MEEP machine shop at Southern Illinois University Carbondale. The other tooling such as the grinder, MIG welder, and acetylene torch were provided by the client, Gibbs Construction.

The cost to outsource the construction of one belly pan jack was provided by Chuck Evans at DMS Welding and Machine [1].

Table 5: Cost to Implement BPJ-2000P

Subsystem	Parts Description	Quantity	Price
Lifting Mechanim	1" x 2" x 3/16" wall thickness 8500 Rectuangular Tubing for Members	22 ft	\$45.10
	1.125" 8500 Pin Stock for Bushings	54 in	\$8.76
	3/4" 8500 Pin Stock for Pins	54 in	\$8.33
	3/4" External Snap-Rings for Pins	16	\$6.00
	1/4" Grease Zerk for Pins	16	\$3.50
	5/8" Washer for Pins	16	\$3.20
	1/4" AISI-1040 Steel Plate for Sliders	72 in ²	On Hand
	2" x 3"x1/4" wall thickness AISI-1040 Rectanguar Steel Tubing for Cylinder Mounting	17.5 in	\$10.50
	3/8" Thick ASTM-1040 Steel Plate for Cylinder Mounting	110 in ²	On Hand
	1/4" AISI-1040 Steel Plate Reinforcements	48 in ²	On Hand
	1/4" AISI-1040 Steel Plate for Slider Braces	160 in ²	On Hand
	1/2" Spacer for Slider Braces	8 in ²	On Hand
	3/8" x 2" Bolts and nuts	4	On Hand
Chassis	1" x 2"x3/16 wall thickness 8500 Rectuangular Tubing for Frame	13 ft	\$26.65
	1/4" AISI-1040 Steel Plate for Lifting Mechanism Mounts	48 in ²	On Hand
	1/2" Thick AISI-1040 Steel Plate for Wheel Mounts	414 in ²	On Hand
	1/4" AISI-1040 Steel Plate for wheel Mounts	96 in ²	On Hand
	6" diameter 1500 lb Caster Wheels	4	\$212.00
	3/8" x 2" Bolts, Nuts, and Washers	16	\$25.00
	1/4" AISI-1040 Plate Steel for Chassis Bracing	330 in ²	On Hand
	1/4" Thick AISI-1040 Steel Plate for Sliders	400 in ²	On Hand
	2" O.D. Steel Pipe for Handle	4 ft	On Hand
	1" x 2" x 3/16" wall thickness 8500 Rectuangular Tubing for Handle	20 in	\$3.50
Platform	1" x 2"x 3/16 wall thicknass 8500 Rectuangular Tubing for Frame	13 ft	\$26.65
	1/4" Thick AISI-1040 Steel Plate for Sliders	400 in ²	On Hand
	AISI-1040 Steel Plate for Platform Mounts	1474 in ²	On Hand
	1" thick Steel Bar Grate	1080 in ²	On Hand
	1.5" x 1.5" Angle Iron for Grate	74 in	On Hand
	3" x 3" Angle Iron for Grate	27 in	On Hand
	1" 8500 Pin Stock for Pins	12 in	\$2.00
	1.5" O.D. AISI-1040 Pin Stock for Bushings	6 in	On Hand
	1/4" Steel Plate Mounts for Screw Adjustments	64 in2	On Hand
	Screw assemblies	2	\$40.00
	3/4" Washers for Screw Adjustments	6	On Hand
	2" Cotter Pins	6	On Hand
	1" External Snap-Rings for Pins	4	\$2.00
	3/4" Washer for Pins	4	On Hand
Power	3" Bore, 12" Stroke Hydraulic Cylinder	1	\$87.95
	3200 psi Air over Hydraulic Pump	1	\$300.00
	1/8" AISI-1040 Steel Plate for Pump Mounting	264 in ²	On Hand
	3/8" Velocity Fuse	1	\$24.04
	3/8" Flow Regulator	1	\$18.72
	1" x 5" Cylinder Pins	2	\$6.00
	Hydraulic Fluid	2 qts	\$10.00
Tooling	3/8" Hydraulic Hose with 90° and Straight Fittings	1	\$30.00
	Lathe	1	On Hand
	Mill	1	On Hand
	Band Saw	1	On Hand
	Grinder	1	On Hand
	Belt Sander	1	On Hand
	Drill Press	1	On Hand
	MIG Welder	1	On Hand
Miscellaneous	Acetylene Torch	1	On Hand
	Shipping of Steel		\$100.00
	Shipping of Pump and Cylinder		\$37.80
	Shipping of Casters		\$60.00
Labor	Shipping of Velocity Fuse and Flow Regulator		\$12.39
	Labor	290 hrs	
Total	Total Cost of Prototype		\$1,110.09
BPJ-2000	Total Cost of Contracted Prototype		\$4,766.84

6.0 Implementation Schedule

If the prototype of the designed belly pan jack were going to be reproduced the implementation schedule should be followed. The design of the jack is rather complex and requires a lot of machining for custom made parts. If the build was to begin June 1, 2011 the first week should be spent acquiring and ordering the parts listed in Table 5: Item/Cost Breakdown. The build could be started the following week, if just one person were construct the project, it would take approximately three to four weeks, depending upon the machining skills and knowledge of the person completing the task.

The time for implementation could be reduced considerably if a manufacturing process was implemented or if multiple people worked on the task together.

Table 6: BPJ-2000P Implementation Schedule

Chassis Subsystem	Time (hrs)
Cut tubing for frame and steel plate for slider tracks	1
Cut and mill caster wheel mounts from steel plate	11
Cut material for pump mounting	2
Cut and mill lifting mechanism mounts	4
Cut and mill cylinder mounts	5
Fabricating handle	3
Welding together and assembly of parts	15
Lifting Mechanism Subsystem	
Cut tubing for members	1
Cut and machine bushings	10
Cut and machine pins	15
Cut and mill slider brackets and bottom	5
Cut and mill cylinder mounts	5
Cut material for member reinforcements	1
Weld bushings and reinforcements to members	11
Assembly of lifting mechanism	6
Weld cross member and cylinder mounts to lifting mechanism	3
Cut material for slider stabilizers	1
Assemble stabilizers to sliders	1.5
Lifting Surface Subsystem	
Cut tubing for frame and steel plate for slider tracks	1
Cut and mill lifting mechanism mounts	4
Cut and mill platform mounts	6
Cutting and assembly of top adjustments	4
Cut and machine bushings for platform mounts	5
Cut and machine pins for platform mounts	4
Fabricate grate for surface	4
Welding together and assembly of parts	12
Power Subsystem	
Mounting of Pump	1
Mounting of Cylinder	2
Plumbing of hydraulic hose	1
Safety Subsystem	
Assembly of velocity fuse and flow regulator	1
Miscellaneous	
Painting	6
Total	151.5

7.0 Conclusion and Recommendations

The belly pan jack offers a complete, easy to use, and effective way of safely removing and reattaching belly pans to large machinery. The designed belly pan jack will greatly improve the safety and reduce the amount of time required by the current methods used for the removal of belly pans. One large advantage of this design is the lifting surface. By implementing a lifting surface that has the ability to tilt in two directions as well as the ability to attach fixtures to the lifting surface, enables the belly pan jack to accommodate the various sizes and shapes of belly pans. However, if the device is going to be considered for manufacturing a couple changes to the design may be considered.

The design of the lifting surface requires a tall profile. Once the lifting surface was built, and the belly pan jack was completely constructed, the overall height was very close to 18 inches which is the needed clearance for low ground clearance machines. A possible design that reduces the height of the lifting surface is to simply put a flat rigid top on the jack which allows blocks and other fixtures to be secured to, would still allow the belly pan jack to accommodate the various sizes and shapes of belly pans. Another design change that may be considered is to use a different material such as aluminum, which would greatly reduce the overall weight of the jack. Also, a design that could allow the belly pan jack to be used in other conditions, such as on the job in the dirt and mud, could be considered.

Appendix A: General Appendices

References

[1] DMS Welding and Machine, 696 Bethel Road, Vergennes, IL, 629941408

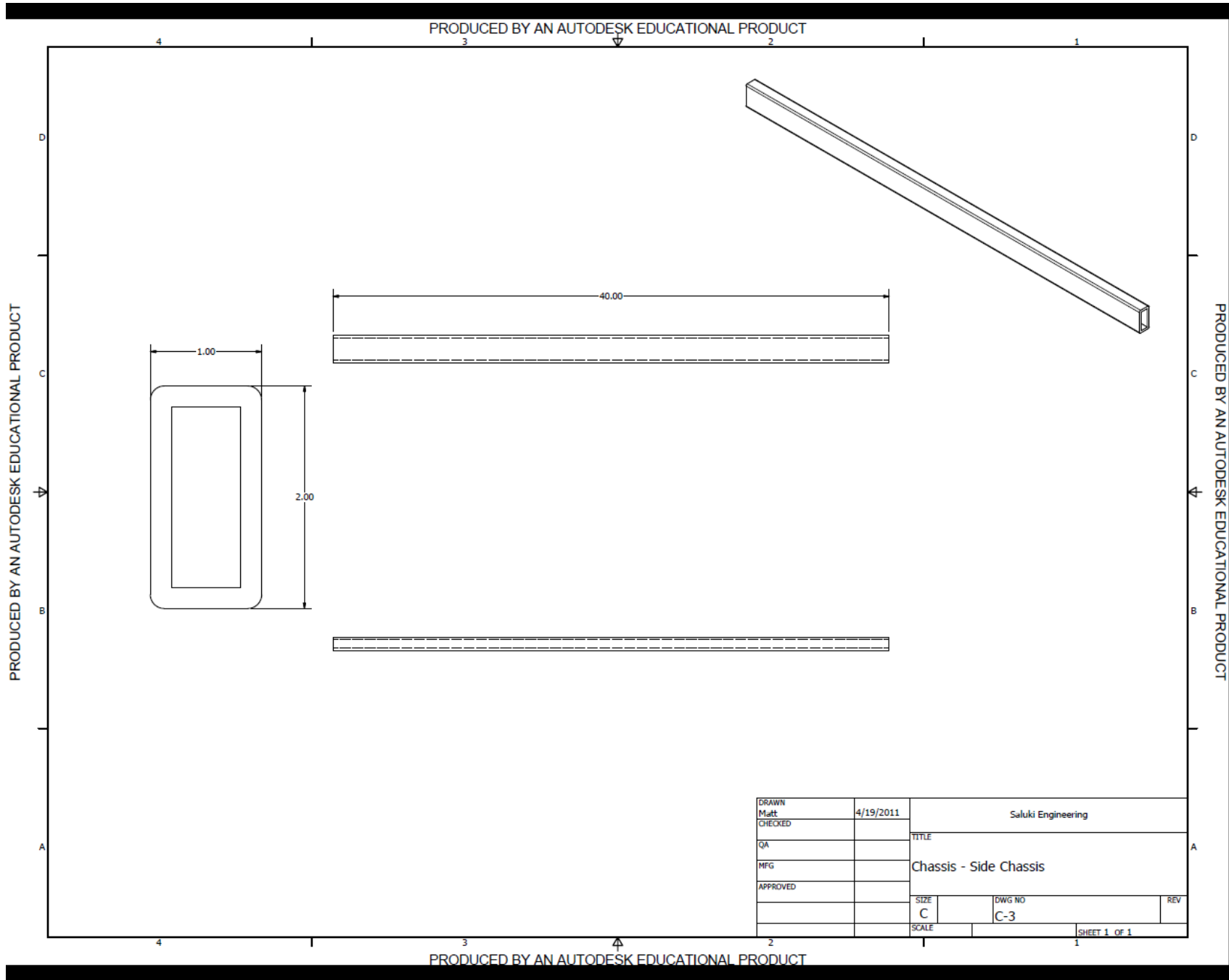
[2] http://www.vonberg.com/flow_regulating_valves/1350.htm

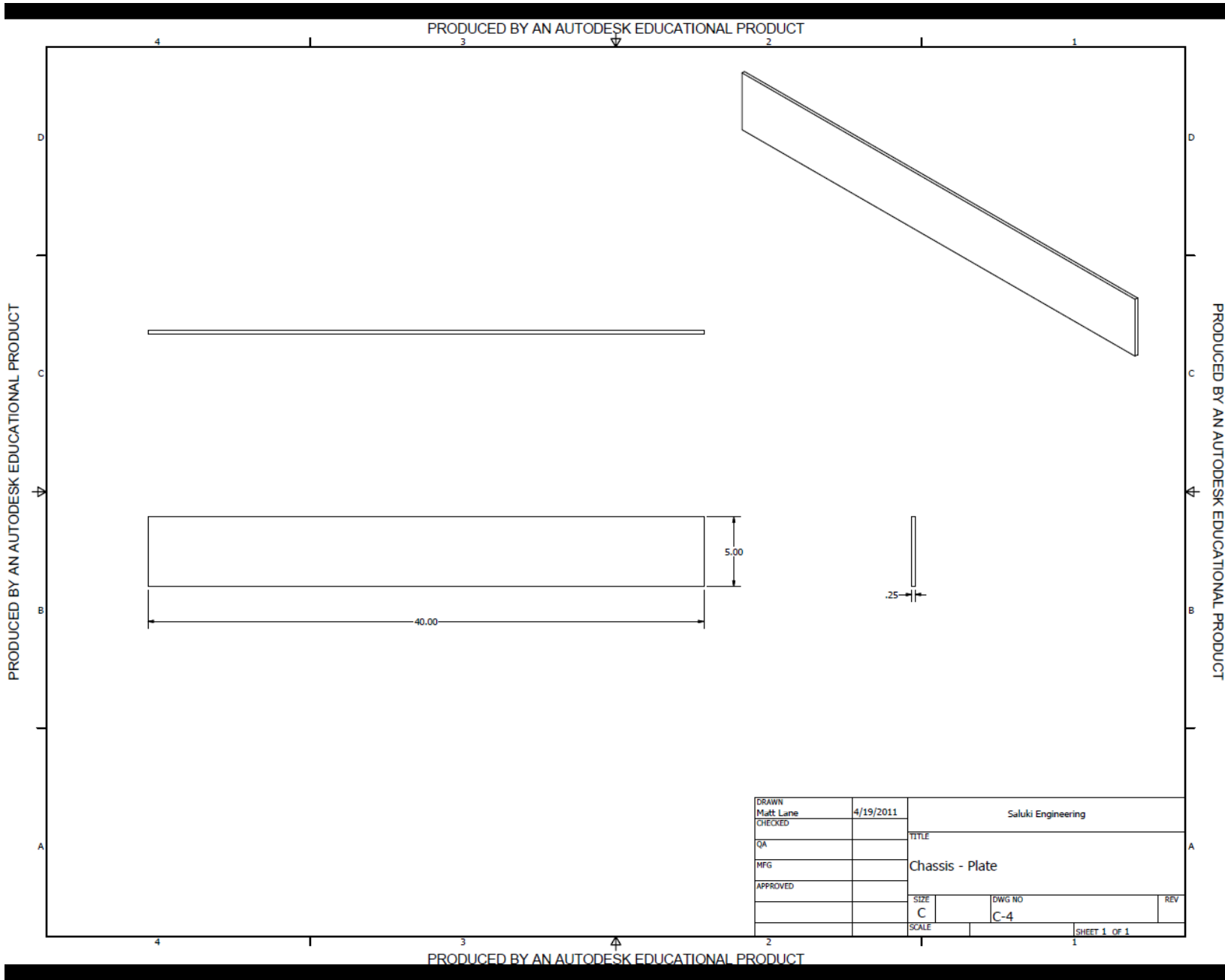
Appendix B: Chassis Subsection

This diagram shows an exploded view of a pallet truck, with its components numbered 1 through 22. The components are distributed as follows:

- 1-4:** Front wheel assembly, including the wheel, axle, and mounting bracket.
- 5-8:** Main frame and handle base, including the front plate, side rails, and handle mounting brackets.
- 9-14:** Fork assembly, including the fork, fork bracket, and various pins and bushings.
- 15-17:** Rear wheel assembly, including the wheel, axle, and mounting bracket.
- 18-22:** Telescopic handle, including the handle tube, handle cap, and various pins and bushings.

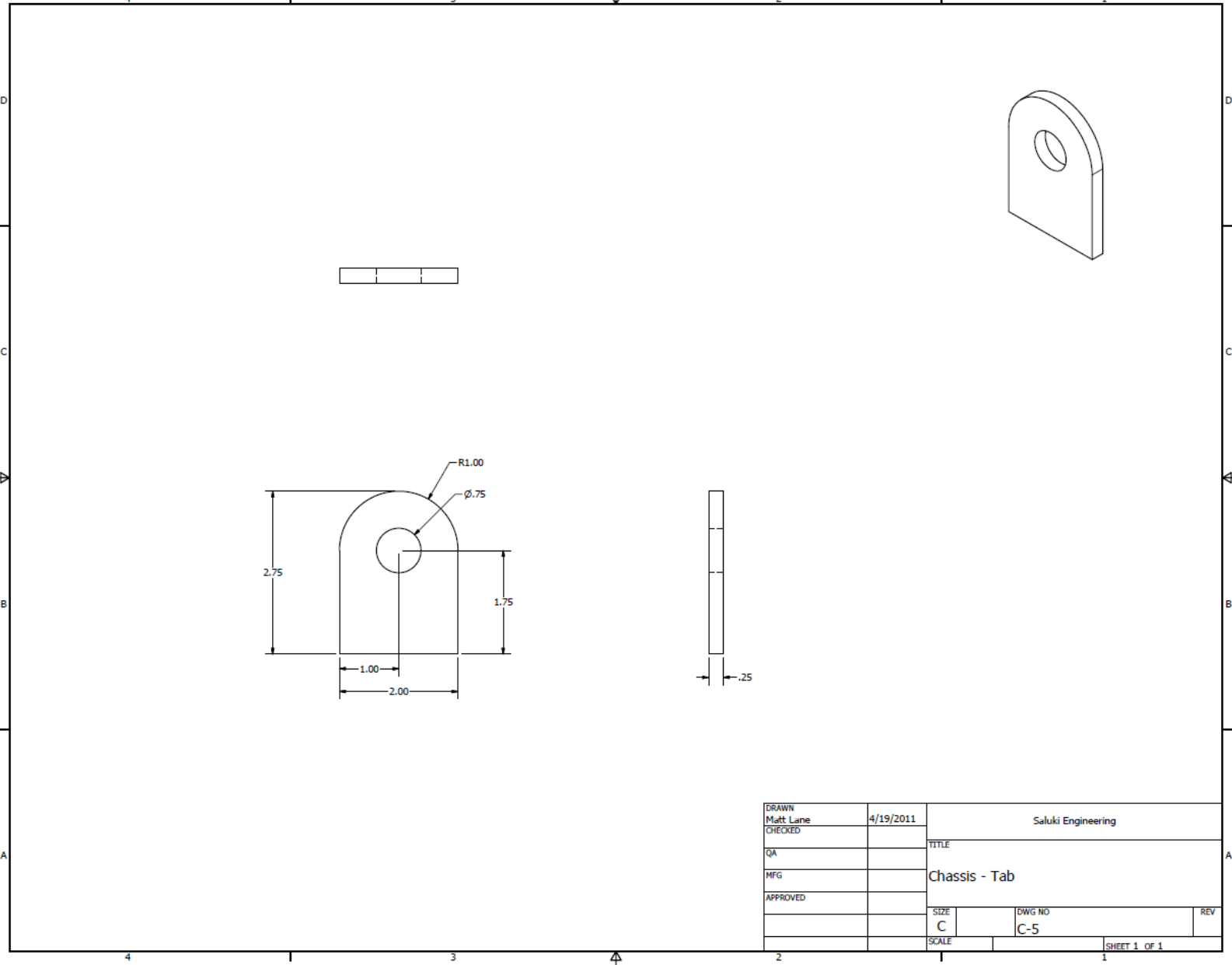
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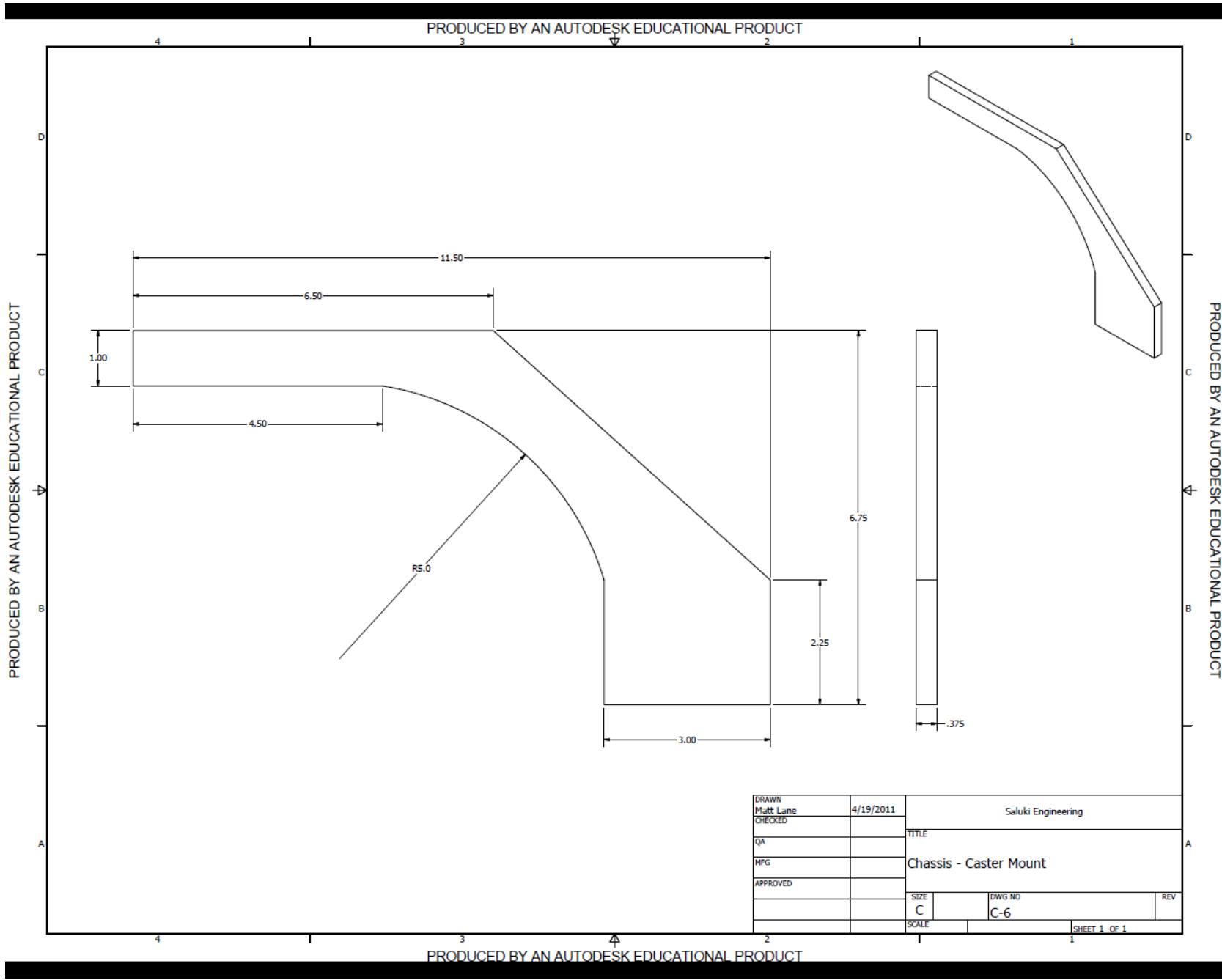


