Hydraulic Front-End Bucket Loader for a Personal Lawn Tractor

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by:

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Thank you very much,
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ABSTRACT

This is a Report and Design Project that has been developed to aid homeowners in their landscaping needs. What developed was a proposal for a Hydraulic Front-End Bucket Loader prototype. This prototype was created to help eliminate the need for an added machine and expense to a homeowner. This Front-End Loader will be fastened on to the existing frame of a personal lawn tractor while minimizing modification to it. The hydraulic and mechanical components of the prototype will be bolted on to the existing frame and chassis components.

The use of light weight material, strong steel joints and bushings allow for the loader to out preform the current markets competition. One of the largest benefits to this design is that it allows for the mower desk to stay attached to the tractor while providing "Quick Disconnect" features. The quick disconnect features allow for one person operation and storage. The loader arm and bucket assemblies are completely detachable from the tractor.

This Prototype also allows for a greater load capacity and lift range. The load capacity is 350lb and has enough lift to be able to put loads of mulch, soil and gravel into a ¼ ton pickup truck. The market comparisons for this size tractor are very different. They only allow for a maximum load of 150lb and lift height of 5-10 inches. This type of minimal load capacity and lift features limits the homeowner's ability to perform normal landscaping task.

Currently, if you want a greater load capacity and lift height you have to purchase a separate machine to do the job. Normally, this extra machine would be much larger in size and may become costly to maintain. This is why this Design Project was developed. Thus, the prototype assists in the elimination of extra storage space and added cost to the homeowner.

All of the components, mechanical and hydraulic, have been developed for a Craftsman/ Husqvarna series lawn tractor (*Craftsman Model #07128857000, Mfr. model #28857*). Yet, it is possible to modify and attach this prototype to three (3) other tractor models.

This particular Craftsman Lawn Tractor has a Hydrostatic driveline and integrated safety features. The beauty of the Loaders Hydraulic System is that it works simultaneously with the tractors driveline. Yet, the sealed hydraulic system functions completely independent from it. Another great feature of the hydraulic system is that it utilizes that the same integrated safety features of tractor. Thus, this eliminates the need for additional wiring complexity and mechanical safety features that would add expense, weight and complexity for the home own to maintain.

The hydraulic system utilizes O-Ring seals to help eliminate the potential for leaks and contamination of the systems. It also has a single joystick controller to allow the operator to focus on the loading system. The system also, has integrated "Dripless" hydraulic disconnect fittings. This not only eliminates potential contamination and lost oil from the system but, also helps to keep the environment free of added contaminates.

This Design Project has many components to it but, the single most important item is that it performs. Testing proves that the system completes the tasks and features that it has defined.

PROBLEM DEFINITION AND RESEARCH

PROBLEM DEFINITION AND BACKGROUND

Some lawn tractors today have hydraulic drive systems and it would great to tap into that systems or create one, for other hydraulic applications. Two versatile applications would be a front-end scoop loader and a snow plow. There are smaller commercial machines that do these functions but, are very expensive for a normal home owner to acquire.

The proposal is to fabricate a prototype hydraulic front-end loader system (perhaps even be able to attach other attachments such as a power auger for homeowners to put in fence post, footings, irrigation heads and more) that will be mounted onto a personal lawn tractor.

There are two main portions/systems of this project. These systems will include the hydraulic distribution lift system and controls. The second will be bucket/plow lifting assembles and tractor mounting points.

RESEARCH-INTERVIEWS

A conducted interview with John Dehne (1) took place. He is a corporate engineer who owns a personal lawn tractor and does a multitude of lawn work at this home. He was interviewed over the phone on September 25, 2011. The features that he felt would be necessary for the loader are as follows.

Table 1: Interview Information

Category	Feature Information
Hydraulic and Loader Mechanism	• Loader arms do not need to be able to detach • Attachment(s) need to be removable • Lift: Minimum of 2ft and a Maximum of 5.5ft
Bucket	• Size: Under a cubic yard • Weight: Under 100lb • Bucket pitch: ± 30º parallel to ground
Snow Plow	• Plow movement: Swivel left to right, up and down • Skid blade or rollers at bottom of blade • Weight: Light enough for one person movement • Storage: Plow will be stored when not in use

(See Appendix A for more). John was able to provide insight to what a real customer would be looking for when it comes to this front-end loader prototype. He developed three main categories for the prototype with specific desired features listed above.

ONLINE RESEARCH - TECHNOLOGY AND EXISTING PRODUCTS

Research was conducted and as a result 4 main categories were created. Category 1: Hydraulic system capacity/form/function, Category 2: Loader capacity/form/function, Category 3: Bucket capacity/form/function and Category 4: Snow Plow capacity/form/function. 5 web sites were utilized from the internet. Three sites are for bucket/loader information and two sites refer to snowplow information. Refer to Appendix A for additional information on the following research objects.

FRONT-END BUCKET LOADER RESEARCH:

The *Johnny Bucket Jr.* (fig. 1) is an electric operated front-end bucket that has a only 200 lbs. load capacity. It attaches to the front most extreme portion to the lawn tractor. One beneficial feature is that it does not interfere with the mowing deck but, it lift height capacity is only 10". This limitation is rather significant when trying to load into a truck bed. The movement of the bucket is rather slow. Although, the system is light weight and the bucket can swing from 0º (parallel to the ground) - 90º (perpendicular to the ground) via a push of a button.

Figure 1: Johnny Bucket Jr. (2)

Limitations and Advantages:
Limitations; lift height, lift capacity, its non-adjustability, slow moving bucket and there is no way to attach a snow plow to it.
Advantages; Moderate weight, Electronic controls, Moderate cost and does not interfere with the mower deck

The *Husqvarna Front Scoop* (fig. 2) is a mechanical, hand lever operated, front-end bucket loader. It attaches to the front most extreme portion to the lawn tractor. This system is less expensive than electric and hydraulic by the utilization of simple to use "man power" lever arms. This system is not adjustable and only has a 200lbs. lift capacity. The lift height is rather short as well. Maximum lift is 5-7" from the ground. One benefit of this system is that it does not interfere with the mowing deck.

Figure 2: Husqvarna Front Scoop (3)

Limitations and Advantages:

Limitations; lift height, lift capacity, mechanical lift mechanism, its non-adjustability, many mechanical linkages and there is no way to attach a snow plow to it. Advantages; light weight, low cost and does not interfere with the mower deck.

The *Koyker Loader Model 50* (fig. 3) is a hydraulic front-end loader that is intended to be used with lager tractor/lawn tractor and/or tractor/lawn tractor without a belly mounted mowing deck. The load capacity is much greater than intended use. The reach and lift height are suitable for intended use. The cost is much more than an electrical loader system. The loader arms are detachable and the bucket is removable as well but, is not intended to be a "quick disconnect" accessory. The systems maximum dump angle is 37º and the digging depth is 3".

Figure 3: Koyker Loader Model 50 (4)

Limitations and Advantages:
Limitations; non-adjustability, cost, non-quick disconnect accessories, must be used with a larger tractor or with one that has no mowing deck and there is no way to attach a snow plow to it.
Advantages; Lift and load capacity is appropriate, bucket reach and lift height is appropriate, sealed hydraulic system

Snow Plow research information:

The *Craftsman 14" Snow Blade* (fig. 4) is a mechanical (lever arm) snow plow system. This snow plow system is not power and attaches to the front most extreme portion to the lawn tractor. It does not interfere with the mowing deck and is light weight. The blade can swivel from left to right to divert snow. Use of a hand lever is needed to lift/lower plow and a hand grip is used to release a pin so that the plow may swivel left to right. The blade/plow is removable with only one person for maintenance but, is not intended to be a "quick disconnect" accessory. The scraper blade at the bottom of the plow is removable to replacement/maintenance.

Figure 4: Craftsman 14" Snow Blade (5)

Limitations and Advantages:
Limitations; mechanical lift mechanism, many mechanical linkages and there is no way to attach a loader bucket to it.
Advantages; light weight, low cost, replaceable scraper blade, swivels from left to right and does not interfere with the mower deck.

The *Johnny Snow Plow* (fig. 5) is an electric operated system. This system is intended to be an add-on to the *Johnny Bucket Jr.* system or can be purchased as a whole system. It attaches to the front most extreme portion to the lawn tractor. It does not interfere with the mowing deck. Its weight is moderate and the plow does swivel left-to-right and up and down for snow diversion. The movement is done electronically but, is minimal and is slow moving. All of the controls are electronic and the plow does have a removable/replicable scraper blade.

Figure 5: Johnny Snow Plow (6)

Limitations and Advantages:
Limitations; lift height, slow moving
Advantages; Moderate weight, swivels from left to right, Moderate cost (is more costly when purchased independently from *Johnny Bucket Jr.* system) and does not interfere with the mower deck

RESEARCH SUMMARY:

The interview and the major systems above, generate information that is used to develop specific customer needs and possible features for this prototype.

CUSTOMER NEEDS TO ENGINEERED FEATURES

CUSTOMER NEEDS/FEATURES

Initial customer features, listed below, are needed in order to zero in on what could be potentially implemented into the design of the front-end loader. Below, in Table 2, are a *General List* of customer features and a *Condensed List* to the right of it.

These two lists are the building blocks of the future function/features of the prototype. The left side list offers ideas of features that could be implemented. These were developed from research and potential personal needed features. The right hand side lists are words and/or phrases that provide parallel thoughts towards the importance of the potential features.

Table 2: Initial Customer Features

General List:	**Condensed List:** *...is important*
• Safety switch- will not be able to operate without sitting on tractor	Safety
• Snow plow will have a removal scraper blade	Ease of Maintenance
• Hydraulic lever controlled • Easy to operate with simple instructions	Ease of Use
• Be hydraulically driven • Will be able to attach/detach bucket/plow, also do so with one person • Will be able to attach/detach hydraulics/mech. arms, also do so with one person	One Person Operation
• Lift 5-6ft of ground • Dig 1-5" into ground • Snow plow will be able to swivel left and right	The ability to perform operational and functional task
Uses of commercial and quality grade material/components/fasteners	Durability/Reliability
• Will be painted/powder coated for easy cleaning	Ease of Cleaning
Uses of current model tractor	Compatibility with Existing lawn tractor models
• Ability to lift 400-500lb load while staying in temperature range of engine and hydraulics	Staying within the limits of the tractor Bucket Capacity
Operate with reasonable speeds	Speed of Operation
• Ability to lift 400-500lb load while staying in temperature range of engine and hydraulics	Operation temperature
• Quick disconnect hydraulic lines for easy removal • Kick stand for lever arms so that it stands up after removal	Ease of Storage

As seen above - The *General list* changed into the new *Condensed List*. The new list was written to clarify a feature and it was written in such a way to keep parallelism between each feature. Each feature from the *Condensed List* is to be read as, "Feature… is important". These are important to the potential function/design of the prototype. This new list is used in the creation of the survey features for the prototype. The survey is seen in the category.

SURVEY FEATURES WITH AVERAGES:

Figure 6 is a list of *Surveyed Customer Features* (see Appendix B). There were 22 surveys returned and tabulated. The people surveyed ranged from engineers and business owners in the construction and hydraulic industry, to engineers and business owner with a mechanical background and to engineering student that would have insight to the design features of the prototype. These items will help depict what feature and objectives will be utilized in the design. They are listed from highest to lowest average rating.

Survey Feature/Item	Avg (out of 5)
Durability/Reliability	4.6
Safety	4.6
Ability to preform Operational Task	4.6
Ease of Use	4.4
Compatibility with current tractor models	4.1
Ease of maintenance	4.1
Overall Cost	3.9
Stay within limits of tractor used	3.9
Bucket Capacity	3.5
Speed of Operation	3.2
Operation Temperature	3.0
Ease of Storage	3.0

Figure 6: Surveyed Customer Features

The list above shows that the surveyed peoples deemed that *Durability/Reliability* should rate the most important with an average of 4.6%. *Ease of Storage* is the lowest rated at 3.0%. Even though there is a top rated and lowest rated feature the averages are not very far apart. All of the features surveyed fall within the top 60%. There is not a distinctive most or least important features to consider. There is only a 35 % difference between each feature.

A note: The survey sent out to be filled out and returned. The second portion of the survey has been omitted. This section was for *"Customer Satisfaction"*. The section was placed on the survey in order to receive information from individuals that have owned/used a front-end loader on another device. Only 5 out of 22 surveys collected had this section filled out. There were not enough data points from this section available in order to deem this information valuable.

PRODUCT/PROTOTYPE FEATURES WITH MODIFIED IMPORTANCE

A *House of Quality* or *QFD* (see Appendix C) is a tool used that utilizes survey results, customer features and engineering characteristics to weights of importance to specific design areas. Figure 7 illustrates these weights of importance and how they were derived.

Using the *Designer's Multiplier,* it allows for the ability to slightly modify the results (± 20%). This modification is sometimes necessary to aid in the display of the designers thought process for each function/feature of the designed prototype. The *Relative Weight* depicts the importance of each function/feature. The importance may change the importance order of the Prototype features.

Prototype Features	Designer's Multiplier	Modified Importance	Relative weight %
Ability to preform Operational Task	1.2	5.5	11%
Ease of Use	1.1	4.9	10%
Durability/Reliability	1.0	4.6	10%
Stay within limits of tractor used	1.2	4.6	10%
Safety	0.9	4.1	9%
Bucket/Plow Capacity	1.1	3.8	8%
Compatibility w/current tractor Models	0.9	3.7	8%
Ease of Maintenance	0.9	3.7	8%
Overall Cost	0.9	3.5	7%
Speed of Operation	1.1	3.5	7%
Ease of Storage	1.2	3.4	7%
Operation Temperature	1.0	3.0	6%

Figure 7: Features sorted by Relative Weight

The only features that were not modified were *Durability/Reliability* and *Operational Temperature.* These features were not modifies because the results that came from the survey were deemed appropriate for the design of the prototype.

All of the others were slightly modified with in the ± 20% range. The design features that were modified positively were done so because these were functional features of the prototype. The system needs to function as intended.

The other features, such as *Safety*, *Compatibility, Maintenance* and *Cost* may not directly affect the functions/features of the prototype. Notice they were not significantly reduced. These features were only reduced 10% out of the potential 20% maximum. The *Designer's Multiplier* is not intended to completely "Out-Do" the survey results yet, it is intended to modify or adjust the result slightly toward some design objective.

PRODUCT OBJECTIVES

The top weighted product objective is shown below. Note: There are 12 total objectives (see fig. 9; also, see appendix D for more detail). The Top two Products Objectives are the most important to the design and to the function/features of the prototype. The loader has to function, period. This is what the main goal of the project and is also the top rated product objective. Above are the listed features definitions for the objective, *"Ability to perform Operational Task"*. The second most important objective is, *"Ease of Use"*. One person operation and the use of hydraulic components with provide the system with easy functional use.

Ability to perform Operational Task (11%):

1. Lift bucket load of 400-500lb to a reasonable height to load into a ¼ Ton Truck bed
2. Dig 1-5in in to soft ground/soil *(Note: weather and lawn conditions must be with in tractors operational limitations)*
3. Snow plow will be able to swivel left and right for snow defection
4. Dead lift load capacity from single point

Figure 8: Top Product Objective

The *Relative Importance Percentage* (fig. 9) was derived from the use of the QFD (appendix C). These *Product Objectives* were developed in order to define the function/features of the prototype by the designer. These are next building blocks for the front-end loader design.

The other 13 objectives are just important to the overall completion of the project but, they have a lower importance weight for the prototype feature/functions. Below is a list of them. The objectives title and importance weight for them are listed in bold text. A collection of definitions created for each objective is below that.

Ease of Use (10%):

1. One person operation
    a. Attachments able to be attached and removed with one person of average size
    b. Controls to be used with one person of average size
2. Controls will be within an appropriate reach of steering wheel for an average size person
3. Hydraulics will be designed to be able to be use with tractors engine HP/Torque
4. Loader will operate when drive line is engaged

Durability / Reliability (10%):

1. Bucket wear surfaces will be selected based on hardness
2. Utilize reliable components/material determined by safety/service factors and for particular application requirements
3. All hardware used will be *Grade 2* and higher

4. All hoses, hard lines and fittings will be commercial grade
5. Fittings will not leak during test period
6. Loader *(as a whole)* will preformed intended functions during the test period *(Note: tractors durability/reliability will not be a determining factor of loaders durability/reliability)*
7. Also, See "*Ease of Maintenance*" No. 1-5

Stay within limits of tractor used (10%):

1. Lift capacity (*load units in lbs.*) at max height and reach may be 30% less than total lift capacity (*limits TBD*)
2. Hydraulic components and sizes of them, will be assigned, dependent on space available within tractor
3. Bucket load and loader lift capacity may change dependent No. 1-2 above
4. Tractor will move on level ground with bucket loaded
5. Also, See "*Bucket Capacity*" Note No. 1

Safety (9%):

1. Lift arm controls will not be operable when operator is not seated on tractors seat (*Note: Bucket may lower due to gravity/normal valve fluid bypass and leakage as well as when lowering action is activated)*
2. Bucket capacity will be sized so that at full load tractor will not tip
3. Loader drive system will not operate if its' operator leaves tractor seat
4. Hydraulic fluid temperature can be monitored with a gauge
5. Hydraulic fluid filter/screen will be used in system
6. Loader arm kickstand will provide rollover resistance on flat ground
7. Components that rotate/move, have driven belt, have pinch points, that are hot to touch and/or that have potential to injure the operator or other persons will have appropriate guards and/or caution labels/placards attached *(Note: any item that is mentioned above (Safety No. 7) that is in an open area but, within the frame/chassis will not be required to have a guard and/or caution label/placard)*
8. Also, See "*Stay within limits of tractor used" feature below*

Bucket/Plow Capacity (8%):

1. Goal: four-five (4-5) cubic feet for soil (Capacity created by average soil weight from dry to wet (i.e. 100lb avg. per cu/ft)) *Note: this is dependent on tractors abilities (i.e. tipping factor and load capacity). Otherwise bucket capacity will be adjusted appropriately.*
2. Snow plow will be 10-14" tall and 38-42" wide

Ease of Maintenance (8%):

1. All steel components will be painted or powder coated
2. Hardware will be Stainless and/or galvanized and/or painted or pre-coated with an anti-corrosion
3. Sealed bearing will be use were applicably
4. Fluid filter/screen
    a. A person with average hand size and arm length will be able to access it

   b. Uses of standard tools may be required
5. Grease fittings (applied to system where appropriate)
   a. A person with average hand size and arm length will be able to access them
   b. Uses of standard tools may be required
6. Snow plow will have a removal-able bottom scraper blade
7. Also, See "*Ease of Storage*" No. 3

Compatibility with current tractor models (8%):

1. To be designed for Craftsman/Husqvarna series lawn tractor (similar but, not limited to, item *Craftsman Model #07128857000, Mfr. model #28857*)

Speed of Operation (7%):

1. Raise time unloaded ≤ 6sec
2. Lowering time ≤ 6sec

Ease of Storage (7%):

1. Attachments detach from lifting arms using standard hand tools
2. Loader arm has ability to detach from tractor using standard hand tools
3. Loader arm has kickstand so that it does not roll/fall over after it is detached from tractor (*on flat, solid ground*)
4. Hydraulic hoses have quick disconnect fittings (*where deemed appropriate by design*)

Overall Cost (7%)

1. Prototype will be no more than 20% over projected budget.

Operation Temperature (6%):

1. Fluid temperature to stay under manufactures recommendation

PRODUCT OBJECTIVES SUMMARY

The list is from 11% to 6%, which is the make-up of importance for each objective. There is no clear winner or loser (Except for the top and bottom of the list). Only one percent divides each objective. This makes for a good decision environment because all fall in order without being too farfetched. Yet, since all of them are very close together that means many of them may rely on its neighbor for success at a particular feature/function of the prototype.

PRODUCT/ENGINEERING CHARACTERISTICS WITH RELATIVE IMPORTANCE

Figure 9 depicts the *Relative Importance* between the function/feature of the prototype and the *Engineering Characteristics*. The strongest relationship between them is Component Selection for the entire system. This relationship does make the most amount of sense. Everything revolves around the selection of components in order to not only complete the project but, for it to be a success and function properly.

There are 15 different *Engineering Characteristics* to consider. They all have been deemed to have either a *Strong*, *Medium* or *Weak* relationship in relation to the *Prototype Features* in Figure 7. The range of *Relative Importance* is from 14.60% (This majority is driven by physical dimensions of the tractor and geometry of the load arms) to as low as 2.65% with *Collision & Abrasion Resistance*.

Engineering Characteristics	*Rel. Importance*
Component Selection	14.60%
Load Capacity	14.49%
Bucket Height and Reach	10.09%
Weight	9.29%
Size	8.64%
Material Selection	6.92%
Operation while drive line Engaged	6.23%

Engineering Characteristics	*Rel. Importance*
Raise and lower time	5.31%
Replaceable Components	4.40%
Removable Attachments/ Accessories	4.32%
Attachments/ Accessories Roll Resistance	3.58%
Attachments/ Accessories Flexability	3.54%
Safety and Service factors	3.30%
Guarding and Signage	2.65%
Collision & Abrasion Resistance	2.65%

Figure 9: Relative Importance of Engineering Characteristics

The figure above does not show a list of characteristics of the system yet, an illustration of how the features of the prototype with interact with them. Figure 7 and 8 are a very important initial pieces of the proverbial puzzle we call this *Senior Design Project*. These two figures aid in the initial steps to determine components/material cost and the budgeting for them. Also, aids in particular design aspects for specific features of the loader system. Refer to Appendix C.

DESIGN

DESIGN ALTERNATIVE

Shown below, in Figure 10, are two different configurations considered for the Loader Arm configuration. The configuration selected for the project is the Mitered Loader Arm. This is mainly due to mechanical similarity to other researched loader arm system configurations. This mechanical similarity is enough for the selection, even without other investigations. Yet, in order to choose a winner between the two, other investigations have taken place.

Some other investigational items to note is that there is a higher probability that the straight loader geometry will interfere with the tractors body panels. Also, the mitered configuration may allow for longer lift cylinder to be installed. This is an important aspect in order to achieve the desired lift capacity of the system.

Observe Location "A" (for both images) on figure 10. They are both the same approximate heights yet, the two individual cylinder strokes are at different positions/rates. The straight loader arm configuration is at 100% of its cylinder stroke; while, the Mitered configuration cylinder is only at 80% stroke. Also, observe location "B". These two heights are not the same. The mitered systems height is approximately 25% higher than the Straight system. Yet, both systems cylinders are at 50% stroke. This provides additional lifting potential needed the desired lift height capacity.

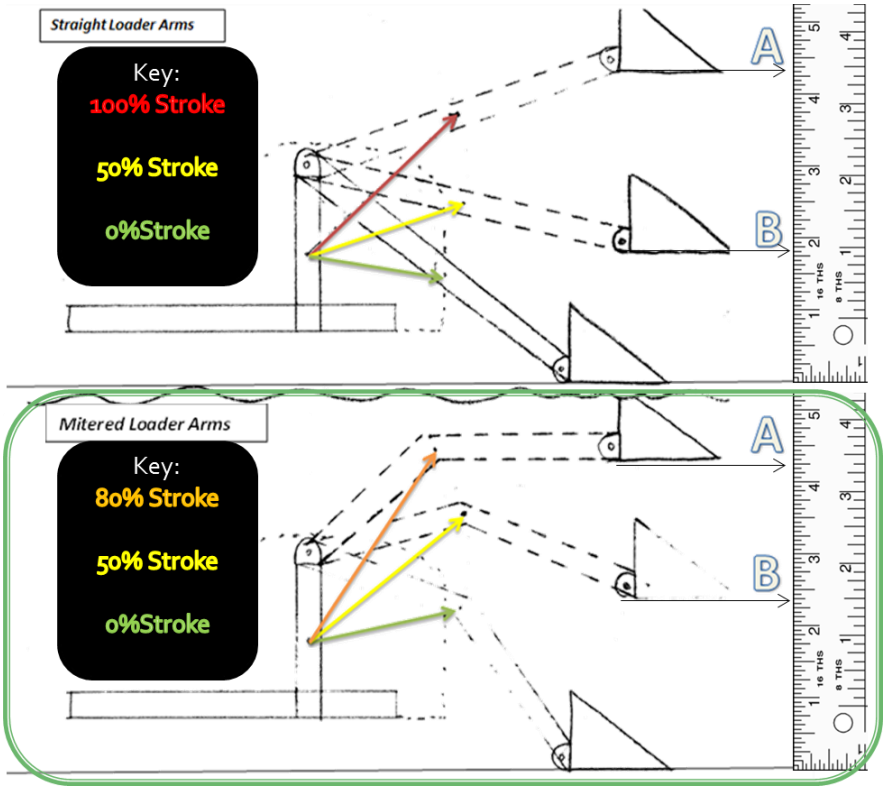


Figure 10: Straight vs. Mitered Loader Arm Configuration

LOAD CAPACITY AND TIP OVER

Load capacity and tip-over are important considerations and calculations. Figure 11 illustrates the particular points of interest and their CG within the system. This figure aids in the calculation of a maximum load capacity within the bucket at point "C". The equations used are shown below:

Without an operator seated:

$$\sum ma = 0 = (B_y * 48") + (60lb * 48") + (440lb * 25") + (36lb * 6") - (270lb * 3.5") - (22lb * 34") - (58lb * 43") - (C * 43.5")$$

If $B_y = 0$
Then C = 225 lb.

With an operator seated during operation of loader system:

$$\sum ma = 0 = (B_y * 48") + (180lb * 48) + (60lb * 48") + (440lb * 25") + (36lb * 6") - (270lb * 3.5") - (22lb * 34") - (58lb * 43") - (C * 43.5")$$

If $B_y = 0$
Then C = 425 lb.