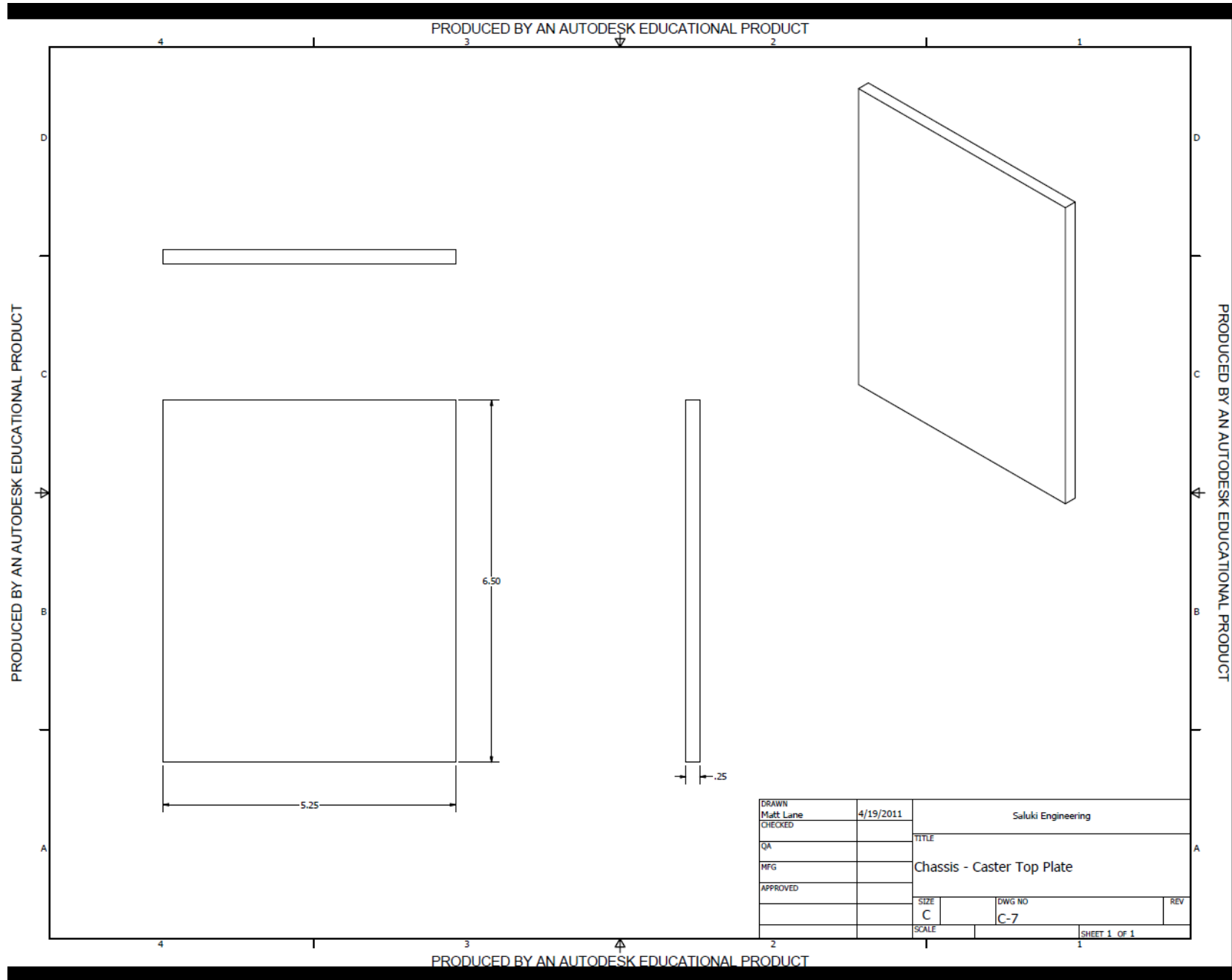
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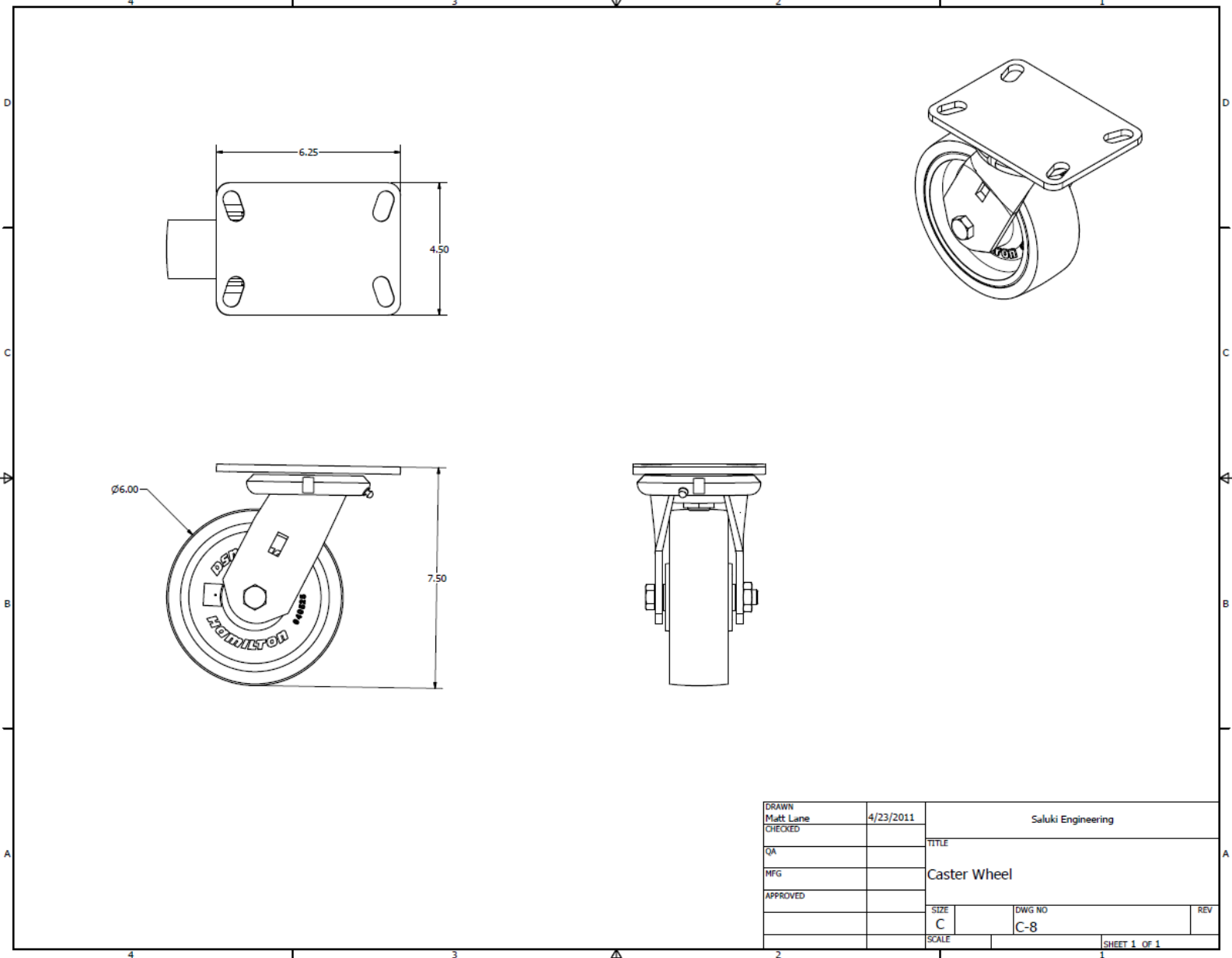
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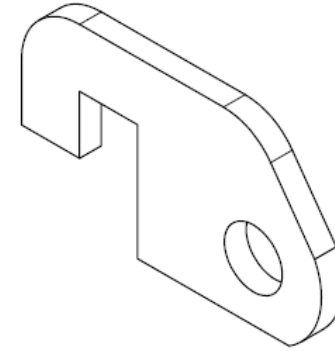
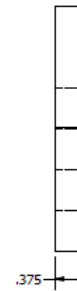
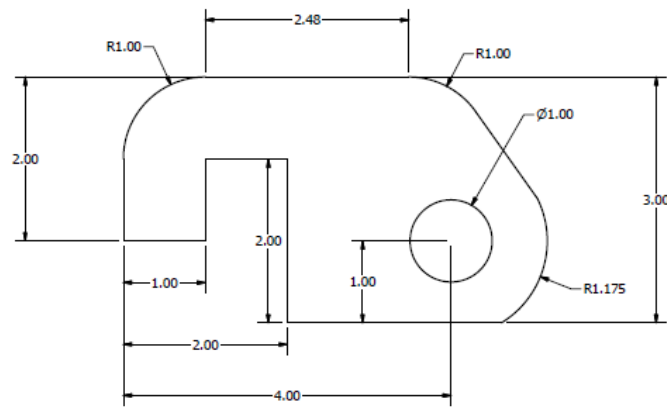
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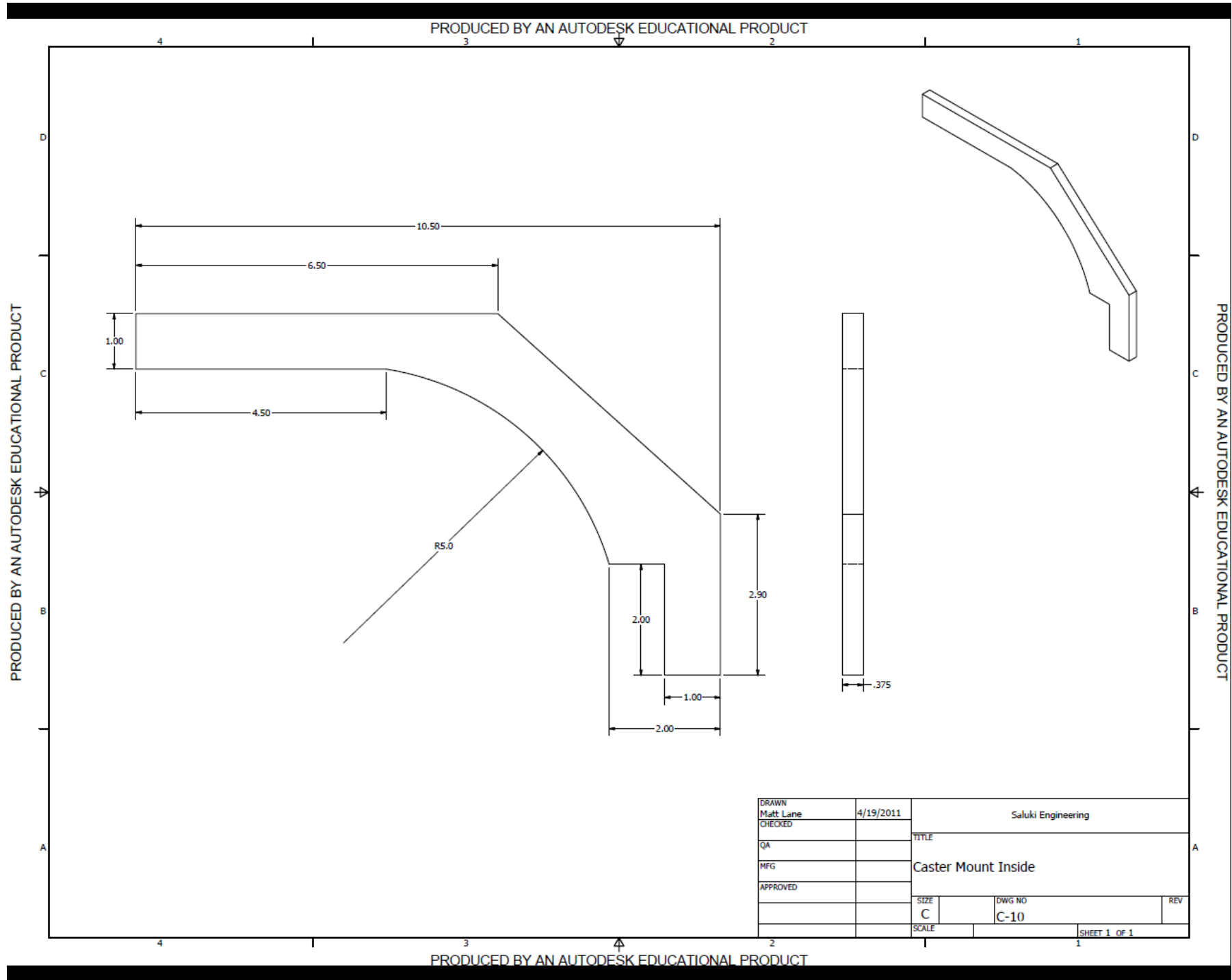
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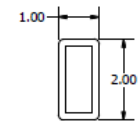
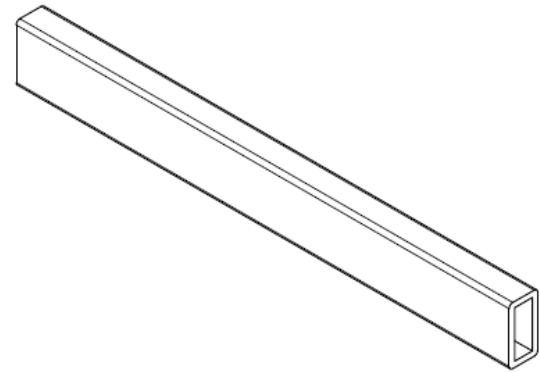
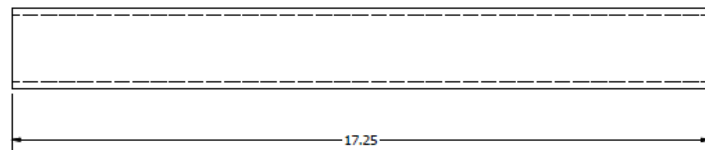


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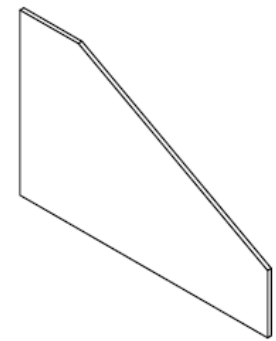
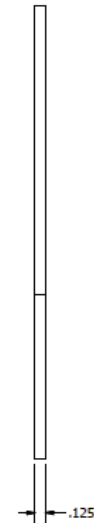
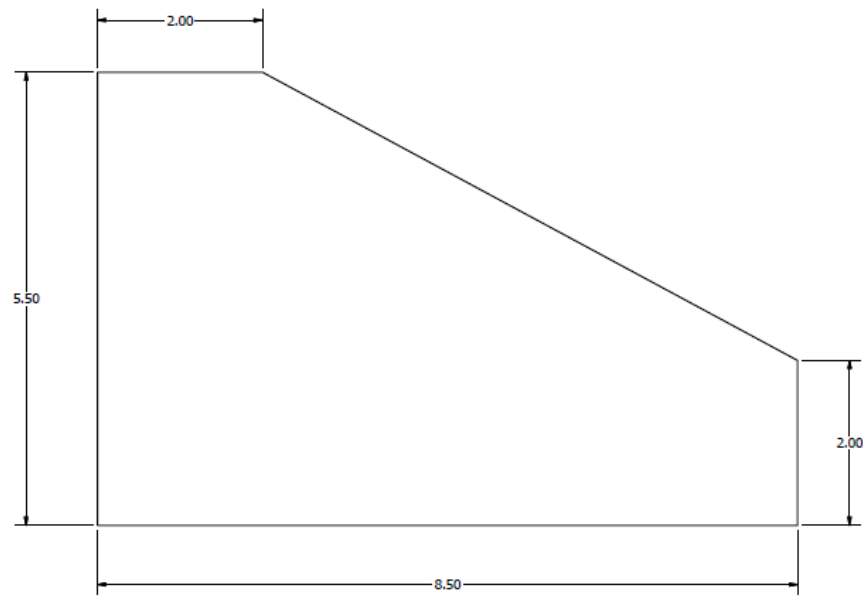


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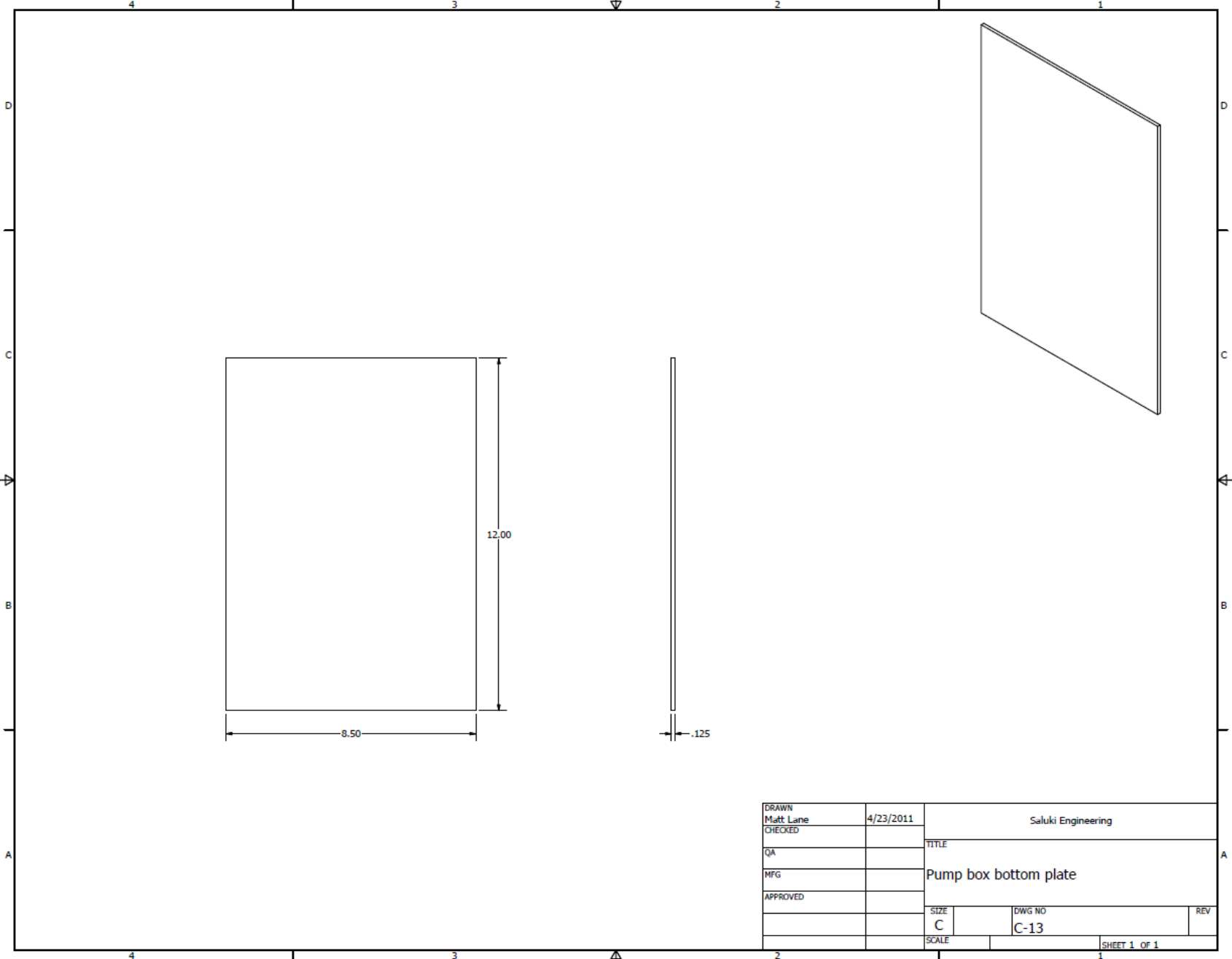
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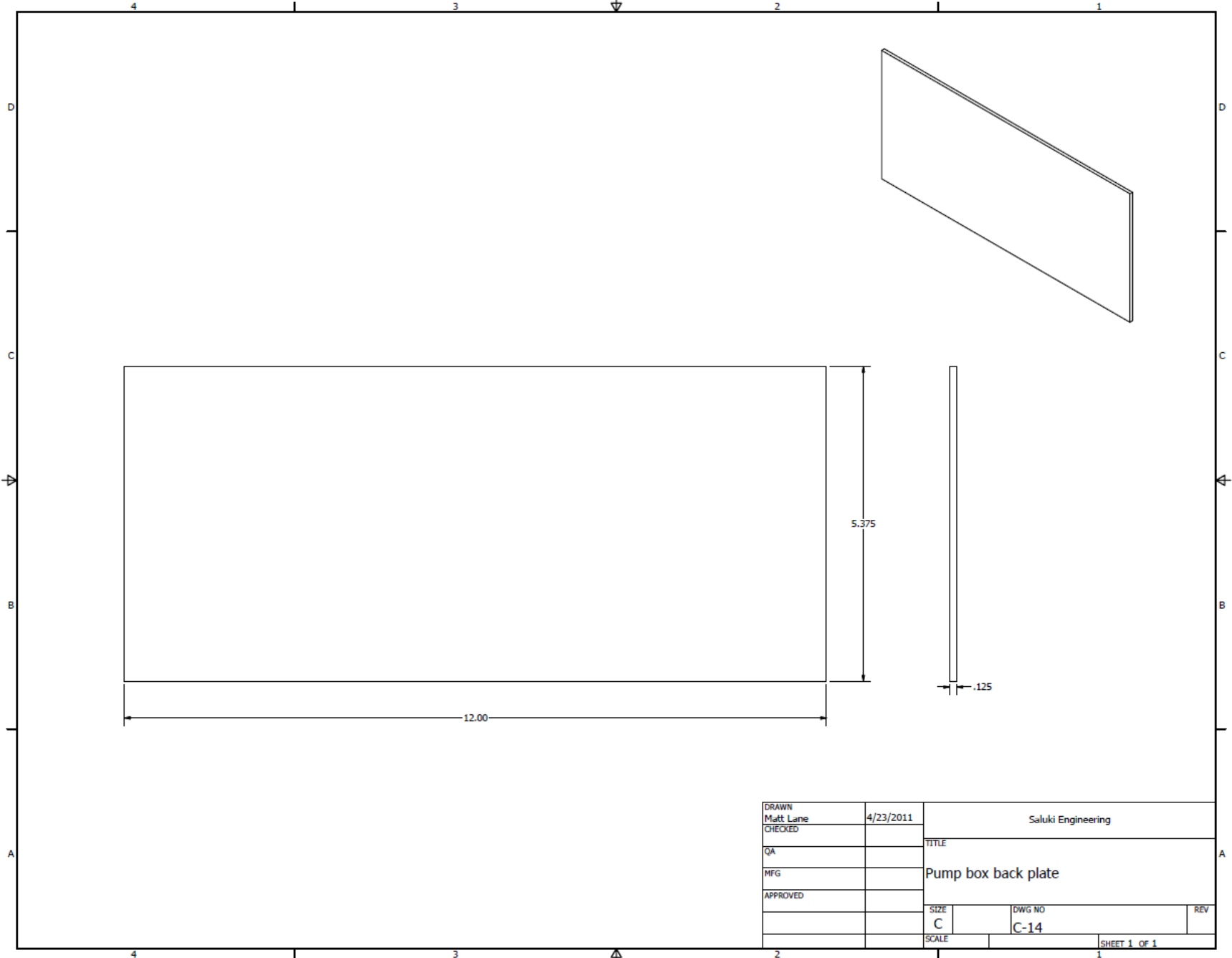
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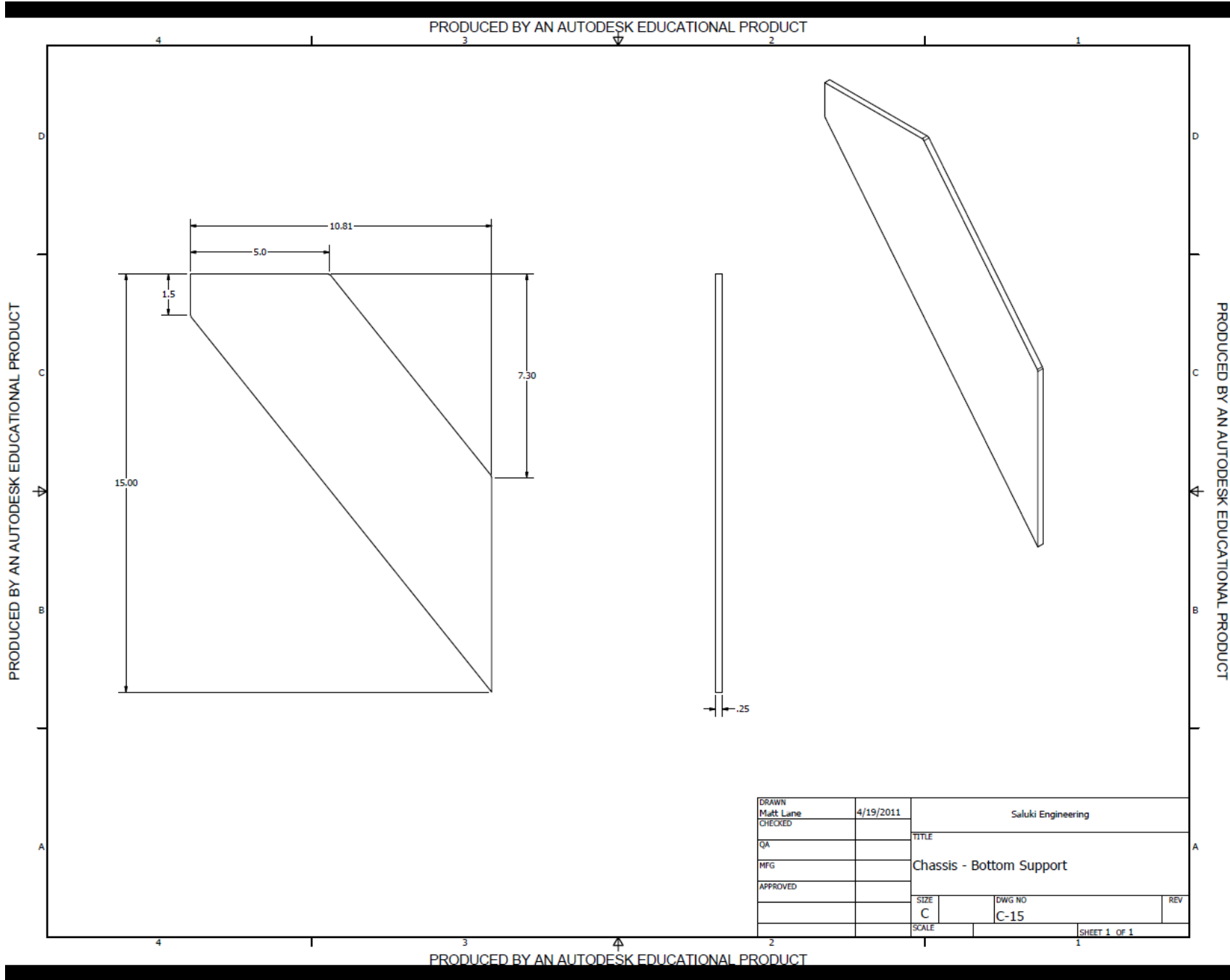
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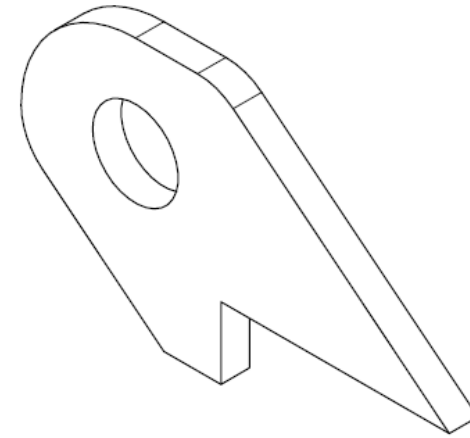
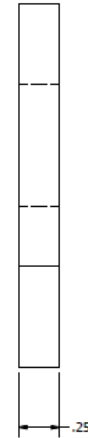
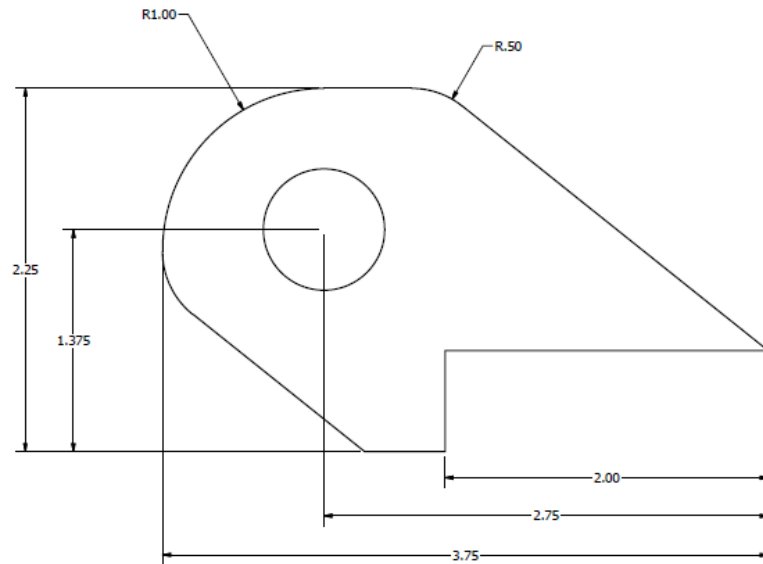
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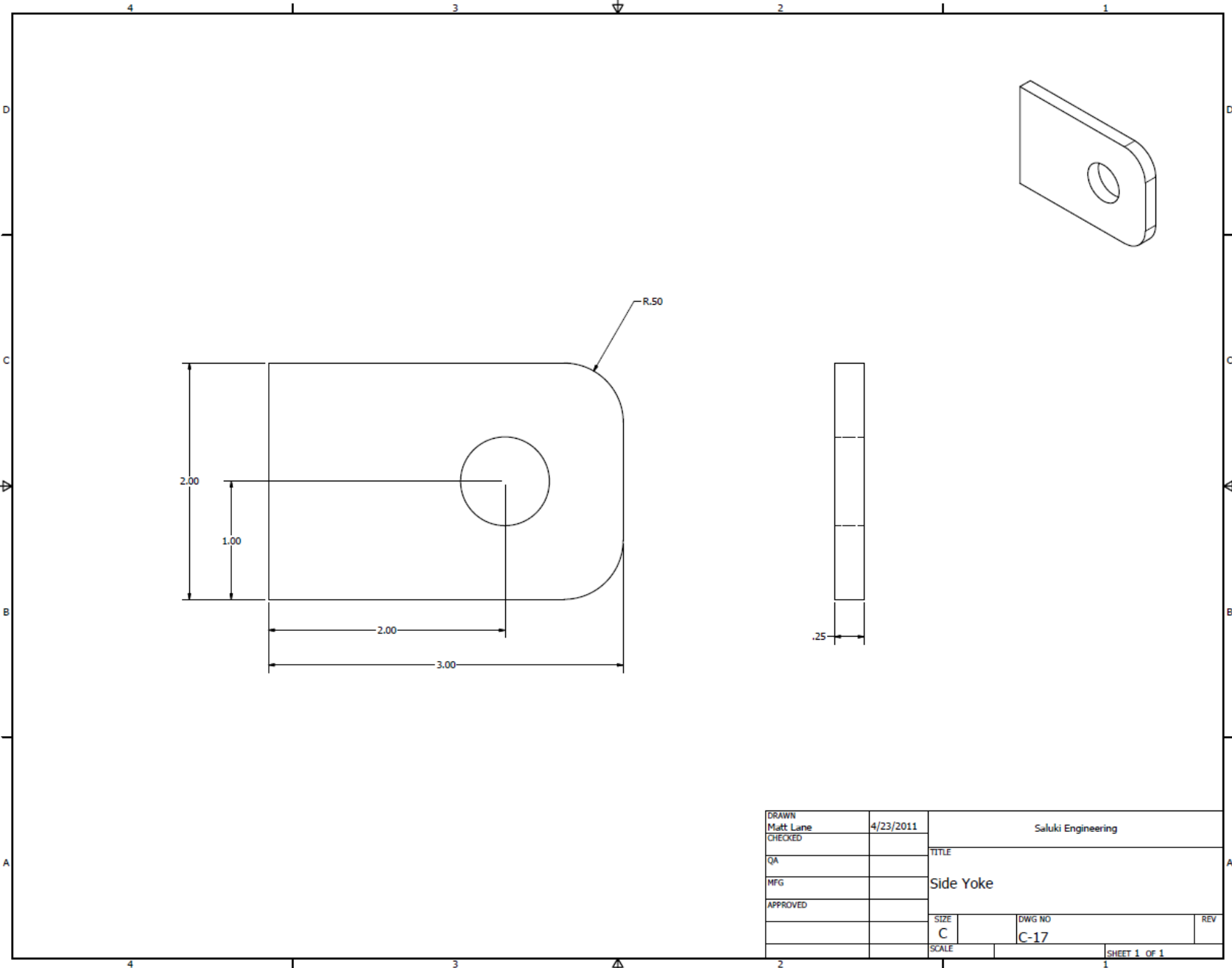




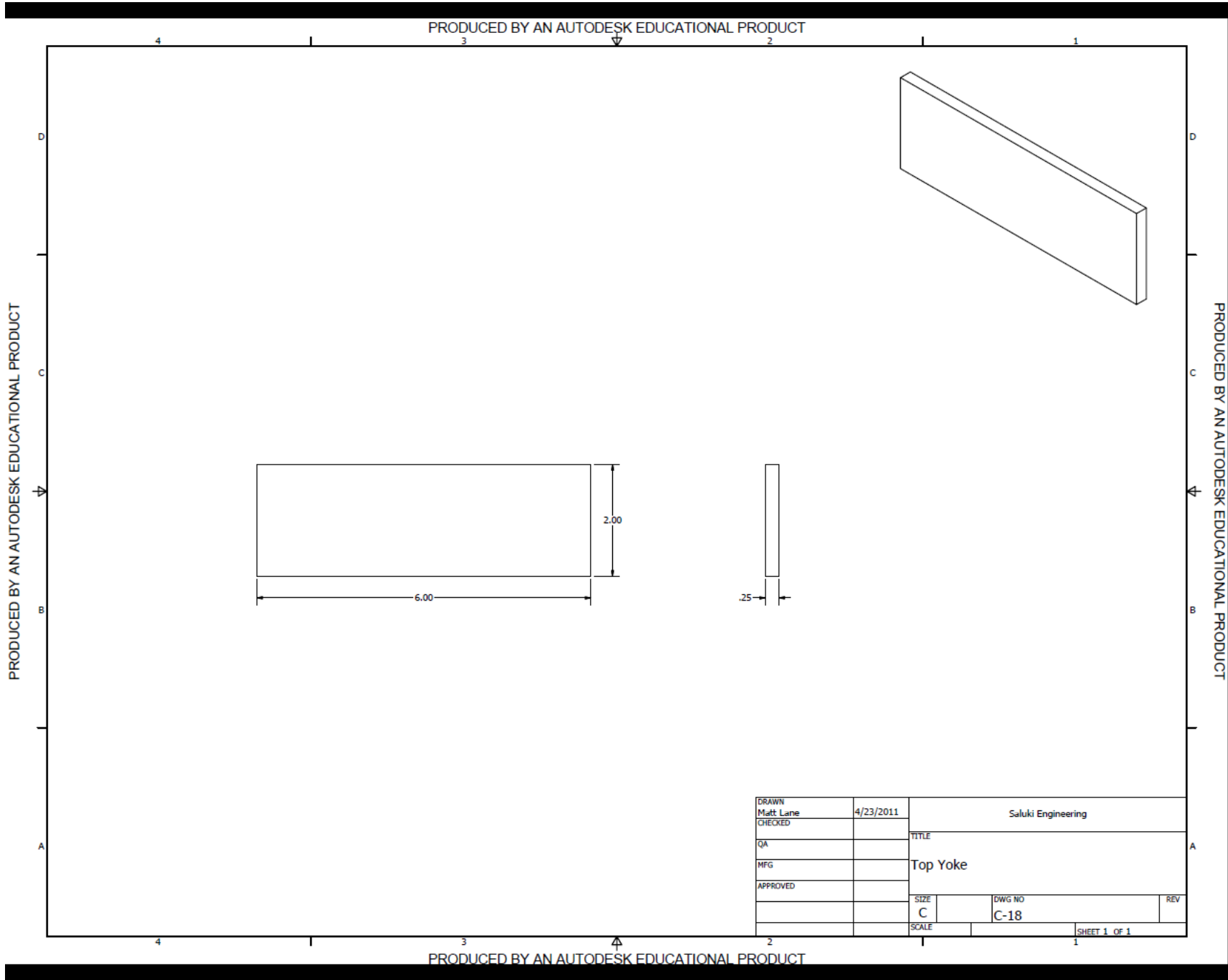
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CHECKED			TITLE	
QA			Handle Mount	
MFG				
APPROVED				
			SIZE	DWG NO
			C	C-16
			SCALE	REV

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

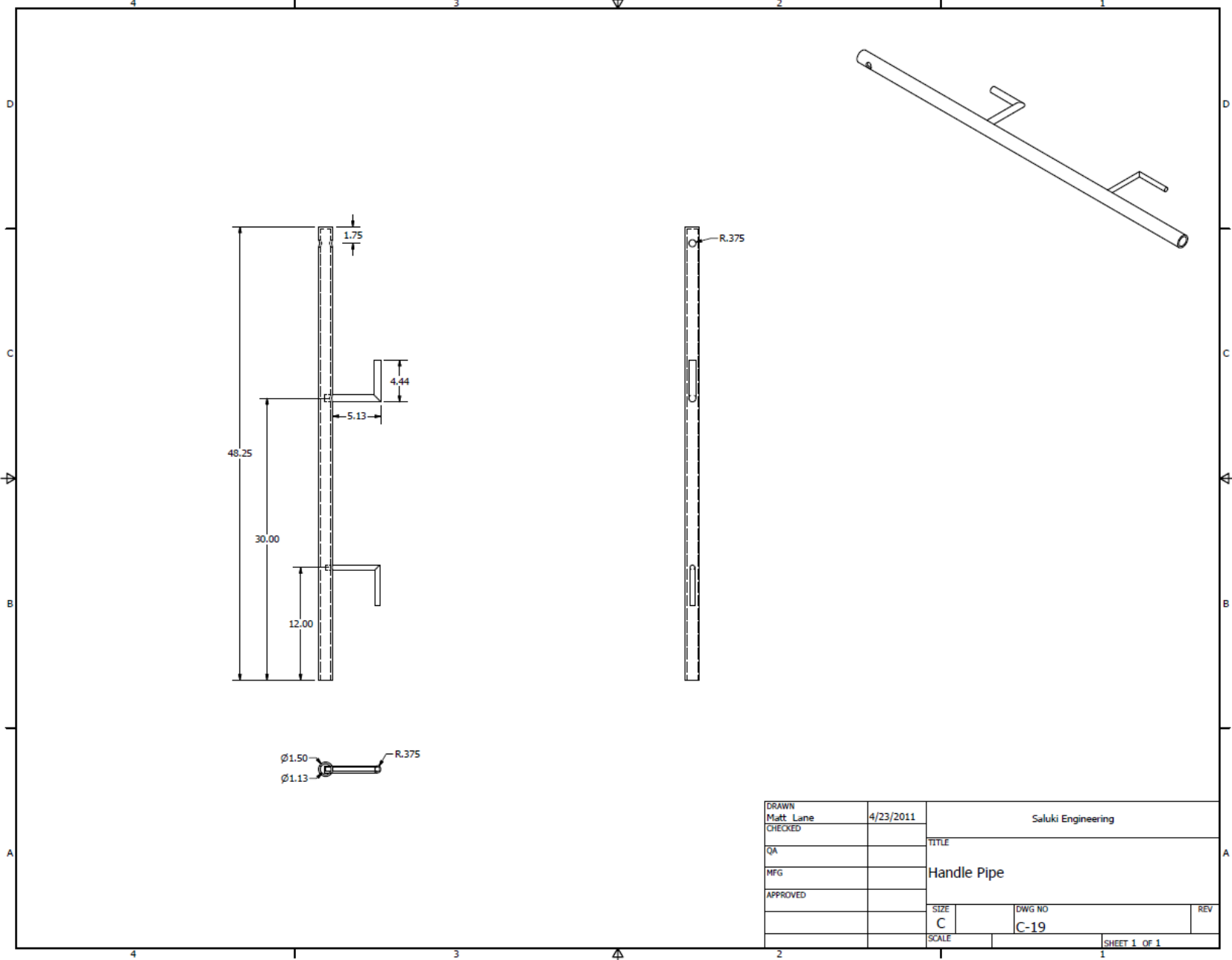


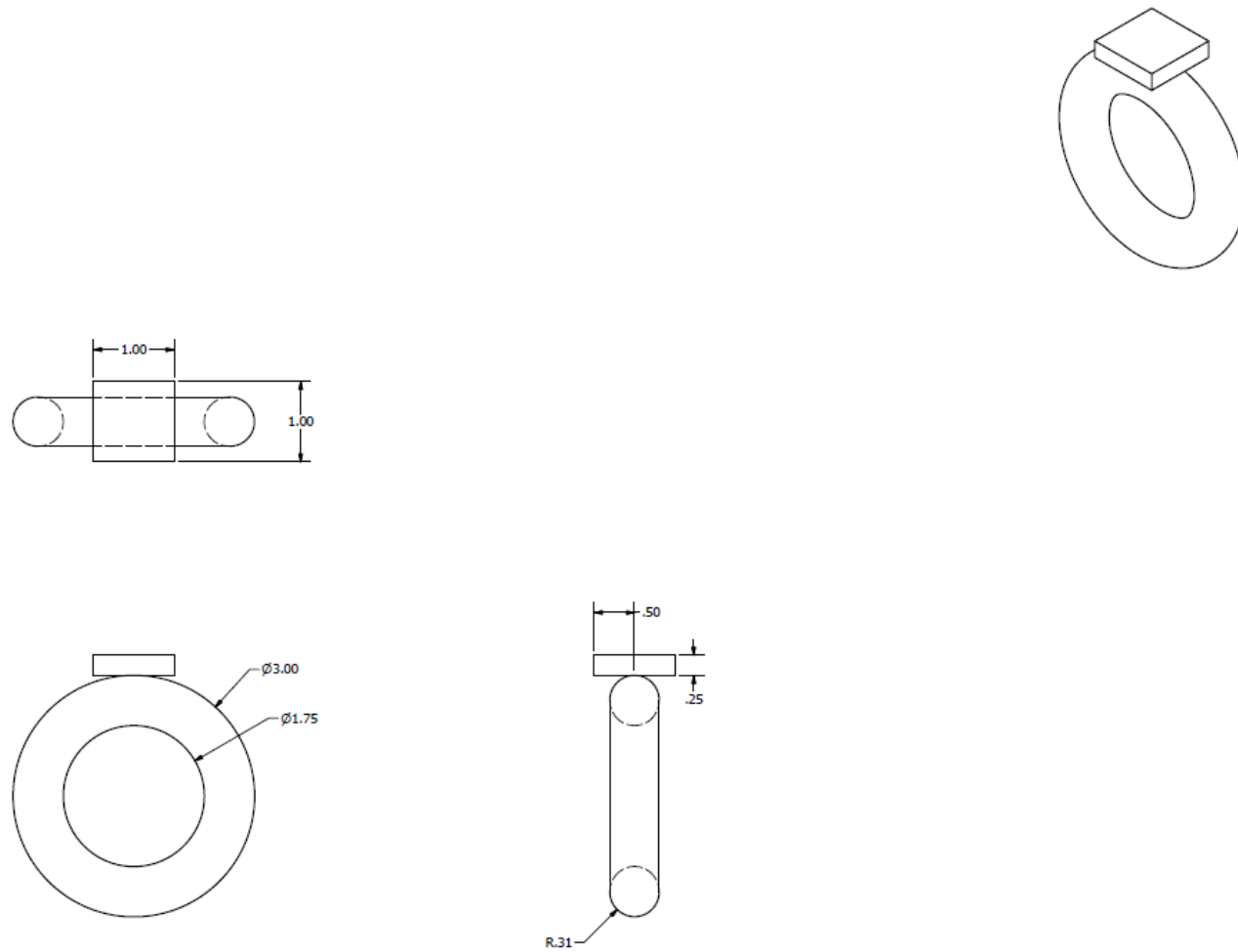
DRAWN Matt Lane	4/23/2011	Saluki Engineering		
CHECKED		TITLE		
QA		Side Yoke		
MFG		DWG NO		
APPROVED		C-17		
		SIZE	C	REV
		SCALE		
				SHEET 1 OF 1



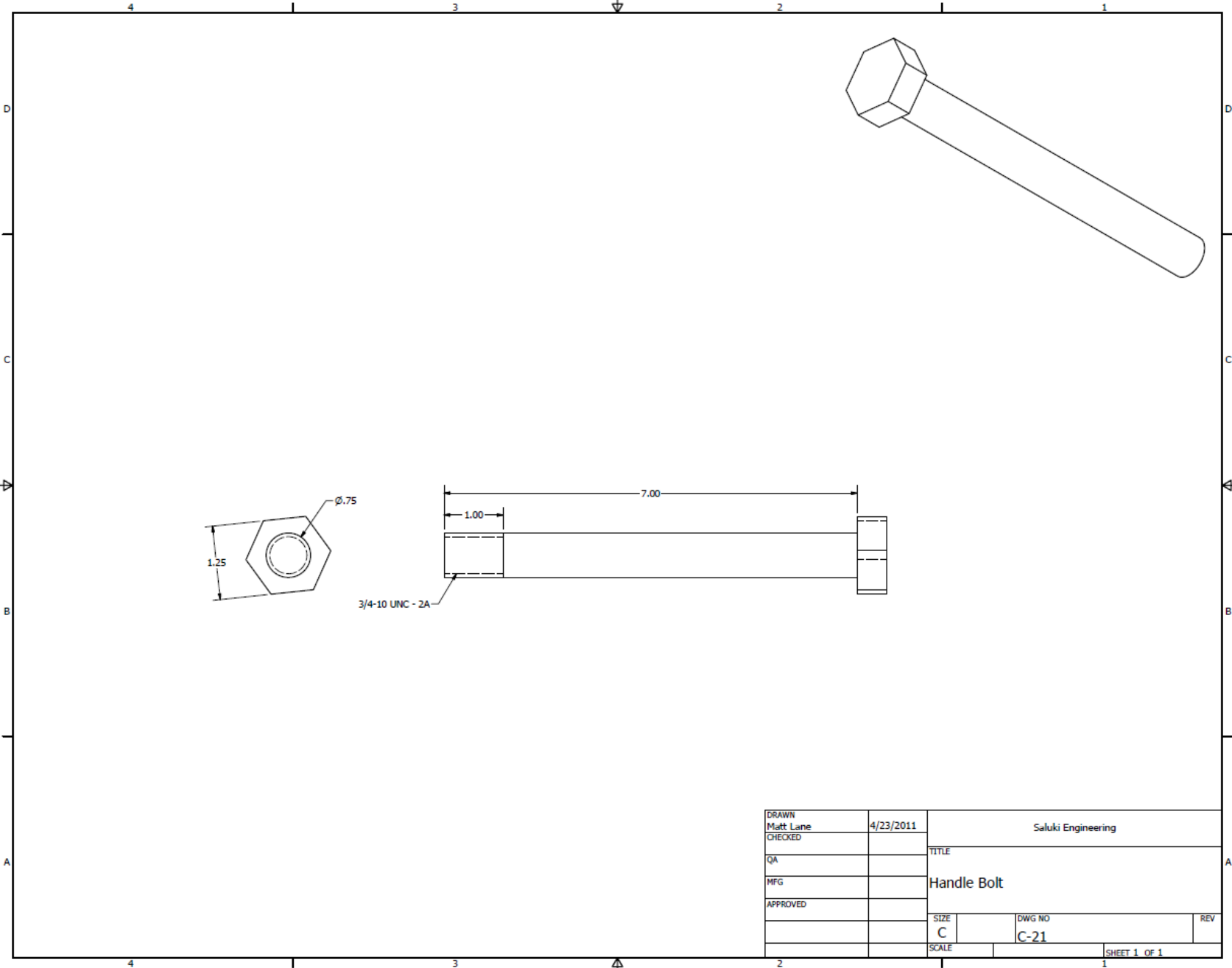
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



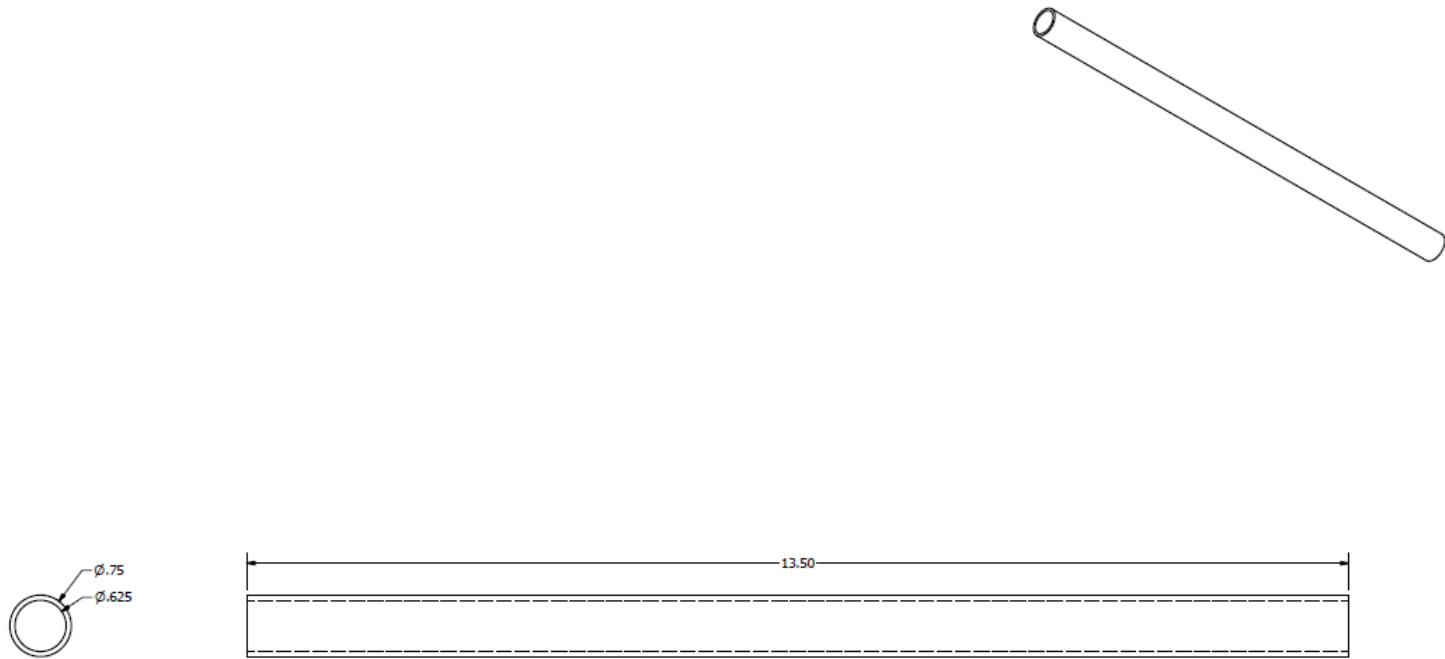


DRAWN	Matt Lane	4/23/2011	Saluki Engineering	
CHECKED			TITLE	
QA			Tow Ring	
MFG			REV	
APPROVED			SHEET 1 OF 1	
			SIZE	DWG NO
			C	C-20
			SCALE	



PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

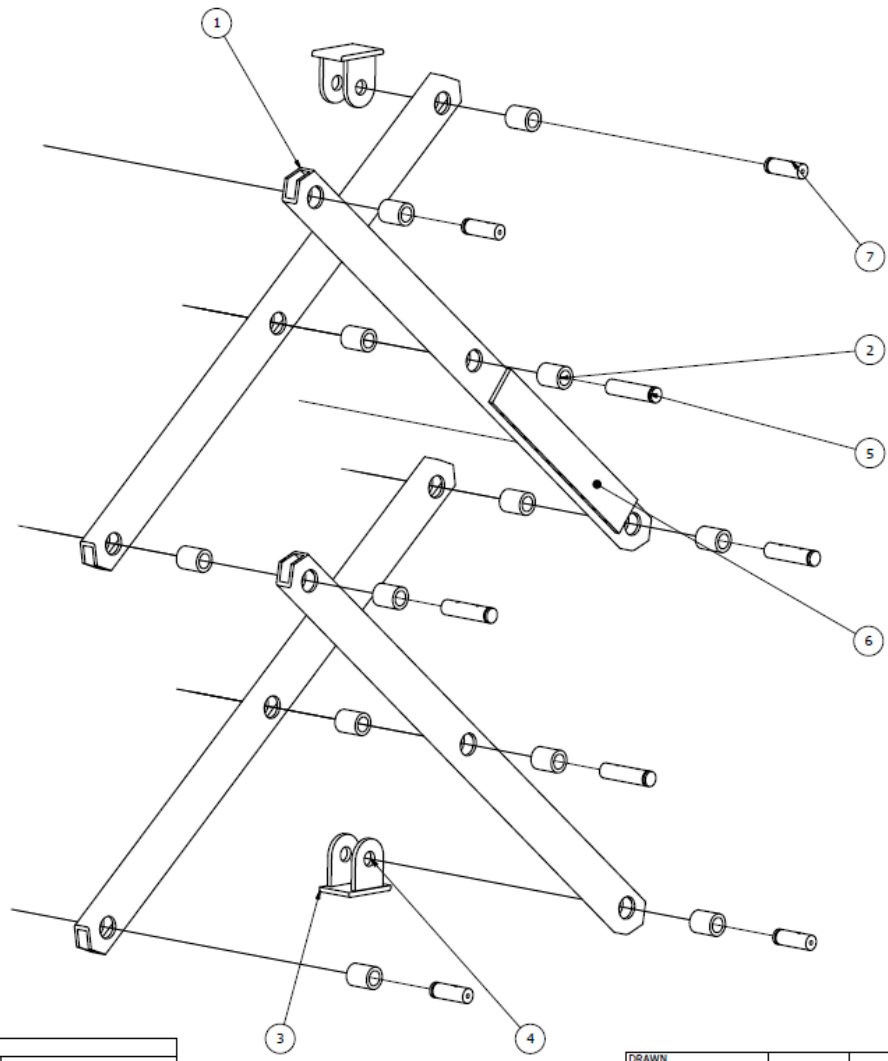


DRAWN Matt Lane	4/23/2011	Saluki Engineering		
CHECKED		TITLE		
QA		Handle Grip		
MFG				
APPROVED				
		SIZE C	DWG NO C-23	REV
		SCALE	SHEET 1 OF 1	

Appendix C: Lifting Mechanism

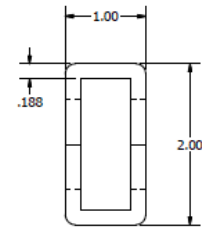
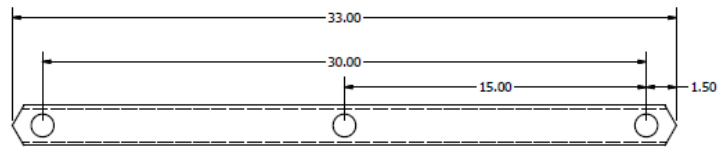
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	L-2	Scissor Arm
2	12	L-3	Sleeve
3	2	L-4	Slider Base
4	4	L-5	SliderTab
5	4	L-6	Grease Pin
6	1	L-7	Cylinder Support
7	4	L-8	Short Grease Pin

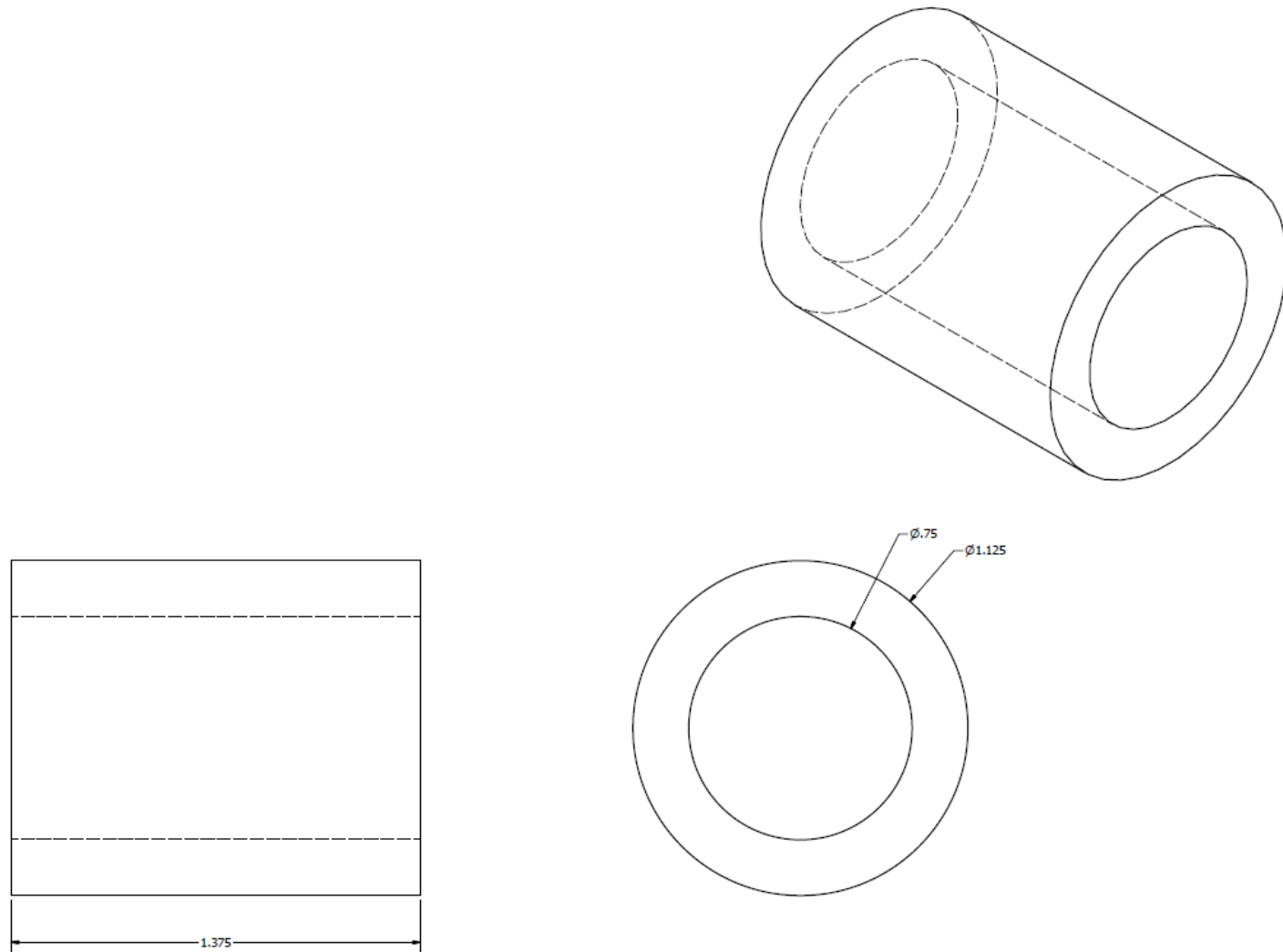
DRAWN Matt Lane	4/19/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Lifting Mechanism	
MFG		SIZE C	DWG NO L-1
APPROVED		SCALE	REV
		SHEET 1 OF 2	



DRAWN	4/19/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Scissor Arm	
MFG			
APPROVED			
		SIZE	DWG NO
		C	L-2
		SCALE	SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

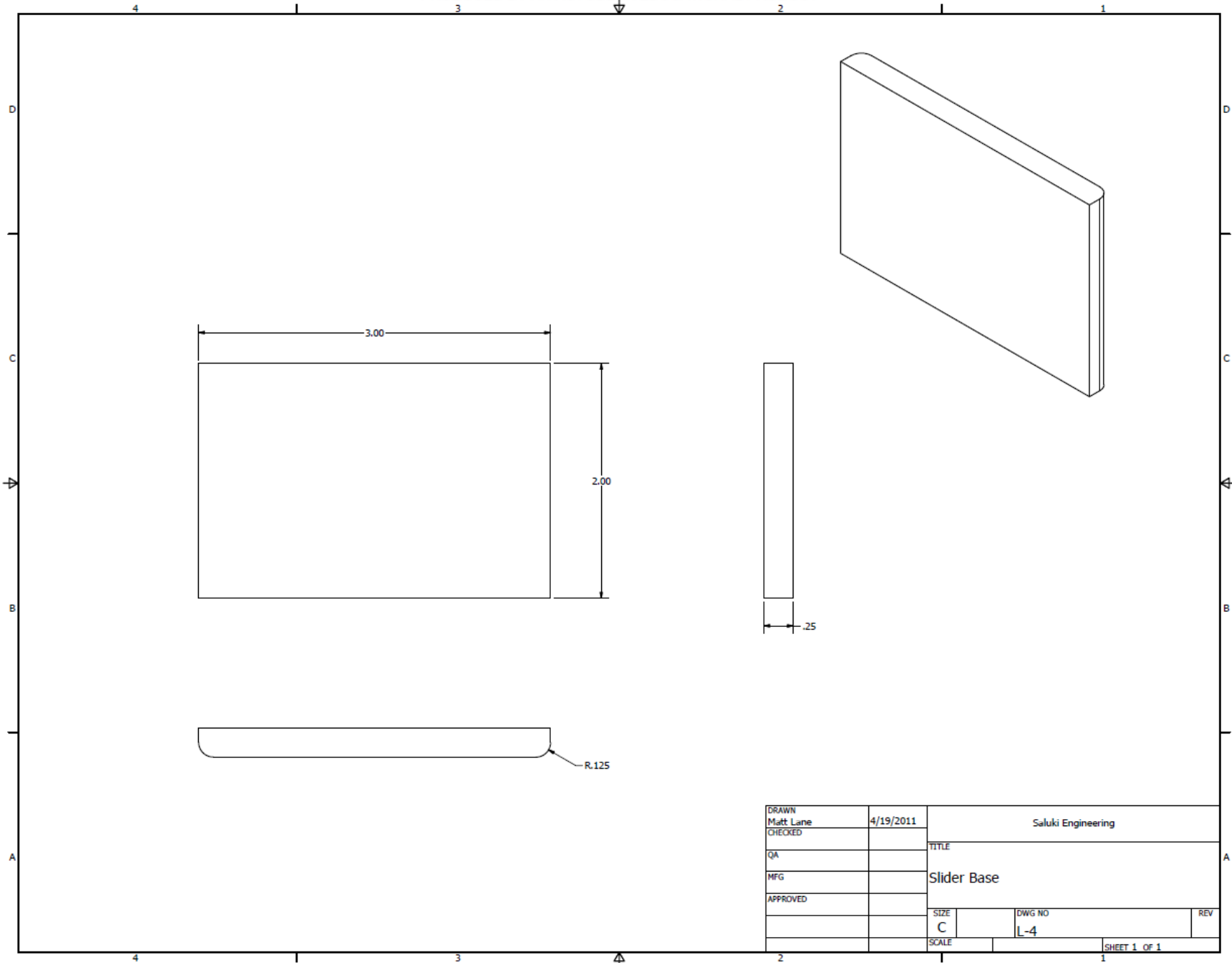
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN Matt Lane	4/19/2011	Saluki Engineering		
CHECKED		TITLE		
QA		Sleeve		
MFG				
APPROVED				
		SIZE C	DWG NO L-3	REV
		SCALE	SHEET 1 OF 1	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