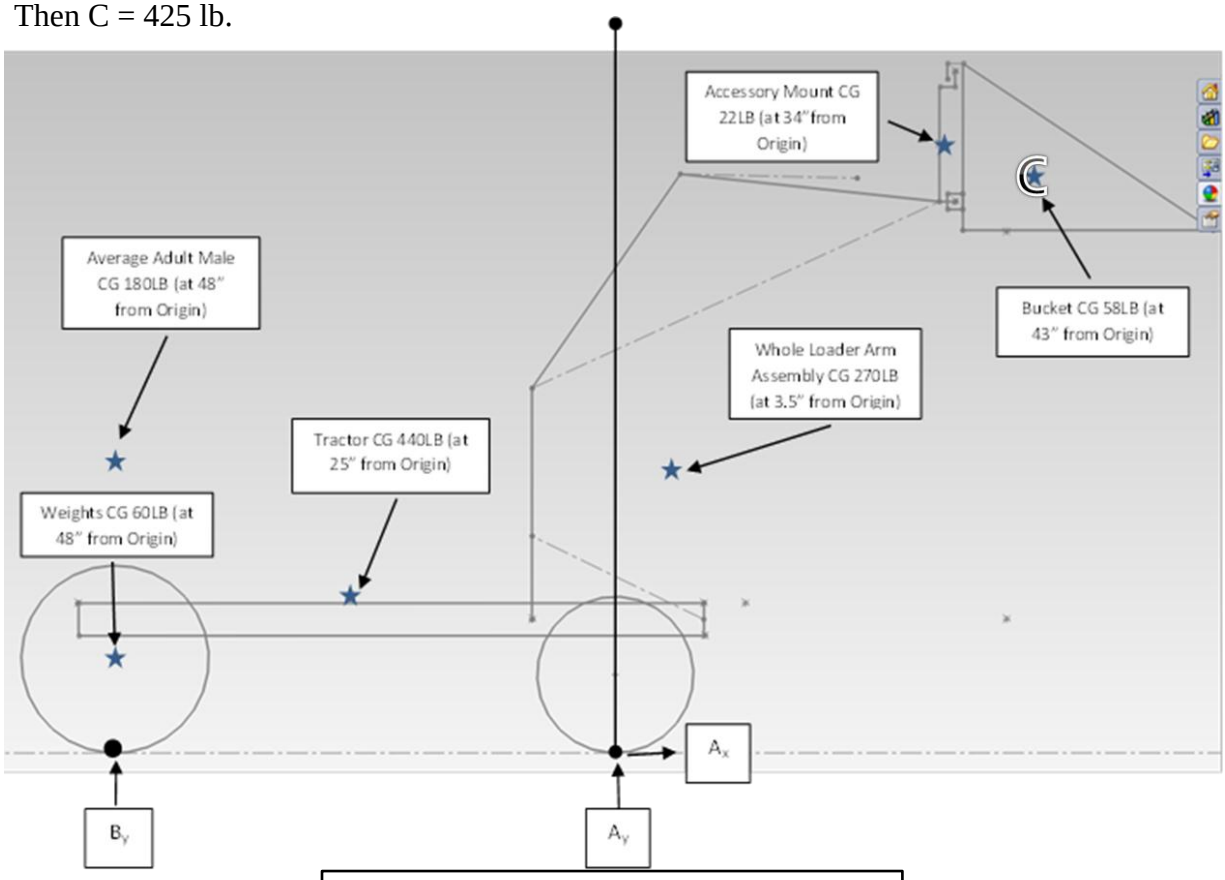


Figure 11: Systems Center of Gravity Points of Intrest

Therefore the theoretical load capacity is 425 lb. Yet, due to potential load applied to the tractors axels and the designed loader arms, the Maximum load capacity will be 350lb.

MECHANICAL SYSTEM OVERVIEW AND SOLID MODEL

There are five main components within the mechanical portion of the loader system. Figure 12 illustrates these components at ground and maximum reach positioning. Figure 13 illustrates a front Isometric view of the mechanical system. See Appendix F for Dimensional Drawings of individual components that make up the Mechanical Systems Assembly and Sub-components.

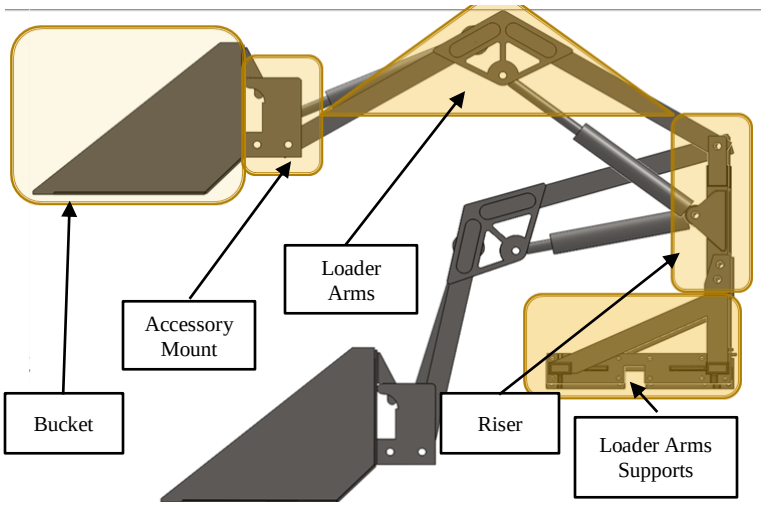


Figure 12: Two position Side View of loader system

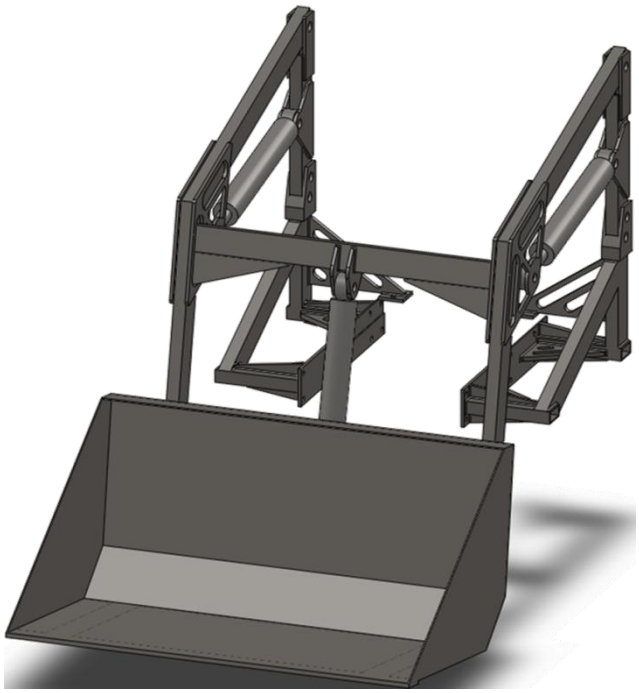


Figure 13: Front Isometric View of Loader System

BUCKET

The ***"Bucket"*** has an approximate volume of 2.75ft^3 and an approximate weight is 50lb. Also, it is designed to have a "Quick Disconnect" feature, in conjunction with the "Accessory Mount". This is for ease of storage and for future use of accessories. This function utilizes the two upper "Hooks" on the back of the bucket and the two lower "Pin Holding Tubes". These are illustrated in figure 14 bellow. See Appendix F for Dimensional Drawing of individual components that make up the Bucket assembly.

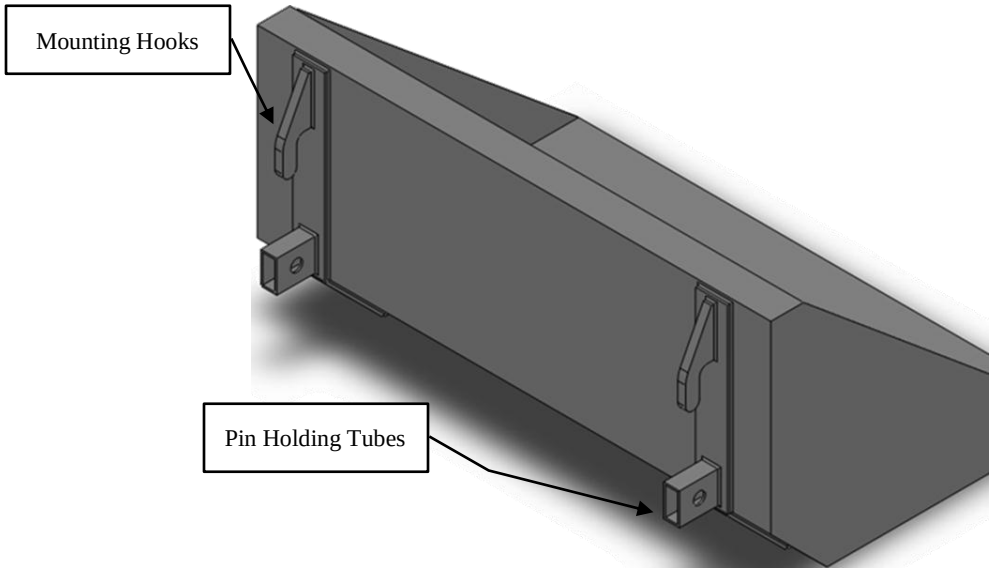


Figure 14: Back Isometric view of the systems Bucket

The buckets main function is to scoop loose mulch, soil and gravel. The load capacity of the whole system is 350lb and is intended to be an even load distribution with in the bucket. The buckets physical design was done so that it will be able to scoop a full bucket of dry clean gravel. This would be heaviest and worst-case scenario.

BUCKET ANALYSIS

Figure 15 below, is a COSMOS FEA image of the designed bucket for the system. You are looking at the bottom of the bucket in order to see the large majority of stress being applied. This analysis was done with a fully loaded and evenly distributed loading situation.

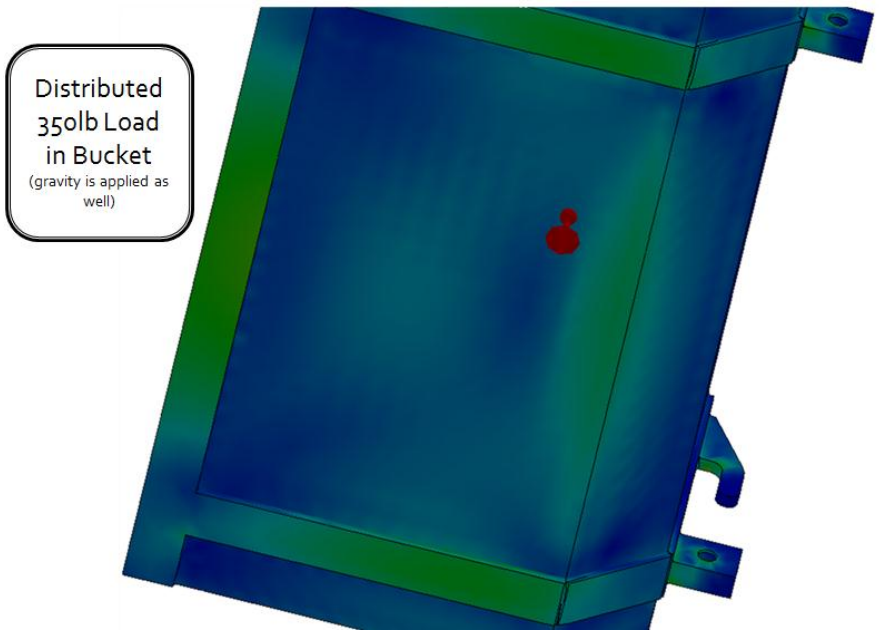


Figure 15:FEA of Bucket

The Yield of the material is 350Mpa and the largest Stress being applied to the bucket is 90Mpa. This provides a large safety factor for this component.

ACCESSORY MOUNT

The ***"Accessory Mount"*** is an intermediate between the Bucket and the Loader Arms. It weighs about 22lb and has the mating feature for the buckets "Quick Disconnect" functions. It also connects to the Bucket Hydraulic Cylinder. Just below the cylinder mounting plate is a "Dead Lift" point so that the Loader could lift the total load capacity at a single point. Figure 16 shows the Accessory Mount and its features. See Appendix F for Dimensional Drawings of individual components that make up the Accessory Mount assembly.

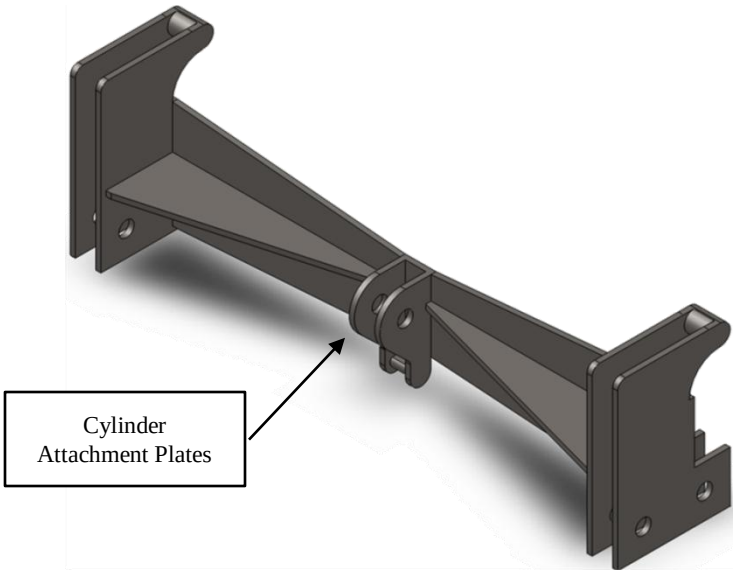


Figure 16: Back Isometric view of the Systems Accessory Mount

ACCESSORY MOUNT ANALYSIS

Figure 17 below, is a COSMOS FEA image of the designed Accessory Mount for the system. The material Yield is 250Mpa and the largest stress observed is 17Mpa. This provides and large safety factor for this portion of the mechanical system.

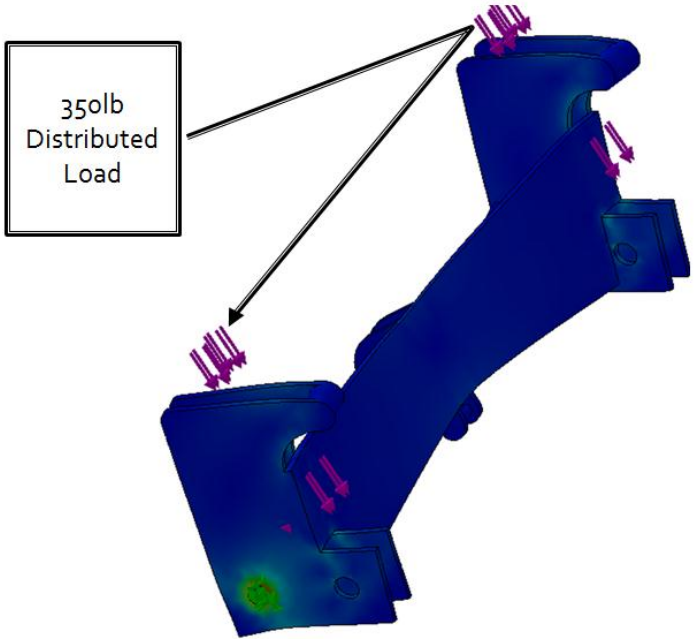


Figure 17: Accessory Mount FEA

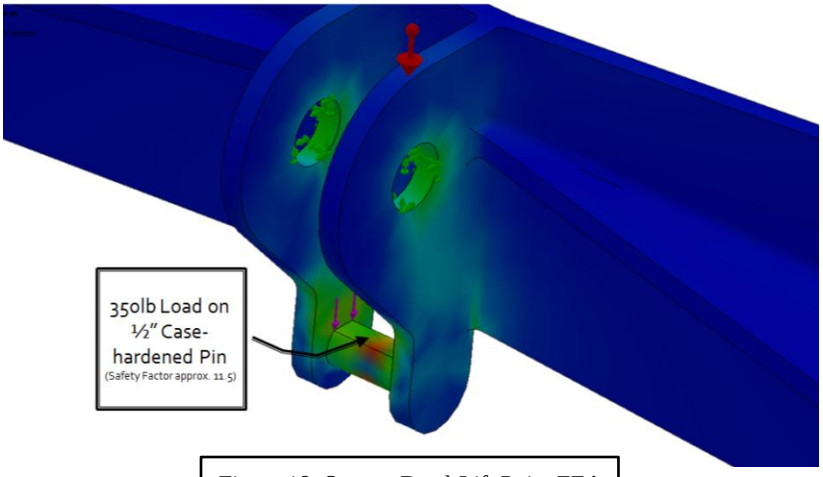


Figure 18: System Dead-Lift Point FEA

The FEA done for the Dead-Lift point for the system is shown in figure 18 above. The analysis was done on a hardened ½" pin. A full 350lb load was applied and supply a safety factor of 11.

LOADER ARMS

The ***"Loader Arms"*** provide the primary movement for the system. They have a central loader arm "Cylinder Attachment Plate". The configurations of the arms are such that they provide enough height to raise the Bucket to the desired lift height. The "Cross Beam" spans between the two arm to aid in the prevention of twisting under a load. Figure 19 shows both the Right Side Loader Arm and the Cross Beam that spans between the two arms.

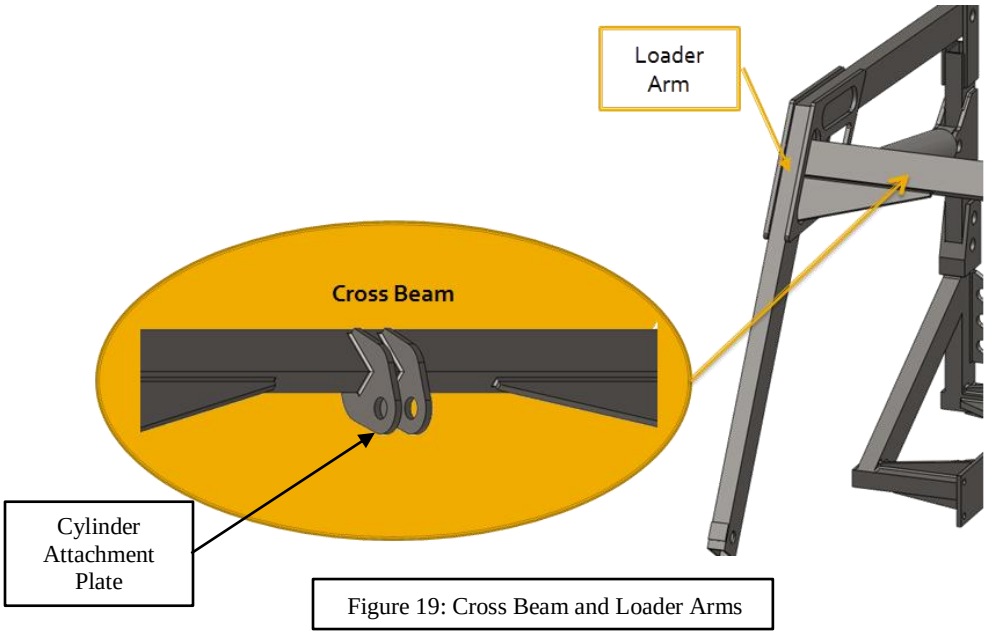


Figure 19: Cross Beam and Loader Arms

See Appendix F for more information and dimensional Drawings.

RISERS

The ***"Riser"*** is the intermediate between the Loader Arms and the Loader Arms Supports. They also provide a "Quick Disconnect Feature" for easy of storage while not in use. Also, the Riser provides the opposing cylinder attachment plates for the Loader Arm cylinders. A special note for the Risers is that even though the physical outside dimension of the rectangular tube stock is the same as all the rest, the wall thickness is larger to aid in Safety Factor for this component. Figure 20 illustrates a single Riser.

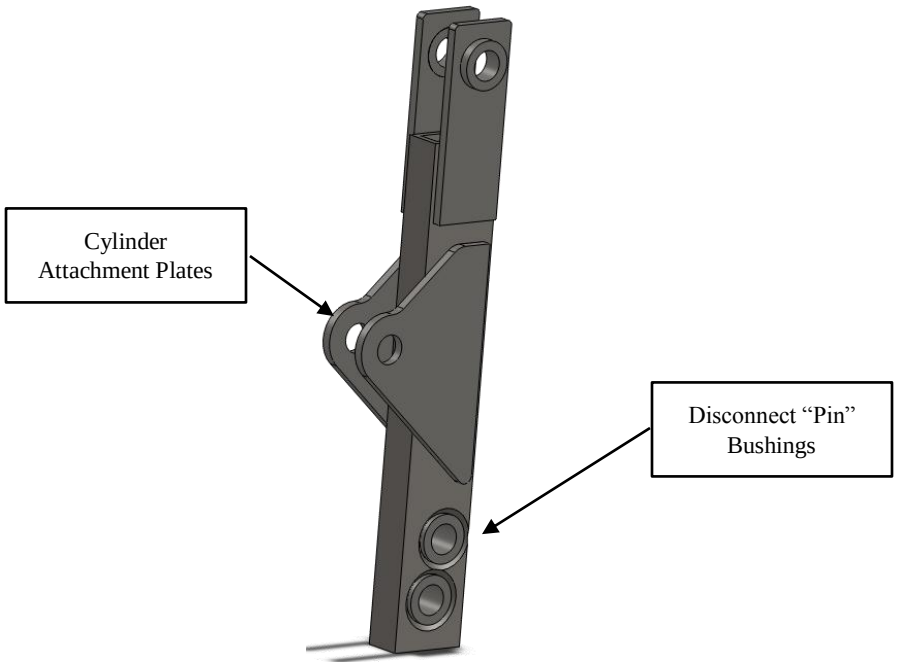


Figure 20: Front Isometric view of a single Riser

See Appendix F for more information and dimensional Drawings.

LOADER ARMS SUPPORTS

The ***Loader Arm Supports (LAS)*** are the main attachment and support feature for the mechanical system. They are designed robustly in order to support the loader arms which are counter levered from the frame. The weight of both LAS's, the Loader Arms and Risers are about 270lb combined. This bring the total weight of the mechanical system (minus all fasteners, hardware, cylinders, hosing and fittings) to approximately 340lb. Figure 21 shows an individual LAS.

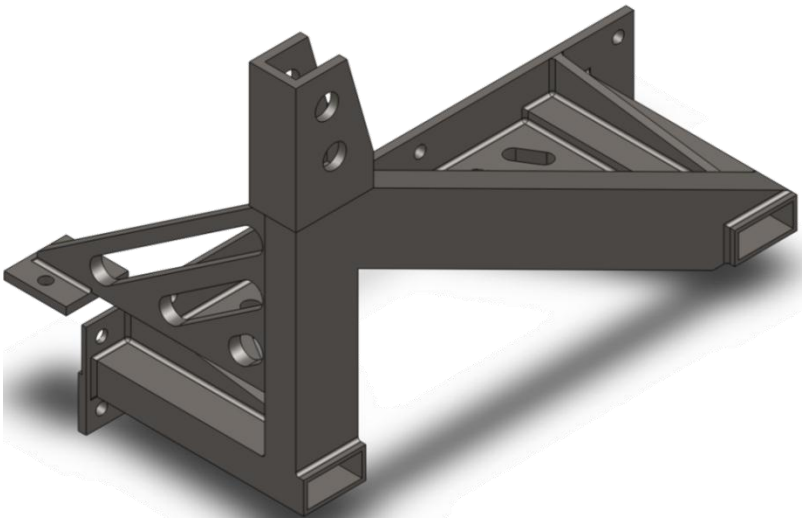


Figure 21: Back Isometric view of an individual LAS

See Appendix F for more information and dimensional Drawings.

LOADER ARM ASSEMBLY ANALYSIS

In Figure 22 below, COSMOS FEA was done on the Loader Arms, Risers and LAS's together. The load applied to the arms is a combination of the full load capacity, the weight of the bucket and the accessory mount. This developed a load of 212lb that was applied to each arm.

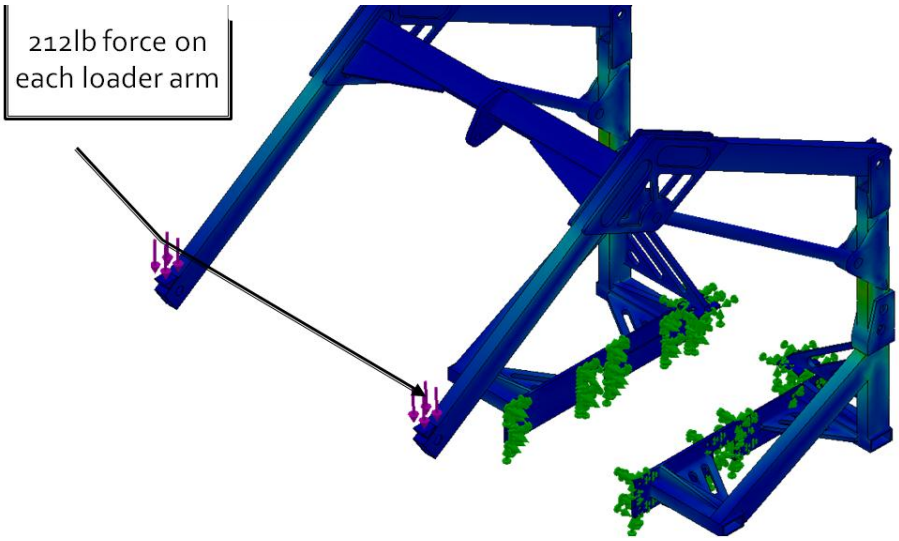


Figure 22: FEA of Loader Arm Assembly

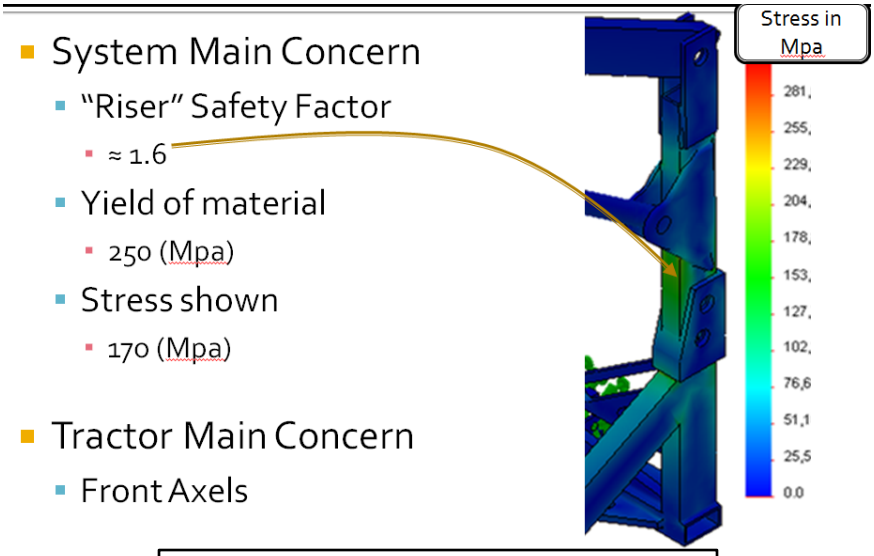


Figure 23: FEA of Riser with Factor of Safety Concern

Shown in Figure 23, the Factor of Safety of Concern for the mechanical portion of the system is within the Risers. This is the location of the highest bending moment. Also, note that the tractor itself is not undergoing testing per-say but, some concerning factors have to considered. The front axels are main concern for the tractors existing structure. Review the *Testing and Proof of Design* section for more information.

MECHANICAL SYSTEMS PINS AND BUSHINGS

Pins and Bushings have been selected and designed for fabrication for the longevity of fulcrum points within the system. The use of purchased 0.75" hardened pins and two different machined 1.25"OD bushings will aid in the material ware resistance at these points. They also will provide some additional strength to these stress concentration locations.

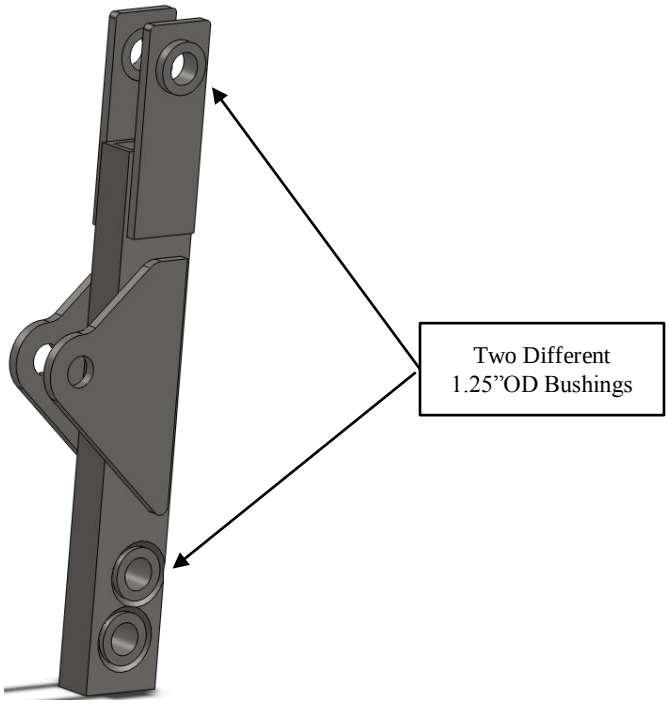


Figure 24: Riser with Machined Bushings

Figure 24 above, shows the bushings installed in a small selection of material within the "Riser". There will be a total of 36 machined bushings for the system. Also see Appendix F for dimensional drawing.

HYDRAULIC SYSTEM OVERVIEW

The hydraulic system consist of a pump, 3 dual acting cylinders, joystick controller, flow divider, hosing, pulleys, belts, hardware, fasteners, fittings and gauges. This portion of the system provides the physical movement to the mechanical portion.

This section will provide insight on the hydraulic components themselves as well as selection methods for them.

PUMP

The ***"Pump"*** is the heart of the hydraulic system and will be driven by a single groove, cast-iron, V-Belt pulley. This particular pump is manufactured by *DYNAMIC* and has a 0.49 in^3 displacement. Figure 25 shows the unattached pump. It is a gear pump that rotates in the CW direction. Its pressure rating at 2000RPM is 2900psi. It also has a maximum pressure rating of 3480psi at 4000RPM. Also to note, is the GPM of the pump, it is 4 GPM at 2000RPM.

Some of the parameters that revolve around the selection of this pump are:

1. Its small physical dimensions. The size is 4" x 4-1/32" x 3-5/16" with a ½" shaft. It was chosen because of the limited space where the pump will be mounted.
2. Its GPM and Pressure Rating
3. Its low weight of 7 lb.

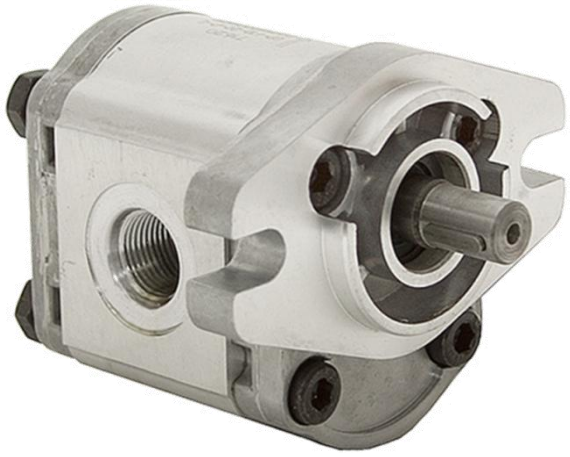


Figure 25: Hydraulic Pump

TWO GROOVE V-BELT PULLEY

A fabricated ***Two Groove V-Belt Pulley*** will drive the pumps supply pulley. The two groove pulley will replace the tractors current differential supply, single groove pulley.

There is a belt that spans between the engine and the rear differential of the tractor. The current belt and pulley system can provide the rotational power supply for the additional hydraulic system being applied. This is by replacing the single groove pulley with the two groove pulley. A belt will be supplied between the new two groove pulley and a single groove "Pump Supply" pulley. See Figure 26 for an image of the fabricated two groove pulley. Also, see Appendix F for dimensional drawings.

A special note about the design of this pulley is that it will have a pressed-in "Hub". This Hub will be cannibalized from the single groove pulley mentioned above. This is to eliminate a special splining procedure within the bore. The shaft that the pulley is being placed on has an irregular spline and replication would be costly. Also, the design provides a prevision for mounting the differential fan to the top of the pulley using the six threaded bolt holes.

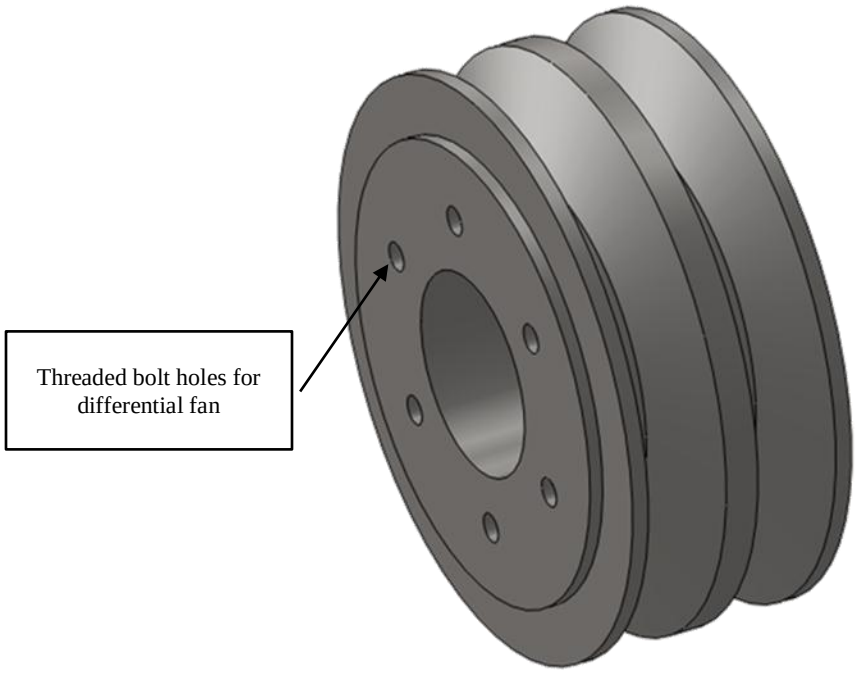


Figure 26: Fabricated Two Groove Pulley

This pulley was created with the use of physical measurements from the current single groove pulley and use of the *Machinist Handbook*. It is basic physical size is 4.25" OD x 1 7/8" tall. The design of this pulley was done so that it does not change and/or affect the current tractors drive system.

SINGLE GROOVE V-BELT PULLEY

The ***Single Groove V-Belt Driven Pump Pulley*** and belt arrangement was chosen to keep with the tractor current belt configuration. Figure 27 shows the unattached pulley. A particular size of pulley was needed to apply a desired speed of about 2000RPM to the new hydraulic pump. This speed is driven by the pumps Normal Operation rating and the hydraulic cylinder pressure rating. The equation used to prove the pulley sizing is shown below.

Pulley Diameter/RPM Calculator Equation:

$$\frac{Driving\ RPM}{Driven\ RPM} * Driving\ Pulley\ Diameter = Driven\ Pulley\ Diameter$$

Optimum Pulley Diameter:

$$\frac{3450\ RPM}{2000\ RPM} * 4.25"\ Dia \approx 7.25"\ Dia$$

Realistic Driven Pulley Diameter and RPM Goal of 2000 RPM:

$$\frac{3450\ RPM}{6"\ Dia} * 4.25"\ Dia \approx 2444\ RPM$$

Figure 27: Pump Pulley

The Realistic Driven Pulley Diameter is 6” OD. This is the largest retail available pulley found with a ½” bore. This is why it has been selected and will be utilized.

CUSTOM IN-LINE BELT AND TENSIONER

The ***V-Belt*** that is used to provide torque and rotational movement to the hydraulic systems pump, in general, is an "A" size "V-Belt". The size of an "A" V-Belt is ½" by 5/16" (Shown in Figure 28). This is the same size used in the existing tractors driveline and mower deck.

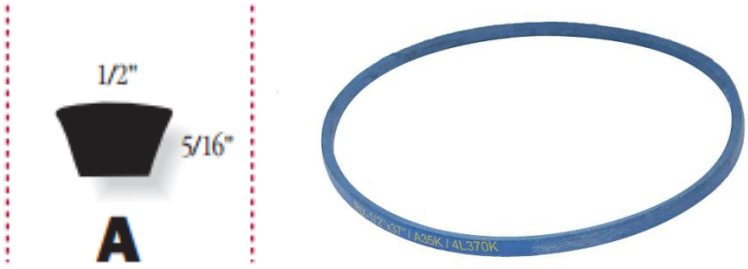


Figure 28: V-Belt Dimensions and Image

In most outdoor applications a special type of belt is needed. These belts are denoted as *Tractor V-Belts or Kevlar V-Belts*. These feature Kevlar cords for strength and premium durability. Figure 28 also show the belt used for the hydraulic system. The length of the belt is 37 inches in circumference.

The ***In-Line Tensioner*** (Shown in Figure 29) was custom made to work in the confined spaces of the tractors chassis. Just like the 2-Groove Pulley, this tensioner was unable to be purchased. Some specific dimensions and criteria were needed in order for the tensioner to work as intended. One such criterion is the amount of extension and the ability to oscillate in order reduce vibrational and torsional shock under load.

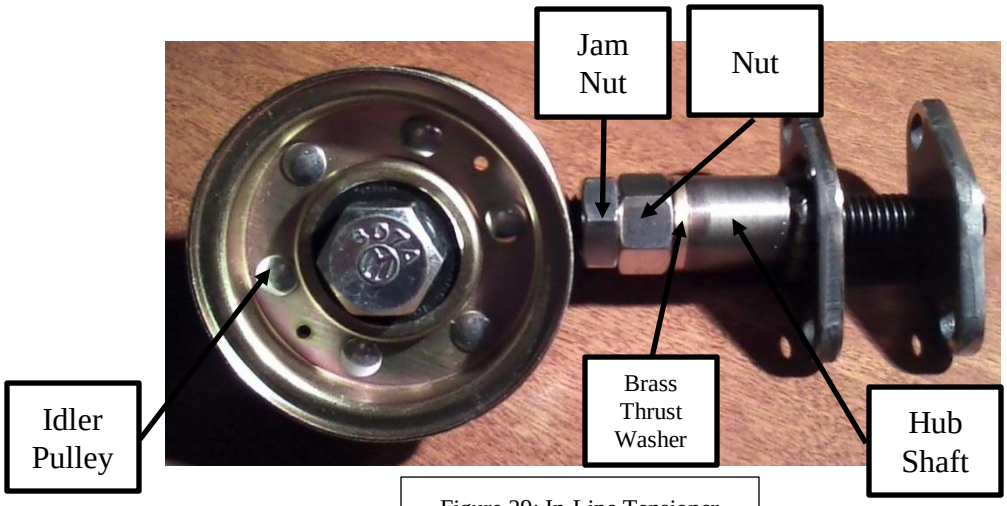


Figure 29: In-Line Tensioner

This tensioner is made up of 12 components. Four (4) of them are fabricated and the others are "Off-the-Shelf". The tensioner extends by threading the 5/8" Nut and Jam Nut, on the 5/8" fixed tie-rod, toward the "Hub Shaft". A brass Thrust Washer is in-between the Nut and the Hub Shaft. This configuration allows for the oscillating movement. Also, attached is a "Flat Faced" ball bearing idler pulley.

HYDRAULIC CYLINDERS

The ***Hydraulic Cylinders*** will physically move the loader arms and the bucket. They have a maximum pressure rating of 3000psi. Also, the speed of the operation has to be considered. Figure 30 shows an unattached cylinder. Also, see Appendix F for a dimensional drawing.

The cylinders chosen were done so by systems operating pressure bore size for speed of operation, lift capacity, geometry, and configuration of the loader arms and physical mounting points of the mechanical system.

There are three, of the same, cylinders used in the system to help keep a modular build. The maximum stroke lengths of the cylinders are 10" each. The bore size is 1.5" and the rod is 1" OD. At 3000psi, each cylinder can produce a hydraulic force of 5300lb.

Figure 30: Systems Hydraulic Cylinders

This systems defined speed of operation is that; from the ground, an unloaded bucket has to lift to its maximum lift capacity and/or the cylinders maximum stroke length within 6 seconds. The equation to prove that the two loader arm cylinders will operate at or under this speed is shown below.

Loader Arm Cylinder Extension Rate (time to extend fully)

$$\frac{(Volume\ of\ cylinder_1 * 0.26) + (Volume\ of\ cylinder_2 * 0.26)}{GPM\ of\ pump}$$

$$\frac{9.189}{4} = 2.9sec$$

The solution above illustrates that the unloaded bucket will be able to rise to it maximum height with a safety factor of two. This safety factor may also allow for the bucket to rise to its maximum height requirement in a loaded situation within the desired lift time.

HYDRAULIC CONTROLLER

The ***"Joystick Controller"*** is a 2 spool controller that supplies fluid to the loader arm cylinders and the bucket cylinder independently and/or simultaneously. This was the main feature that contributed to its selection. It also was chosen due to it port sizes (SAE 6 and 8), its maximum flow rate of 10GPM and its adjustable 3000psi system relief valve.

Figure 31: Hydraulic Joystick Controller

The controller will be mounted on the right hand side of the tractor near the steering wheel. It will be within reach of an average sized male. See figure 31, above, for an illustration of the controller. Also, see Appendix F for dimensional information.

FLOW DIVIDER

The hydraulic system needs a "Flow Divider". This is to aid in the resistance of twist within the loader arm assembly. The twisting action may be introduced if the loading condition within the bucket is uneven. The large majority of the twist resistance come from the structure of the loader arms and the cross beam between them. Yet, the Flow divider within the hydraulic system acts as an additional safety devise. Figure 32 show a cross-section of the "Flow Divider".

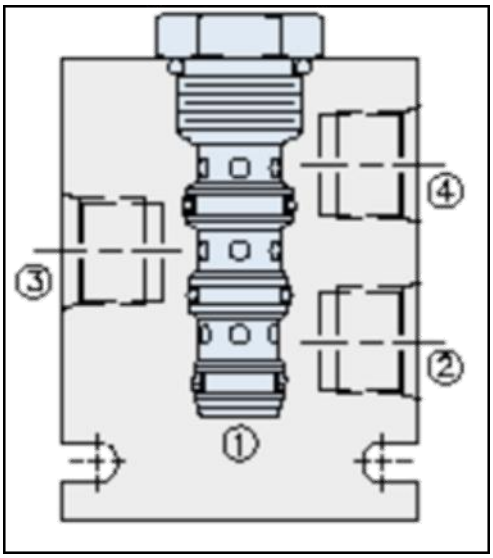


Figure 32: Flow Divider Cross-Sectional View

This particular Flow Divider is manufactured by a HydraForce. It is a spool/cartridge style flow divider. It has a working pressure of 3000psi and has an Aluminum body to aid in corrosion resistance for the system. It can flow and regulate the pressure between the two loader arm cylinders. On the up stroke of the cylinders the flow of hydraulic fluid enters port No. 3 and is split into two sections. The flow diverges with in the unit and exit out of ports 2 and 4. All three ports are SAE 6 size and style ports. See Appendix F more information and a dimensional drawing.

HYDRAULIC HOSE AND FITTINGS

Commercial grade ***Parker*** hose and fittings are going to be utilized for the fluid transfer within the hydraulic system. The large majority of fittings are O-ring seal style. This type of sealing is much more durable and provides a high seal pressure capacity as well as longevity of the fitting and seals within. Figure 33 shows the Parker Tough Cover hosing that will be utilized within the hydraulic system. Figure 34 show Face-Seal and SAE O-Ring Style sealed fittings.

Figure 33: Example of Parker Commercial Grade hydraulic Hose

This style hose has a working pressure of 4000psi and is doubled braded for burst resistance. These hoses have a built in safety factor of 3 from the factory. Also, the systems operating pressure will be 3000psi, which provides an additional working safety factor of 1.3. The safety factor is 4.3 for the hosing. The system will utilize a 3/8" hose sizing that allows for up to 7GPM of fluid flow.

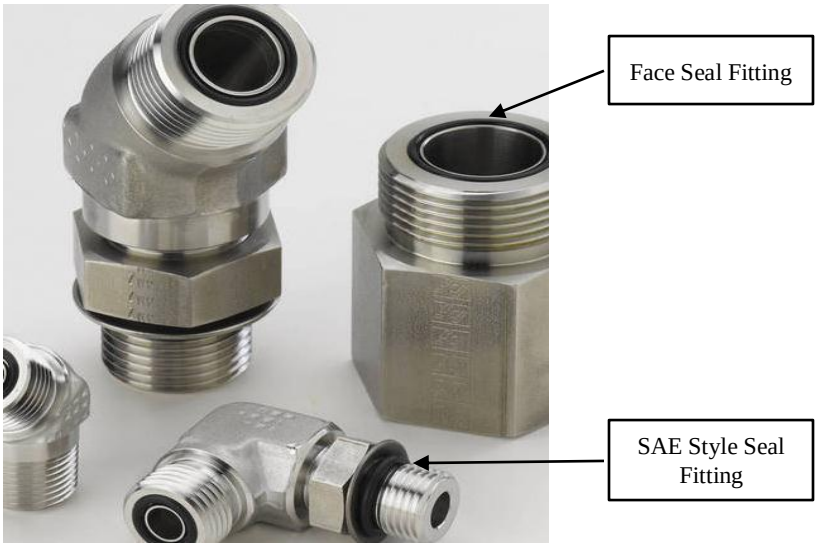


Figure 34: Example of Parker O-Ring Style Fittings

FABRICATION AND ASSEMBLY

There are some special procedures and components that were needed to complete this prototype. Some of the special procedures involved parts and components to be machined with the use of CNC Milling and also, manual milling machines. Other parts and components were created with the use of a CNC Lathe and also, manual Lathe processes. A large majority of parts and components used CNC Plasma Cutting techniques that allowed for items to be designed and then rapidly cut out to a rough dimension.

All of these parts and components were later cleaned, shaped and assembled in to sub-assemblies and then full-assemblies, if needed. These assemblies were fabricated with the use of welding and mechanical fasteners. The use of other Machine Shop equipment was also used in the preparation, fabrication and assembly of this front-end bucket loader prototype. Below are a few parts and/or components that utilized some of these special procedures.

2-GROOVE V-BELT PULLEY

This Pulley needed to be custom made because the shaft that it rides on. It has an irregular 18-Spline arrangement. Currently, there are no "Off-the-Shelf" pulleys that come in this particular arrangement. Yet, with proper planning, equipment and machinery, a solution can be created with the use of in-house equipment, instead of outsourcing an expensive custom splining procedure. Below are the basic steps and procedures used in order to create this special component.

1) Manual and computer analysis started the process. Later, Solid Modeling was completed to provide further analysis. Finally, a concluding subsequent drawing and solid model was created so that the part could be produced.

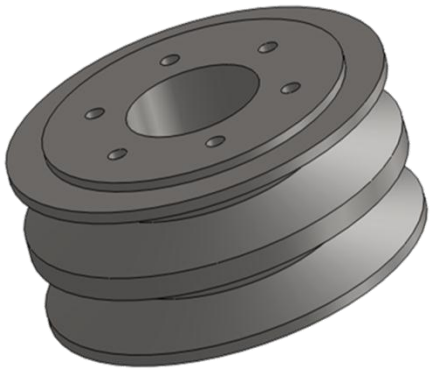


Figure 35: 2-Groove Pulley Solid Model

2) Next, a plaster Rapid Prototype was produced. This allowed for a physical part to be used to aid in the "Mock-Up" and measurement of other components that work in conjunction with the pulley. This prototype pulley can be placed onto the shaft that the actual pulley will be placed. This provides a real-world scenario for measurement. This plaster prototype was created in three days were the final metal pulley will take in upwards to five weeks to fabricate.

Figure 36: 2-Groove Pulley Plaster Prototype

3) *Final fabricating steps:* An Aluminum pulley was "Turned" with the use of a CNC metal lathe and program. Also, the splined "Hub" is cut out of the preexisting single groove pulley to be final "Turned" and then pressed into the new Aluminum pulley. In order to decrease the potential of the pressed-in Hub spinning loose from the Al pulley; set screws were fastened into place. The use of "lock-tight" and tightening them down secured the Hub from spinning.

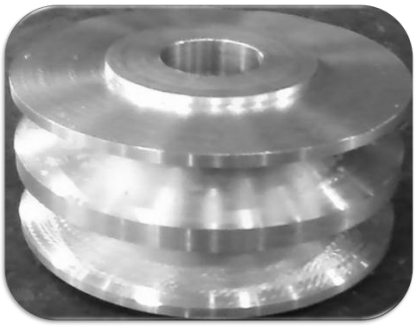


Figure 37: 2-Groove Pulley CNC Machined

LOADER BUCKET

The Loader Bucket has a number of different machining and fabrication elements to its creation. The use of a CNC Plasma cutter, CNC Milling Machine, CNC Lathe operations were used to make some of the components need to assembly the bucket. Other machine shop equipment including TIG and MIG welding was utilized.

The CNC plasma cutting was used to create the main body components and the entire supporting and ware brackets system. Figure 38 shows the bucket being assembled and welded together.

Figure 38: Assembly of the Bucket

The CNC Milling Machine was used to make the "Quick Disconnect Hooks" which mount onto the Accessory Mount. Also, it was used to bore the 1.25" holes into the rectangular tubing in order to fit the steel bushing (Shown below in Figure 39). The CNC Lathe was used in the making of the steel bushings.

Figure 39: Milling Operations used for the Bucket

The bucket as well as all of the other assemblies, created to complete the Loader System, was made with the use of these special procedures. Also, a large majority of the system was assembled with the use of welding equipment as well as other particular assembly and fabrication techniques.

TESTING AND PROOF OF DESIGN

ROLLING FEATURE TESTING

This particular type of testing involves the tractor moving around and moving/working the loader system as intended. This type of testing allows for the loader system to not only work the mechanical systems (i.e. providing movement of loader arms and bucket) but, also the initial function of the hydraulic system.

There are a number of different sub-systems that have to work and function properly (mainly in the hydraulic driveline and within the hydraulic system itself) in order for the larger more obvious mechanical components to work properly.

Figure 40: Picture of Completed Prototype During Rolling Testing

The rolling test involved adjustment of the hydraulic drive belt as well as to the hydraulic controller. The belt needed to be tensioned properly so to reduce slippage during high pressure/torque loading conditions. The controller was adjusted during the same time frame. The controller's output pressure supply is able to be adjusted from 800-3000psi. The operating system was adjusted close to 3000psi.

The GPM and Pressure of the system will be about 5.5gpm and 3000psi respectfully. These inherent features of the systems not only allow for the cylinders to move quickly enough but, also allow for enough force to be supplied during a loading condition. A successfully Rolling Test was observed.

FULL LOAD TESTING

During this portion of the prototype's testing, a full 350lb load is applied to the system. Earlier in the Design portion for the report, a key concern of whether the front axels, of the tractor, would be able to support a fully loaded system arose. A very short FEA analysis/study was done on the axels but, the specific material that the axels are made of is still unknown. The study was complete and the axel analysis showed that they may fail under a full "Dynamic" load. So even though the axels may not fail, precautions were implemented to insure a successful Full Load Test.

The testing allowed for two different but, similarly integrated features/functions to be tested at the same time. These two features include being able to lift a maximum of 350lb and also to be able to lift at a single "Dead Lift" location. A metal bin was used (Shown in Figure 41) to hold the supplied weight. The bin was sitting on a scale to measure the amount of weight being supplied to it. While the operator was seated on the tractor, 360lb (10lb over the intended maximum load) was successfully lifted by the loaded. Successful use of the Dead-Lift feature/location was also observed.

Figure 41: Tractor During Full Load Test

A special note for the Full Load Testing: The new front-end loader prototype is the intended system to be tested. Testing the tractors ability to with stand the loading test is not the main concern. With that being said, there were numerous studies (in general) completed to make sure that this prototype will function, as intended, with the selected tractor.

PROJECT MANAGEMENT

SCHEDULE:

This is a working schedule for the project starting at Oct 23rd through June 9th. The actual schedule will be updated and is depicted, in full detail; at Appendix E. Table 3 below is a condensed version project schedule.

Part 1: There are three tasks before winter break. These three tasks entail some basic measurement, concept sketches and a proof of design for faculty/project advisor. All three of them have a finial due date of November 23rd.

The eight other tasks are specific to design and solid modeling for the loader non-hydraulic components. They entail basic calculation, tractor breakdown with measurements, an initial mechanical components selection, frame reinforcement/attachment points model, loader arms model, accessories attachment configuration model, bucket model, snow plow model and COSMOS/FEA completed on these models.

Part 2: The first six tasks in the Winter Quarter are design and solid modeling tasks. The seventh task is the design freeze date which is February 4th. At this time no major design or component changes can occur.

Raw and standard material may be ordered when it is appropriate. During the winter quarter a multitude of items and components will be drawn and evaluated and once something is completed basic and major components/mater may be ordered.

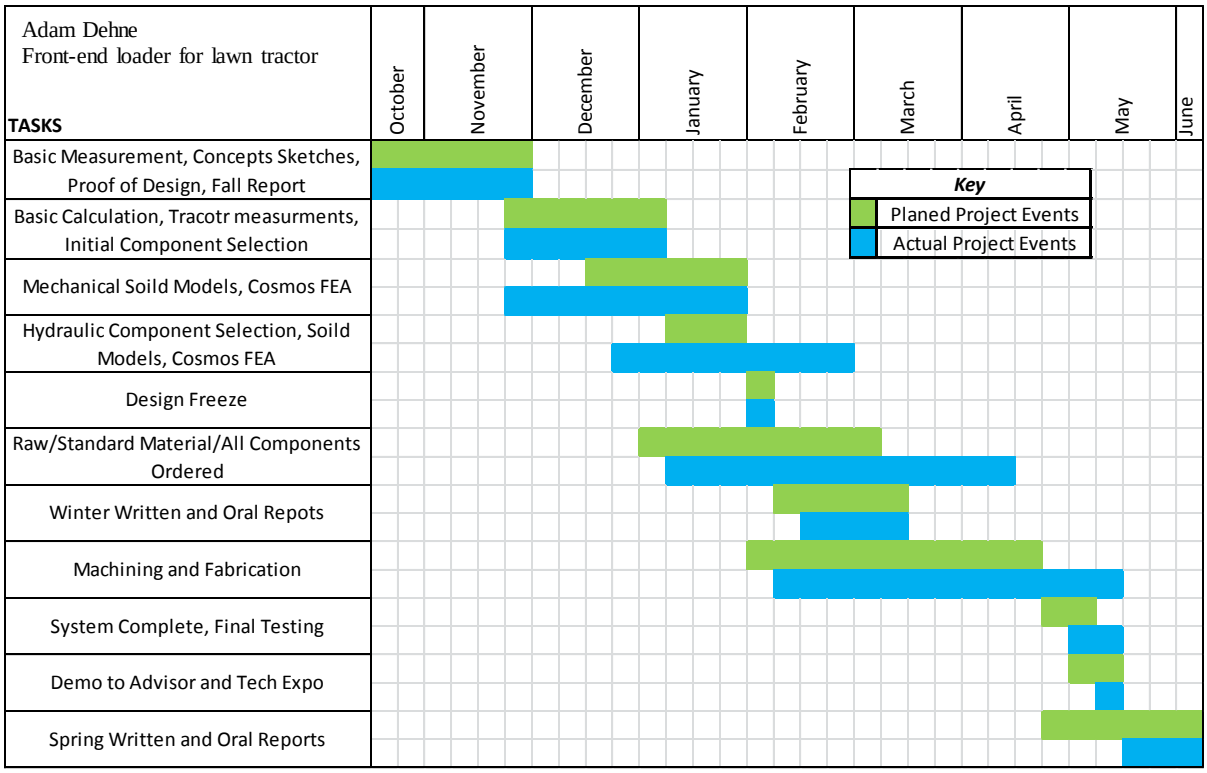
The winter report and oral presentation will take place on the week of March 3rd. Machining, fabricating and assembling components commence during the week of February 5th and will continue until the 21st of April.