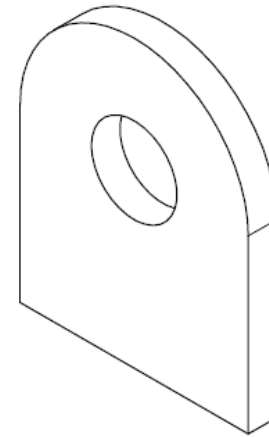
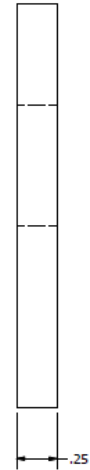
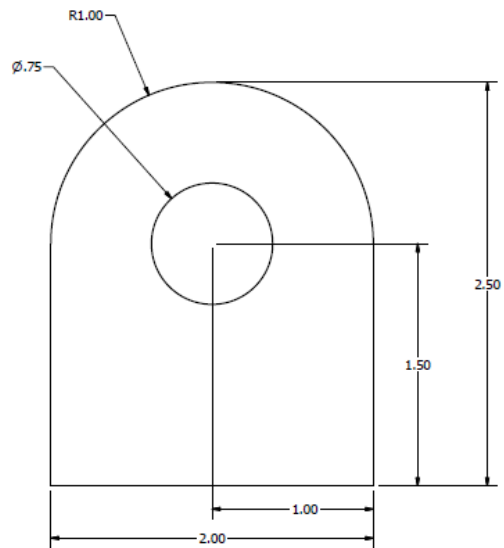
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN Matt Lane	4/19/2011	Saluki Engineering		
CHECKED		TITLE		
QA		Slider Base		
MFG				
APPROVED				
		SIZE	DWG NO	REV
		C	L-4	
		SCALE	SHEET 1 OF 1	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

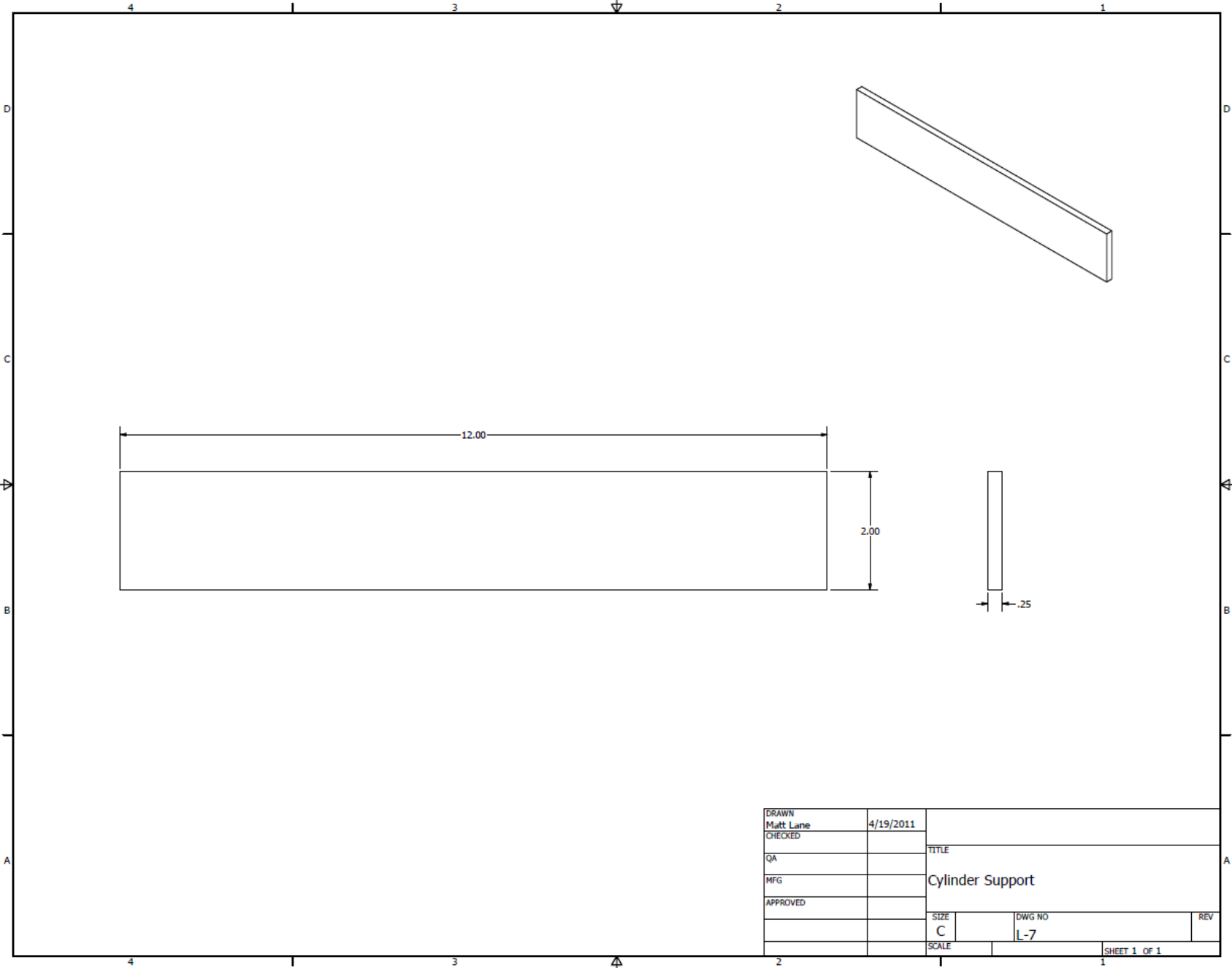
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN Matt	4/19/2011	Saluki Engineering		
CHECKED		TITLE		
QA		Slider Tab		
MFG				
APPROVED		REV		
		SIZE C	DWG NO L-5	
		SCALE	SHEET 1 OF 1	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

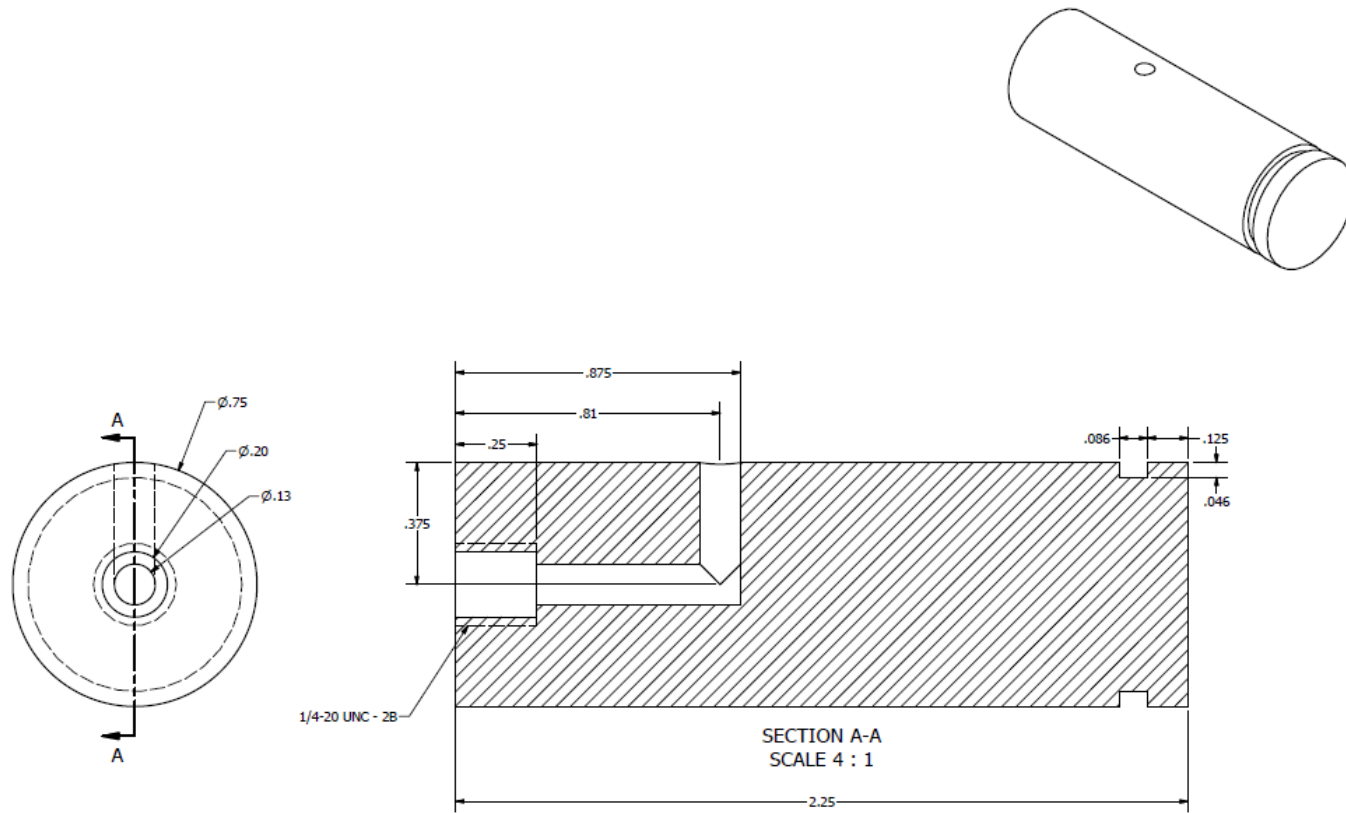
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN	Matt Lane	4/19/2011			
CHECKED			TITLE		
QA			Cylinder Support		
MFG					
APPROVED					
			SIZE	DWG NO	REV
			C	L-7	
			SCALE		SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

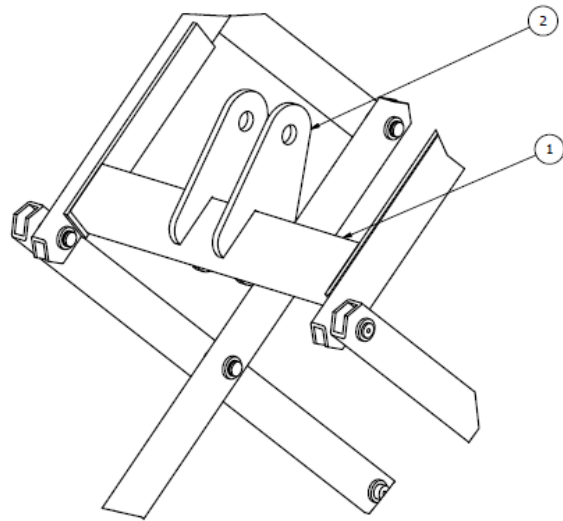
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



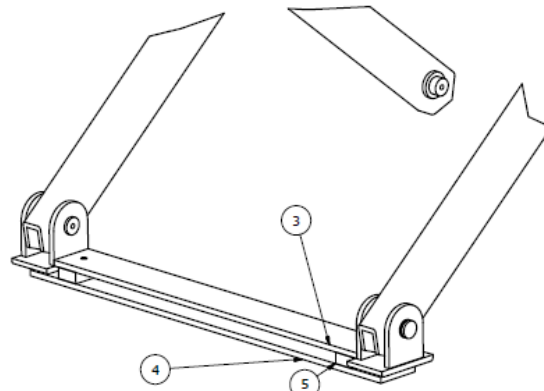
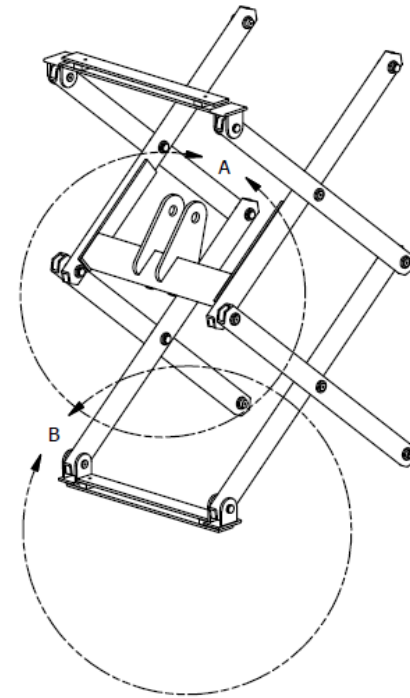
DRAWN Matt Lane	4/19/2011	Saluki Engineering		
CHECKED		TITLE		
QA		Short Grease Pin		
MFG				
APPROVED				
		SIZE C	DWG NO L-8	REV
		SCALE	SHEET 1 OF 1	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DETAIL A
SCALE .25: 1



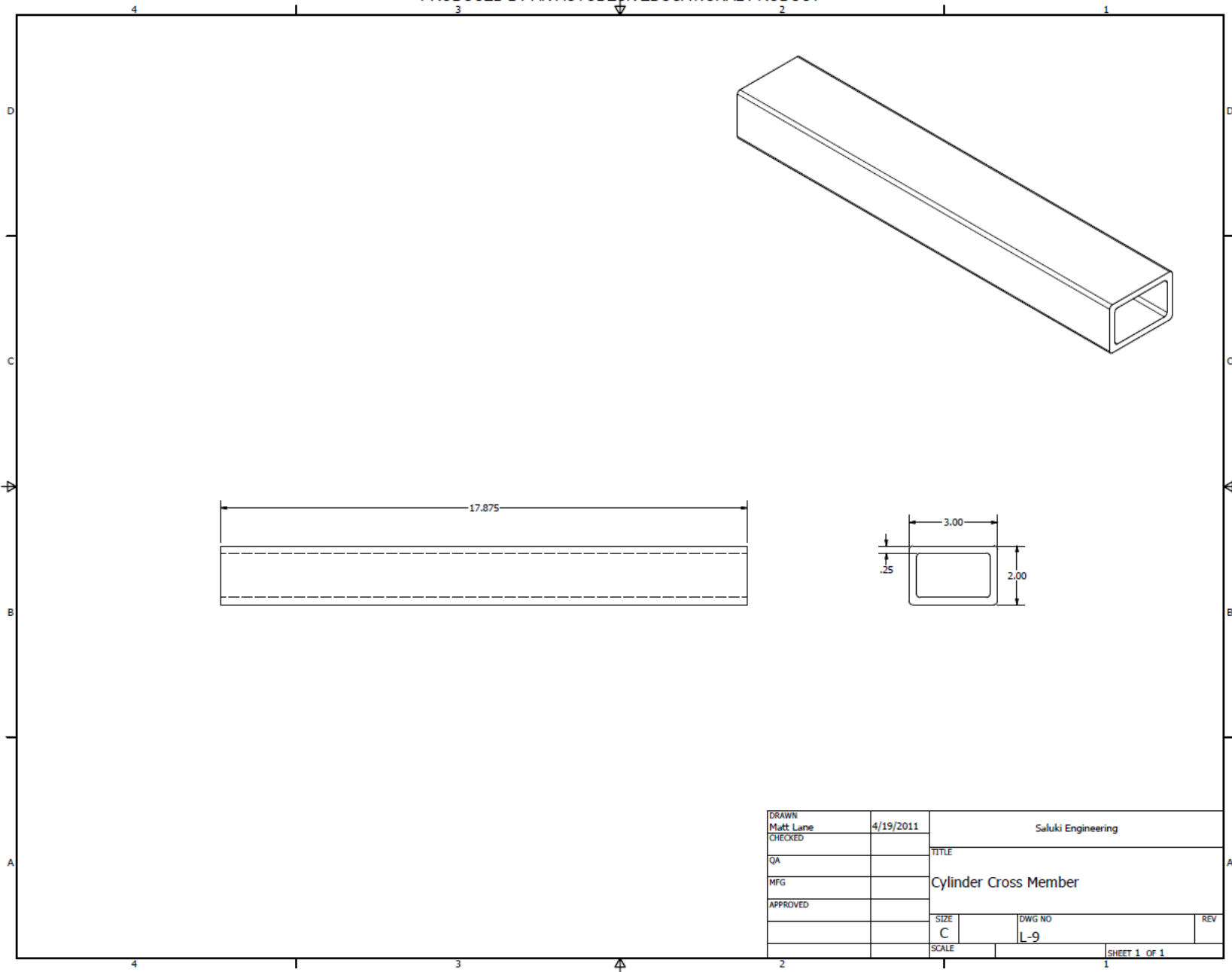
DETAIL B
SCALE 0.3 : 1

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	L-9	Cylinder Cross Member
2	2	L-10	Cylinder Bracket
3	1	L-11	Bottom Stabilizer
4	3	L-12	Top Stabilizer
5	4	L-13	Spacer

DRAWN Matt Lane	4/19/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Lifting Mechanism	
MFG		REV	
APPROVED		SCALE	
		SIZE C	DWG NO L-1
		SHEET 2 OF 2	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

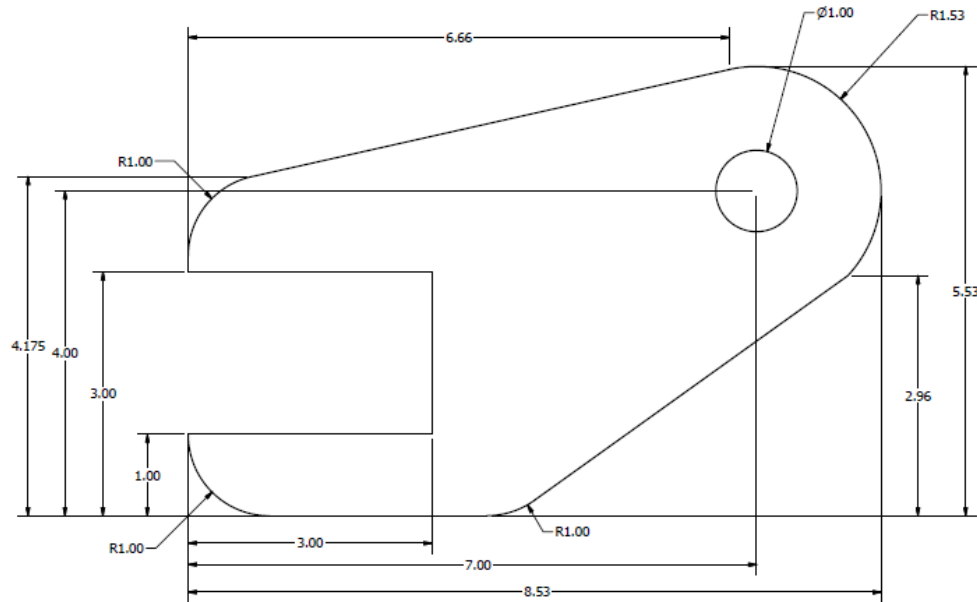


DRAWN Matt Lane	4/19/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Cylinder Cross Member	
MFG			
APPROVED			
		SIZE	DWG NO
		C	L-9
		SCALE	REV

SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

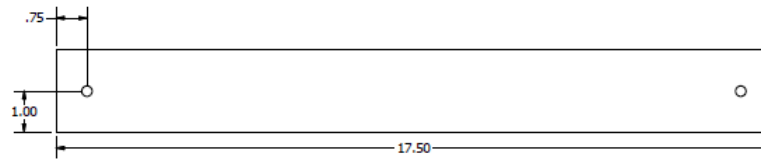
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN	Matt Lane	4/19/2011	Saluki Engineering		
CHECKED			TITLE		
QA			Cylinder Bracket		
MFG			SIZE	DWG NO	REV
APPROVED			C	L-10	
			SCALE	SHEET 1 OF 1	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

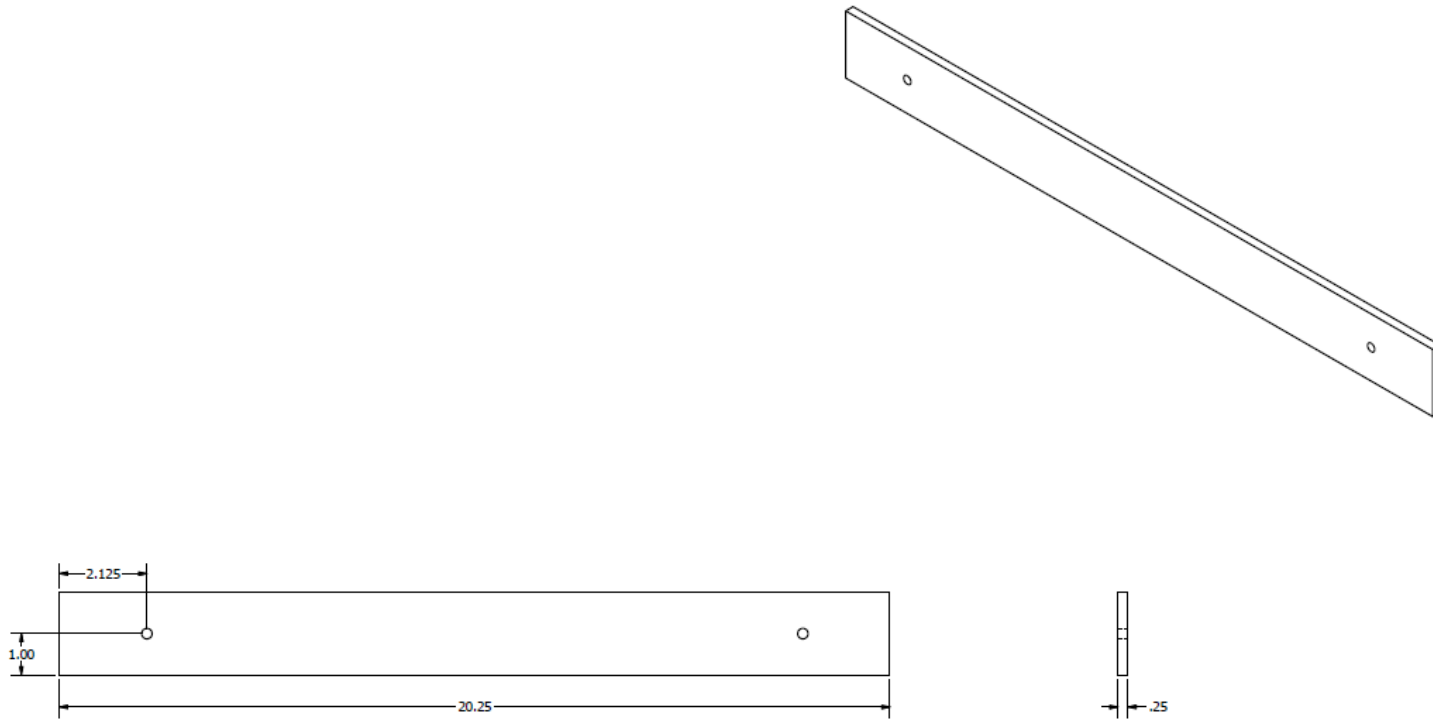
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN Matt Lane	4/19/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Bottom Stabilizer	
MFG			
APPROVED			
		SIZE C	DWG NO L-11
		SCALE	REV
			SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

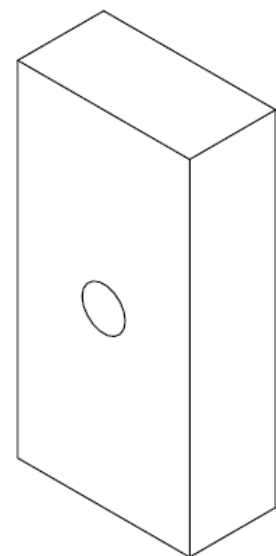
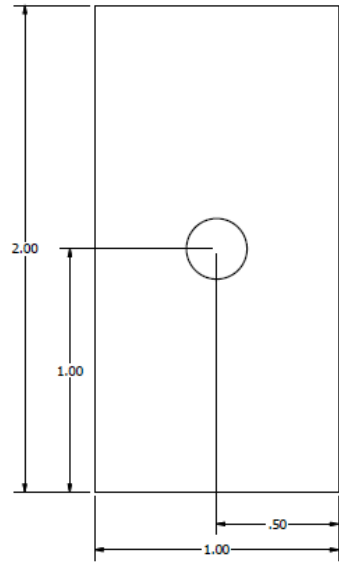
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN Matt Lane	4/19/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Top Stabilizer	
MFG			
APPROVED			
		SIZE C	DWG NO L-12
		SCALE	REV
			SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN	Matt Lane	4/19/2011	Saluki Engineering		
CHECKED			TITLE		
QA			Spacer		
MFG			REV		
APPROVED			SIZE		
			C		
			DWG NO		
			L-13		
			SCALE		
			SHEET 1 OF 1		

Equations used for force analysis of lifting mechanism.

Since the lifting mechanism subsystem is composed of two identical halves, the force analysis was done only on one half of the mechanism to simplify the equations. The right half of the mechanism was considered when completing the force analysis. The following equations were obtained when while doing the force analysis.

$$b = 30 * \cos(\theta) + a \quad (1)$$

$$l_{ram} = (30^2 + x^2 - 30 * x * \cos(2\theta))^{1/2} \quad (2)$$

$$\alpha = \sin^{-1} \left(\frac{x * \sin(2\theta)}{l} \right) \quad (3)$$

$$w * l = F_{1y} * a + F_{2y} * b \quad (4)$$

$$w = F_{1y} + F_{2y} \quad (5)$$

$$F_{3y} * (15 * \cos(\theta)) - F_{3x} * (15 * \sin(\theta)) - F_{2y} * (30 * \cos(\theta)) = 0 \quad (6)$$

$$F_{3y} + F_{5y} - F_{2y} = 0 \quad (7)$$

$$F_{3x} + F_{5x} = 0 \quad (8)$$

$$F_{5y} * (15 * \cos(\theta)) + F_{5x} * (15 * \sin(\theta)) + F_{8y} * (15 * \cos(\theta)) = 0 \quad (9)$$

$$F_{6y} + F_{8y} - F_{5y} = 0 \quad (10)$$

$$F_{6x} - F_{5x} = 0 \quad (11)$$

$$F_{1y} * (30 * \cos(\theta)) + F_{3y} * (15 * \cos(\theta)) + F_{3x} * (15 * \sin(\theta)) - F_c * (x * \cos(2\theta - 90 + \alpha)) = 0 \quad (12)$$

$$F_{4y} + F_c * \sin(\theta + \alpha) - F_{3y} - F_{1y} = 0 \quad (13)$$

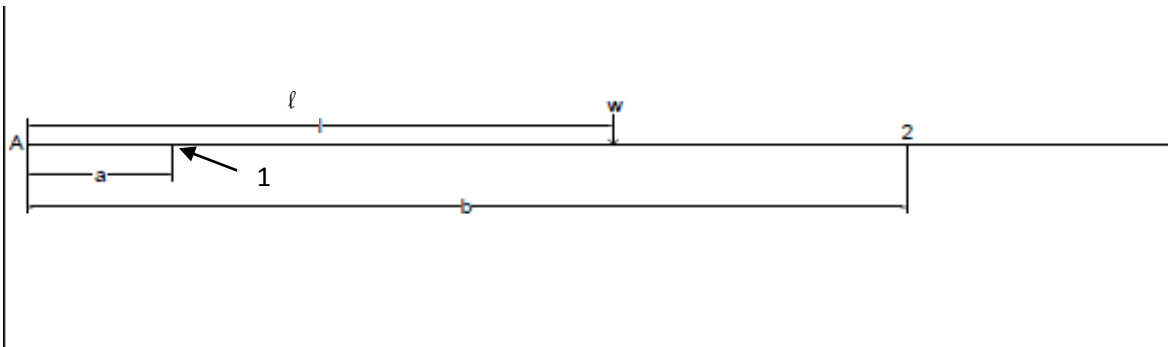
$$F_{4x} - F_{3x} + F_c * \cos(\theta + \alpha) = 0 \quad (14)$$

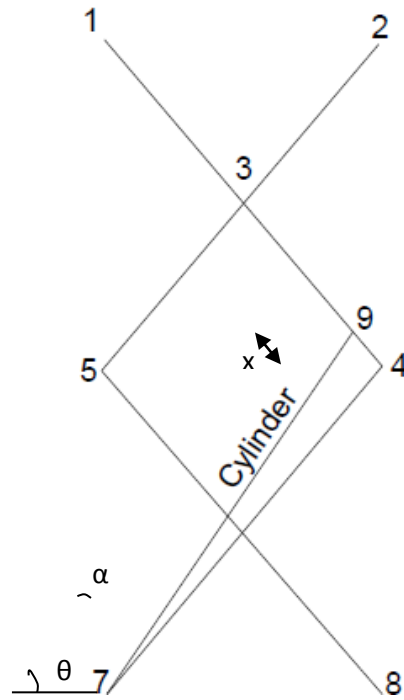
$$F_{8y} = F_{2y} \quad (15)$$

The following table describes the variables used in the above equations.

w	Weight of the load
a	Distance of Fixed member on Lifting surface to the left end of the Lifting Surface
l	Distance of center of mass of belly pan from left end of Lifting Surface
θ	Angle between lifting member and horizontal axis
b	Distance of slider from left end of Lifting Surface
x	Distance between cylinder mounts and joint
l_{ram}	Length of the cylinder
α	Angle between cylinder and lifting member
F_{1y}	Vertical force at point 1
F_{2y}	Vertical force at point 2
F_{3x}	Horizontal force at point 3
F_{3y}	Vertical force at point 3
F_{4x}	Horizontal force at point 4
F_{4y}	Vertical force at point 4
F_{5x}	Horizontal force at point 5
F_{5y}	Vertical force at point 5
F_{6x}	Horizontal force at point 6
F_{6y}	Vertical force at point 6
F_c	Force applied by cylinder
F_{8y}	Vertical force at point 8

The next two figures show the schematics of the lifting surface and the lifting mechanism that was used for the force analysis. The first figure is a figure of the lifting surface. The point 1 represents the pin where the lifting mechanism is mounted to the lifting surface, and point 2 represents the pin of the mechanism that is connected to the slider. The second of the two figures shows one half of the lifting mechanism and the numbered joints that correspond to the variables in the table above.