Part 3: The final tasks of the project and are in the Spring quarter. The project/system must be completed by the 27th of April. The Prototype Testing, Demo to Advisor, Demo to Faculty are in the month of May and are on the 10th, 12th and 19th respectfully.

The Spring Written and Oral Report will be work on starting the week of April 15th and will be completed on the 2nd of May.

SCHEDULE CONT.

Table 3: Scheduled Tasks



PROJECT SCHEDULE SUMMARY

The major tasks for *Part 1* are Proof of design (Nov. 23rd), Tractor Breakdown with Measurements, Solid Modeling and FEA being completed January 26th.

The major tasks for *Part 2* are the completion of solid modeling and FEA of the hydraulic system. The Design Freeze for all major design systems and components is scheduled for the 4th of February. The Winter Report and Winter Oral Presentation will end on the 3rd of March. All material and components to be ordered and the commencement of fabrication all happen during this *Part 2*.

The major tasks for *Part 3* are the completion of the prototype and testing it during the test period. Other major tasks are the demonstration of the prototype to the faculty and to the advisor. One of the finial task due dates is the 2nd of May. This is when the written report is to be turned in to the faculty.

Please note: Table 3 above is a condensed version of the actual schedule. For more detailed information please see Appendix E.

BUDGET: PROPOSED

This is a working budget that was created by going through the basic thought process of the build. The expectation is that this proposed budget is at least 10% over what should be budgeted. Since a design of the prototype has not yet begun some items have been over budgeted for the unknown. Table 4 shows the main categories and funds budgeted for them.

The current proposed budget for the front-end loader prototype is just over $9,700 (See Appendix F). There is a cell for every *True Expenditure* that will not only show the percent difference but, it will also automatically deduct what was spent from the remaining budget.

Table 4: Proposed Budget Overview

Category	**Est. Total (USD)**	**Percent of the total budget**
Hydraulics	$4,772.58	48.9%
Tractor	$1,700.00	17.4%
Loader Arms	$1,369.25	14.0%
Loader Arm Supports	$345.75	3.5%
Snow Plow	$344.00	3.5%
Additional Rear Weight Added	$320.00	3.3%
Bucket	$305.00	3.1%
Potential Axel Reinforcement	$223.00	2.3%
Other	$110.00	1.1%
Other Raw Material	$100.00	1.0%
Other Miscellaneous Components	$100.00	1.0%
Potential Frame Reinforcement	$78.00	0.8%

The main categories are seen in the table above. They are Hydraulics, Loader Arms, Loader Arms Supports, Bucket, Snow Plow, Additional Rear Weight Added, Potential Axel Reinforcement, Potential frame Reinforcement, Other and Tractor.

The hydraulics encompasses almost 50% of the budget. Some of the components include a pump, lift cylinders, hose and fittings. The second biggest percentage is the lawn tractor itself. This tractor was selected because of its size, features/functions and overall cost. The third largest category is the fabrication of the loader arms. A large amount of the funds needed are in the build material.

The rest of the categories have a much smaller percentage. From 3.5% to 2.3% is the most crucial in this grouping. This is the other designed and fabricated components. Such as the Snow Plow, Lift Bucket, Rear Weight to help prevent tipping and Potential Front Axel Reinforcement in order to carry the load.

BUDGET: ACTUAL

Table 5 below is a condensed version of the total budget. There are five main categories. The top three are Raw material, Hydraulic and Tractor. Overall spending for the project had a 35.5% difference between the initial budget. This lowered the budget spending from $9,700 to just under $6,500.

Table 5: Actual Budget, Condensed

Category	**Est. Total (USD)**	**Donated or Owned Material/Components**
Raw Material	1,950	225
Hydraulics	1,900	1,000
Tractor	1,700	1,700
Other	530	
Miscellaneous toolng/items	225	
Total	6,305	2,925
Total Spent	$3,380	

With the aid of Sponsorships, donations and personal material/components, the actual spending was just under $3,500. An important key note is that the Budget and actual spending number are artificially low. This is due to the fact that there were no costs for large tooling expenses or CNC Milling, Turning and Plasma Cutting Operations. The initial budget did not account for these items either.

All of the items/components that needed this type of operation were completed at no charge. This was understood in the very beginning of the project and was completed as such. Subsequent spending charges were not recorded or denoted within the project budget.

CONCLUSION

This is a project that involves many disciplines and all had to be well planned out in order for the successful completion of the project to occur. The largest and most important feature of the prototype (noted in the Product Objectives) was the ability to perform its intended operational tasks.

The Loader system is able to perform as intended per the design. After further testing the bucket cylinder was flipped 180 degrees to avoid the bucket and at the same time provided a hard stop. Also, after the hydraulic controller was adjusted and the new belt was tensioned properly the system is able to lift the 350lb load to desired height of 55 inches. The hydraulic system works as intended and there were no leaks during the testing period. Also, the tractor does not tip over during full loading and the mower deck is still fully functional.

This project was completed by one person in the allotted time frame given. It has been very well received by the Engineering faculty and peers. All of the sub-components work as intended and the Front-End Bucket Loader Prototype and the Senior Design project, as a whole, have been deemed successes.

RECOMMENDATIONS

Note: This Front–End Loader Bucket Prototype was designed and fabricated by myself with personal and Machine Shop equipment available to me. The use of more specialized equipment would be preferable if the design and system were to be created for mass public sales. Below are a few numbered items that could be recommended if this prototype were to move into future manufacturing phases.

1) The use of the CNC Plasma cutter was very beneficial but, I would recommend the use of a Water Jet machine, if possible or available. There were many days devoted to the cleaning, shaping and dimensioning the parts that were cut out using the CNC Plasma machine. This is because the machine could not hold a close tolerance with the thicker material used. Even though the material used stayed well within the limits of the machines capabilities.

2) A great deal of preparation, in general, was used while welding all of the assemblies together. This is because as the metal has a tendency to move and warp during the welding process. Even though this prototype has been created and works as intended; the use of custom/special holding fixtures would be recommended if this prototype were to be manufactured for a larger scale.

3) This is a very large project for one person to take-on. It requires many different fabrication, assembly and design practices in order to be accomplished. If there is another project of this size, in the future, a suggested minimum of two people should be allowed.

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4. loader information. *Koyker Maunfacturing.* [Online] [Cited: Sept 23, 2011.] http://www.koykermfg.com/index.php/products/loaders/info/.
5. Craftsman 14" High Lawn Tractor Snow Blade. *Sears.com.* [Online] [Cited: Sept 26, 2011.] http://www.sears.com/shc/s/p_10153_12605_07124441000P?sid=IDx20070921x00003a&ci_src=14110944&ci_sku=07124441000P.
6. Johnny plow jr. snow plow acessory. *Johnny products.com.* [Online] [Cited: Sept 26, 2011.] http://www.johnnyproducts.com/J_Bucket_HTMs/Johnny_Plow_Jr.htm.

APPENDIX A – LOADER/PLOW REASEARCH

Interview with customer, Sept. 25, 2011
John Dehne, Home owner, 5498 lakefront drive, Cincinnati, OH 45215
Snowplow info:

- Would like the plow to be able to swivel, lift up and down, have some form of rollers or rubber/nylon skid bar on the bottom of plow
- Will store plow when not in use, must be light weight so that one person can move

Bucket info:

- Size to be under a cubic yard
- Light weight, under 100lb so that one person can move
- Minimum bucket movement $30^{o} \pm$ for parallel to ground

Hydraulic and mechanism info:

- After initial installation; does not have to be able to remove. Only attachment(s) need to be removable
- Minimum two (2) feet lift from ground and max lift of five and one half (5.5) feet from the ground

http://www.johnnyproducts.com/J_Bucket_HTMs/JBpage_Jr_Craftsman-LT.htm, 9/24/11, Johnny Bucket, electric front end loader

Installs in Minutes After installing the included adaptor hitch and control wiring to the tractor, the **Johnny Bucket Jr (JBJr)** attaches with just a few clips and pins.

Independent Lift The **JBJr** has it's own dedicated electric lift system. To lift or lower, just press the toggle switch. It couldn't be easier.

Leave the Mower on!! Can be left on since the Johnny Bucket Jr. doesn't interfere with mowing deck or it's lift system.

Down Force Pressure The **JBJr** has just as much down force pressure as it has lift capacity. It works great for scraping and back dragging.

Two Attachments at Once. You can run a rototiller simultaneously to dig up and loosen dirt and come back with your **JBJr** to move it away. *Perfect for making gravel walkways, driveways or ditches.* The possibilities are endless. (rototiller not included)

Practically Eliminates The Wheelbarrow. Instead of loading the wheel barrow by hand and then having to maneuver it up and around treacherous terrain, the **JBJr** will scoop and transport any material without, ***YOU THE USER***, ever leaving your seat. Now, you can tackle those big weekend landscaping projects in a fraction of the time and effort.

Ease of Lifting and Dumping. The **JBJr** Can be easily lifted and dumped with just a press of the included toggle switches.

- **Width:** 42"
- **Height:** 10"
- **Depth:** 14"
- **Over Travel:** 4"
- **Approximate Capacity:** 2.5 cubic feet.
- **Maximum Weight Capacity:** 200 lbs.
- **Down Force Pressure :** 200 lbs.
- **Weight:** approximately. 100 lbs

Price: $ **$1789.90**

Electric operation

Only 200 lb load limit

Only 10” lift height

Mounts to front of frame

Does not interfere with mowing deck

Bucket moves from 0-90º only

Light weight

http://www.mowersdirect.com/Images/Husqvarna-531-30-71-68/i4599.html 9/21/11, Husqvarna Front Scoop, Mowers Direct  Easily Haul Loose Dirt, Rock Or Mulch •Scoop measures 36" wide x 14" deep x 12" high •200 lb. load capacity •Great for spreading sand •Move heavy rocks or bags of soil and mulch Operate Right From The Tractor Seat •Lift, lower and dump using easy to reach ergonomic handles •Bucket raises 5 to 7 inches from the ground •Bottom of bucket can be used for leveling Mower Deck Does Not Have To Be Removed To Use Tire Chains & Weights (sold separately) Recommended Fits All Husqvarna Consumer Tractors Model Year 2006 And After Price $700	Less expensive than electric/hydraulic units Simple to use (man power) Not powered Not adjustable Lots of Mechanical linkages 36" wide x 14" deep x 12" high Only 200lb load limit Only raises 5-7” from ground Does not interfere with mowing deck Mounts to the front of the frame

http://www.koykermfg.com/index.php/products/loaders/info 9-23-11, Model number 50, Koyker manufacturing

MODEL 50 ASABE INFORMATION

Bucket Size	3 ft. 6 in.
Rated Flow	4 GPM
Maximum Pressure	2000 PSI
Lift Cylinder Diameter	1 1/2 in. Bore
Attachment Cylinder Diameter	1 1/2 in. Bore
Tractor Horsepower Range	10-25
Maximum Lift Height To Pivot Pin	5 ft. 10 in.
Lift Height Under Level Bucket	5 ft. 3 in.
Clearance With Bucket Fully Dumped	4 ft. 4 in.
Reach At Maximum Lift Height	
Maximum Dump Angle	37 Degrees
Digging Depth	3 in.
Overall Height In Carry Position	3 ft. 8 in.
Lift Capacity To Maximum Height At Pivot Pin	700 lbs
Lift Capactity To Maximum Height 19.7" Forward Of Pivot Pin	470 lbs
Breakout Force At Ground Line At Pivot Pin	1240 lbs
Breakout Force At Ground Line 19.7" Forward Of Pivot Pin	870 lbs
Raising Time	3 seconds
Lower Time	2 seconds
Attachment Dumping Time	3 seconds
Attachment Rollback Time	2 seconds

Good amount of capacity from bucket

Good amount of lift and power to do so

Cannot be used with mower deck

Use with tractor that is larger than intended use

Hydraulically driven

Built to suit from manufacturer - unknown price

Used for larger items and area than intended use

http://www.sears.com/shc/s/p_10153_12605_07124441000P?sid=IDx20070921x00003a&ci_src=14110944&ci_sku=07124441000P, 9/26/11, Craftsman 14” snow blade, sears.com  42 in. wide blade angles center, left or right, and is 14 in. high. It lifts with lever from driver seat. Fits Craftsman Lawn, Yard, Monster, Fairway and Deluxe Lawn Series tractors only. Tractors with 22 in. or smaller rear tires • For snow removal only • Can be lifted and lowered from the tractor seat • Blade pivots left, right and center from the tractor seat • Skid shoes are adjustable for use on smooth surfaces or rock driveways • Scraper blade is replaceable • Single Adjustable trip spring on rear of blade head allows blade head to ride over obstacle • After 1-time installation of mounting brackets, blade can be removed/attached w/out tools Item weighs 76LB 42” width, 14” height Price: $300	Not powered Mounts to front of frame Does not interfere with mowing deck Light weight Does swivel Lift by hand from seat Blade removes with one person Replaceable scraper blade

http://www.johnnyproducts.com/J_Bucket_HTMs/Johnny_Plow_Jr.htm, 9/26/11, Johnny snow plow, - johnnyproducts.com

- **Width:** 48"
- **Height:** 15"
- **Over Travel:** 8".
- **Down Force Pressure:** 200 lbs.
- **Construction:** 12ga

Compatible with all Johnny Bucket Hitches. The **"Johnny Plow Jr."** will attach to all **Johnny Bucket Jr** adaptor hitches ever made from 2001 to present.

Attaches in Minutes. After removing the **Johnny Bucket Jr** bucket assembly from it's adaptor hitch, attach the **"Johnny Plow Jr."** with just two bolts and you're ready to go snow plowing.

Power Angling Option: With just a touch of a switch, The **"Johnny Plow Jr."** can be turned from **left** to **right** without ever leaving the comfort of your seat. (***Note:*** *Angling actuator not included. Customer must use their JBJr power dump actuator or purchase the power angling kit at extra cost.*) Movie from seat

Manual Angling Option: Just release the lock pin and manually angle the **"Johnny Plow Jr."** from **left** to **right**.

Float Setting. The **"Johnny Plow Jr."** has the ability float up and down over obstacles using only the weight of the blade scraping.

Down Force Pressure The **"Johnny Plow Jr."** also has built in down force pressure for scraping packed snow and ice.

Price: $750

Electric powered

Mounts to front of frame

Does not interfere with mowing deck

Does swivel

Electronically controlled

Replaceable scraper blade

Raises and swivels minimally

APPENDIX B – SURVEY WITH RESULTS

Customer Survey
Front-End Loader/Snow Plow for a Personal Lawn Tractor

This survey will be used to weigh specific operation and components that will be used. This project will consist of hydraulic lifting arms and bucket attachment to be controlled by operator while seated.

How important is each feature to you for the design this front end loader?
Please circle the appropriate answer. 1 = low importance 5 = high importance

Safety	1(0)	2(0)	3(1)	4(7)	5(14)	N/A
					Avg: 4.59	
Ease of Maintenance	1(0)	2(0)	3(4)	4(12)	5(6)	N/A
					Avg: 4.09	
Ease of use	1(0)	2(0)	3(2)	4(9)	5(11)	N/A
					Avg: 4.41	
Ability to perform Operational Task	1(0)	2(0)	3(2)	4(5)	5(15)	N/A
					Avg: 4.59	
Durability / Reliability	1(0)	2(0)	3(2)	4(4)	5(16)	N/A
					Avg: 4.64	
Compatibility with current tractor models	1(0)	2(2)	3(2)	4(9)	5(9)	N/A
					Avg: 4.14	
Stay within limits of tractor used	1(0)	2(2)	3(6)	4(7)	5(7)	N/A
					Avg: 3.86	
Bucket Capacity	1(0)	2(2)	3(10)	4(8)	5(2)	N/A
					Avg: 3.45	
Speed of operation	1(1)	2(1)	3(14)	4(5)	5(1)	N/A
					Avg: 3.18	
Operation Temperature	1(0)	2(8)	3(9)	4(3)	5(2)	N/A
					Avg: 2.95	
Ease of Storage	1(3)	2(4)	3(9)	4(3)	5(3)	N/A
					Avg: 2.95	

How satisfied are you with the current front end loader? If you do not have one √ here _____ and Please Omit the next section. Section Omitted

Please circle the appropriate answer.	**1 = very unsatisfied**				**5 = very satisfied**	
Safety Section Omitted	1	2	3	4	5	N/A
Ease of Maintenance Section Omitted	1	2	3	4	5	N/A
Ease of use Section Omitted	1	2	3	4	5	N/A
Ability to perform Operational Task Section Omitted	1	2	3	4	5	N/A
Durability / Reliability Section Omitted	1	2	3	4	5	N/A
Compatibility with current tractor models Section Omitted	1	2	3	4	5	N/A
Stay within limits of tractor used Section Omitted	1	2	3	4	5	N/A
Bucket Capacity Section Omitted	1	2	3	4	5	N/A
Speed of operation Section Omitted	1	2	3	4	5	N/A
Operation Temperature Section Omitted	1	2	3	4	5	N/A
Ease of Storage Section Omitted	1	2	3	4	5	N/A

How much would you be willing to spend on this Loader/Plow in a retail store?

$2500-$3500(12) $3500-$4500(4) $4500-$5500(2) $5500-$6500(0)

Cost was not a factor (4) Avg: 3.91

Thank you for your time and consideration.

APPENDIX C – QFD RESULTS

Adam Dehne
Front-End Loader/Snow Plow for a Personal Lawn Tractor

House of Quality "Relation"
Key:
9 = Strong
3 = Moderate
1 = Weak

	Size	Safety and Service factors	Weight	Material Selection	Attachments/Accessories Roll Resistance	Operation while drive line Engaged	Guarding and Signage	Replaceable Components	Bucket Height and Reach	Collision & Abrasion Resistance	Attachments/Accessories Flexability	Load Capacity	Removable Attachments/Accessories	Component Selection	Raise and lower time	Customer importance	Designer's Multiplier	Modified Importance	Relative weight	Relative weight %
Safety	3	1	1	9	9	1	9		3	1		9		1	1	4.6	0.9	4.1	0.09	9%
Ease of Maintenance	1		3	3	1	1	1	9	1	1	1	3	9	3	1	4.1	0.9	3.7	0.08	8%
Ease of Use	3	1	3	3	1	9	1	1	9		9	3	3	9	3	4.4	1.1	4.9	0.10	10%
Ability to preform Operational Task	3	3	3	3		3			9		1	9	1	9	1	4.6	1.2	5.5	0.11	11%
Durability/Reliability	1	3	3	9	1	3	1		1	9	1	9		9		4.6	1	4.6	0.10	10%
Compatibility w/current tractor Models	9		3	1		9		9	3	1	1	9		9	1	4.1	0.9	3.7	0.08	8%
Stay within limits of tractor used	9	3	9	3		3	1	3	9	1	1	9	1	9	3	3.9	1.2	4.6	0.10	10%
Bucket/Plow Capacity	9	1	9	3	1		1		9	1	1	9	1	9	9	3.5	1.1	3.8	0.08	8%
Speed of Operation	3	3	9	1		3		1	1		1	9	1	9	9	3.2	1.1	3.5	0.07	7%
Operation Temperature		1	3	1		1	1	3	3			9		9	3	3	1	3.0	0.06	6%
Ease of Storage	9		9	1	9				1		1	1	9	3		3	1.2	3.4	0.07	7%
Overall Cost	3	3	3	3	1	3	1	3	9	1	3	9	3	9	3	3.9	0.9	3.5	0.07	7%
Abs. importance	4.40	1.68	4.73	3.53	1.83	3.17	1.35	2.24	5.14	1.35	1.80	7.38	2.20	7.44	2.70	50.9		48.3	1.0	
Rel. importance	0.09	0.03	0.09	0.07	0.04	0.06	0.03	0.04	0.10	0.03	0.04	0.14	0.04	0.15	0.05	1.00				

APPENDIX D - PRODUCT OBJECTIVES

Product Objectives
Front-End Loader/Snow Plow for a Personal Lawn Tractor

These *Product Objectives* will be focused on a Craftsman/Husqvarna series lawn tractor (similar but, not limited to, item *Craftsman Model #07128857000, Mfr. model #28857*).

Ability to perform Operational Task (11%):

1. Lift bucket load of 400-500lb to a reasonable height to load into a ¼ Ton Truck bed
2. Dig 1-5in in to soft ground/soil *(Note: weather and lawn conditions must be with in tractors operational limitations)*
3. Snow plow will be able to swivel left and right for snow defection
4. Dead lift load capacity from single point

Ease of Use (10%):

5. One person operation
    a. Attachments able to be attached and removed with one person of average size
    b. Controls to be used with one person of average size
6. Controls will be within an appropriate reach of steering wheel for an average size person
7. Hydraulics will be designed to be able to be use with tractors engine HP/Torque
8. Loader will operate when drive line is engaged

Durability / Reliability (10%):

8. Will be able to pick up rocks and other heavy abrasives (*up to the load capacity*) during testing period
9. Utilize reliable components/material determined by safety/service factors and for particular application requirements
10. All hardware used will be *Grade 2* and higher
11. All hoses, hard lines and fittings will be commercial grade
12. Fittings will not leak during test period
13. Loader *(as a whole)* will preformed intended functions during the test period *(Note: tractors durability/reliability will not be a determining factor of loaders durability/reliability)*
14. Also, See "*Ease of Maintenance*" No. 1-5

Stay within limits of tractor used (10%):

6. Lift capacity (*load units in lbs.*) at max height and reach may be 30% less than total lift capacity (*limits TBD*)
7. Hydraulic components and sizes of them, will be assigned, dependent on space available within tractor
8. Bucket load and loader lift capacity may change dependent No. 1-2 above

9. Tractor movement with bucket load, dependent on ability of unmodified tractor
10. Snow removal dependent on ability of unmodified tractor
11. Also, See "*Bucket Capacity*" Note No. 1

Safety (9%):

9. Lift arm controls will not be operable when operator is not seated on tractors seat (*Note: Bucket may lower due to gravity/normal valve fluid bypass and leakage as well as when lowering action is activated)*
10. Bucket capacity will be sized so that at full load tractor will not tip
11. Loader drive system will not operate if its' operator leaves tractor seat
12. Hydraulic fluid temperature can be monitored with a gauge
13. Hydraulic fluid filter/screen will be used in system
14. Loader arm kickstand will provide rollover resistance on flat ground
15. Components that rotate/move, have driven belt, have pinch points, that are hot to touch and/or that have potential to injure the operator or other persons will have appropriate guards and/or caution labels/placards attached *(Note: any item that is mentioned above (Safety No. 7) that is in an open area but, within the frame/chassis will not be required to have a guard and/or caution label/placard)*
16. Also, See "*Stay within limits of tractor used" feature below*

Bucket/Plow Capacity (8%):

3. Goal: four-five (4-5) cubic feet for soil (Capacity created by average soil weight from dry to wet (i.e. 100lb avg. per cu/ft)) *Note: this is dependent on tractors abilities (i.e. tipping factor and load capacity). Otherwise bucket capacity will be adjusted appropriately.*
4. Snow plow will be 10-14" tall and 38-42" wide

Ease of Maintenance (8%):

8. All steel components will be painted or powder coated
9. Hardware will be Stainless and/or galvanized and/or painted or pre-coated with an anti-corrosion
10. Sealed bearing will be use were applicably
11. Fluid filter/screen
    a. A person with average hand size and arm length will be able to access it
    b. Uses of standard tools may be required
12. Grease fittings (applied to system where appropriate)
    a. A person with average hand size and arm length will be able to access them
    b. Uses of standard tools may be required
13. Snow plow will have a removal-able bottom scraper blade
14. Also, See "*Ease of Storage*" No. 3

Compatibility with current tractor models (8%):

2. To be designed for Craftsman/Husqvarna series lawn tractor (similar but, not limited to, item *Craftsman Model #07128857000, Mfr. model #28857*)

Speed of Operation (7%):

3. Raise time unloaded ≤ 6sec
4. Lowering time ≤ 6sec

Ease of Storage (7%):

5. Attachments detach from lifting arms if needed for storage purposes
6. Loader arm has ability to detach from tractor
7. Loader arm has kickstand so that it does not roll/fall over after it is detached from tractor (*on flat, solid ground*)
8. Hydraulic hoses have quick disconnect fittings (*where deemed appropriate by design*)

Overall Cost (7%)

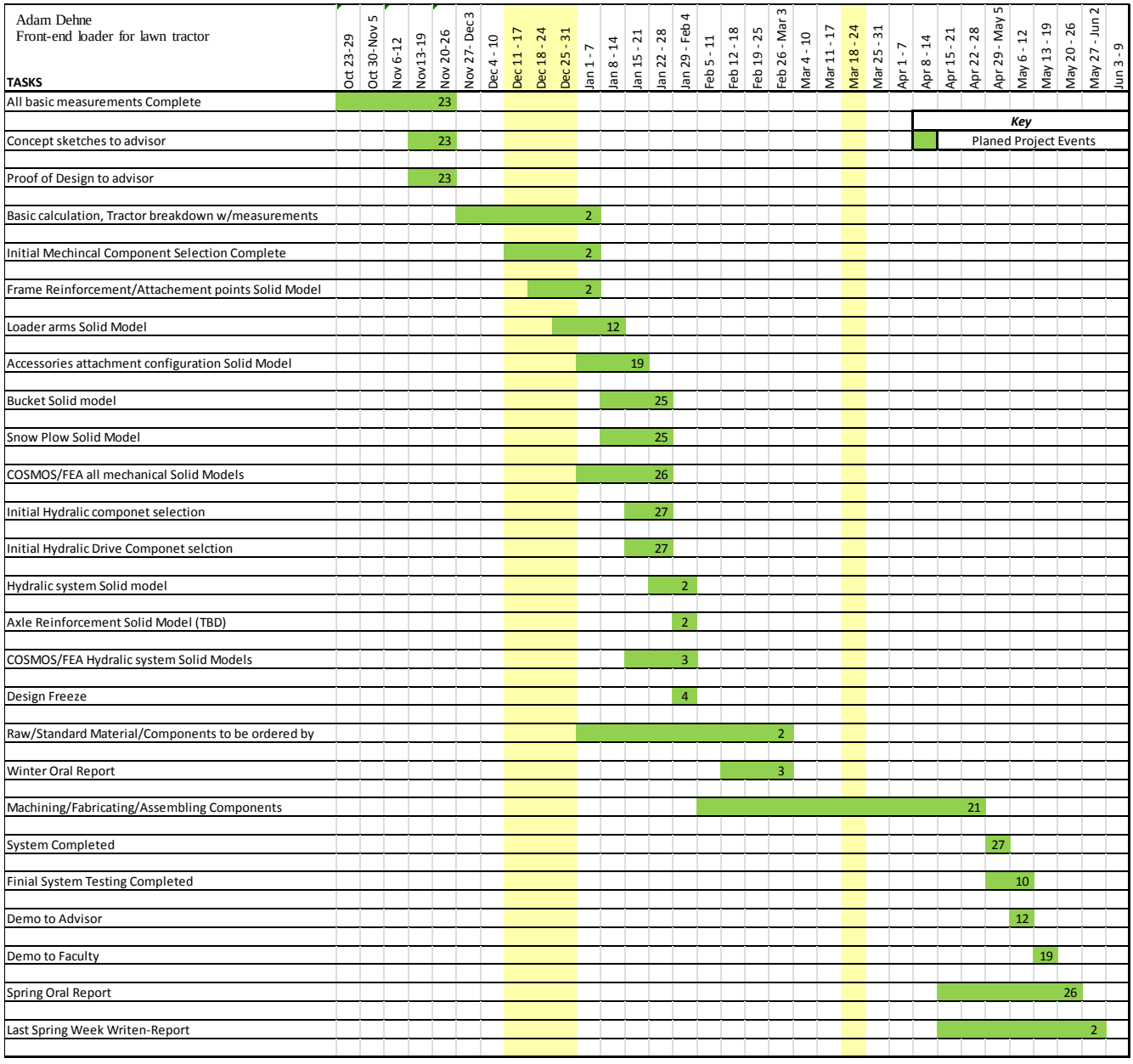
2. Select components while keeping in mind its cost in relation to others