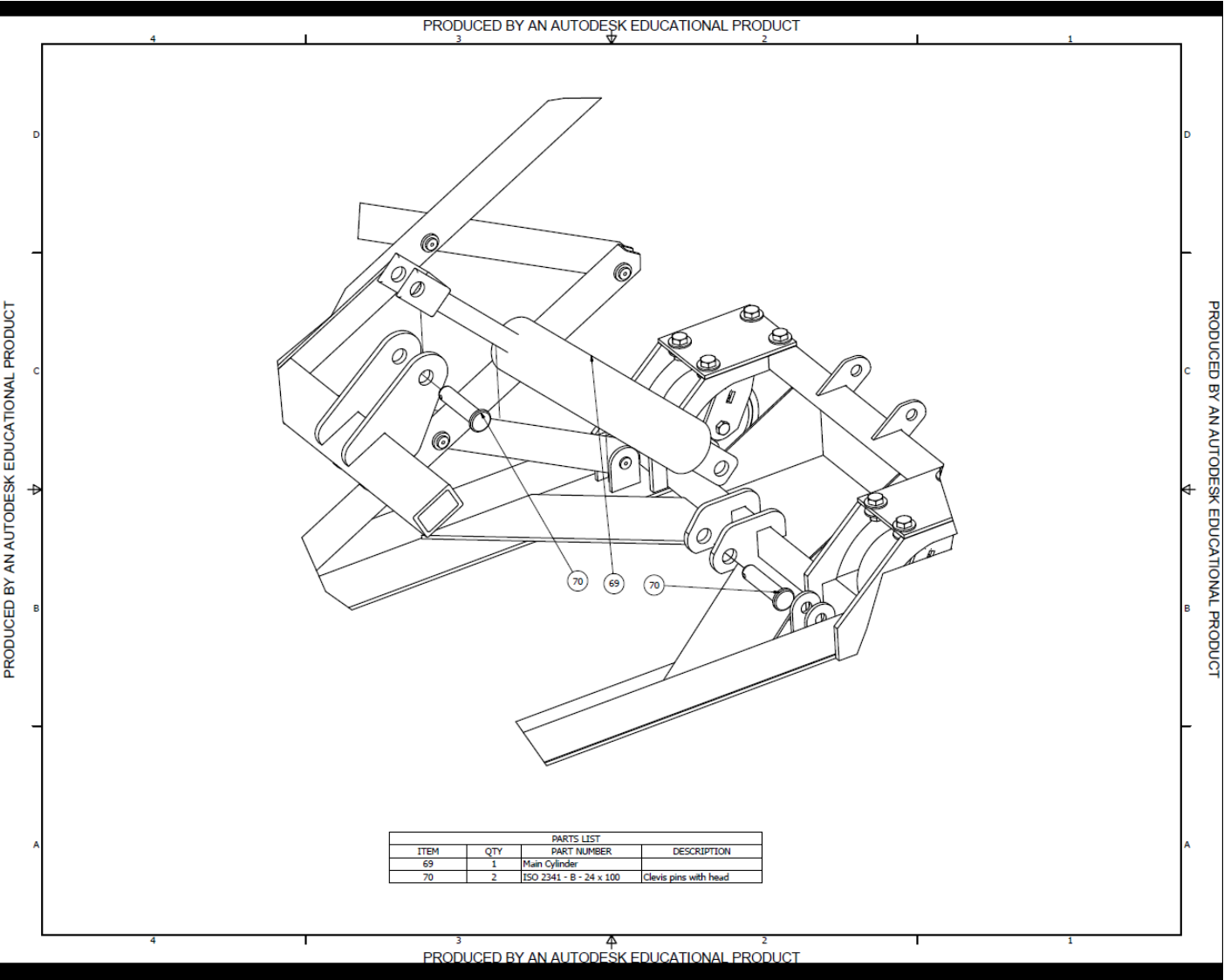


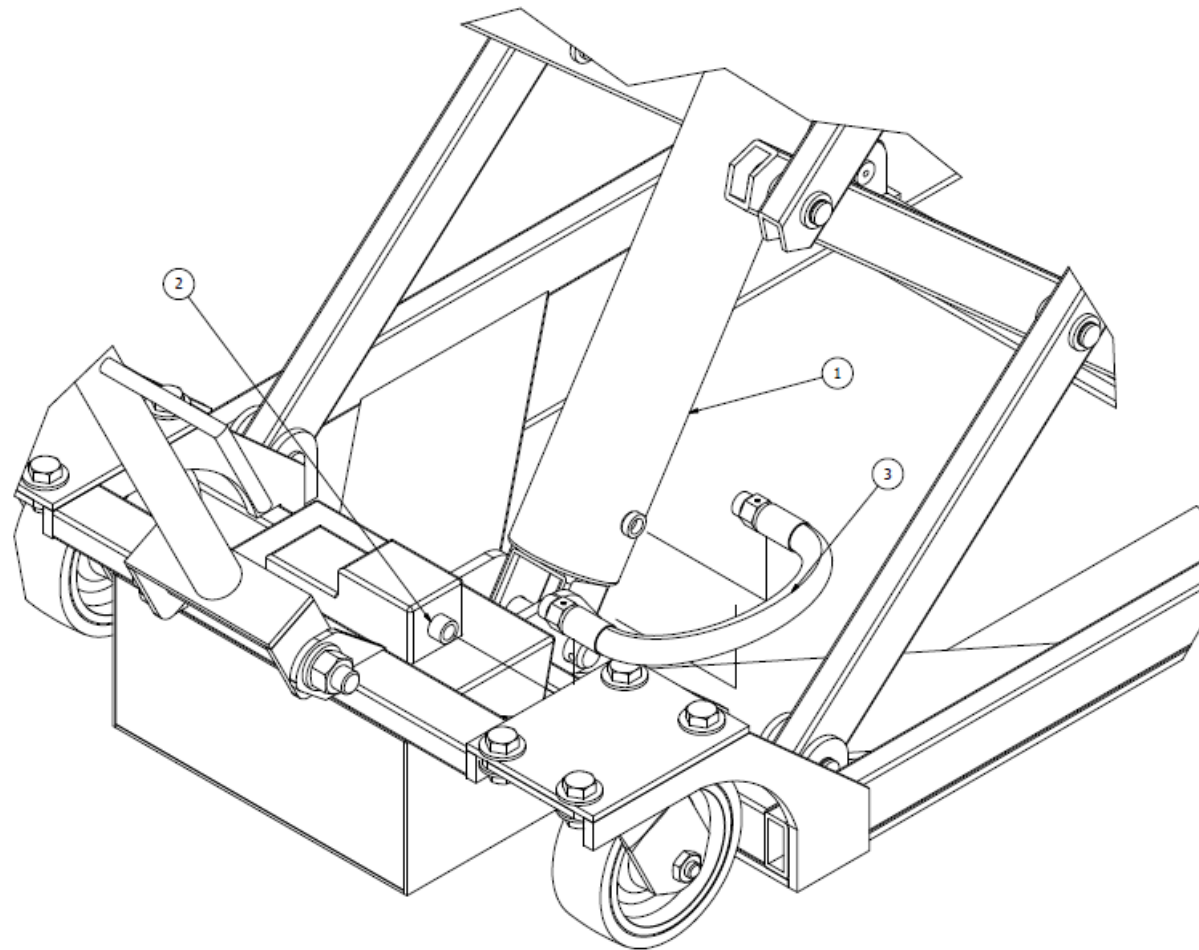
Once all of the equations had been developed they were put in matrix form and the variables were solved for using Microsoft Excel. The following figures show the spread sheet that was used to calculate the forces in the members. The variables w , l , a , b , x , and θ are design parameters, so an initial guess had to be taken and then the forces could be solved for. These variables were put into the Excel spread sheet so they could be changed and different combinations of the design parameters could be used to optimized the parameters and find what combinations gave the best results.

W=	2500			I_{xx} =	26.482619															
a=	10			α =	0.1818084	3.12506	<= degrees													
l =	20																			
θ =	10	0.17453	<= radians	F_{1x} =	1653.8112															
b =	39.5442			F_{2x} =	846.18884															
z =	14																			
Matrix																				
F_{1x}	F_{1y}	F_{4x}	F_{4y}	F_{5x}	F_{5y}	F_{6x}	F_{6y}	F_c												
-2.6047	14.7721	0	0	0	0	0	0	0		F_{1x}								25000		
0	1	0	0	0	1	0	0	0		F_{1y}								846.19		
1	0	0	0	1	0	0	0	0		F_{4x}								0		
0	0	0	0	2.60472	14.772116	0	0	0	*	F_{4y}	=							-12500		
0	0	0	0	0	-1	0	1	0		F_{5x}								-846.19		
0	0	0	0	-1	0	1	0	0		F_{5y}								0		
2.60472	14.7721	0	0	0	0	0	0	7.088		F_{6x}								-48861		
0	-1	0	1	0	0	0	0	0.3488		F_{6y}								1653.8		
-1	0	1	0	0	0	0	0	0.9372		F_c								0		
Inverse of Matrix																				
F_{1x}	F_{1y}	F_{4x}	F_{4y}	F_{5x}	F_{5y}	F_{6x}	F_{6y}	F_c		F_{1x} =	-5E-13									
-0.192	2.83564	0.5	-0.19196	0	0	0	0	0		F_{1y} =	1692									
0.03385	0.5	0.08816	-0.03385	0	0	0	0	0		F_{4x} =	9766									
-0.192	4.78881	0.8444	-0.32418	0	0	-0.1322	0	1		F_{4y} =	6981									
0.03385	1.22703	0.21636	-0.08306	0	0	-0.0492	1	0		F_{5x} =	-9E-13									
0.19196	-2.8356	0.5	0.191959	0	0	2.8E-17	0	0		F_{5y} =	-846.2									
-0.0338	0.5	-0.0882	0.033848	0	0	-5E-18	0	0		F_{6x} =	-1E-12									
0.19196	-2.8356	0.5	0.191959	0	1	2.8E-17	0	0		F_{6y} =	-1692									
-0.0338	0.5	-0.0882	0.033848	1	0	0	0	0		F_c =	-10420									
0	-2.0841	-0.3675	0.141083	0	0	0.14108	0	0												
										2*F_c =	14737									

Since the force analysis was done on just half of the lifting mechanism, the actual force in the cylinder have to be found by multiplying F_c by 2.

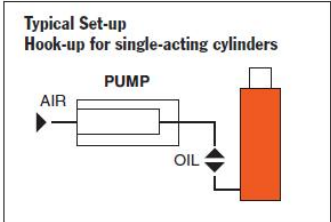
Appendix D: Power Subsection





PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Main Cylinder	
2	1	Air Over Hydraulic Pump	
3	1	Hydraulic Hose	

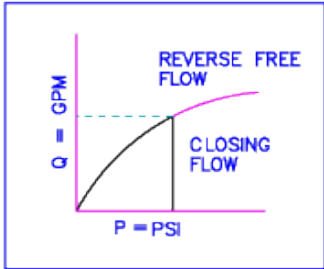
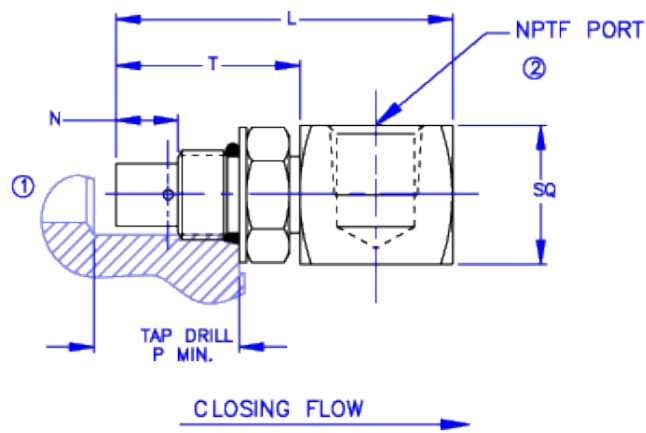
Pump Specifications



For use with Cyl. Type	Description	Order No.	Valve No.	Air Supply Req'd (psi)	Reservoir		Oil Port (in.)	Prod. Wt (lbs.)
					Cap. (cu. in.)	Usable (cu. in.)		
Single-Acting	Base model pump with high density polyethylene reservoir.	PA50	—	40-120	105	98	3/8 NPTF	14.2
Single-Acting	PA50, except has metal reservoir.	PA50M	—	40-120	105	98	3/8 NPTF	16.2
Single-Acting	PA50, except has 12 foot remote control.	PA50R	—	40-120	105	98	3/8 NPTF	18.5
Single-Acting	PA50, except has metal reservoir.	PA50RM	—	40-120	105	98	3/8 NPTF	20.5
Single-Acting	PA50R, except has 2 gallon reservoir.	PA50R2	—	40-120	2 gal.	454	3/8 NPTF	28.5
Single- and Double Acting	PA50, except designed to operate either single- or double-acting systems. Valve function: Advance / Return.	PA50D	9504, 3-way/ 4-way	40-120	105	98	3/8 NPTF	18.4

Notes: Air inlet port 1/4" NPTF. Requires 20 cfm at 100 psi shop air pressure at the pump.

Appendix E: Safety Subsection



DESCRIPTION

- AN IN-LINE 90° ELBOW SWIVEL VELOCITY FUSE WITH AN NPTF OUTLET PORT THAT PROVIDES FULL-LINE SHUT-OFF IN THE EVENT OF A LINE FAILURE.

OPERATION

- A FLOW BELOW THE SPECIFIED CLOSING FLOW IS ALLOWED FROM "1" TO "2".
- FLOW ABOVE THE SPECIFIED CLOSING FLOW FROM "1" TO "2" IS ASSUMED TO BE A LINE FAILURE AND IS BLOCKED.
- FLOW FROM "2" TO "1" PASSES THRU THE CONTROLLING ORIFICE BUT IS UNCONTROLLED.
- CLOSING FLOW TOLERANCE=+15%-0%.

FEATURES

- SWIVEL DESIGN FOR EASY ALIGNMENT.
- 90° ELBOW FOR LOW PROFILE APPLICATIONS.
- FAIL SAFE EMBEDDED FUSE DESIGN.
- STEEL BODY & COMPONENTS.
- RAPID RESPONSE.
- POSITIVE CLOSE.

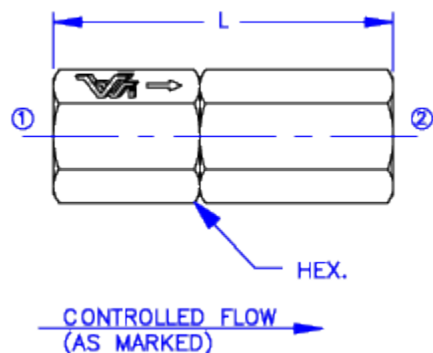
- SPECIFICATIONS -	
Hydraulic Symbol	
Operating Pressure	3500 PSI
Temperature Range	250°F to -40°F
Reopening Differential	50 PSI
ALL DIMENSIONS IN INCHES	

- ORDERING INFORMATION -	
ASSEMBLY NUMBER	83XX-XX
SERIES NUMBER	
OUTLET PORT SIZE	
CLOSING FLOW (GPM)	

MODEL	THREAD ②	CAVITY THREAD	P	RATED FLOW	L	T	N	SQ
8302	1/4 - 18 NPTF	9/16 - 18	1.000	0.2 - 5 GPM²	2.125	1.160	0.390	0.875

* FUSE NOSE REQUIRES A DEEPER TAP DRILL DEPTH. SEE DIM P.

² Range of applicable set flow rate, the setting used was 0.35 GPM.



DESCRIPTION

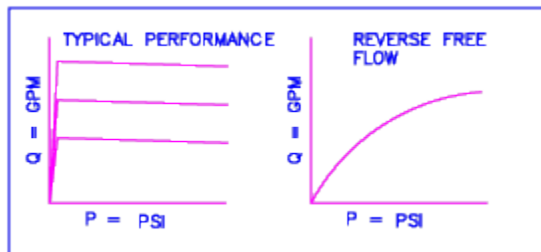
- AN IN-LINE, PRESSURE-COMPENSATED, NONADJUSTABLE FLOW REGULATOR WITH FEMALE NPT PORTS, INTENDED FOR FIXED DISPLACEMENT HYDRAULIC CIRCUIT APPLICATIONS.

OPERATION

- IN THE CONTROLLED DIRECTION THIS REGULATOR WILL MAINTAIN A CONSTANT FLOW RATE THROUGHOUT A SPECIFIED PRESSURE RANGE.
- REVERSE FLOW PASSES THROUGH THE CONTROLLING ORIFICE AND IS UNCONTROLLED PRODUCING A PRESSURE DIFFERENTIAL OF 120 PSI MAX. AT 150% OF CONTROLLED FLOW.

FEATURES

- **S.I.D.** SURGES INTERNALLY DAMPENED FEATURE IS OPTIONAL FOR LOAD LOWERING APPLICATIONS.
- STEEL BODY, STEEL INTERNALS.
- HYDRAULIC FLUIDS – GENERAL.



- SPECIFICATIONS -

Hydraulic Symbol	
Pressure Range	50 PSI TO 3500 PSI
Temperature Range	250°F to -40°F
Flow Tolerance	+/- 10%
ALL DIMENSIONS IN INCHES	

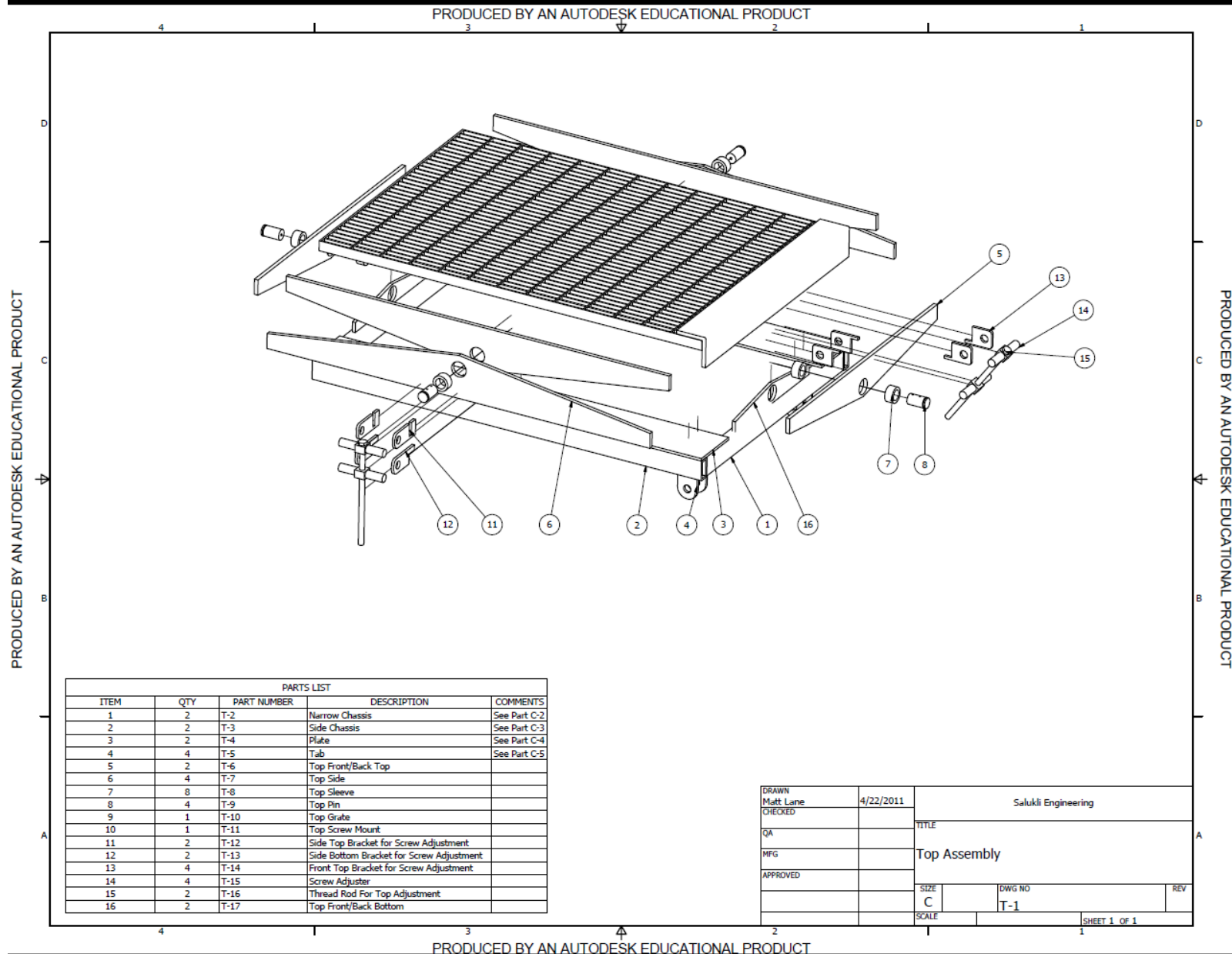
- ORDERING INFORMATION -

ASSEMBLY NUMBER 135X-X-XX
 SERIES NUMBER
 UNDAMPENED - BLANK
 DAMPENED (S.I.D.) - 1
 REGULATED FLOW RATE (GPM)

MODEL	PORT 1/2	FLOW RANGE	L	HEX.
1352	1/4-18 NPT	0.25 – 4.0 GPM*	2.50	0.938

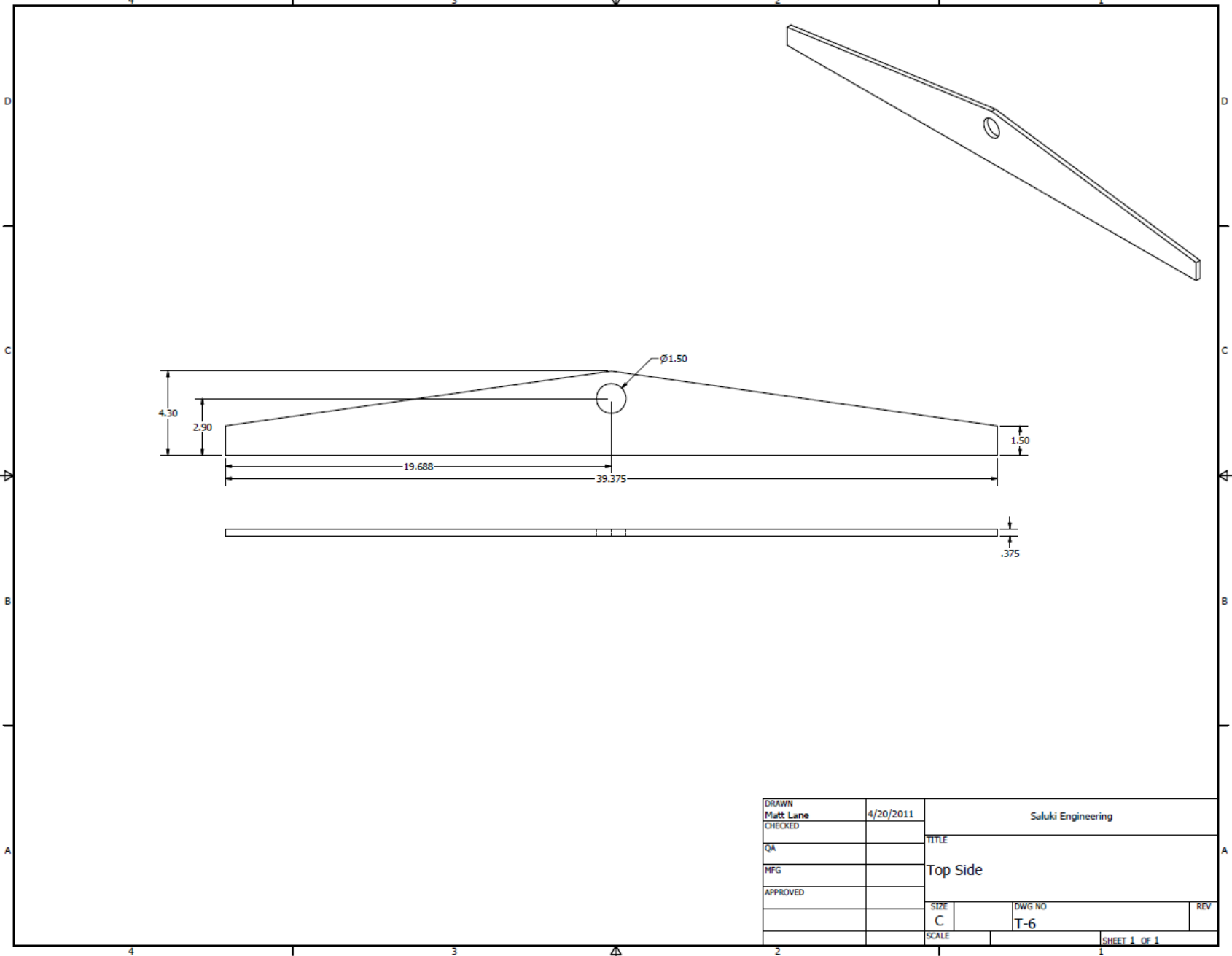
* Range of applicable set flow rate, the setting used was 0.25 GPM.

Appendix F: Platform Subsection



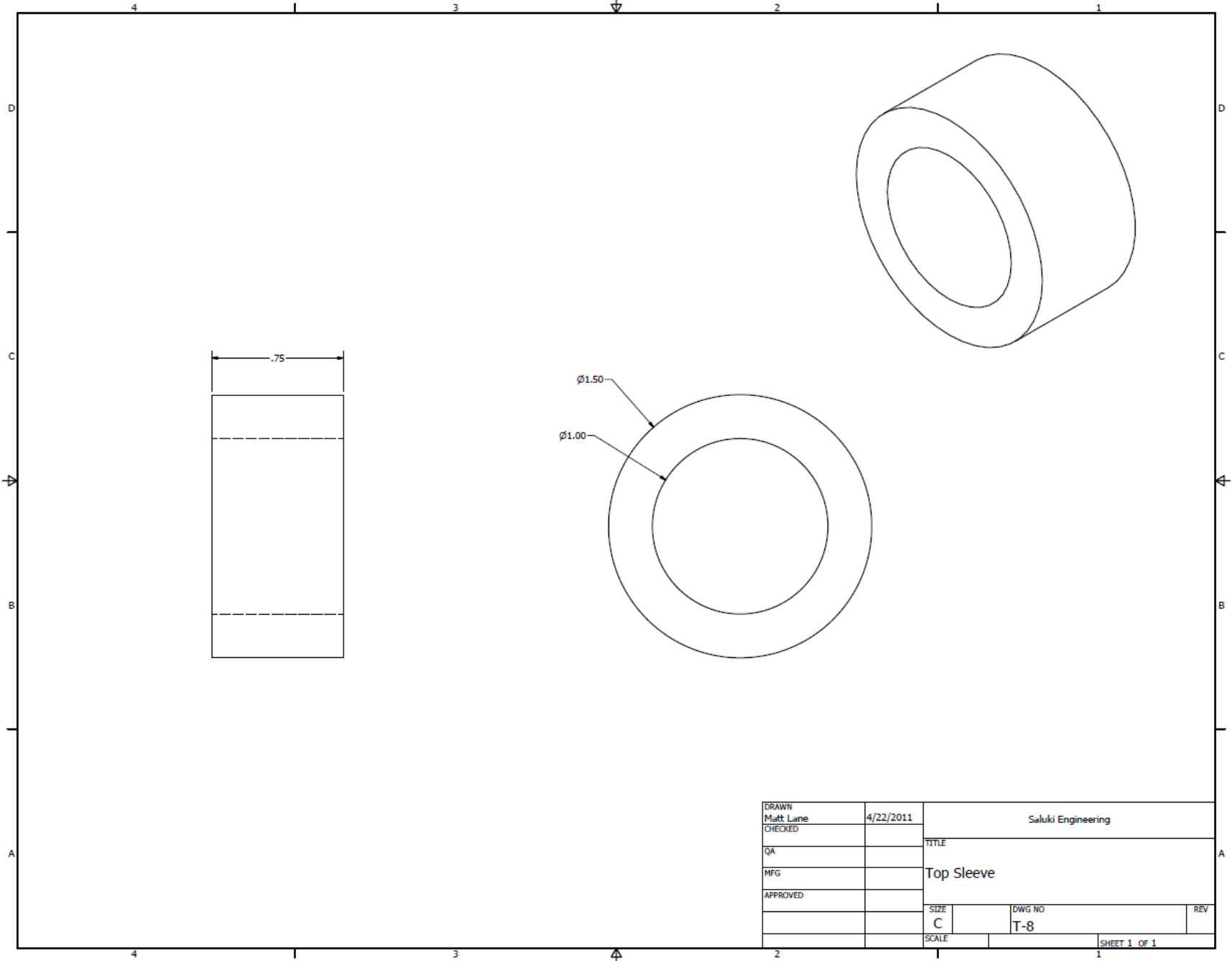
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PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



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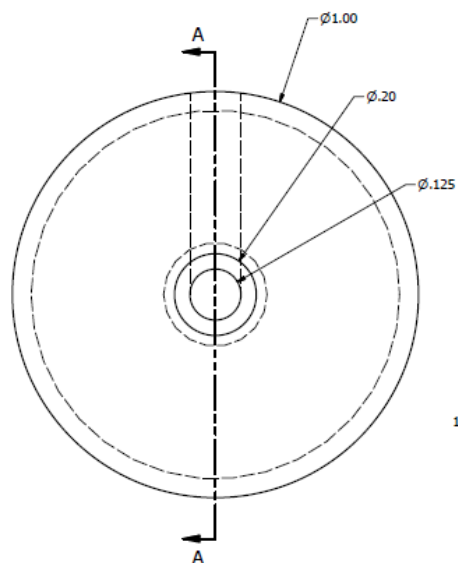
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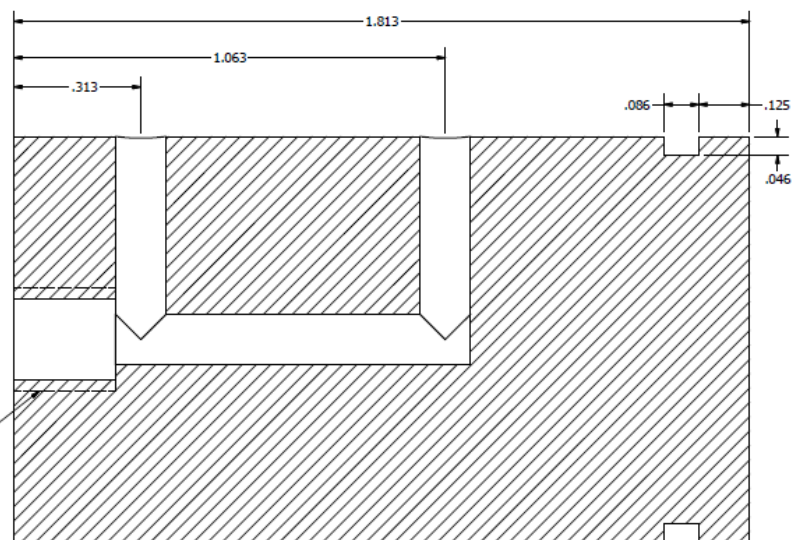
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CHECKED		TITLE		
QA		Top Sleeve		
MFG		REV		
APPROVED		SIZE		
		C	DWG NO T-8	
		SCALE	SHEET 1 OF 1	

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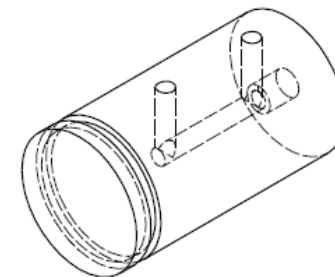
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1/4-20 UNC - 2B



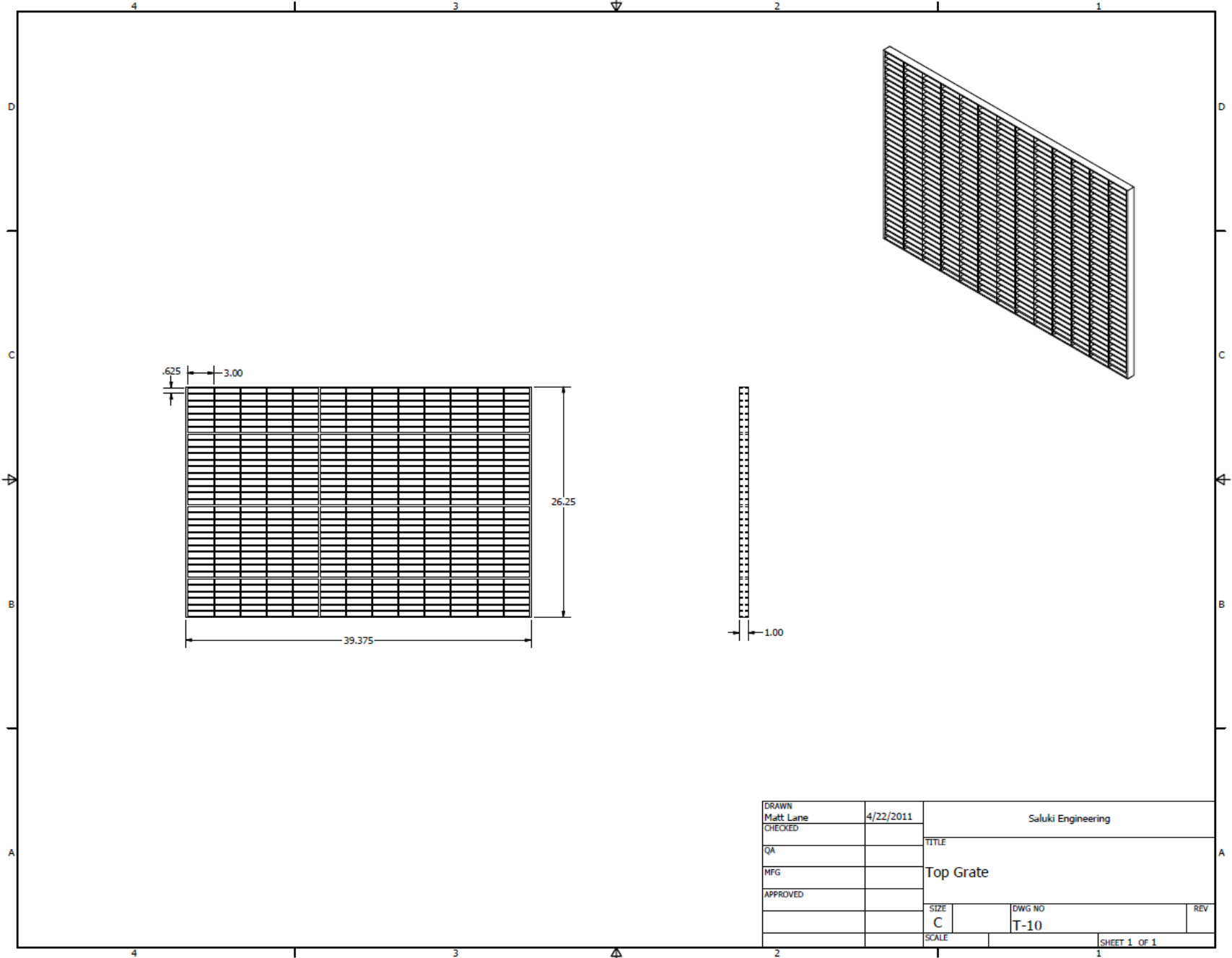
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SCALE 5 : 1



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CHECKED		TITLE	
QA		Top Pin	
MFG		SIZE	DWG NO
APPROVED		C	T-9
		SCALE	REV
			SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

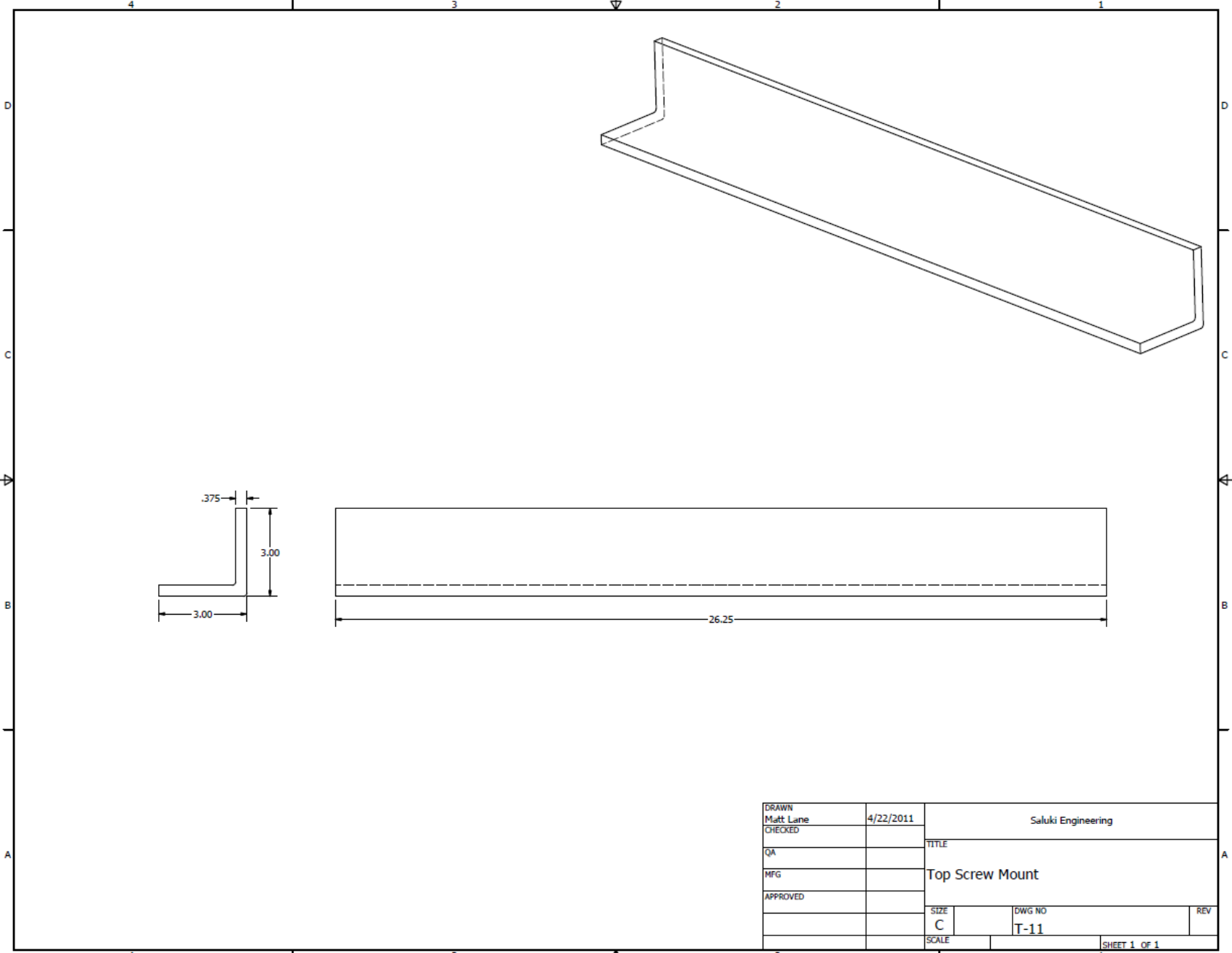
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN	Matt Lane	4/22/2011	Saluki Engineering	
CHECKED			TITLE	
QA			Top Grate	
MFG			REV	
APPROVED			SIZE	
			C	T-10
			SCALE	SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

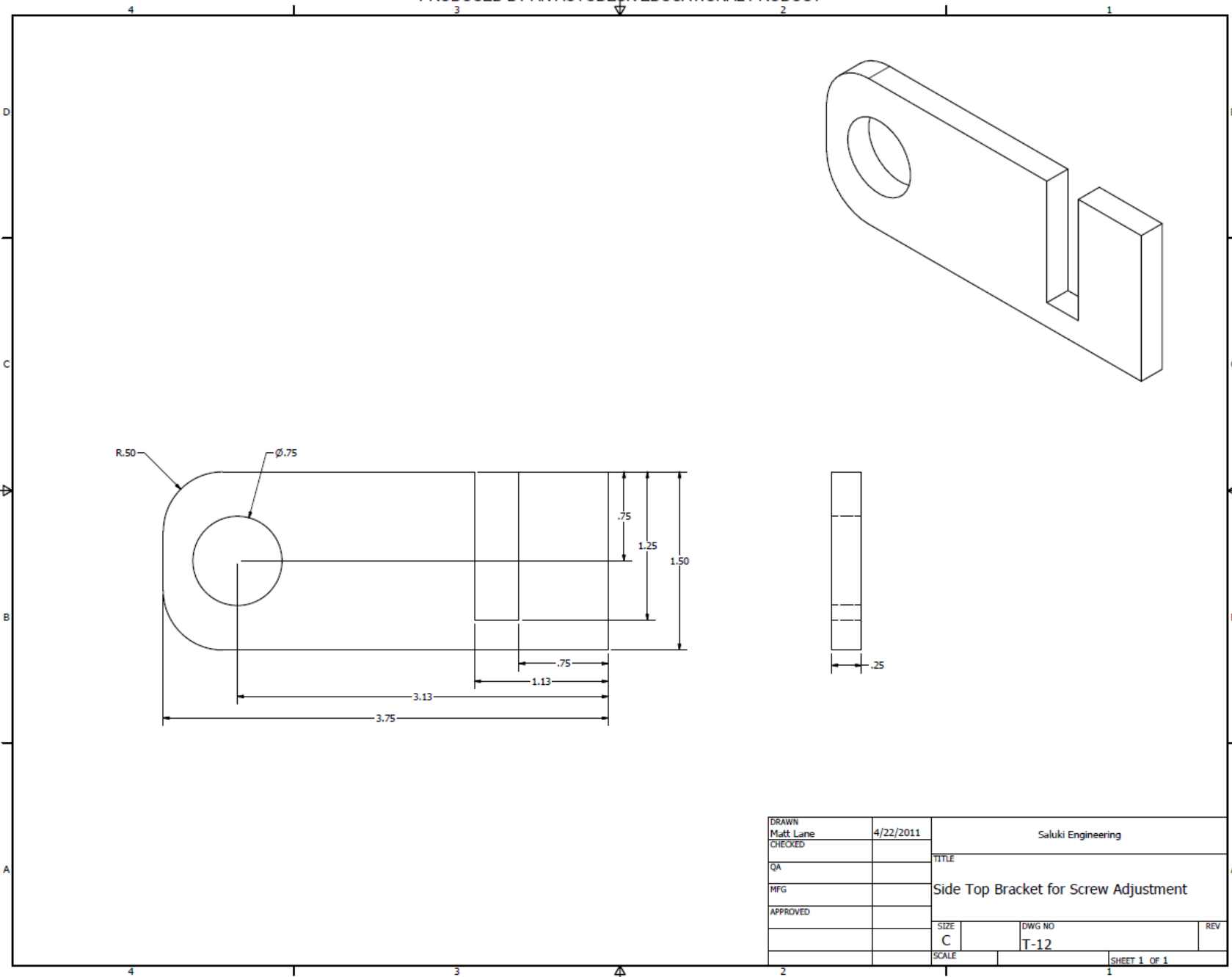
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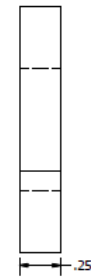
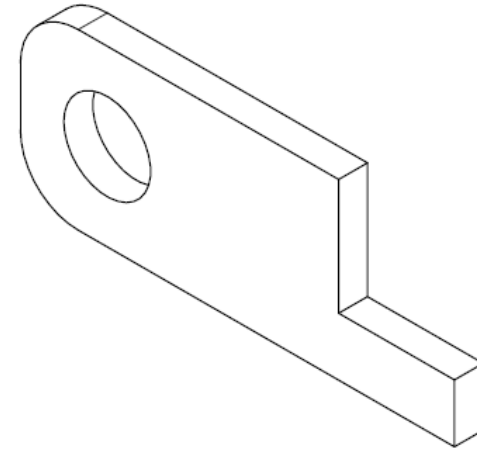
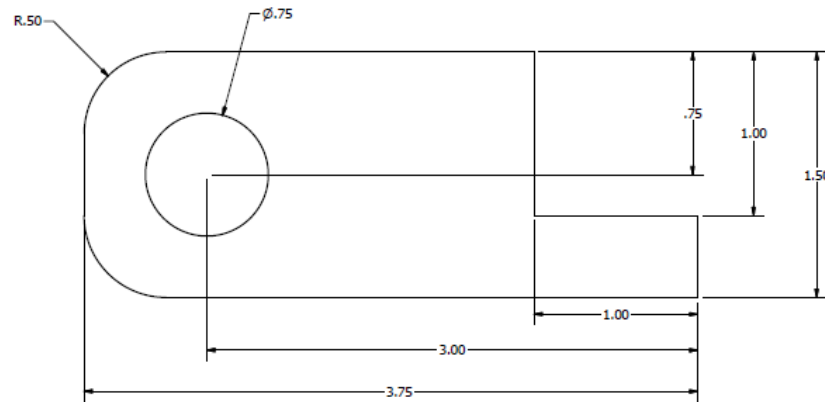
DRAWN Matt Lane	4/22/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Top Screw Mount	
MFG			
APPROVED		SIZE C	DWG NO T-11
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PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



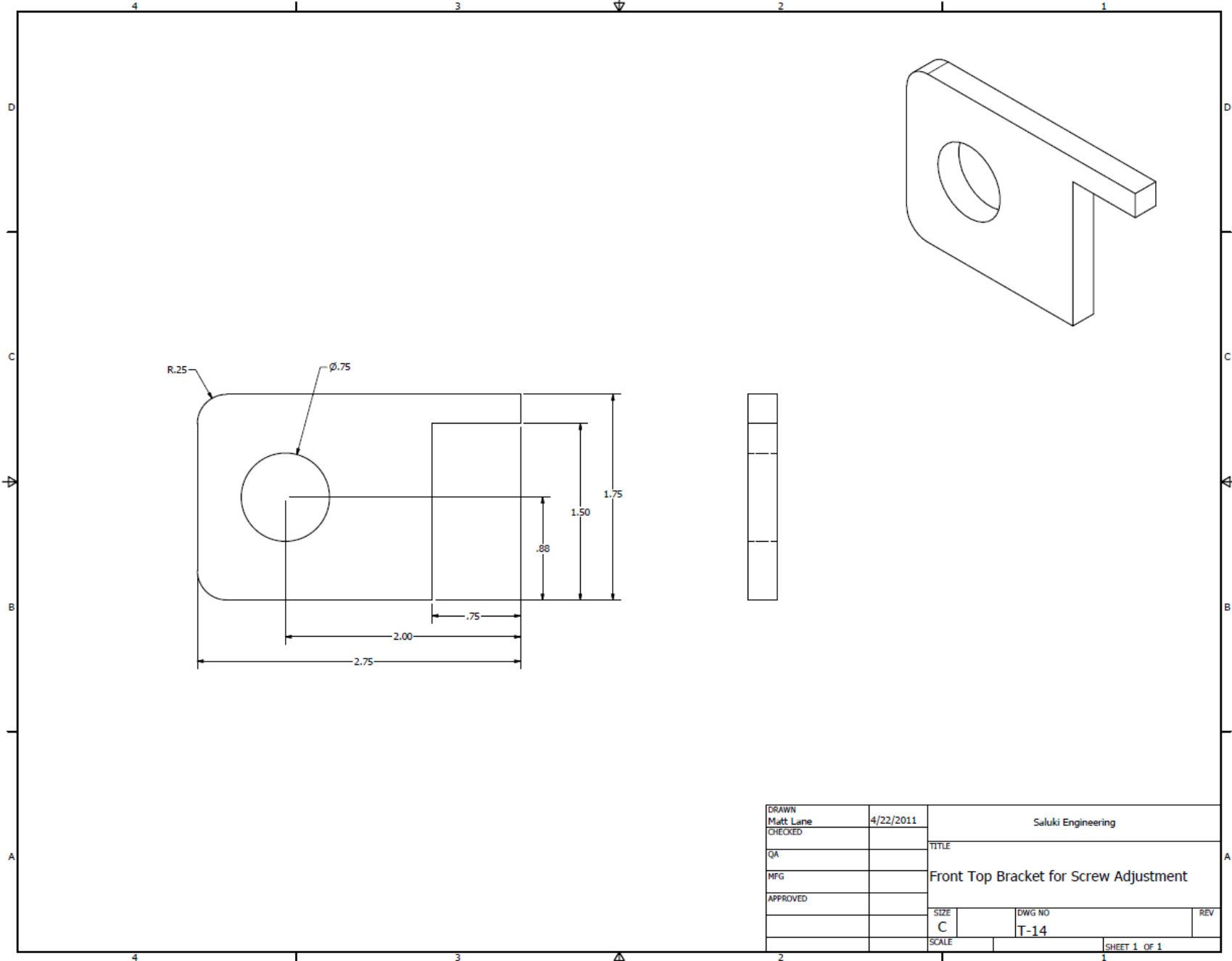
DRAWN Matt Lane	4/22/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Side Top Bracket for Screw Adjustment	
MFG			
APPROVED		SIZE C	DWG NO T-12
		SCALE	REV
			SHEET 1 OF 1



DRAWN Matt Lane	4/22/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Side Bottom Bracket for Screw Adjustment	
MFG			
APPROVED		REV	
		SIZE C	DWG NO T-13
		SCALE	SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

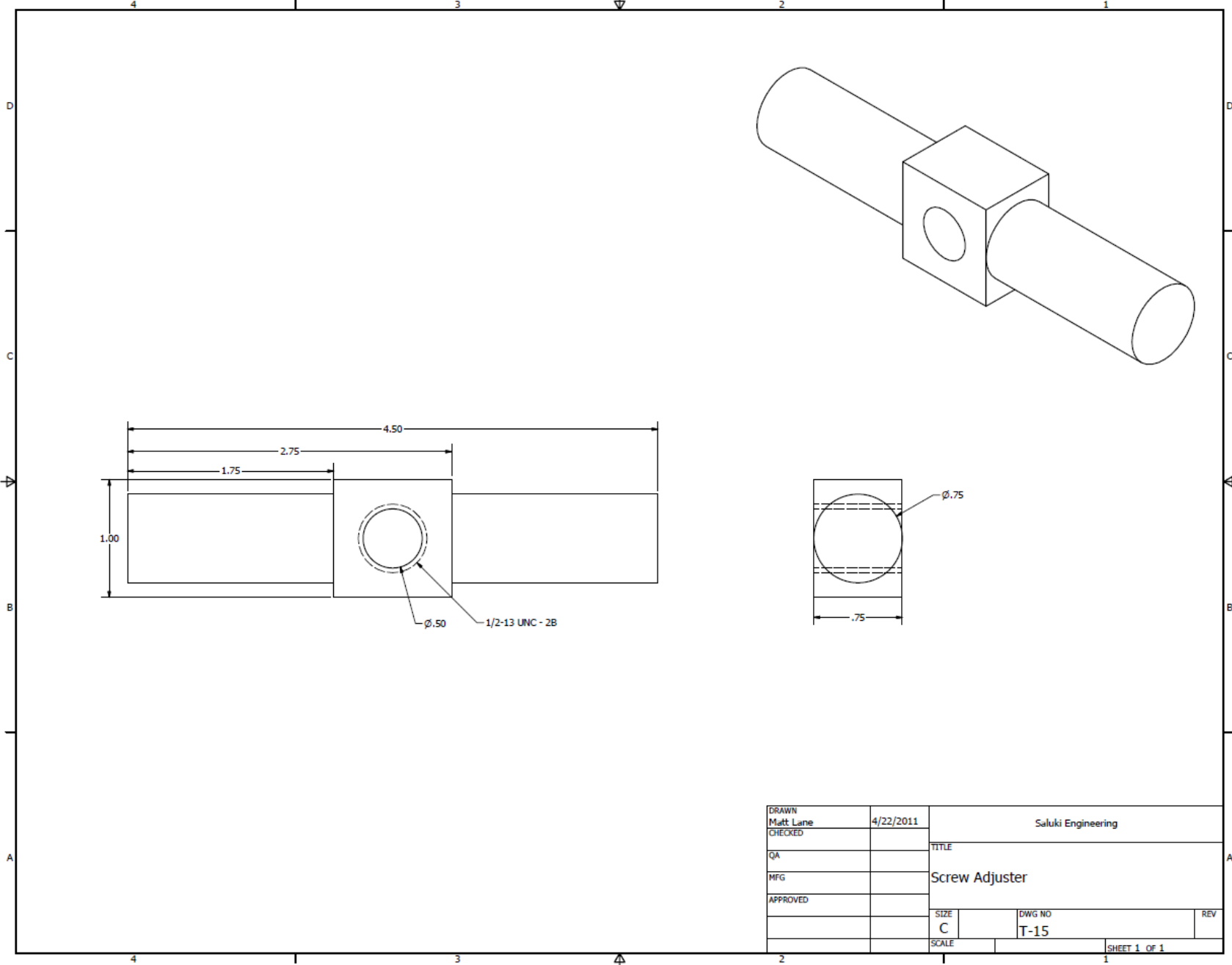


DRAWN Matt Lane	4/22/2011	Saluki Engineering	
CHECKED		TITLE	
QA		Front Top Bracket for Screw Adjustment	
MFG			
APPROVED		SIZE	DWG NO
		C	T-14
		SCALE	REV

SHEET 1 OF 1

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

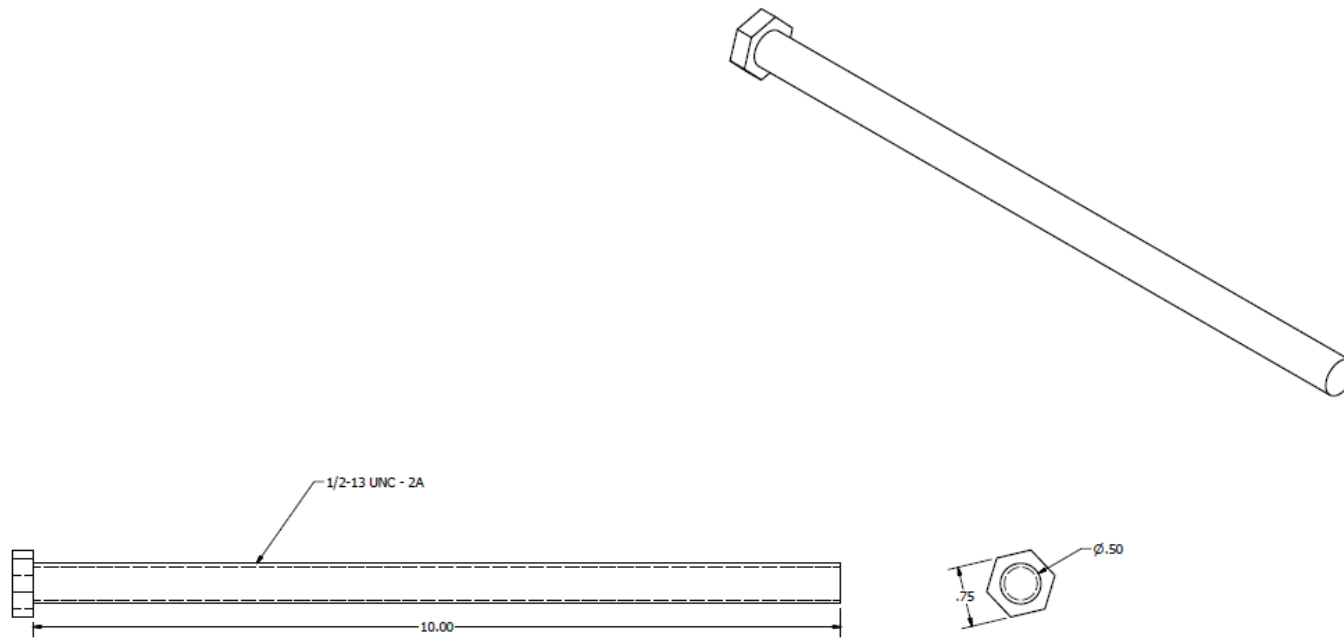
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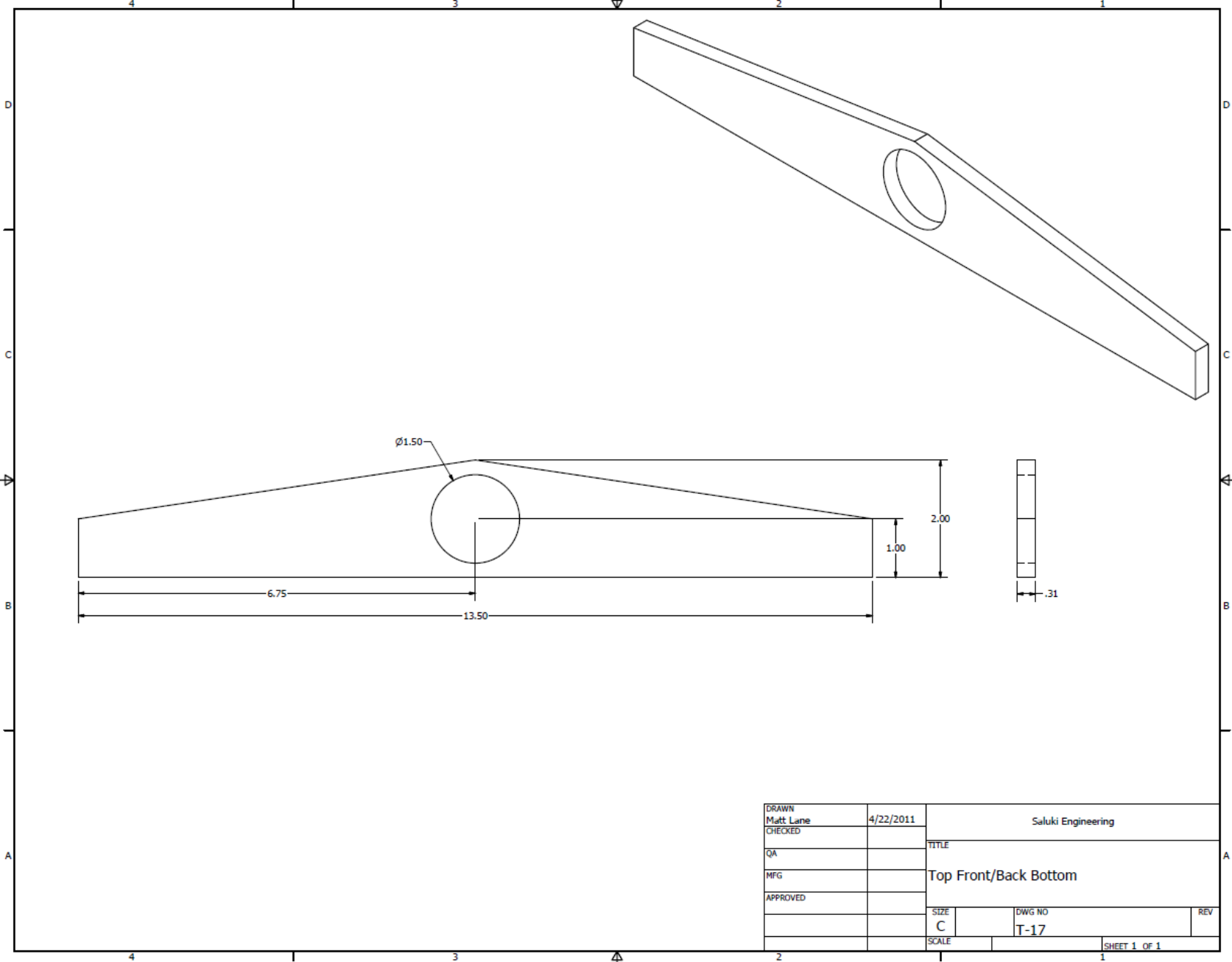
DRAWN	Matt Lane	4/22/2011	Saluki Engineering		
CHECKED			TITLE		
QA			Screw Adjuster		
MFG					
APPROVED					
			SIZE	DWG NO	REV
			C	T-15	
			SCALE	SHEET 1 OF 1	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