Operation Temperature (6%):

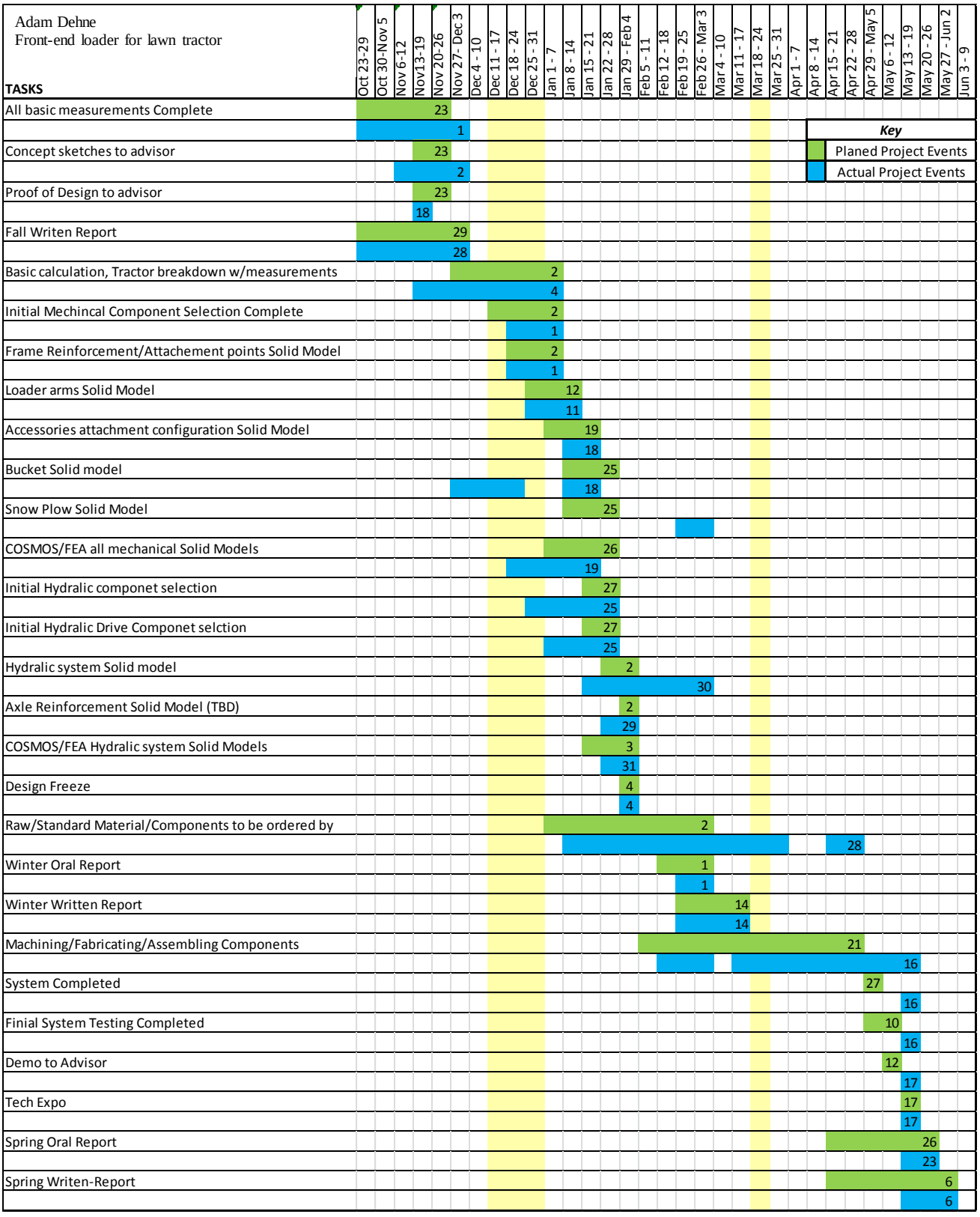
4. Fluid temperature to stay under manufactures recommendation

APPENDIX E – SCHEDULE

PROPOSED SCHEDULE

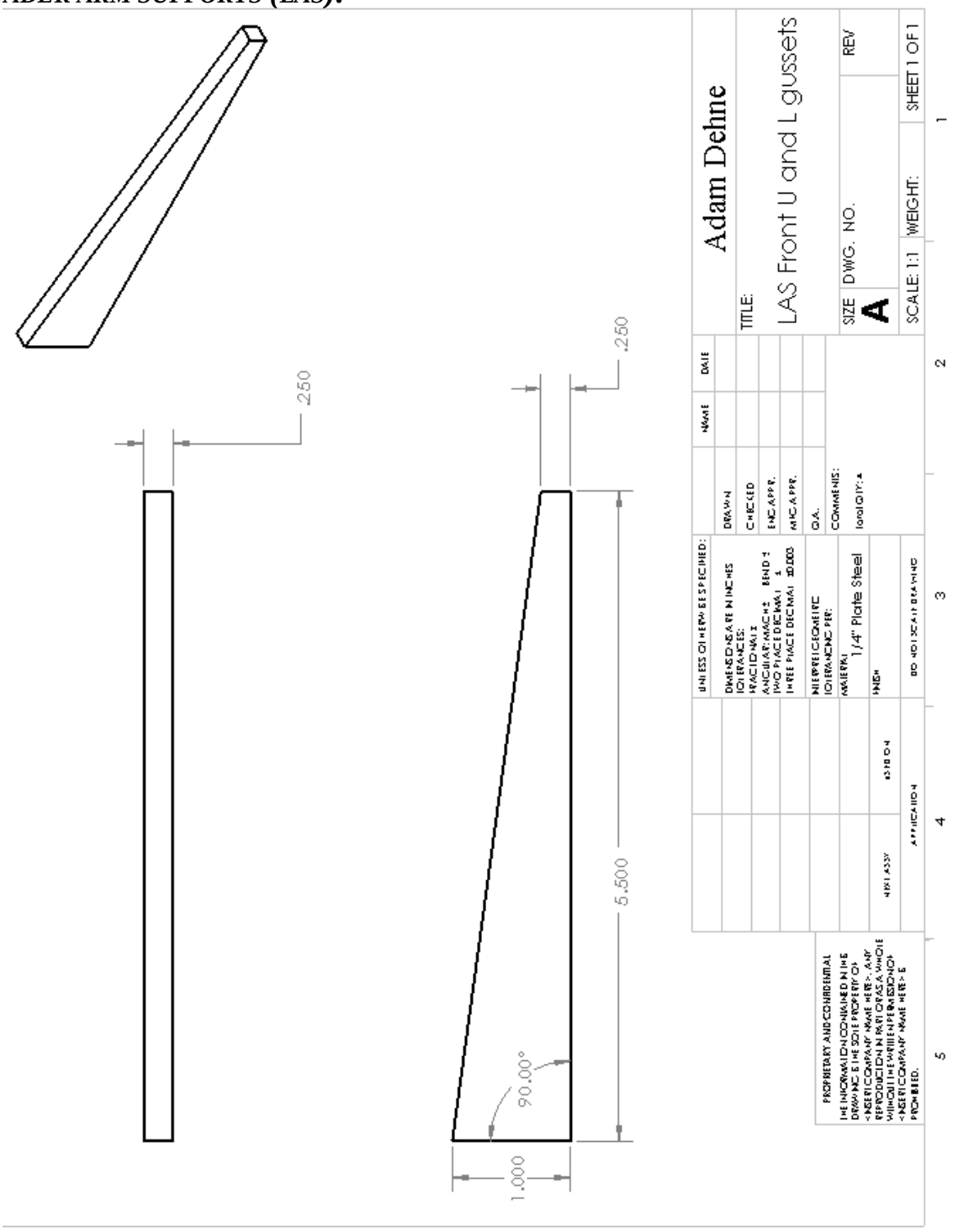


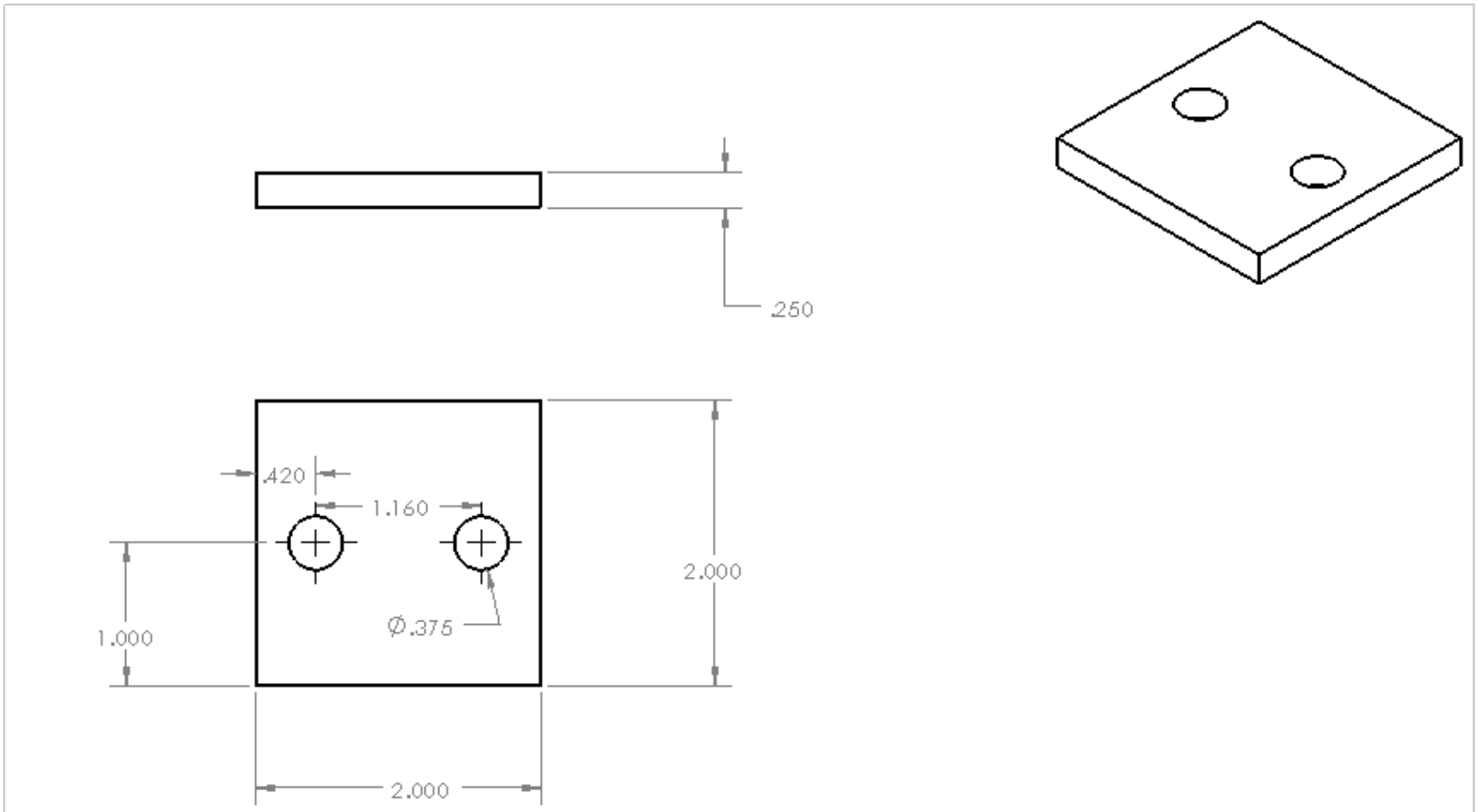
ACTUAL SCHEDULE



APPENDIX F – DIMENSIONAL DRAWINGS

LOADER ARM SUPPORTS (LAS):





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		NEXT PRECEDENCE TOLERANCING PER:	COMMENTS: Total QTY: 2		
		MATERIAL 1/4" Plate Steel			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

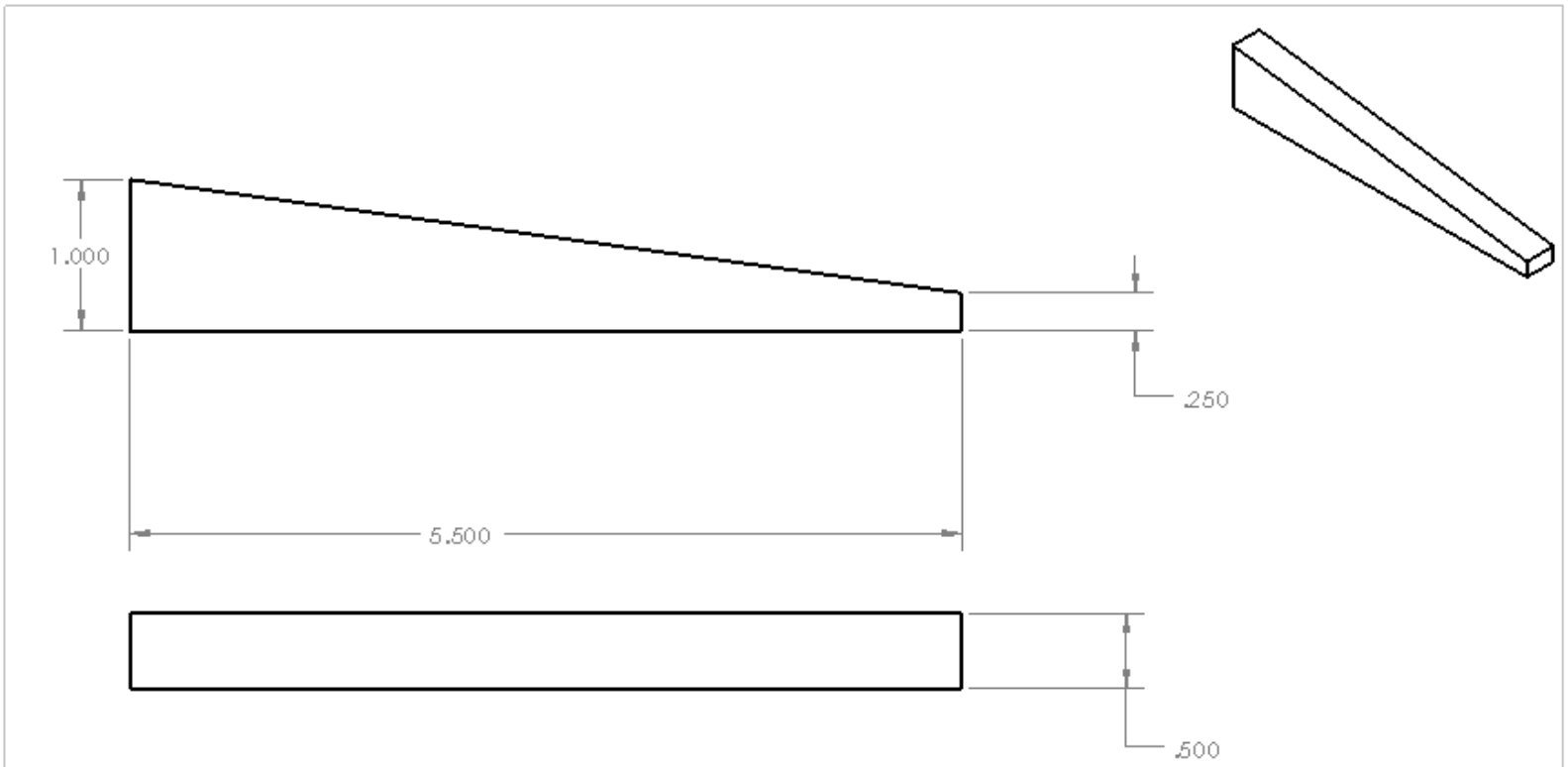
TITLE:

LAS Main Web Attachment Plate to frame

SIZE	DWG. NO.	REV
A		

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: LAS 0.5 thick Back U and L gussets	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 1/2" Plate Stock	COMMENTS: Total QTY: 4			SIZE A	DWG. NO. REV
FINISH				SCALE: 1:1	WEIGHT: SHEET 1 OF 1
NEXT ASSY / USED ON					
APPLICATION	DO NOT SCALE DRAWING				

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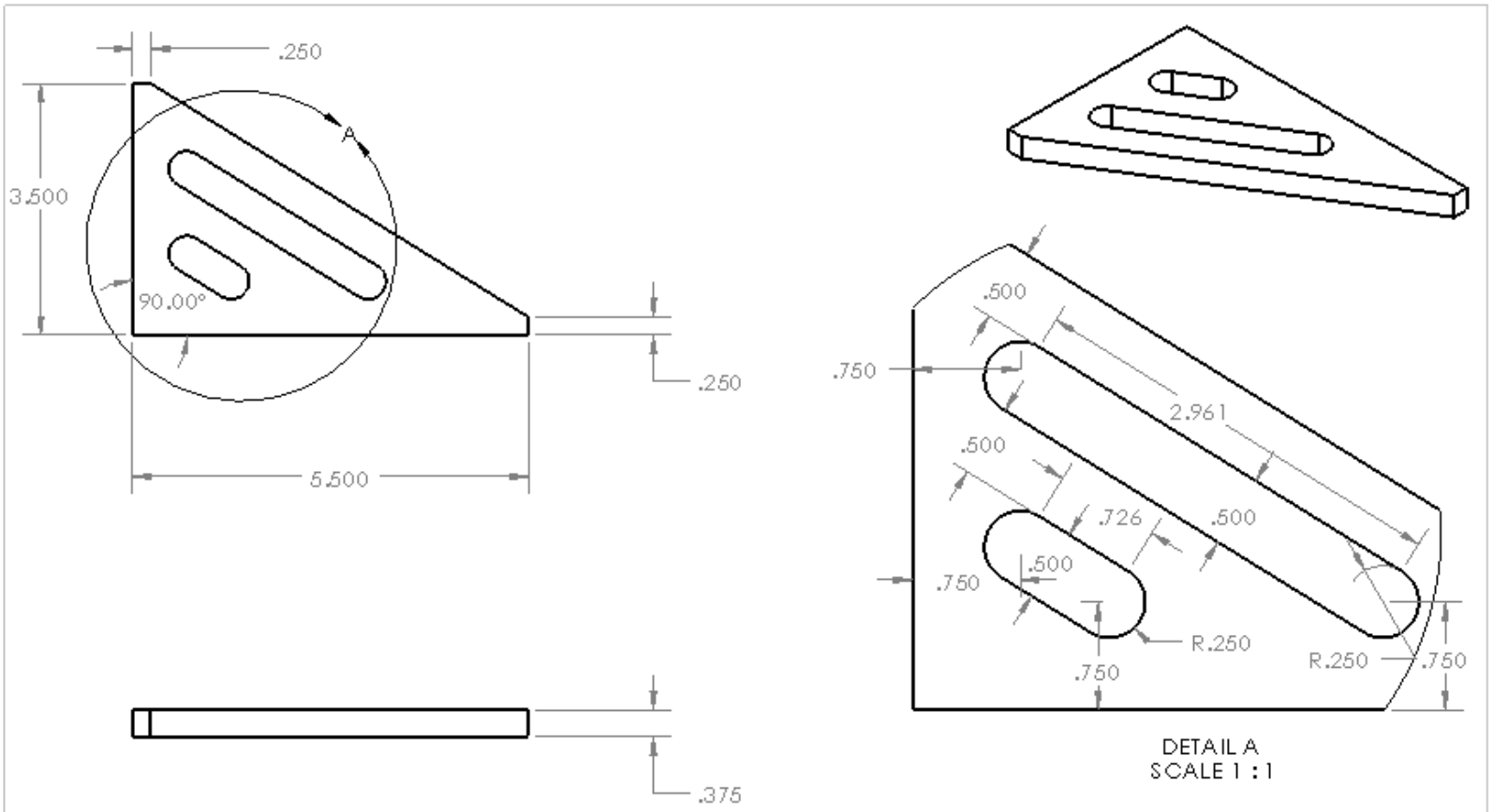
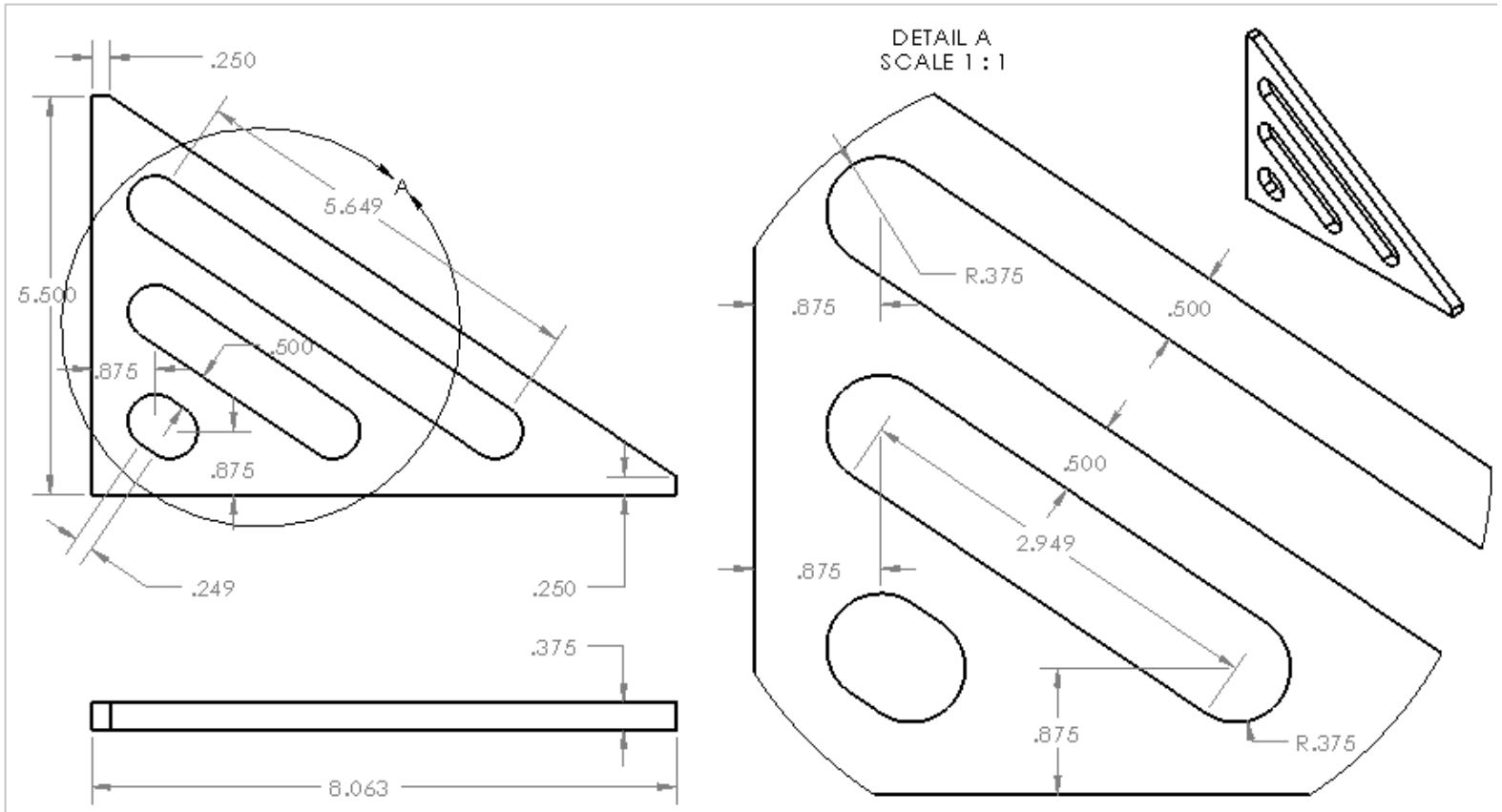
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: 0.375 horz gussets	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 3/8" Plate Steel	COMMENTS: Total Qty: 4			SIZE A	DWG. NO. REV
FINISH				SCALE: 1:2	WEIGHT: SHEET 1 OF 1
NEXT ASSY	USED ON				
APPLICATION	DO NOT SCALE DRAWING				

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±.0005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS: Total QTY: 2		
		MATERIAL 3/8" Plate Steel			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

TITLE:

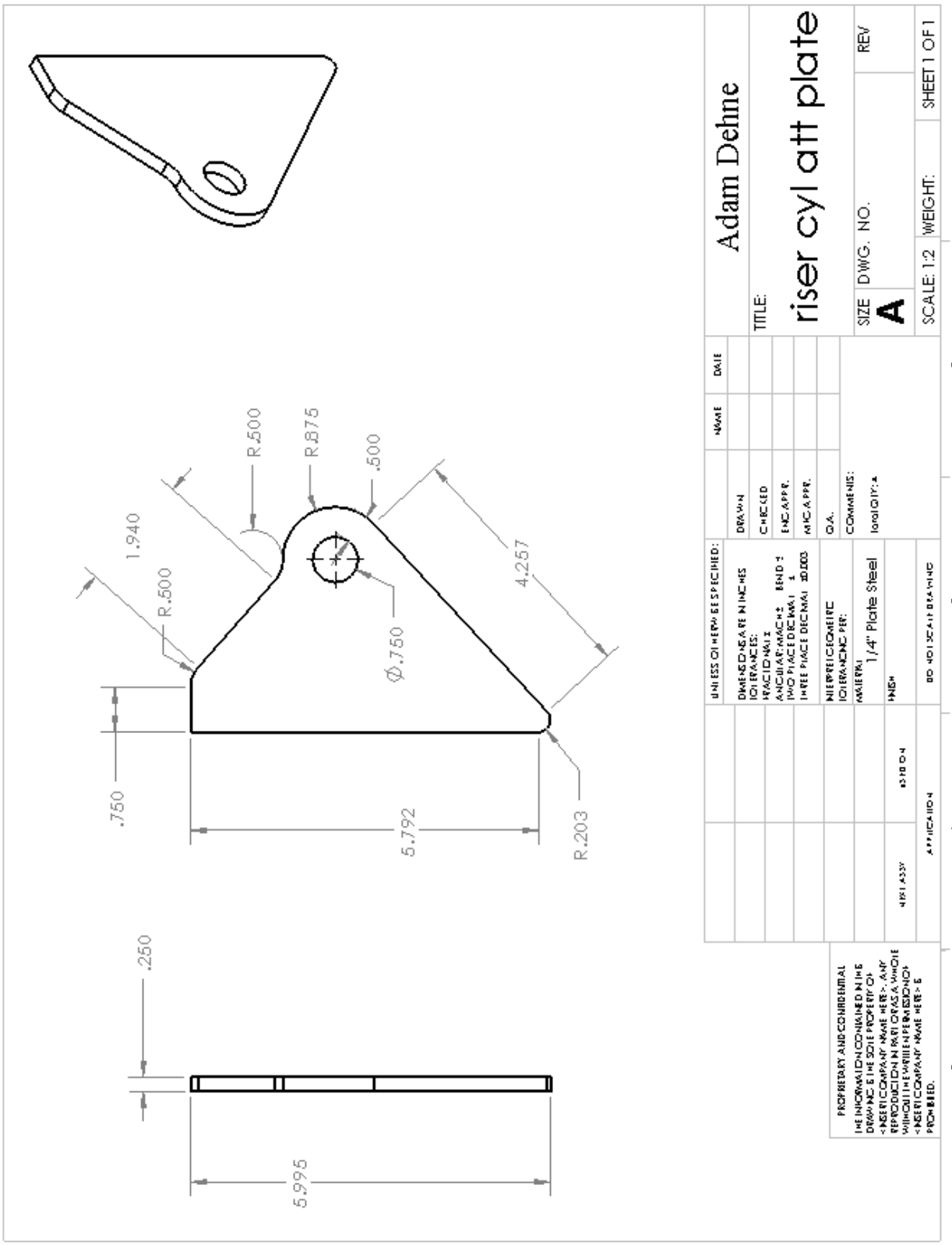
Main Web for loader support to frame

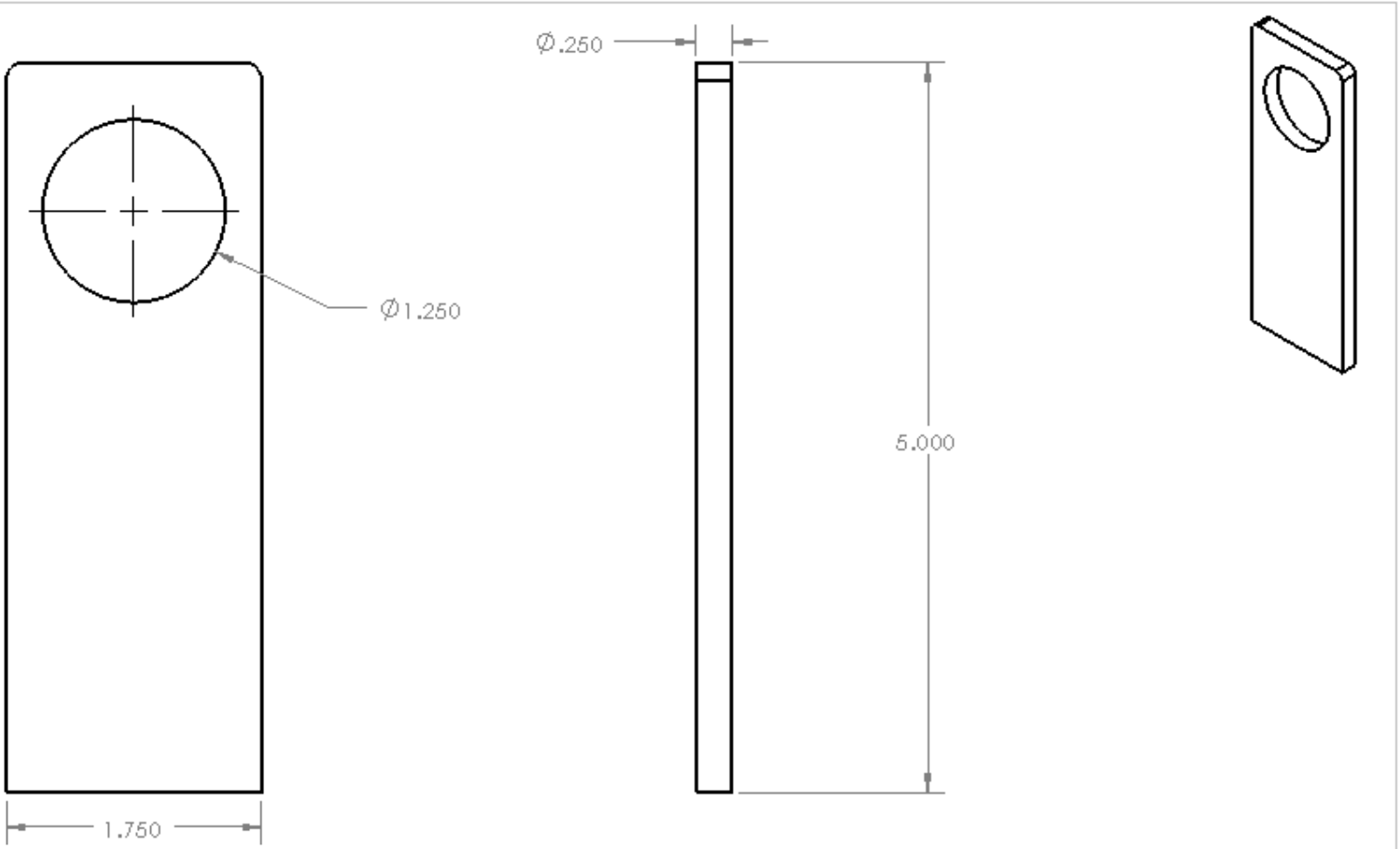
SIZE	DWG. NO.	REV
A		

SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

RISER:


R.500
R.875
.500
1.940
R.500
Ø.750
4.257
.750
5.792
R.203
.250
5.995
Adam Dehne
TITLE:
riser cyl att plate
SIZE
A
DWG. NO.
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
1/4" Plate Steel
PROPRIETARY AND CONFIDENTIAL



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS: Total QTY: 4		
		MATERIAL 1/4" Plate Steel			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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Adam Dehne

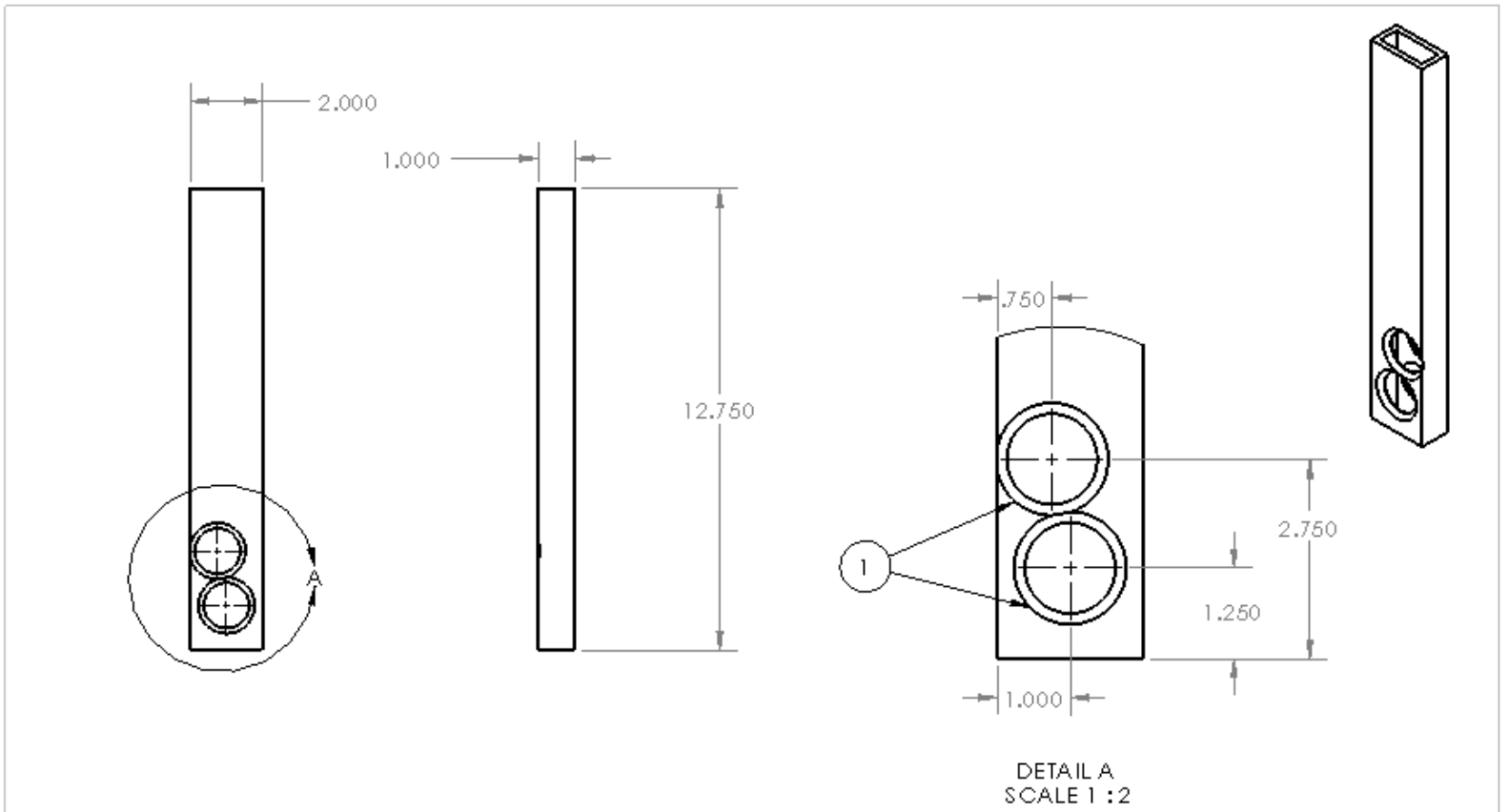
TITLE:

riser pin plate for loader arms

SIZE	DWG. NO.	REV
A		

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL 1x2x0.188 Reg Tube	COMMENTS: Total QTY: 2		
NEXT ASSY	USED ON	FINISH	Balloon Note No. 1: Counter Sink or ASDeg		
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

TITLE:

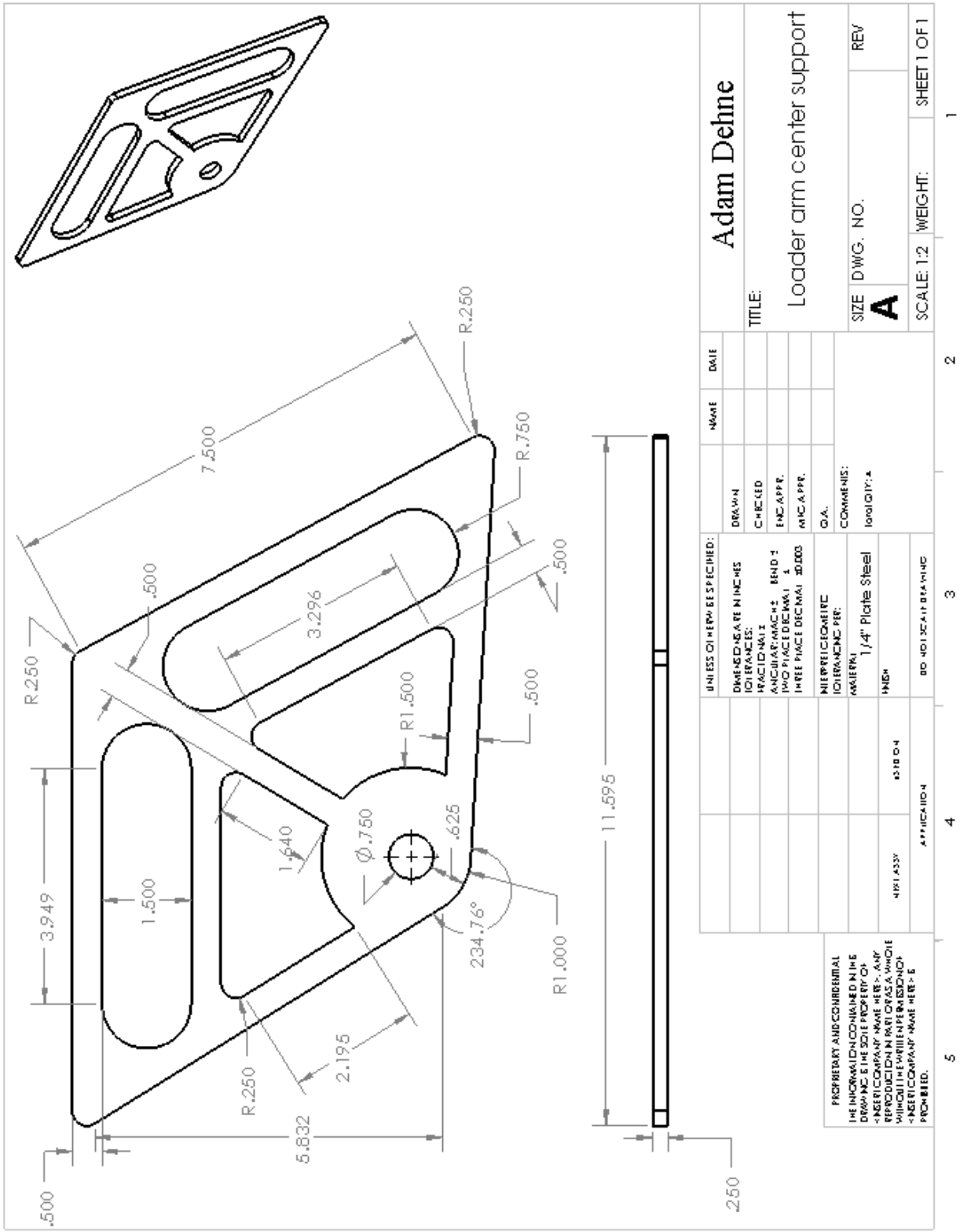
riser 0.188

SIZE	DWG. NO.	REV
A		

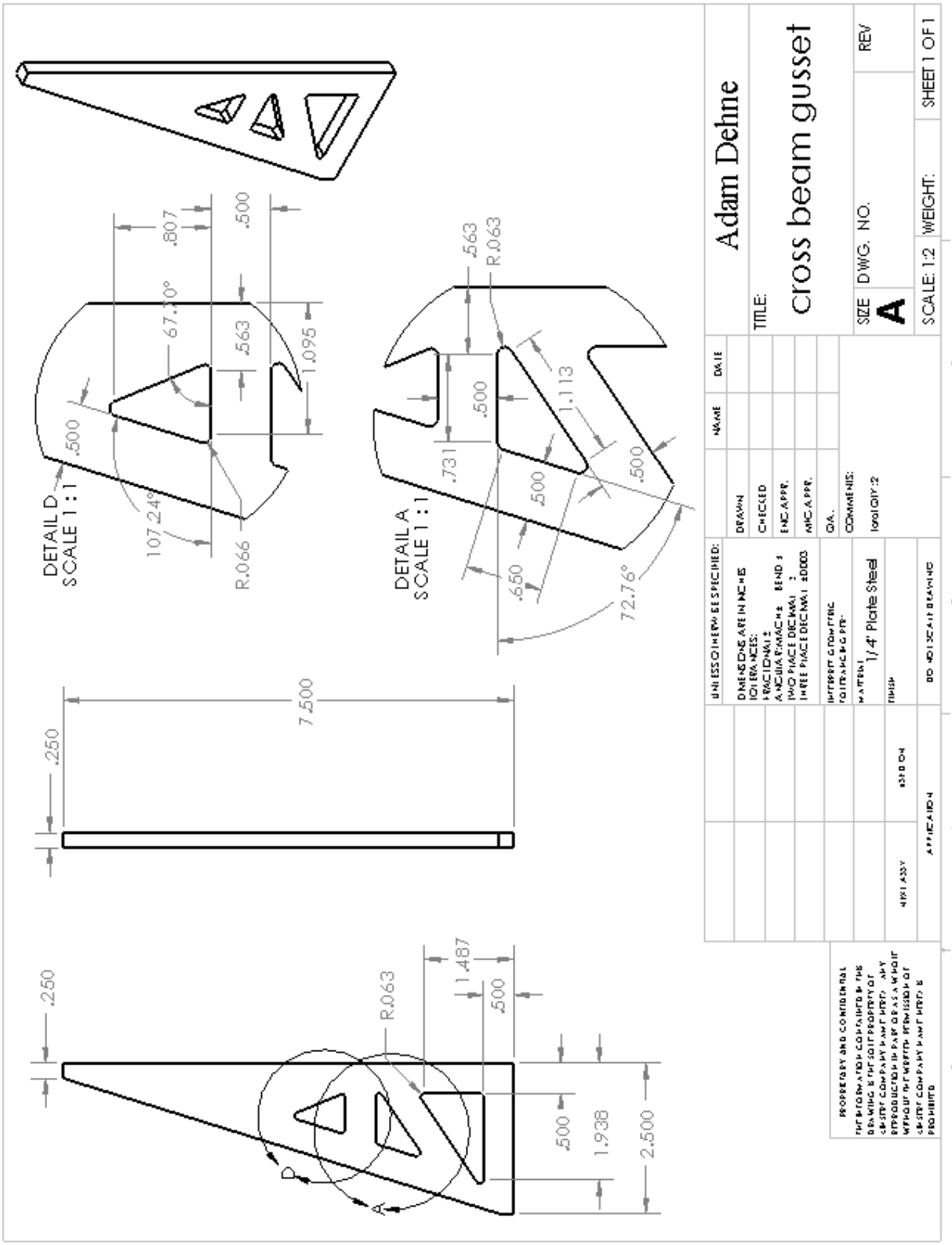
SCALE: 1:4	WEIGHT:	SHEET 1 OF 1

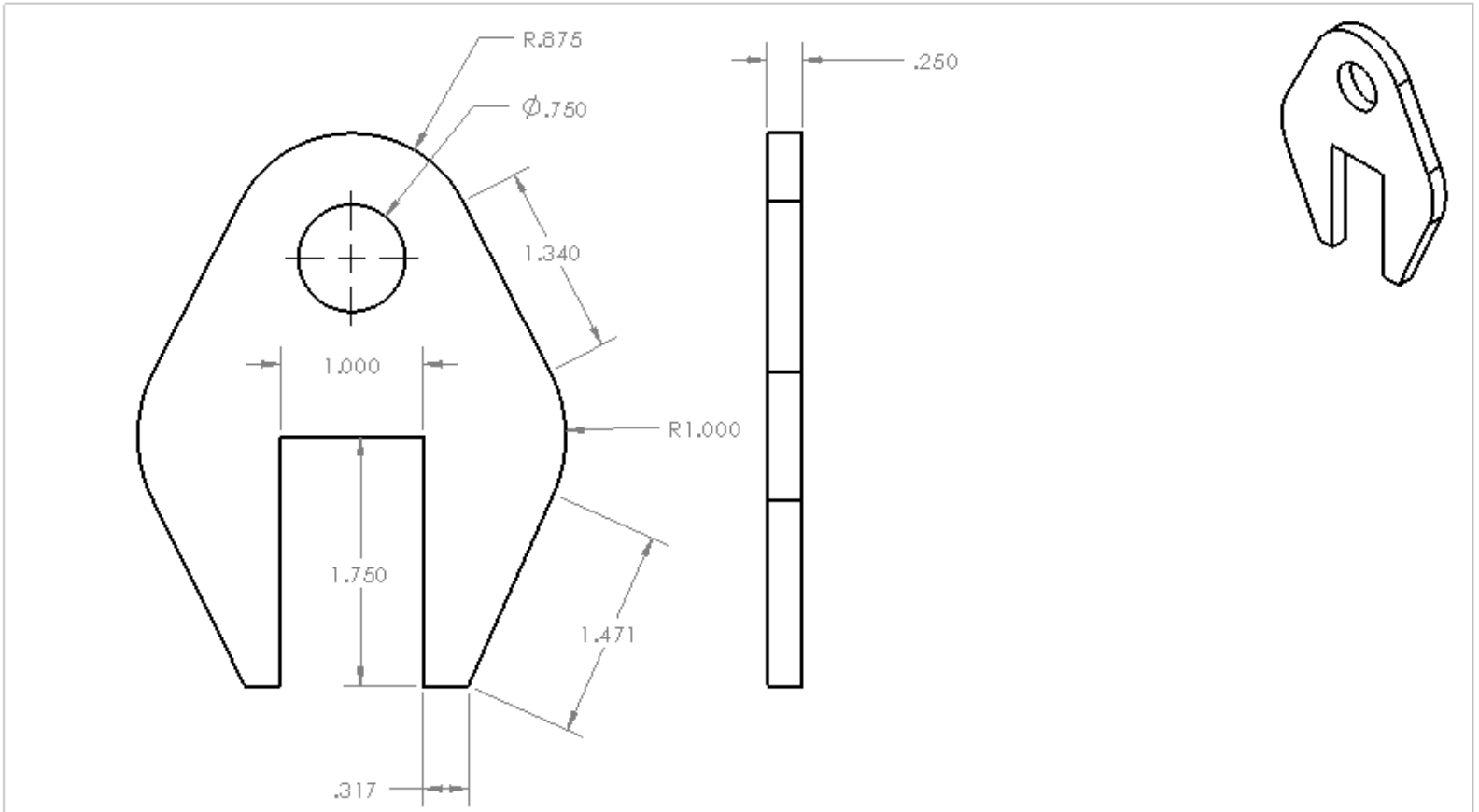
5 4 3 2 1

LOADER ARMS:


Adam Dehne
Loader arm center support
TITLE:
SIZE A
DWG. NO.
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
1/4" Plate Steel
7.500
3.296
3.949
1.500
1.640
Ø.750
.625
R1.500
R1.000
11.595
5.832
2.195
234.76°
R.250
R.750
.500
.250

CROSS BEAM:

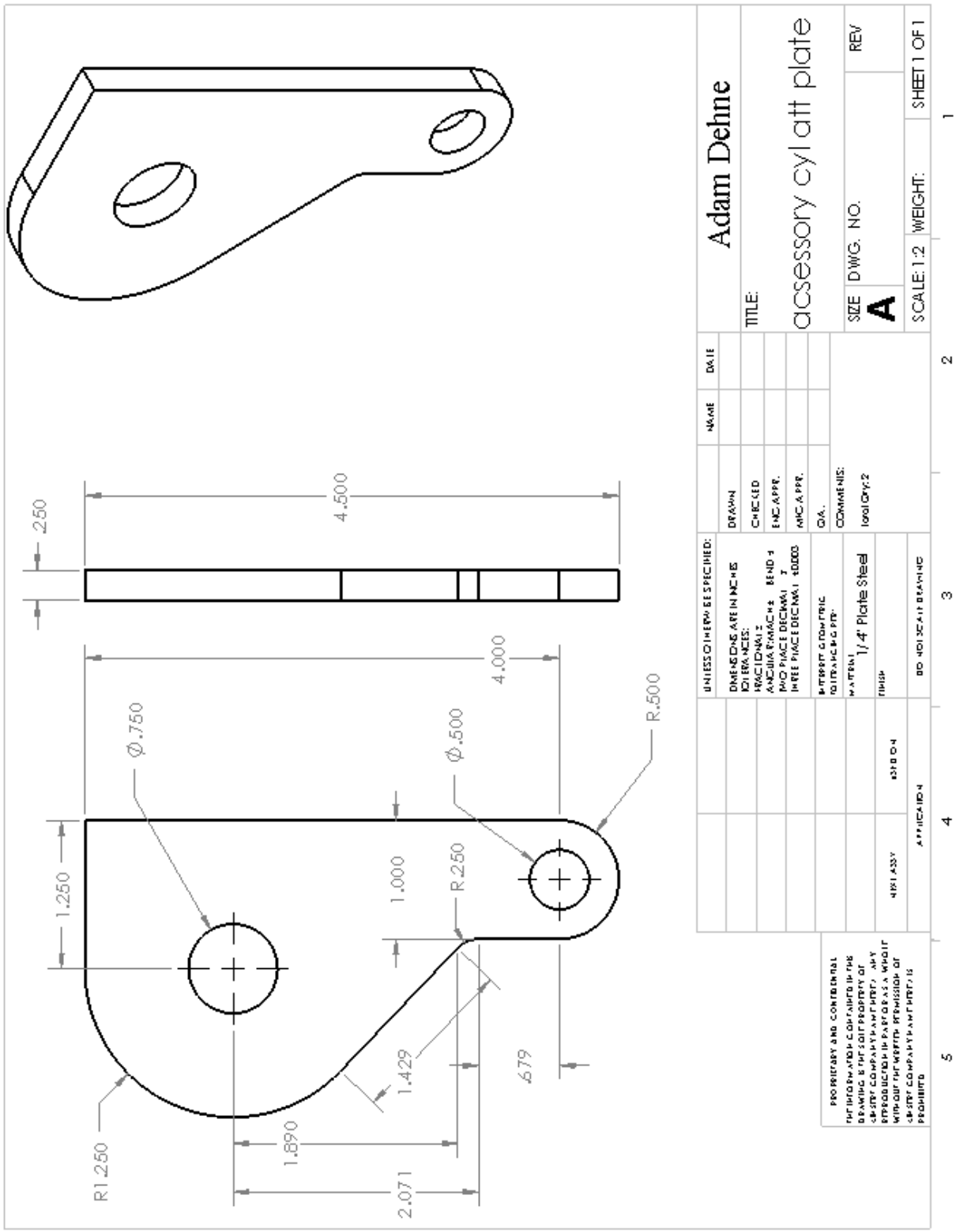

DETAIL D
SCALE 1 : 1
DETAIL A
SCALE 1 : 1
.250
7.500
.500
1.487
1.938
2.500
R.063
R.066
.563
1.095
.807
67.10°
107.24°
.731
1.113
72.76°
Adam Dehne
cross beam gusset
1/4" Plate Steel
SIZE A
SCALE: 1:2
SHEET 1 OF 1