DRAWN	Matt Lane	4/22/2011	Saluki Engineering	
CHECKED			TITLE	
QA			Thread Rod For Top Adjustment	
MFG			REV	
APPROVED			SIZE	DWG NO
			C	T-16
			SCALE	SHEET 1 OF 1



DRAWN	Matt Lane	4/22/2011	Saluki Engineering	
CHECKED			TITLE	
QA			Top Front/Back Bottom	
MFG			DWG NO	
APPROVED			T-17	
			SCALE	SHEET 1 OF 1



BPJ-2000

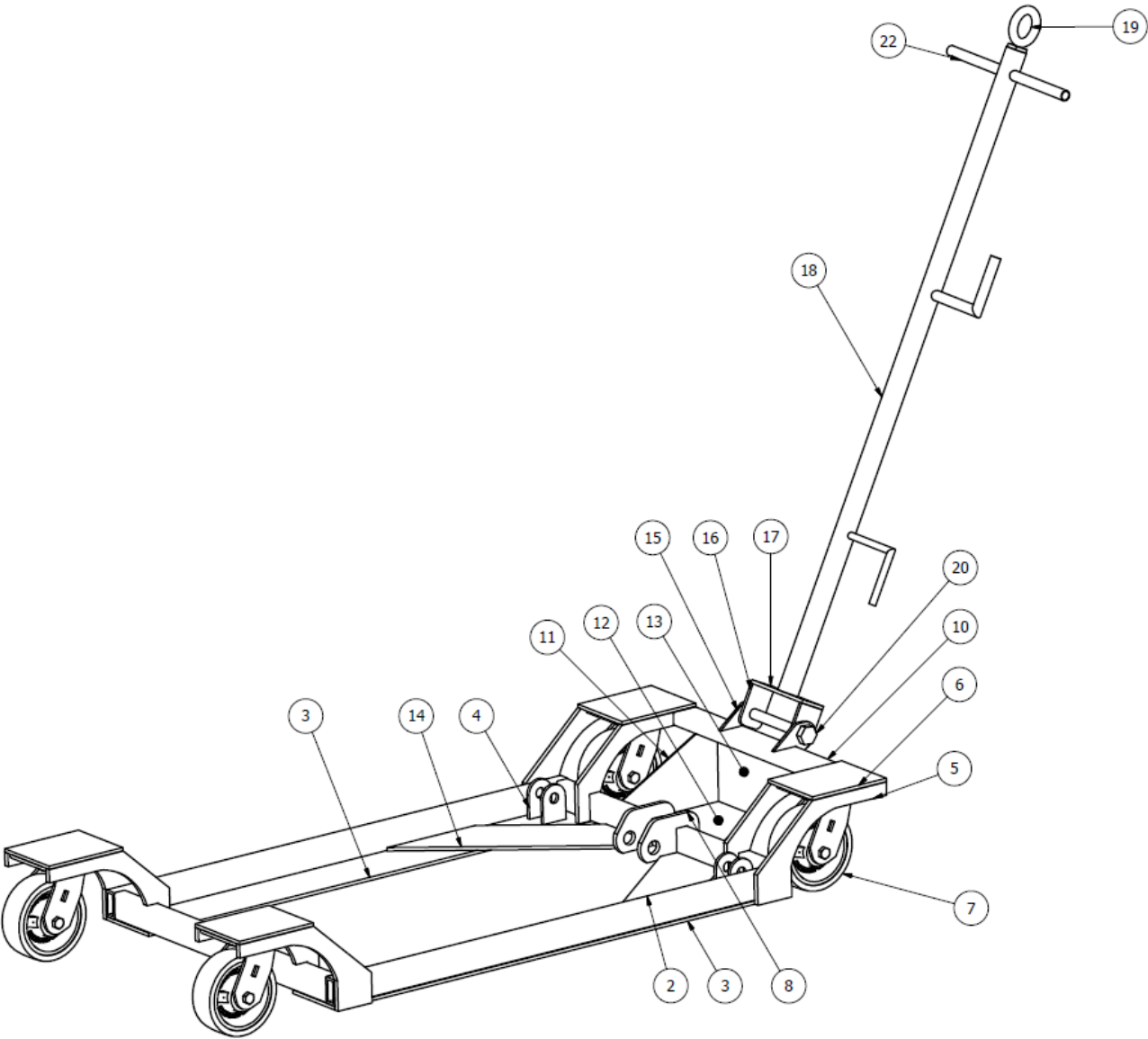
Technical Manual

This manual includes a complete technical description of each subsystem of the jack. Refer to this manual before servicing or performing maintenance to the jack.

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Chassis



Chassis Parts List

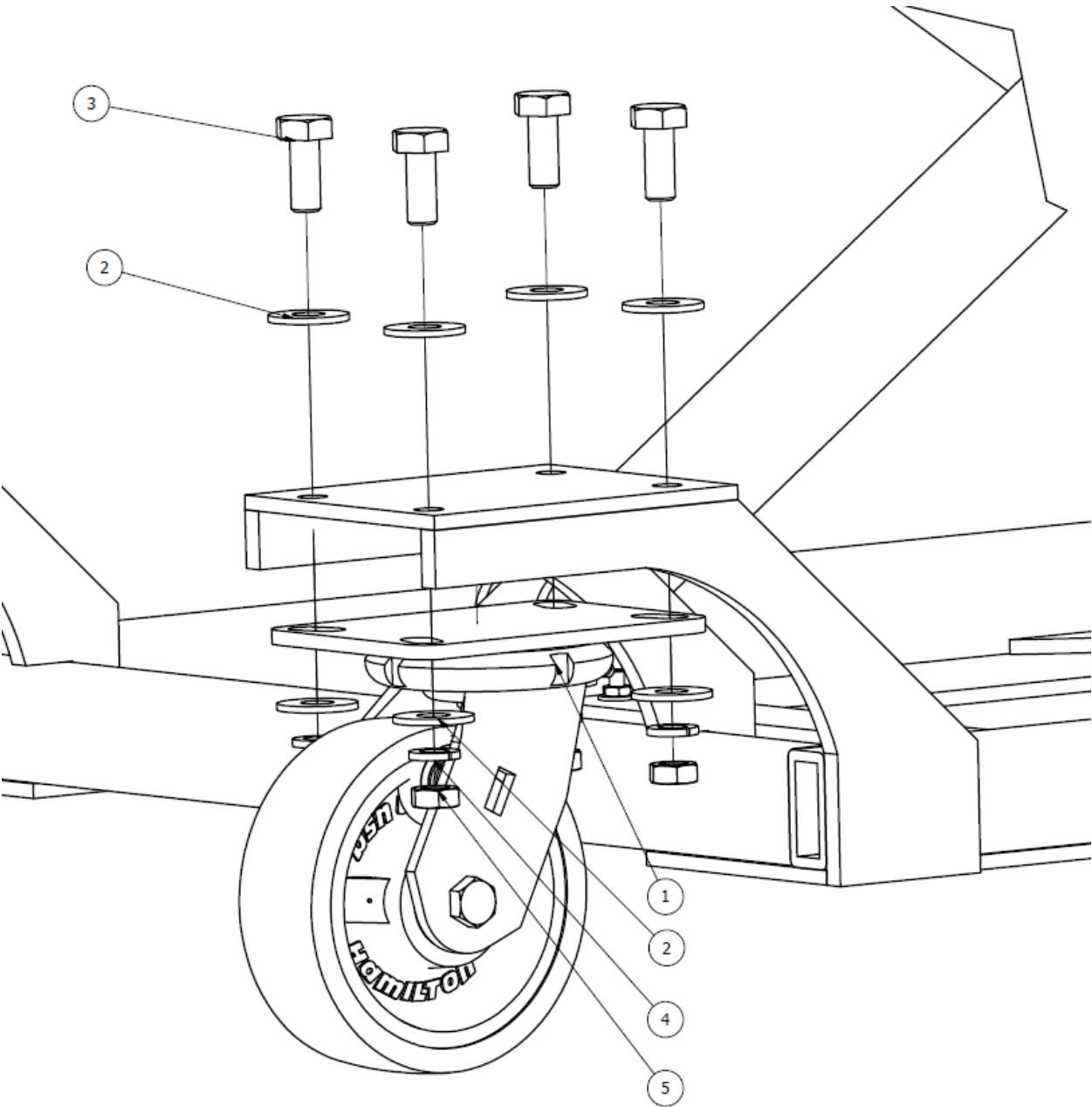
Parts List			
Item	Quantity	Part Number	Description
1	2	C-2	Narrow Chassis
2	2	C-3	Side Chassis
3	2	C-4	Plate
4	4	C-5	Tab
5	4	C-6	Caster Mount Outside
6	4	C-7	Caster Top Plate
7	4	C-8	Caster Wheel
8	2	C-9	Cylinder Bracket Bottom
9	4	C-10	Caster Mount Inside
10	1	C-11	Handle Support
11	2	C-12	Pump Box Side Plate
12	1	C-13	Pump Box Bottom Plate
13	1	C-14	Pump Box Back Plate
14	2	C-15	Bottom Support
15	2	C-16	Handle Mount
16	2	C-17	Side Yoke
17	1	C-18	Top Yoke
18	1	C-19	Handle Pipe
19	1	C-20	Tow Ring
20	1	C-21	Handle Bolt
21	1	C-22	Handle Nut
22	1	C-23	Handle Grip

Chassis Maintenance

The chassis of the jack requires very little maintenance. The only service point on the chassis is the caster wheels. The caster wheels are equipped with ball bearings and should be greased after 8 hours of continuous service.

Chassis Assembly Drawings

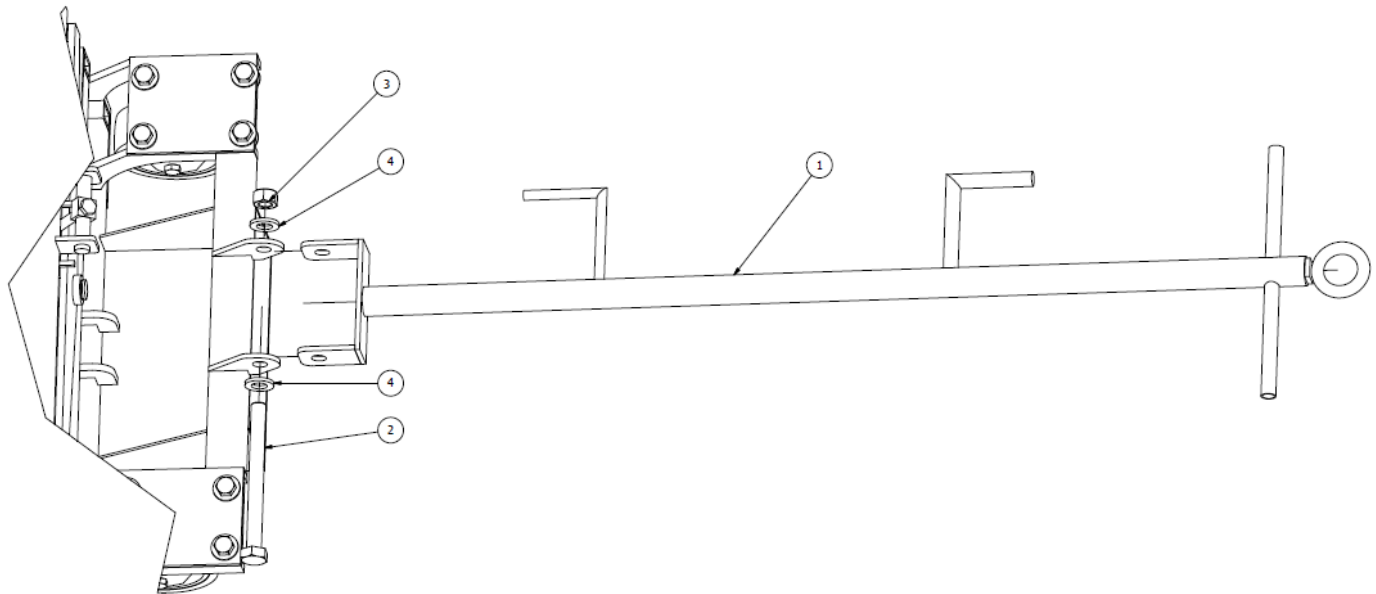
Caster Wheels



Caster Wheels Parts list

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	Caster Wheel	
2	32	ANSI B18.22.1 - 1/2 - wide - Type A	Plain Washer (Inch)Type A and B
3	16	ANSI B18.2.1 - 1/2-13 UNC - 1.25	Heavy Hex Bolt
4	16	ASME B18.21.1 - 1/2	Regular Helical Spring Lock Washers(Inch Series)
5	16	ANSI B18.2.2 - 1/2 - 13	Hex Nuts (Inch Series) Hex Jam Nut

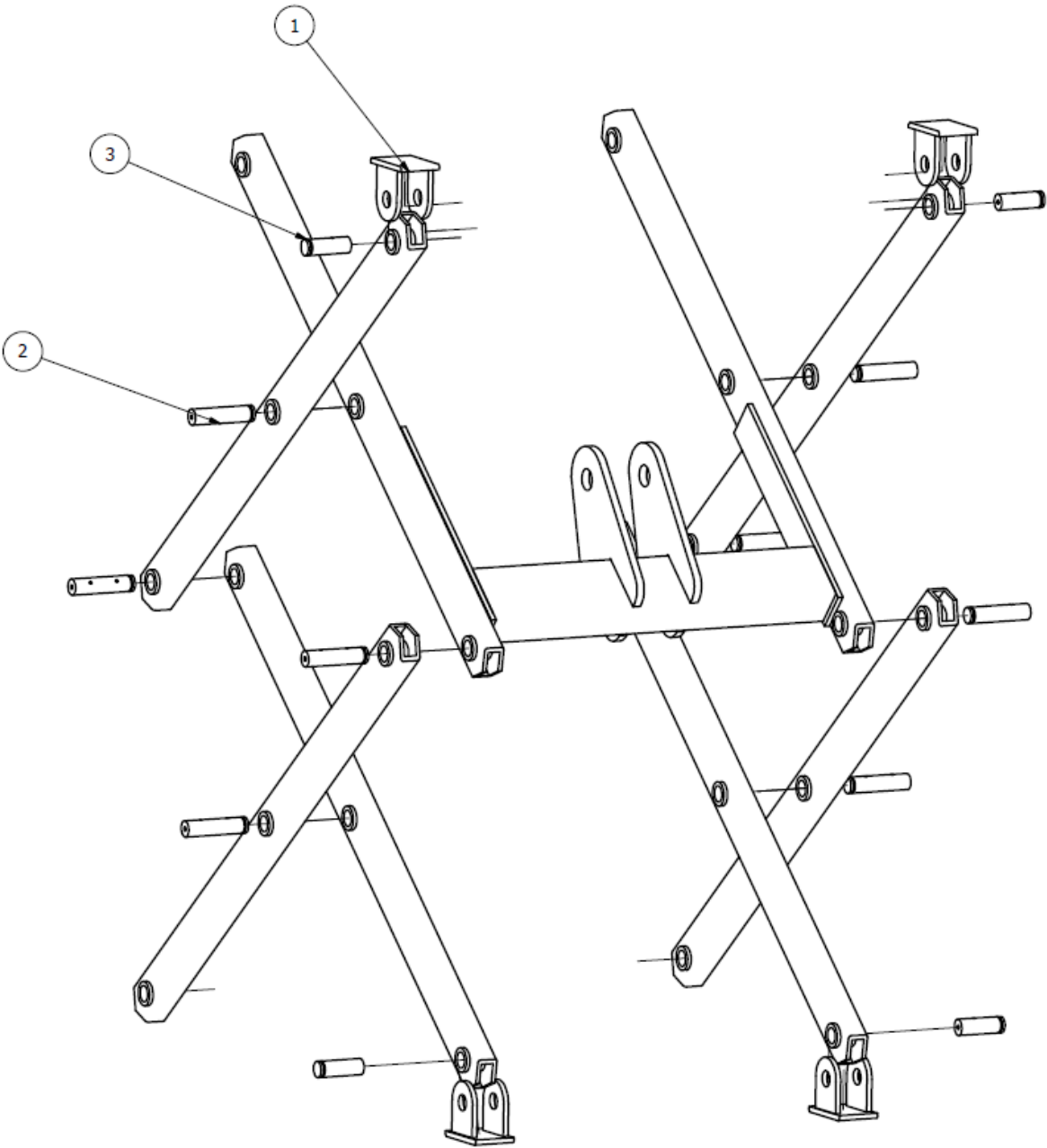
Handle



Handle Parts List

Parts List			
Item	QTY	Part number	Description
1	1	HP1	Handle
2	1	HB2	3/4"x8" Coarse Grade 8 Bolt
3	1	NH2	3/4 " Coarse Grade 8 Nut
4	2	HW2	3/4" Grade 8 Flat Washer

Lifting Mechanism



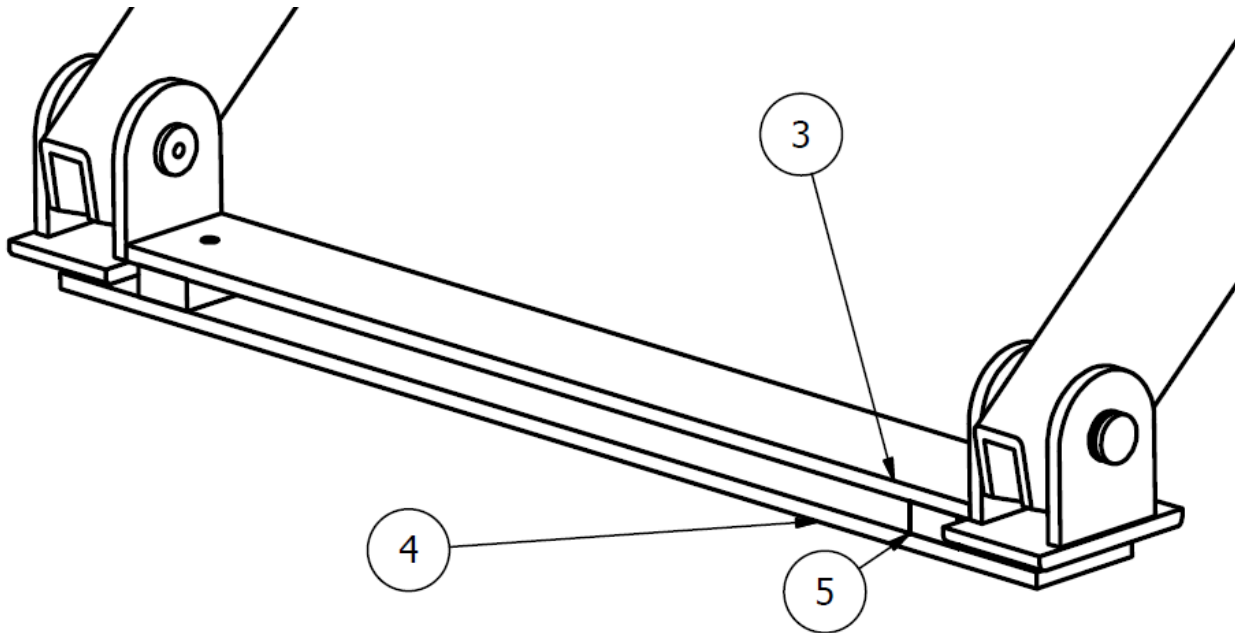
Lifting Mechanism Parts List

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	Slider Base	
2	8	grease pin	
3	4	Short grease pin	

Maintenance

The lifting mechanism has a substantial amount of pivot points that are all equipped with grease fittings. These pivot points should be greased after 8 hours of continuous service. Special attention should be directed to the path in which the feet of the lifting mechanism slide. This path should be checked often to ensure that it is clear of debris. Proper lubrication of the contacting surface of the feet is also important. Use a standard No. 2 grease to lubricate this area as needed.

Slider Guide Mechanism

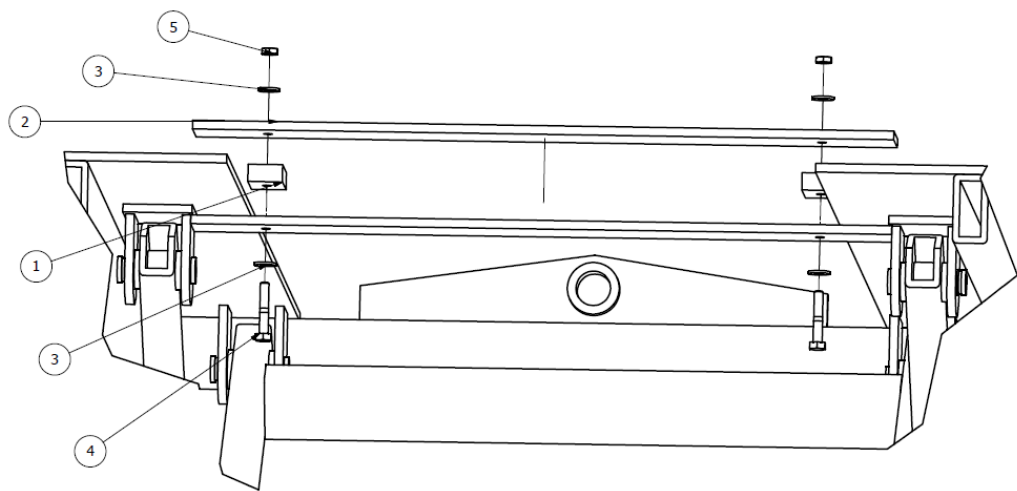


Slider Guide Mechanism Parts List

Parts List			
Item	Quantity	Part Number	Description
1	1	L-9	Cylinder Cross Member
2	2	L-10	Cylinder Bracket
3	1	L-11	Bottom Slider Guide
4	3	L-12	Top Slider Guide
5	4	L-13	Spacer

Slider Guide Mechanism Assembly Drawings

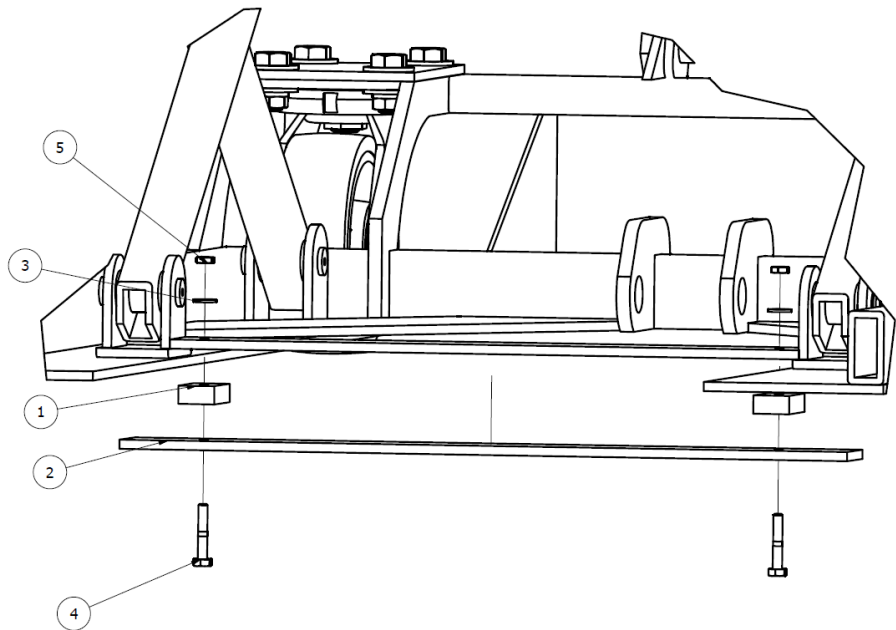
Top Slider Guide



Top Slider Guide Parts List

Parts List			
Item	Quantity	Part Number	Description
1	4	L-13	Spacer
2	3	L-12	Top Slider Guide
3	6	HW	0.625" Grade 8 Flat Washer
4	4	5HB	0.5x1.5" Coarse Grade 8 Bolt
5	4	5N	0.625" Coarse Grade 8 Nut

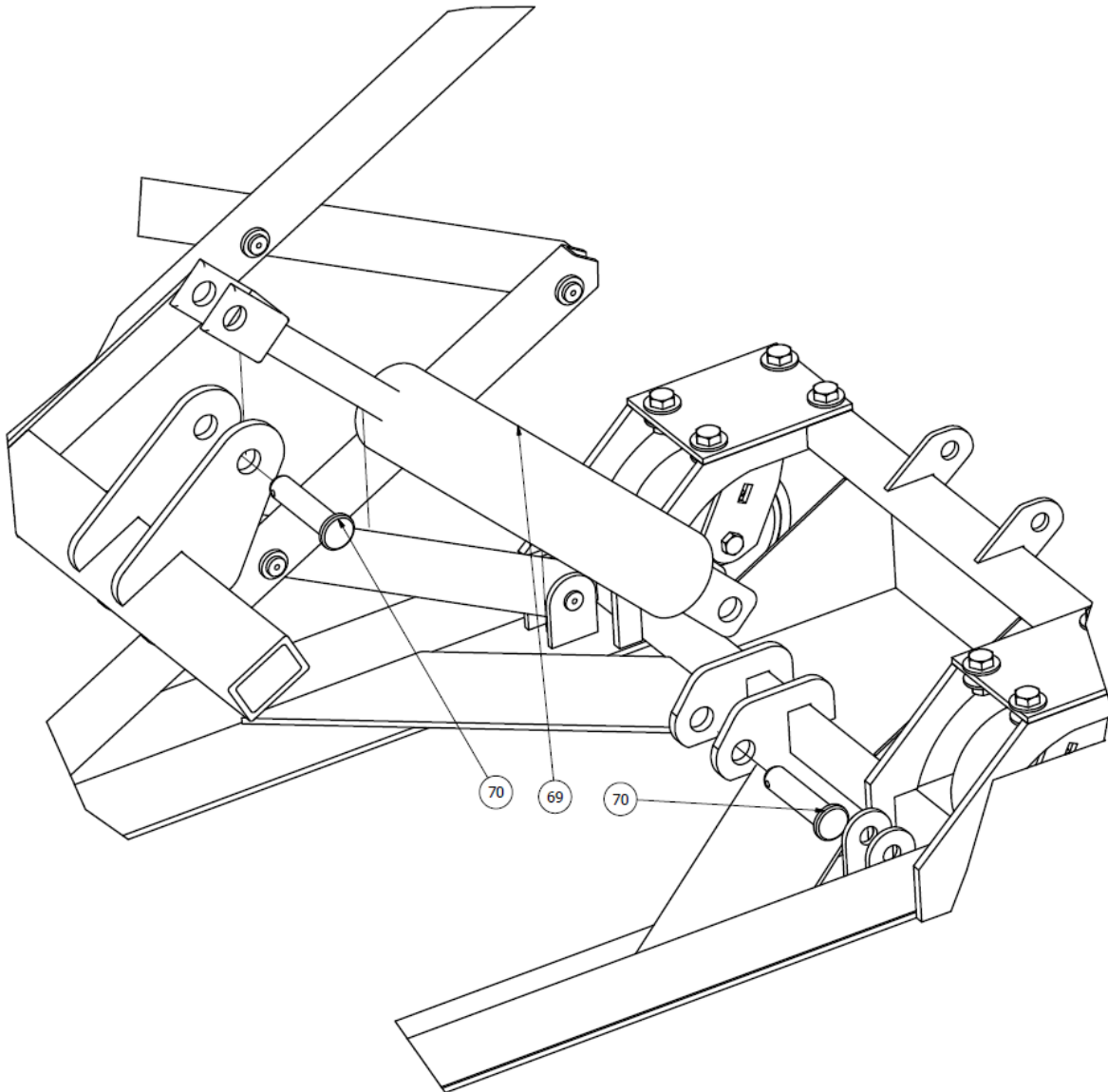
Bottom Slider Guide



Bottom Slider Guide Parts List

Parts List			
Item	Quantity	Part Number	Description
1	4	L-13	Spacer
2	3	L-12	Bottom Slider Guide
3	6	HW	0.625" Grade 8 Flat Washer
4	4	5HB	0.5x1.5" Coarse Grade 8 Bolt
5	4	5N	0.625" Coarse Grade 8 Nut

Power System



Power System Parts List

Parts List			
Item	Quantity	Part Number	Description
69	1	CYL	Cylinder
70	2	CYLP	4.25" Pin with Manufactured Head

Power System Cylinder

The power system is designed for a 3x12x1.25" 3500 PSI cylinder, with a required retracted length of 22 inches.

Power System Pump

The hydraulic pump that powers the cylinder is a Power Team model PA50R. A detailed description of this pump is located in the appendix of this manual.

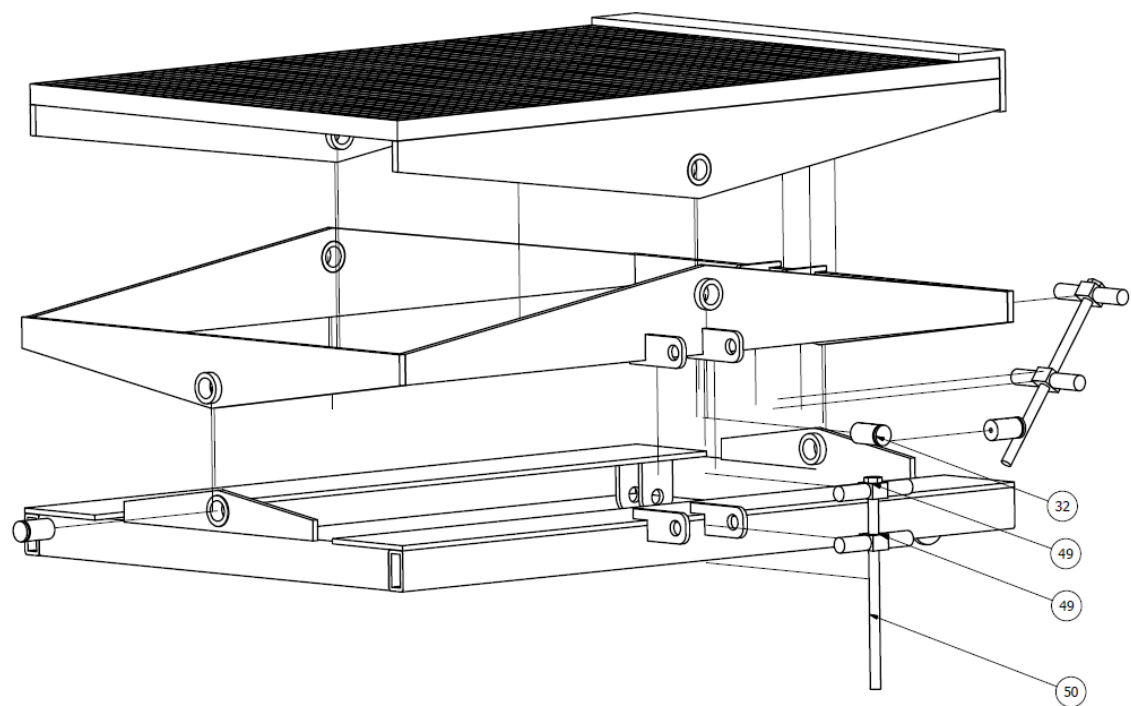
Pump Maintenance

The hydraulic pump of this product is rather maintenance free. The only item that will need attention regularly is the level of fluid in the reservoir. Check the hydraulic fluid level after 8 hours of continuous operation.

Safety System

The safety system of this product consists of a hydraulic flow regulator and a velocity fuse. The flow regulator and velocity fuse were purchased from Vonberg Valve, INC. The valves were special ordered from Vonberg to match this application. A complete technical description of the regulator and fuse are located in the appendix of this manual.

Platform System



Platform System Parts List

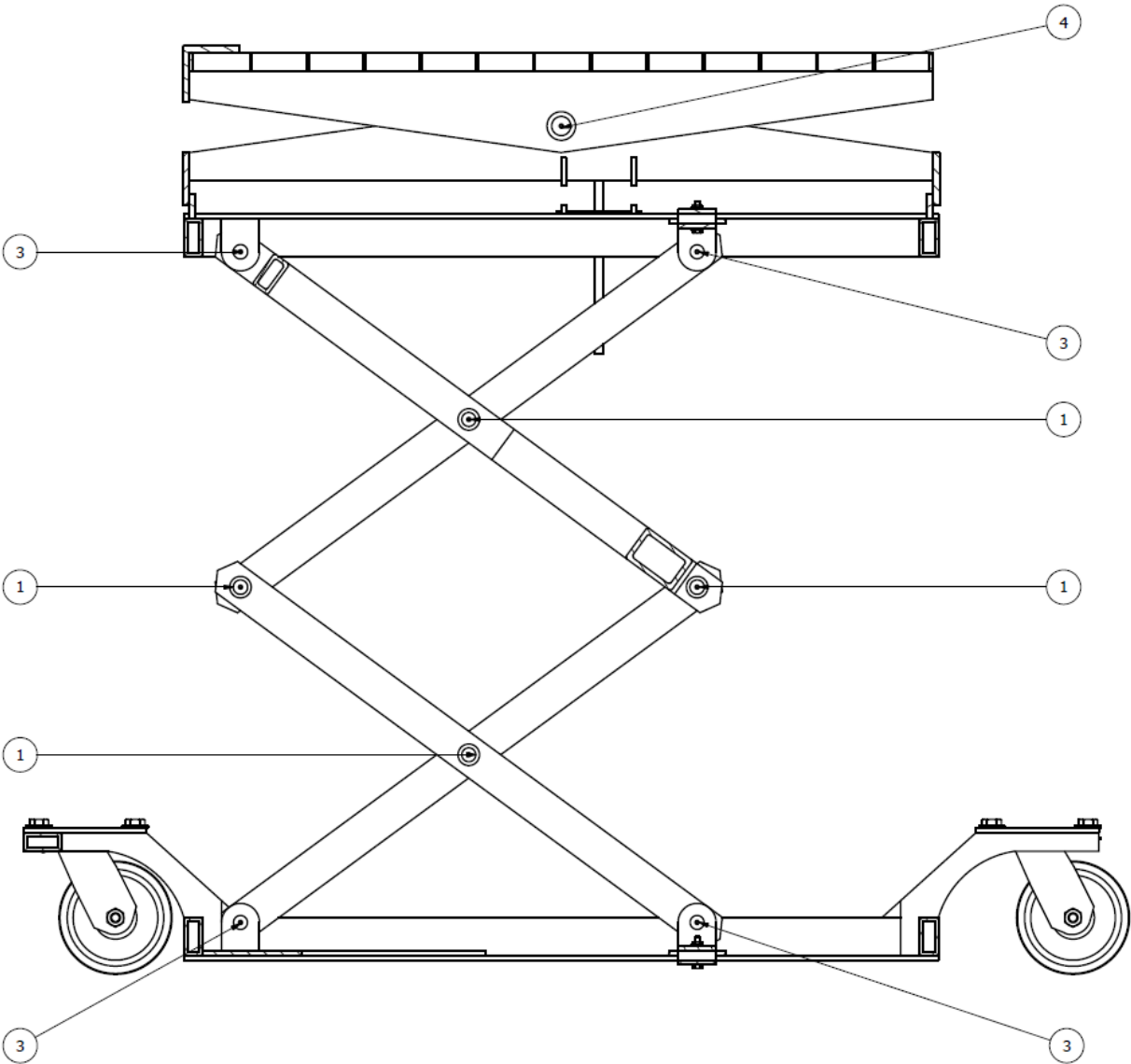
Parts List			
Item	Quantity	Part Number	Description
32	4	TP1	Top Pin
49	4	SA1	Screw Adjuster
50	2	TR	Threaded Rod

Platform Maintenance

The platform of this product has four pins which are equipped with grease fittings. The threaded rods that allow the platform to tilt are lubricated with 80/90W gear lube. These areas should be serviced after 8 hours of continuous operation.

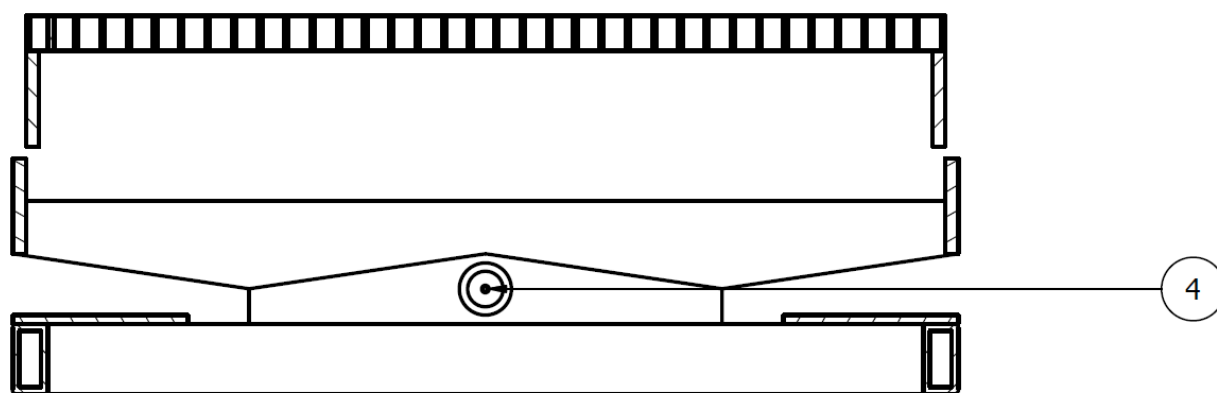
Service Charts

Chassis Service

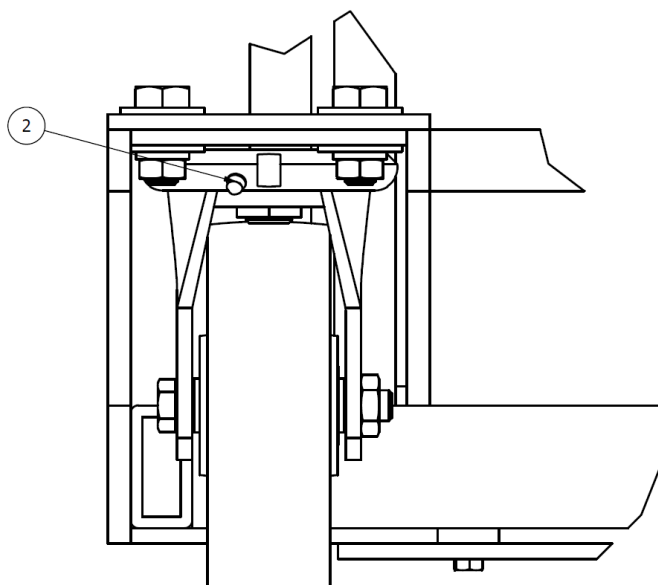


Service Chart			
Service Location	QTY	Discription	Interval
1	8	Grease Fitting	8 Hours
2	4	Grease Fitting	8 Hours
3	8	Grease Fitting	8 Hours
4	4	Grease Fitting	8 Hours

Platform Service

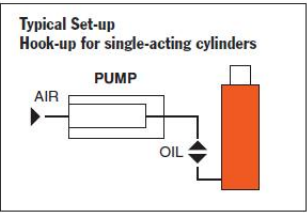


Caster Wheel Service



Service Chart			
Service Location	QTY	Discription	Interval
1	8	Grease Fitting	8 Hours
2	4	Grease Fitting	8 Hours
3	8	Grease Fitting	8 Hours
4	4	Grease Fitting	8 Hours

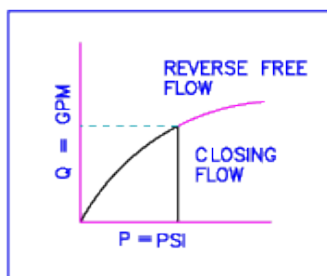
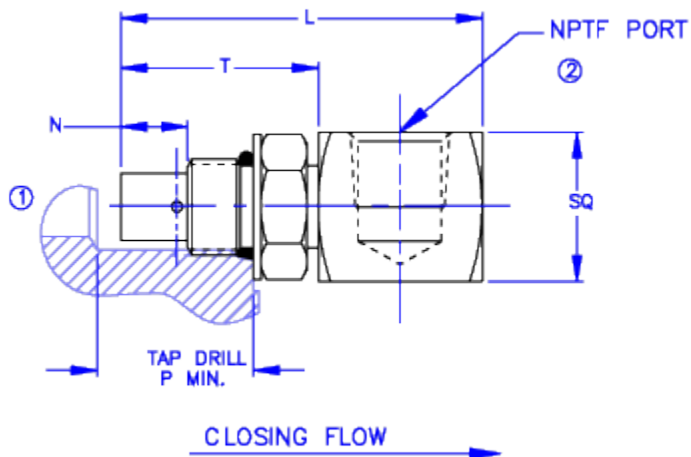
Pump Specifications



For use with Cyl. Type	Description	Order No.	Valve No.	Air Supply Req'd (psi)	Reservoir Cap. (cu. in.)	Usable (cu. in.)	Oil Port (in.)	Prod. Wt (lbs.)
Single-Acting	Base model pump with high density polyethylene reservoir.	PA50	—	40-120	105	98	3/8 NPTF	14.2
Single-Acting	PA50, except has metal reservoir.	PA50M	—	40-120	105	98	3/8 NPTF	16.2
Single-Acting	PA50, except has 12 foot remote control.	PA50R	—	40-120	105	98	3/8 NPTF	18.5
Single-Acting	PA50, except has metal reservoir.	PA50RM	—	40-120	105	98	3/8 NPTF	20.5
Single-Acting	PA50R, except has 2 gallon reservoir.	PA50R2	—	40-120	2 gal.	454	3/8 NPTF	28.5
Single- and Double Acting	PA50, except designed to operate either single- or double-acting systems. Valve function: Advance / Return.	PA50D	9504, 3-way/ 4-way	40-120	105	98	3/8 NPTF	18.4

Notes: Air inlet port 1/4" NPTF. Requires 20 cfm at 100 psi shop air pressure at the pump.

Valve Specifications



DESCRIPTION

- AN IN-LINE 90° ELBOW SWIVEL VELOCITY FUSE WITH AN NPTF OUTLET PORT THAT PROVIDES FULL-LINE SHUT-OFF IN THE EVENT OF A LINE FAILURE.

OPERATION

- A FLOW BELOW THE SPECIFIED CLOSING FLOW IS ALLOWED FROM "1" TO "2".
- FLOW ABOVE THE SPECIFIED CLOSING FLOW FROM "1" TO "2" IS ASSUMED TO BE A LINE FAILURE AND IS BLOCKED.
- FLOW FROM "2" TO "1" PASSES THRU THE CONTROLLING ORIFICE BUT IS UNCONTROLLED.
- CLOSING FLOW TOLERANCE=+15%-0%.

FEATURES

- SWIVEL DESIGN FOR EASY ALIGNMENT.
- 90° ELBOW FOR LOW PROFILE APPLICATIONS.
- FAIL SAFE EMBEDDED FUSE DESIGN.
- STEEL BODY & COMPONENTS.
- RAPID RESPONSE.
- POSITIVE CLOSE.

- SPECIFICATIONS -

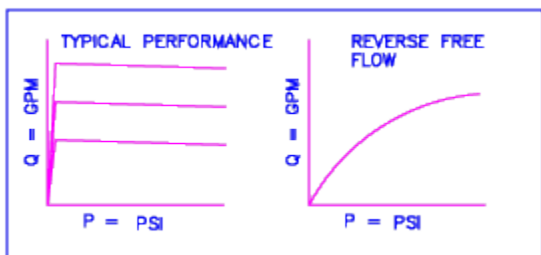
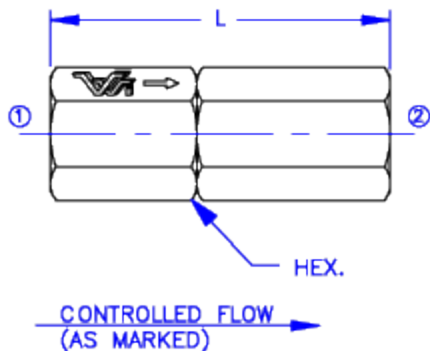
Hydraulic Symbol	
Operating Pressure	3500 PSI
Temperature Range	250°F to -40°F
Reopening Differential	50 PSI
ALL DIMENSIONS IN INCHES	

- ORDERING INFORMATION -

ASSEMBLY NUMBER 83XX-XX
 SERIES NUMBER
 OUTLET PORT SIZE
 CLOSING FLOW (GPM)

MODEL	THREAD ②	CAVITY THREAD	P	RATED FLOW	L	T	N	SQ
8302	1/4 - 18 NPTF	9/16 - 18	1.000	0.2 - 5 GPM	2.125	1.160	0.390	0.875
8303	3/8 - 18 NPTF	3/4 - 16	1.250	0.5 - 15 GPM	2.555	1.430	0.550	1.000
8304	1/2 - 14 NPTF	7/8 - 14	1.688	1.0 - 25 GPM	3.230	1.870	0.850	1.125
8306	3/4 - 14 NPTF	1 1/16 - 12	1.980	2.0 - 40.0 GPM	3.625	2.065	0.905	1.375

* FUSE NOSE REQUIRES A DEEPER TAP DRILL DEPTH. SEE DIM P.



DESCRIPTION

- AN IN-LINE, PRESSURE-COMPENSATED, NONADJUSTABLE FLOW REGULATOR WITH FEMALE NPT PORTS, INTENDED FOR FIXED DISPLACEMENT HYDRAULIC CIRCUIT APPLICATIONS.

OPERATION

- IN THE CONTROLLED DIRECTION THIS REGULATOR WILL MAINTAIN A CONSTANT FLOW RATE THROUGHOUT A SPECIFIED PRESSURE RANGE.
- REVERSE FLOW PASSES THROUGH THE CONTROLLING ORIFICE AND IS UNCONTROLLED PRODUCING A PRESSURE DIFFERENTIAL OF 120 PSI MAX. AT 150% OF CONTROLLED FLOW.

FEATURES

- **S.I.D.** SURGES INTERNALLY DAMPENED FEATURE IS OPTIONAL FOR LOAD LOWERING APPLICATIONS.
- STEEL BODY, STEEL INTERNALS.
- HYDRAULIC FLUIDS – GENERAL.

- SPECIFICATIONS -

Hydraulic Symbol	
Pressure Range	50 PSI TO 3500 PSI
Temperature Range	250°F to -40°F
Flow Tolerance	+/- 10%
ALL DIMENSIONS IN INCHES	

- ORDERING INFORMATION -

ASSEMBLY NUMBER 135X-X-XX
 SERIES NUMBER
 UNDAMPENED - BLANK
 DAMPENED (S.I.D.) - 1
 REGULATED FLOW RATE (GPM)

MODEL	PORT 1/2	FLOW RANGE	L	HEX.
1352	1/4-18 NPT	0.25 – 4.0 GPM	2.50	0.938
1353	3/8-18 NPT	0.5 – 5.0 GPM	2.50	0.938
1354	1/2-14 NPT	0.5 – 10.0 GPM	2.88	1.062



BPJ-2000

USER'S MANUAL

Preface

Thank you for purchasing your BPJ-2000 belly pan jack. The Saluki Engineering Company would like to thank you for your purchase. Our dedication to quality and performance will ensure your complete satisfaction with our product. Before using your BPJ-2000 please read and understand this user's manual. Use of this product without a complete understanding of this manual could cause personal injury or death. Once again thank you for your purchase if you require any additional information feel free to contact us.

Sincerely,

Management of Team 56

Saluki Engineering Company

Southern Illinois University Carbondale
College of Engineering – Mail Code 6603
Carbondale, Illinois 62901-6604

Please read and understand the following warnings before continuing:

- Before use of jack thoroughly read and understand the user's manual.
- Only use jack on level surfaces.
- Never exceed the rated load capacity of the jack of 2000 LBS.
- Always keep the load centered on jack.
- Never supply more than 120 PSI of air pressure to the hydraulic pump.
- Keep hands, arms, and tools away from scissor mechanism while in motion.
- Always secure remote leads to handle when maneuvering the jack.
- Never maneuver jack without completely lowering the load.
- Always clear planned path of travel of any obstructing objects.
- **Failure to heed these warnings can cause person injury or death.**

Intended Use

This jack was designed and intended with a sole purpose of raising, lowering, and transport of belly pans of large earthmoving equipment on level shop floors. Any other use is NOT recommended by the manufacture and Saluki Engineering Company will NOT be liable for misuse of this product.

Jack Maneuvering

ALWAYS HAVE LOAD FULLY LOWERED BEFORE MANEUVERING JACK. Make certain that the remote control leads are secured on the handle before moving. Check path of travel for rocks, cables, hoses, or any object which might hinder the travel of the jack. Lock wheels via the swivel locks if desired. Using the handle, maneuver the jack into the desired position.

Tilting Top

ONLY ADJUST TOP WITH JACK AT REST. IF LOADED, MAKE SURE THE LOAD IS SECURE BEFORE ADJUSTING. If adjusting the angle of the top of the jack is necessary, adjust with supplied tools to match the desired angle.

Raising the Jack

ALWAYS STAY CLEAR OF THE SCISSOR MECHANISM. ONLY OPERATE JACK ON LEVEL SURFACE. After maneuvering jack into the desired position, check the surface of the object intended to be made contact with. Check that the surface is clear of any buildup of mud, sticks, or any other foreign material that may jeopardize the securing of the object. Once object has been prepared for contact press the raise button on the remote control to raise the jack until it just touches the object (excessive force is not necessary) while keeping clear of the scissor mechanism.

Lowering the Jack

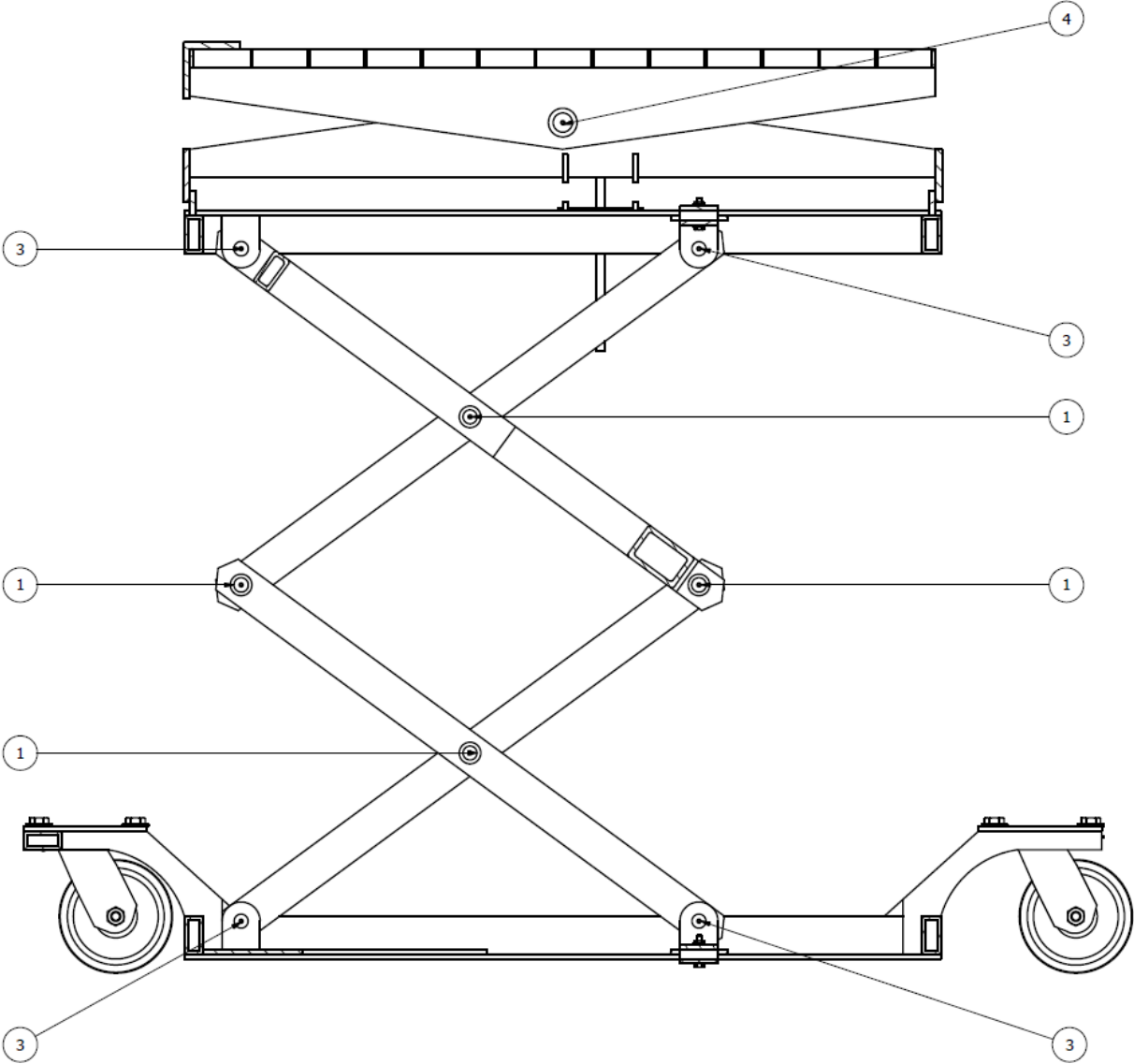
ALWAYS STAY CLEAR OF THE SCISSOR MECHANISM. When ready to lower jack, ensure that all hoses, tools, or any other objects are clear of the scissor mechanism. When the scissor mechanism is clear of objects, press the lower button on the remote control and FULLY LOWER JACK BEFORE MANEUVERING.

**FAILURE TO FOLLOW THIS USER'S MANUAL CAN CAUSE
PERSONAL INJURY OR DEATH.**

Appendix

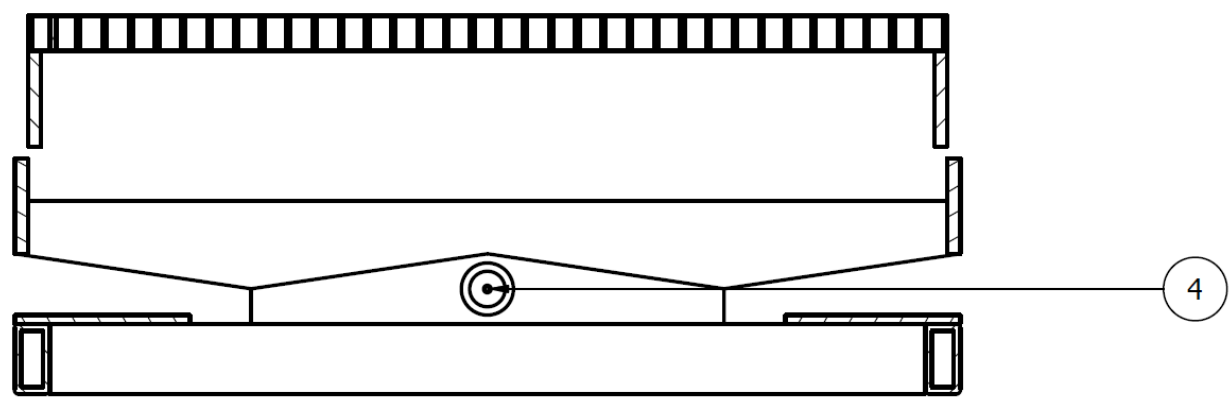
Service Charts

Chassis Service

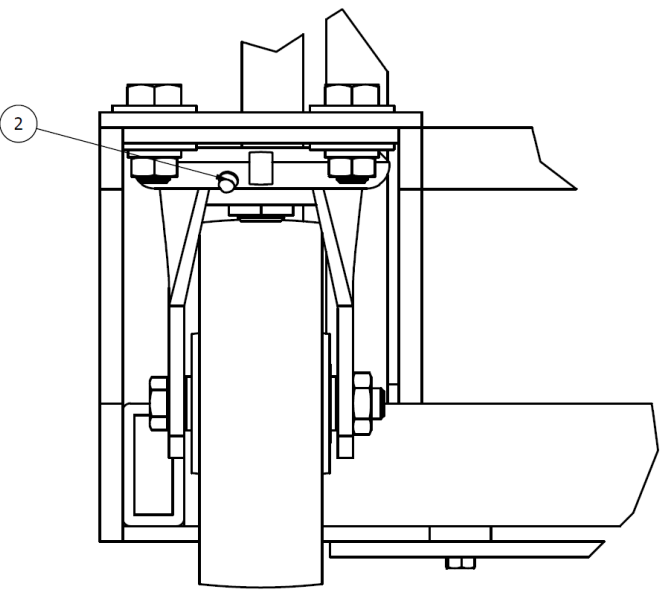


Service Chart			
Service Location	QTY	Discription	Interval
1	8	Grease Fitting	8 Hours
2	4	Grease Fitting	8 Hours
3	8	Grease Fitting	8 Hours
4	4	Grease Fitting	8 Hours

Platform Service



Caster Wheel Service



Service Chart			
Service Location	QTY	Discription	Interval
1	8	Grease Fitting	8 Hours
2	4	Grease Fitting	8 Hours
3	8	Grease Fitting	8 Hours
4	4	Grease Fitting	8 Hours