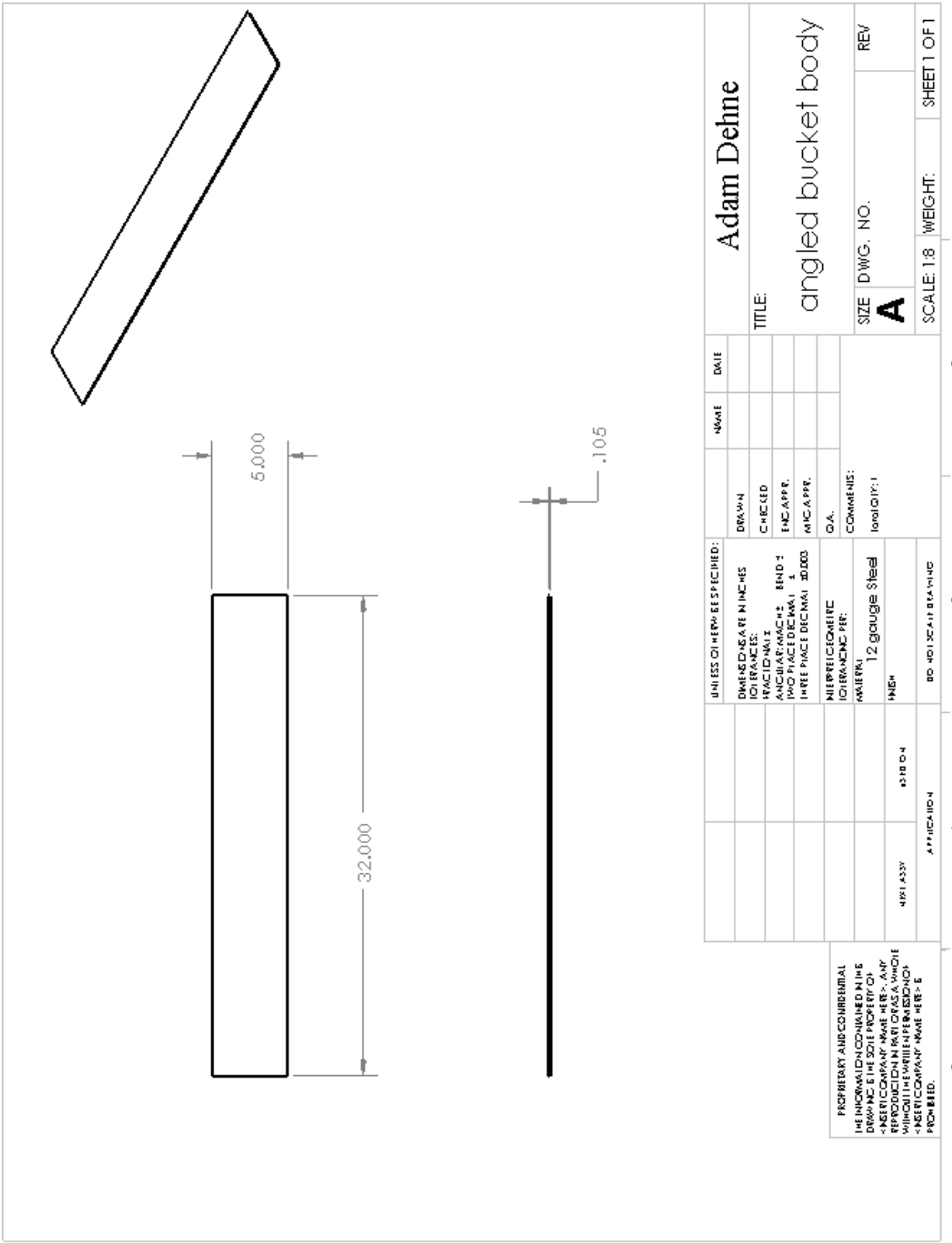
UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: cross beam cyl att plate	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 1/4" Plate Steel	COMMENTS: Total QTY: 2			SIZE A	DWG. NO. REV
FINISH				SCALE: 1:1	WEIGHT: SHEET 1 OF 1
NEXT ASSY / USED ON					
APPLICATION / DO NOT SCALE DRAWING					

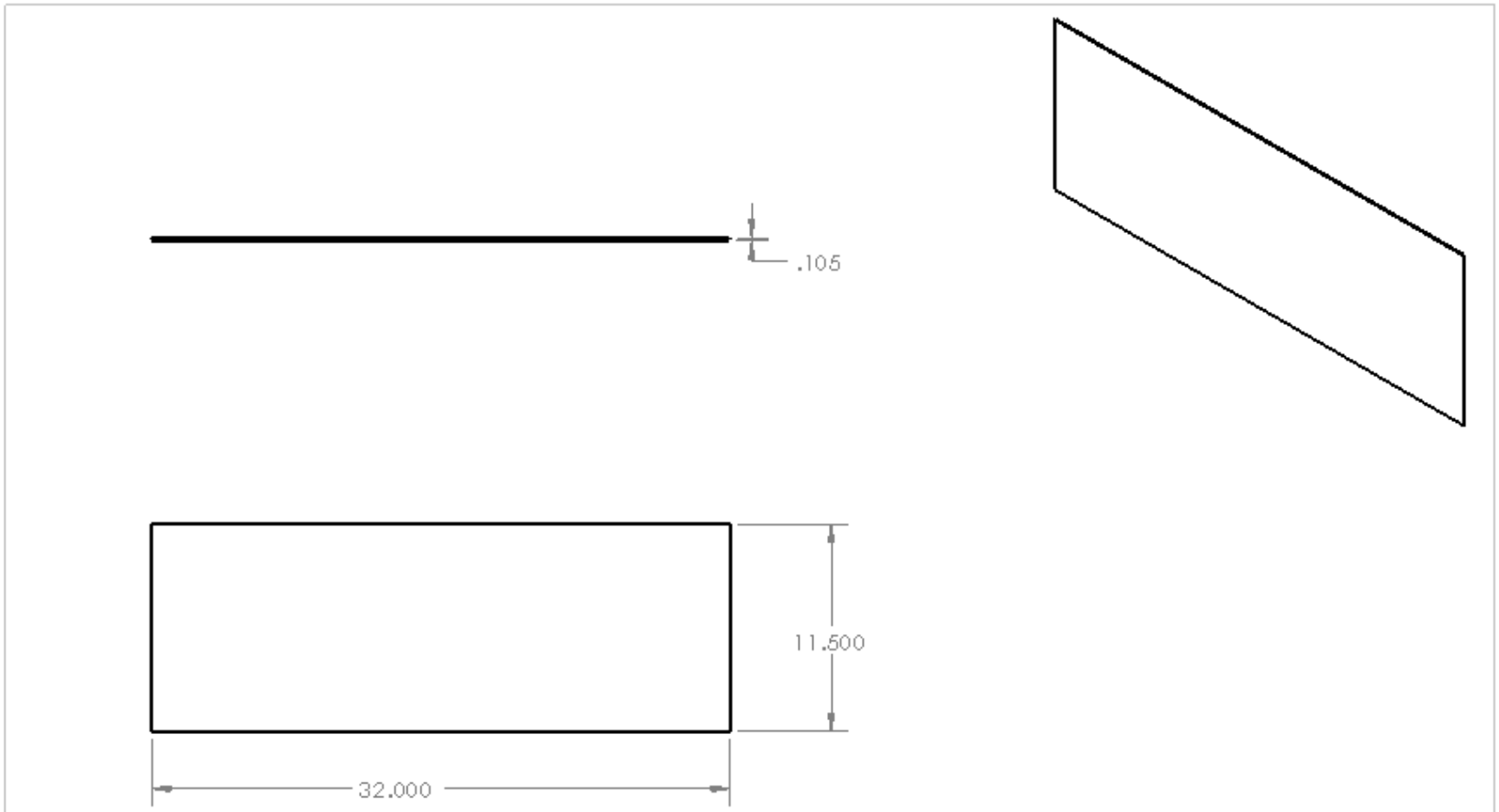
5 4 3 2 1

ACCESSORY MOUNT:



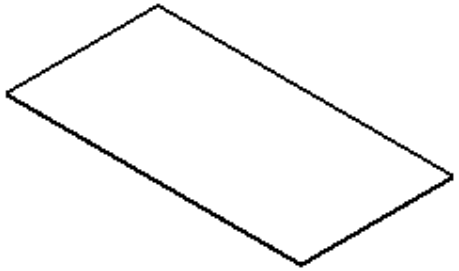
BUCKET:

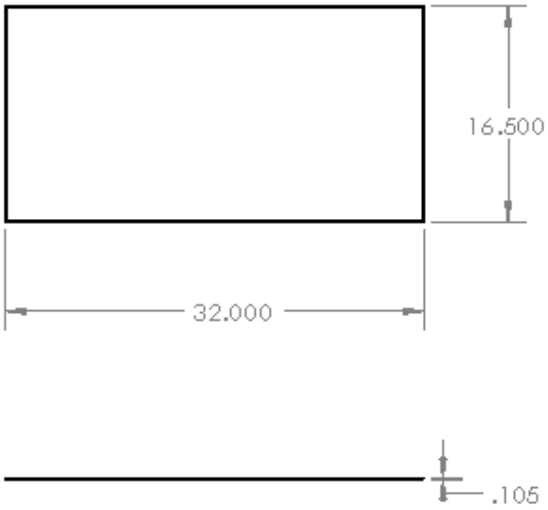

5.000
32.000
.105
Adam Dehne
angled bucket body
TITLE:
SIZE
A
DWG. NO.
REV
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
12 gauge Steel
UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
PROPRIETARY AND CONFIDENTIAL



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: bucket back body	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 12 gauge Steel	COMMENTS:			SIZE A	DWG. NO. REV
FINISH	Total QTY: 1				
NEXT ASSY / USED ON				SCALE: 1:8	WEIGHT: SHEET 1 OF 1
APPLICATION / DO NOT SCALE DRAWING					

5 4 3 2 1





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS: Total QTY: 1		
		MATERIAL 12 gauge steel			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

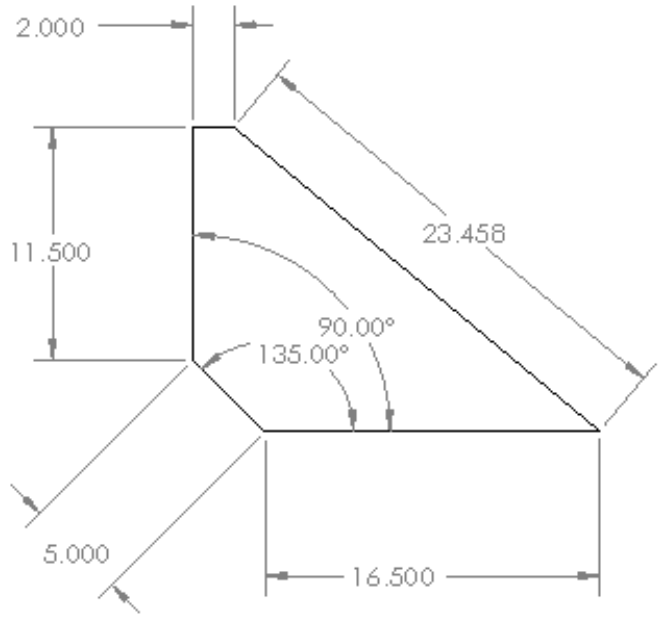
TITLE:

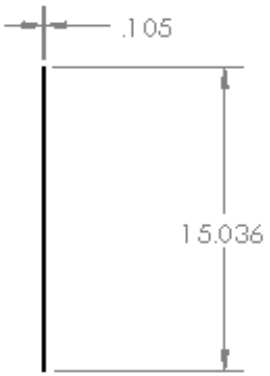
bucket bottom sheet

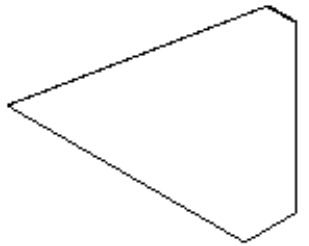
SIZE	DWG. NO.	REV
A		

SCALE: 1:12	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1







		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL 12 gauge steel	COMMENTS: Total QTY:2		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dene

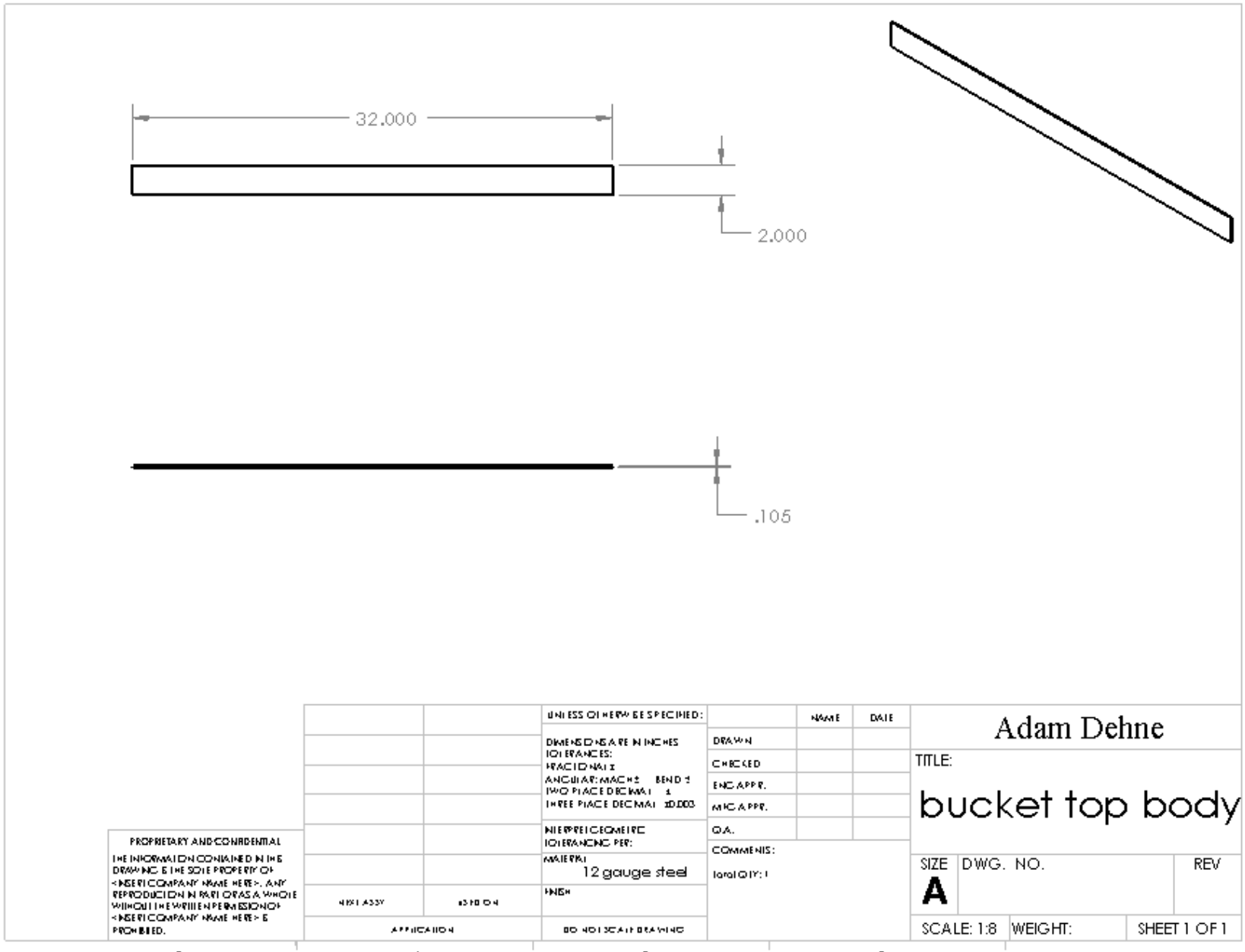
TITLE:

bucket side body

SIZE	DWG. NO.	REV
A		

SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1


32.000
2.000
.105
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±0.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
12 gauge steel
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Total QTY: 1
Adam Dehne
TITLE:
bucket top body
SIZE
A
DWG. NO.
REV
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
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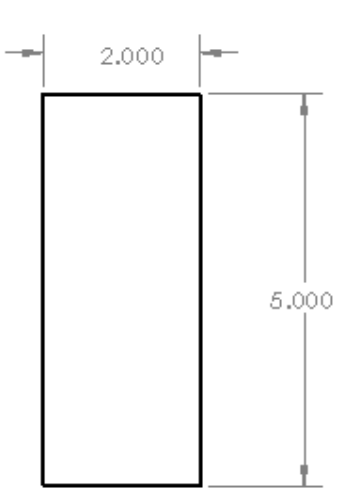
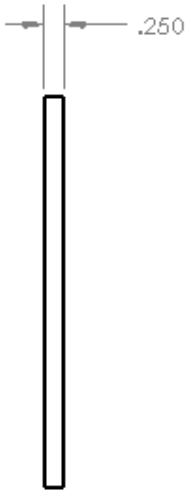
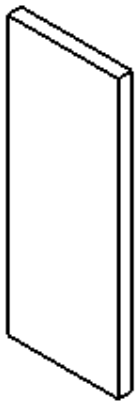
NEXT ASSY
USED ON
APPLICATION
5
4
3
2
1

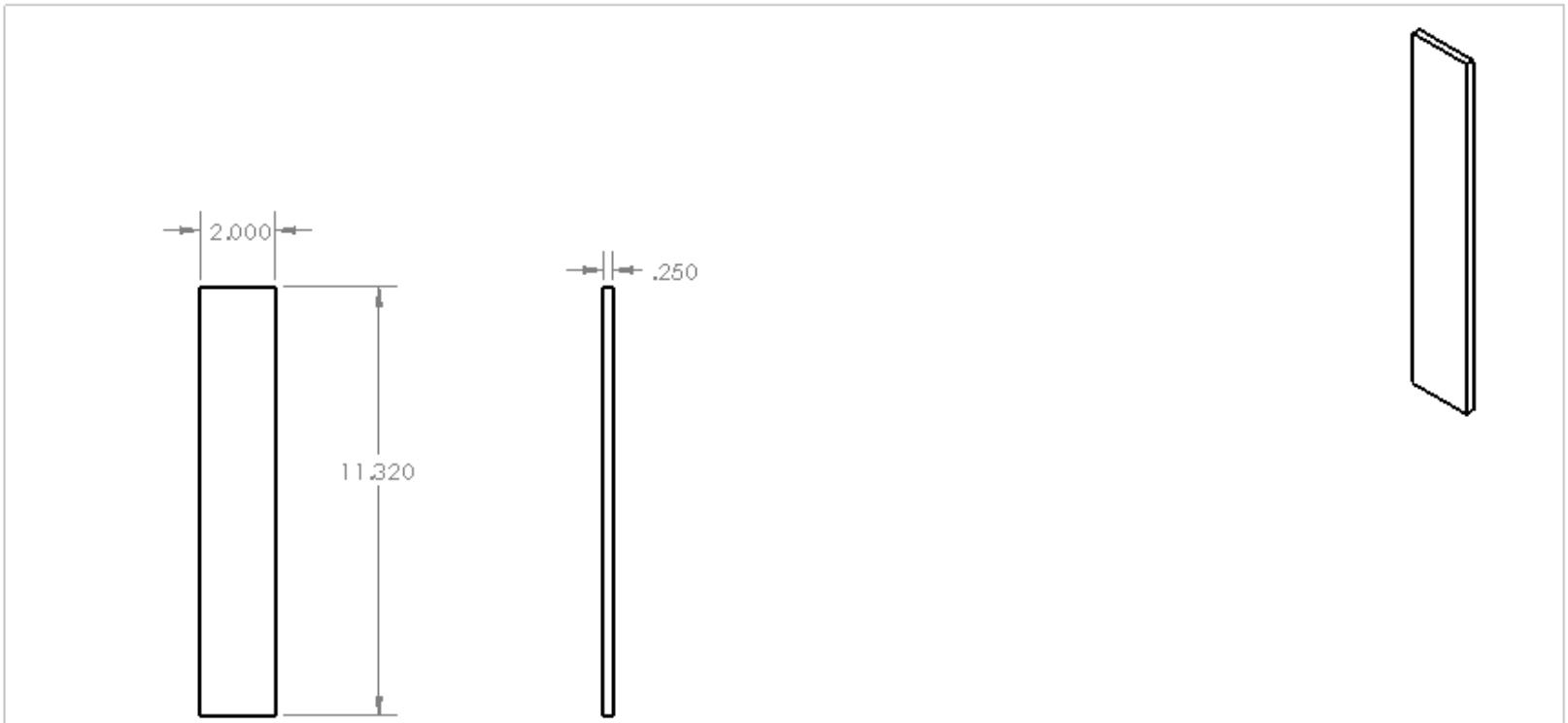






UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: bucket angled brace	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 1/4" Plate Steel	COMMENTS: Total QTY: 2			SIZE A	DWG. NO. REV
FINISH				SCALE: 1:2	WEIGHT: SHEET 1 OF 1
NEXT ASSY / USED ON					
APPLICATION	DO NOT SCALE DRAWING				

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		NEXT ASSY	COMMENTS: Total QTY: 2		
		APPLICATION	DO NOT SCALE DRAWING		

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INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: 1/4" Plate Steel

FINISH

Adam Dehne

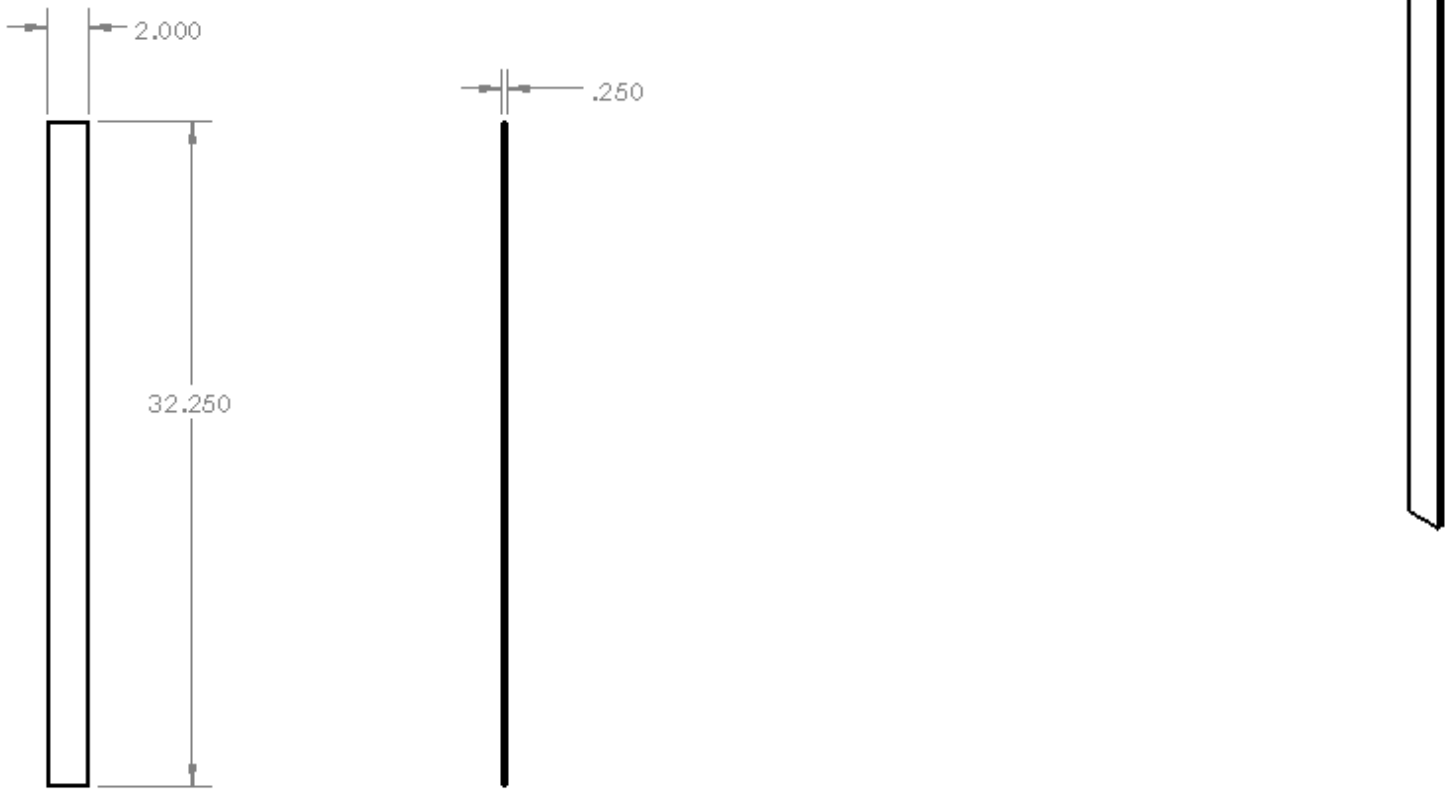
TITLE:

bucket hook and pin tube brace

SIZE	DWG. NO.	REV
A		

SCALE: 1:4	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		NEXT ASSY	Q.A.		
		MATERIAL 1/4" Plate Steel	COMMENTS: Total QTY: 1		
		FINISH			
USED ON					
APPLICATION		DO NOT SCALE DRAWING			

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Adam Dehne

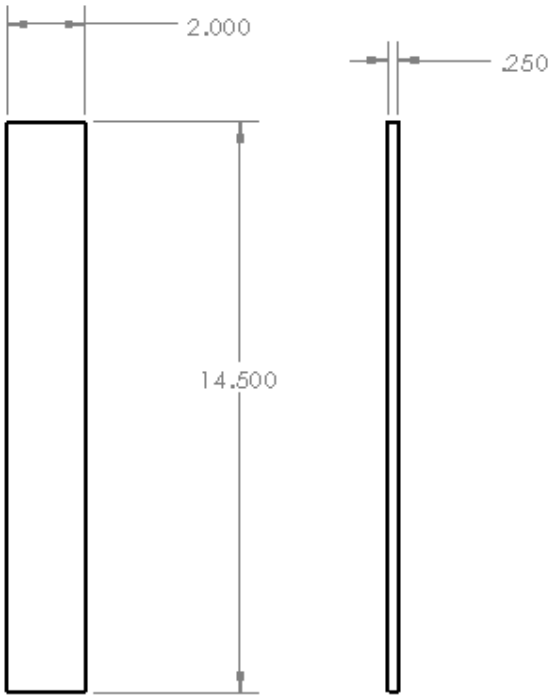
TITLE:

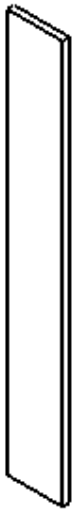
bucket toe support brace

SIZE	DWG. NO.	REV
A		

SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

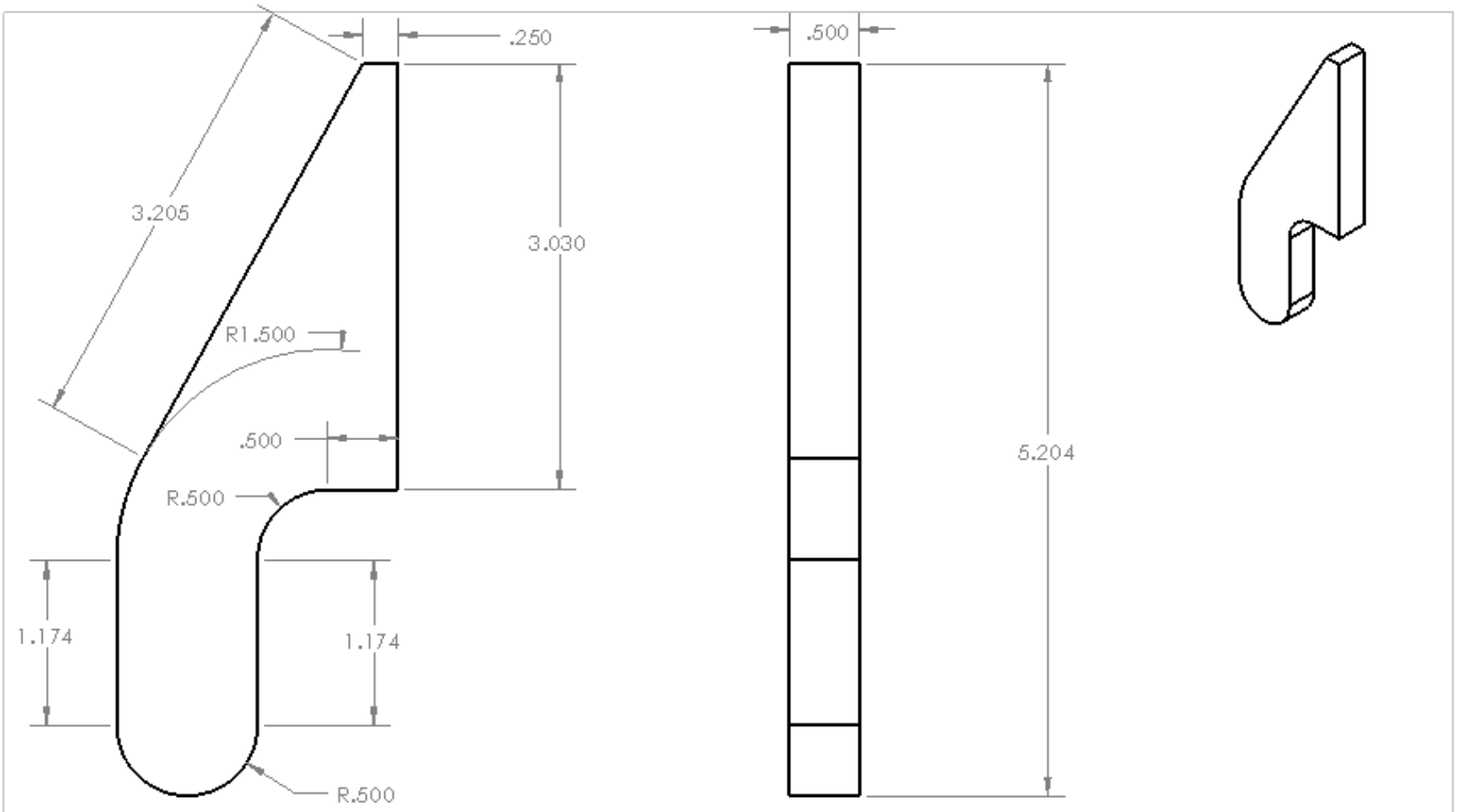




		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:		
		MATERIAL 1/4" Plate Steel	Total QTY: 2		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne			
TITLE: bucket under support brace			
SIZE A	DWG. NO.		REV
SCALE: 1:4	WEIGHT:	SHEET 1 OF 1	

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:		
		MATERIAL 1/2" Plate Steel	Total QTY: 2		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

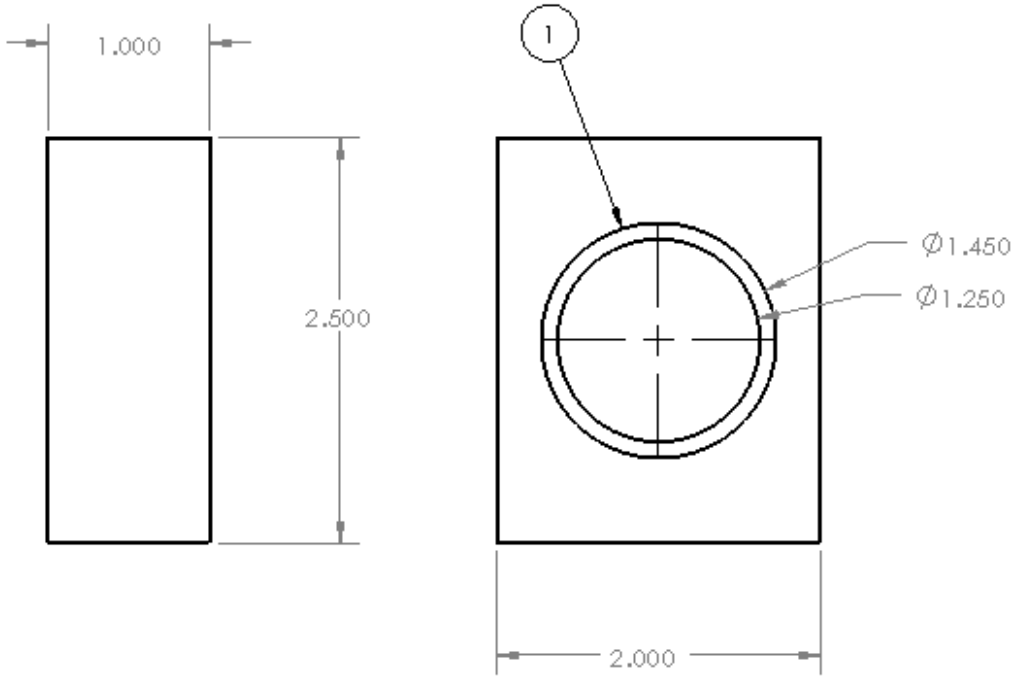
TITLE

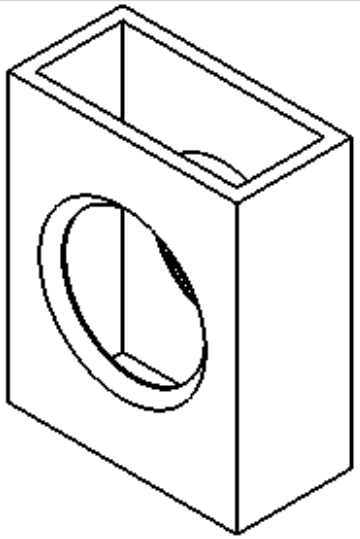
bucket 0.5 hook

SIZE	DWG. NO.	REV
A		

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: bucket pin req tube	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
NEXT ASSY	USED ON	Q.A.		SIZE A	DWG. NO. REV
APPLICATION	DO NOT SCALE DRAWING	COMMENTS: Total QTY: 2 Balloon No. 1: Counter sink 45 Deg		SCALE: 1:1	WEIGHT: SHEET 1 OF 1
MATERIAL: 1x2x0.120 Rec Tube FINISH					

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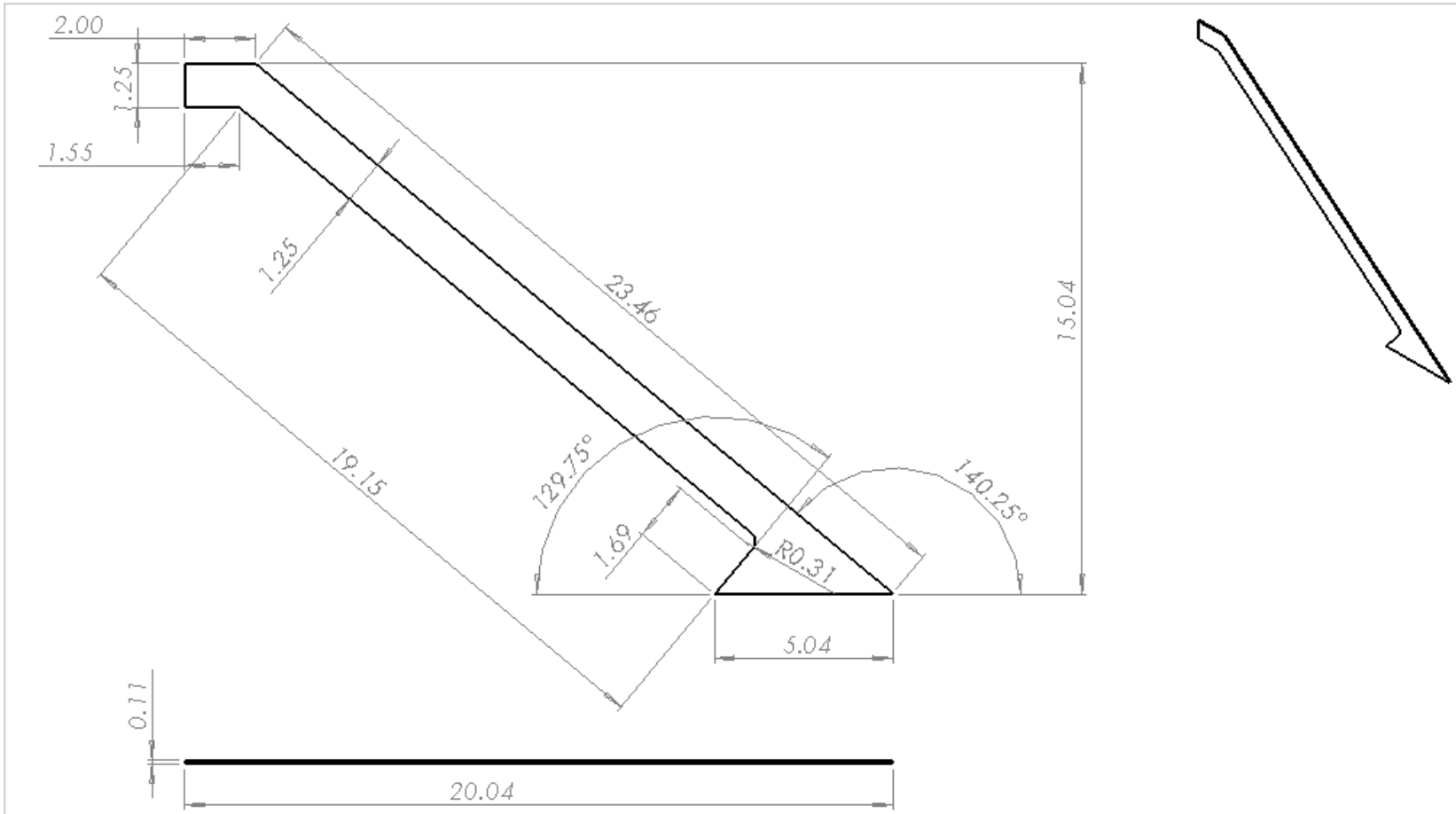
5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.003	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL 1/4" Steel Plate	COMMENTS: Total QTY: 2		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

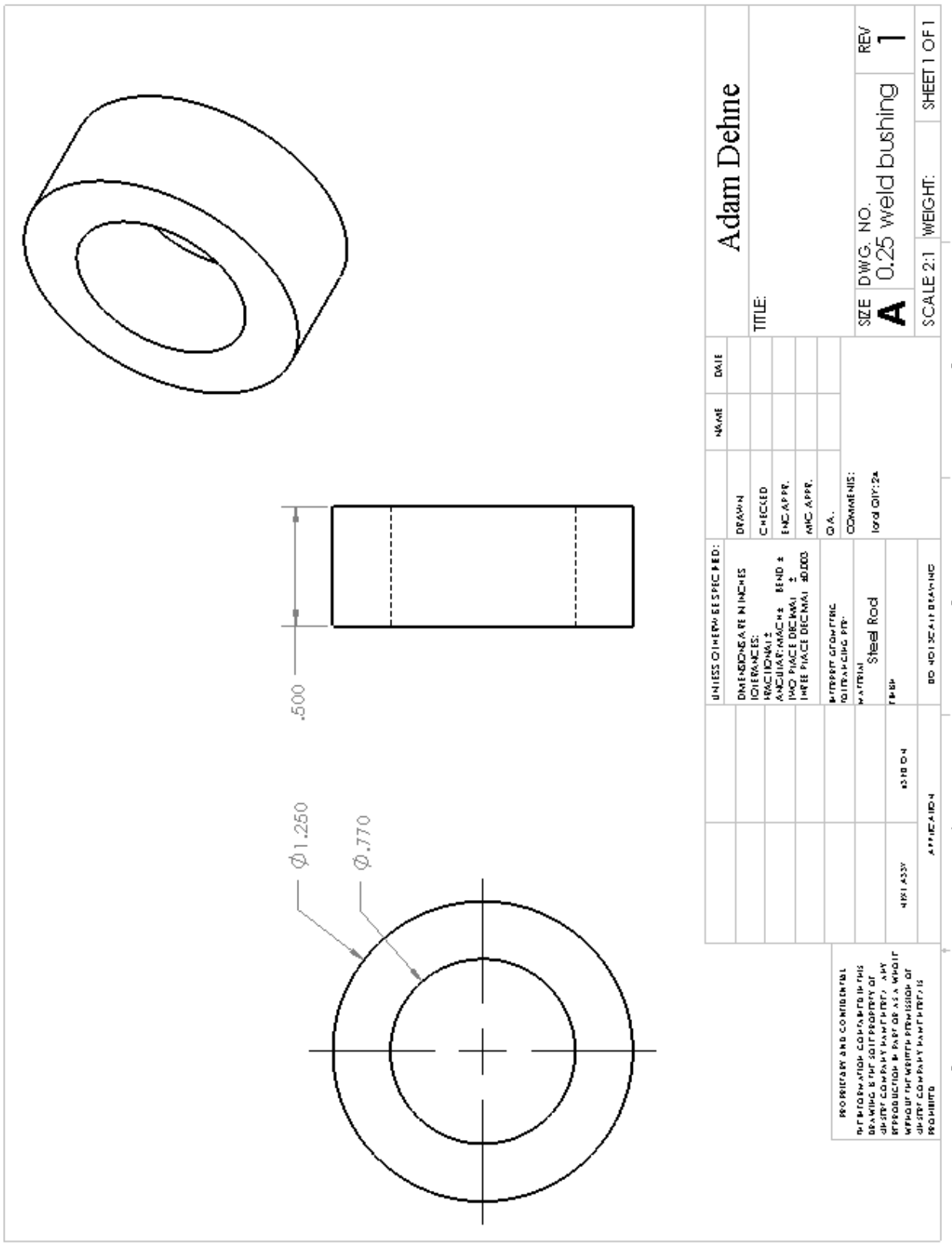
TITLE:
bucket side body TRI reinforcement

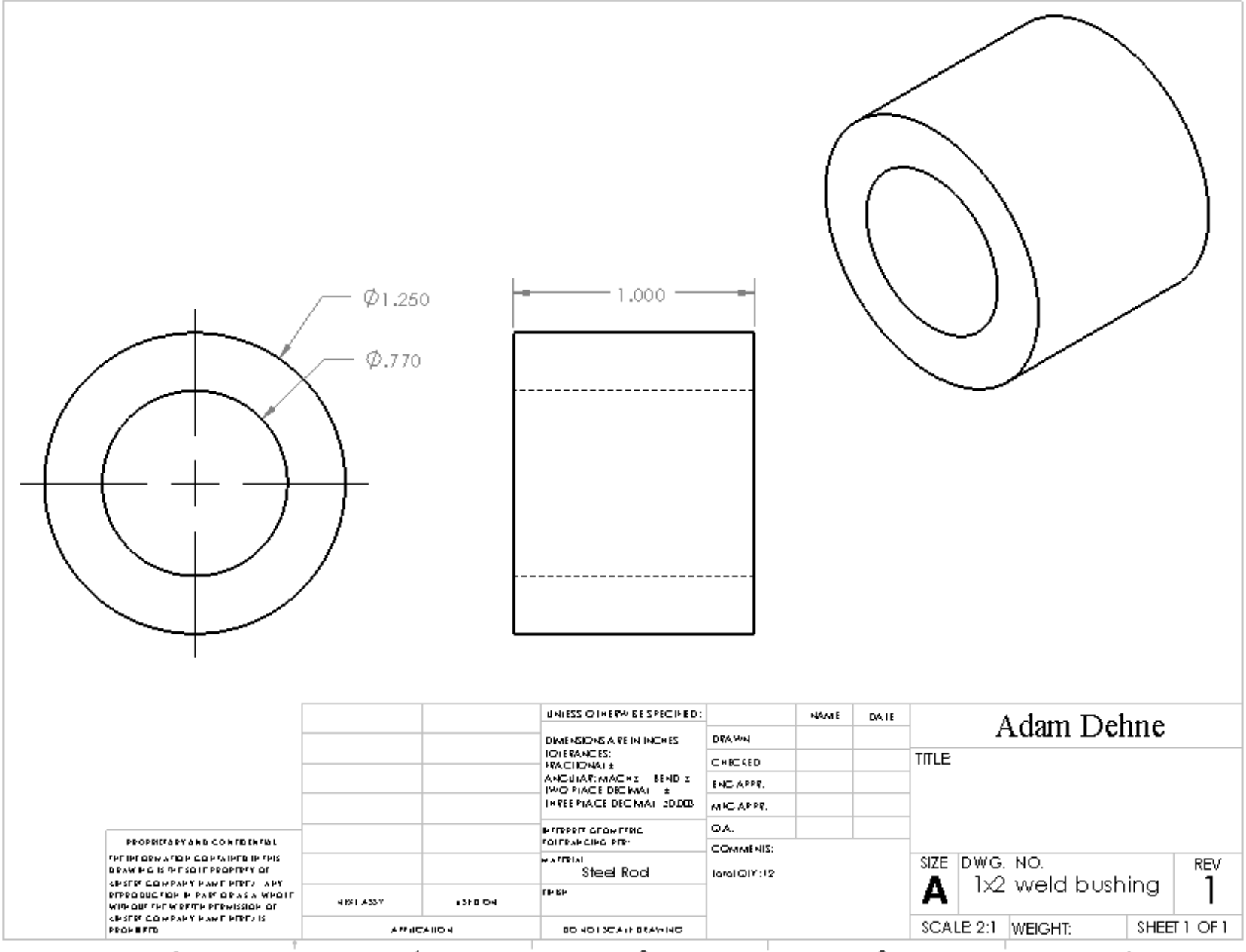
SIZE	DWG. NO.	REV
A		

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

5 4 3 2 1

PIN BUSHINGS:




Ø1.250
Ø.770
1.000
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±0.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
Steel Rod
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Total QTY: 12
NAME
DATE
Adam Dehne
TITLE
SIZE
A
DWG. NO.
1x2 weld bushing
REV
1
SCALE 2:1
WEIGHT:
SHEET 1 OF 1
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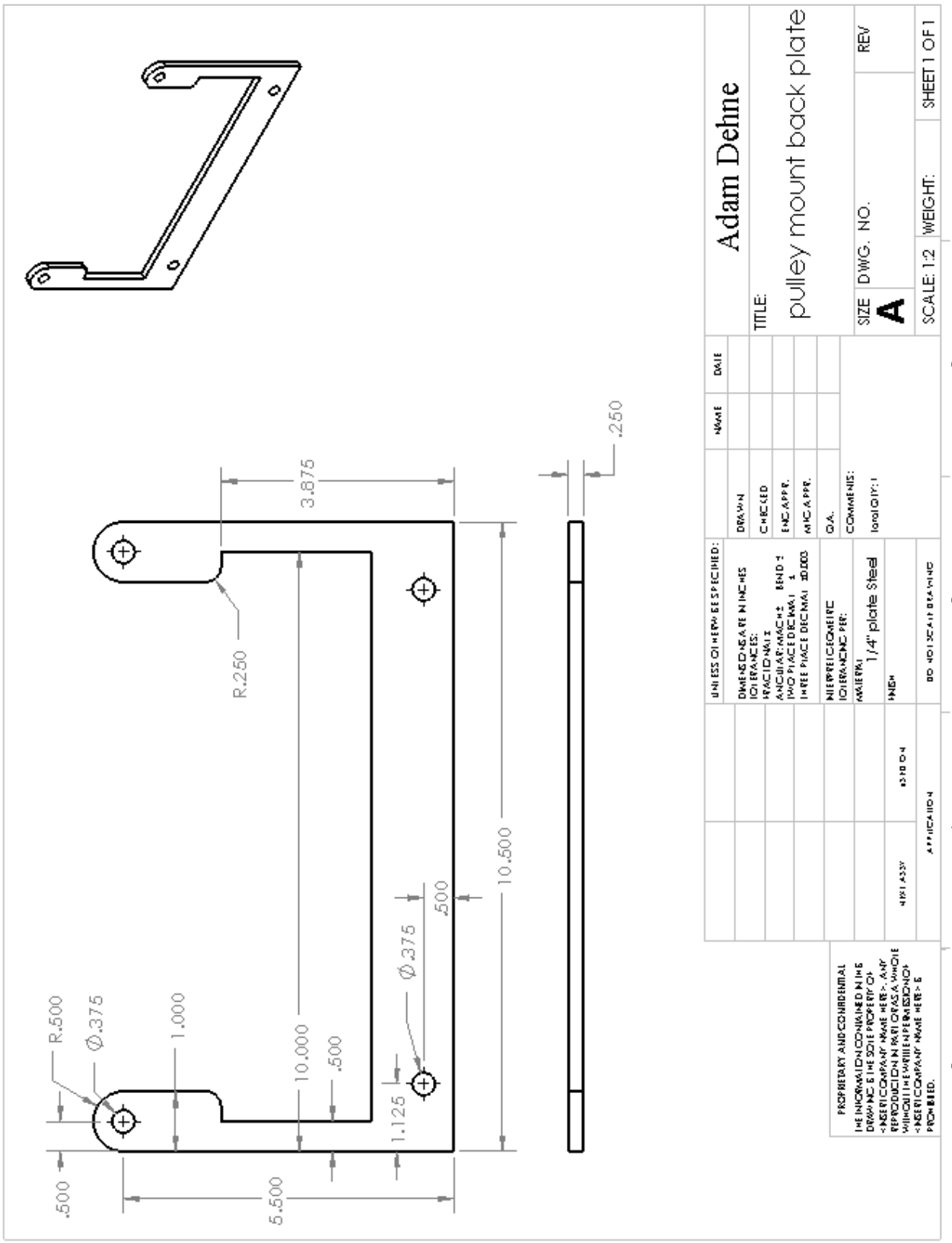
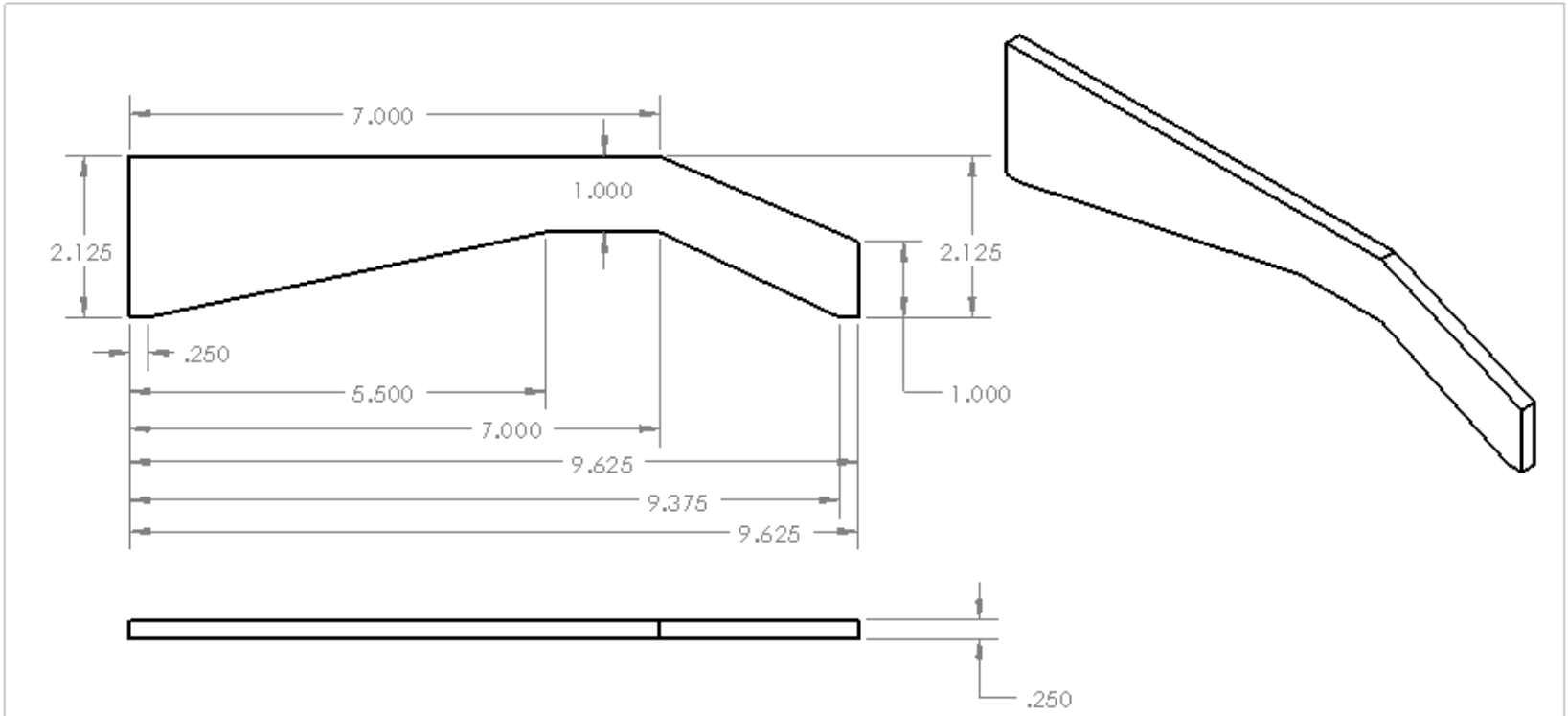
5
4
3
2
1

HYDRAULIC PUMP MOUNT:





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS: Total QTY: 2		
		MATERIAL 1/4" plate steel			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

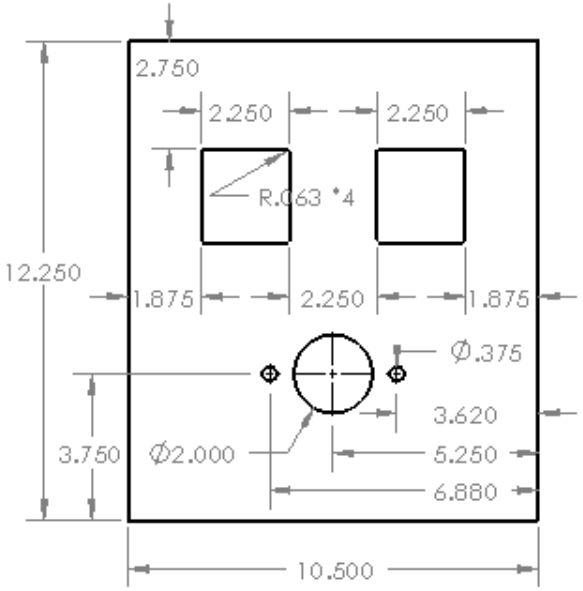
Adam Dehne

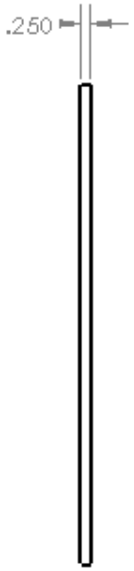
TITLE:
pulley mount lower gusset support

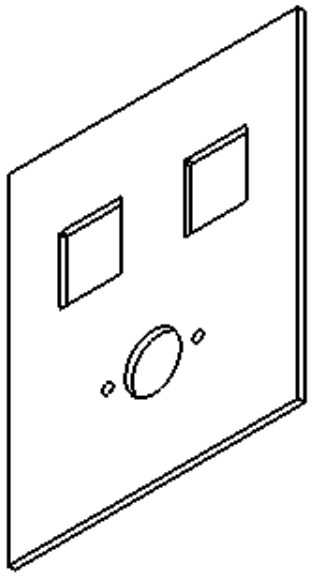
SIZE	DWG. NO.	REV
A		

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

5 4 3 2 1







		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS: Total QTY: 1		
		MATERIAL 1/4" plate steel			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

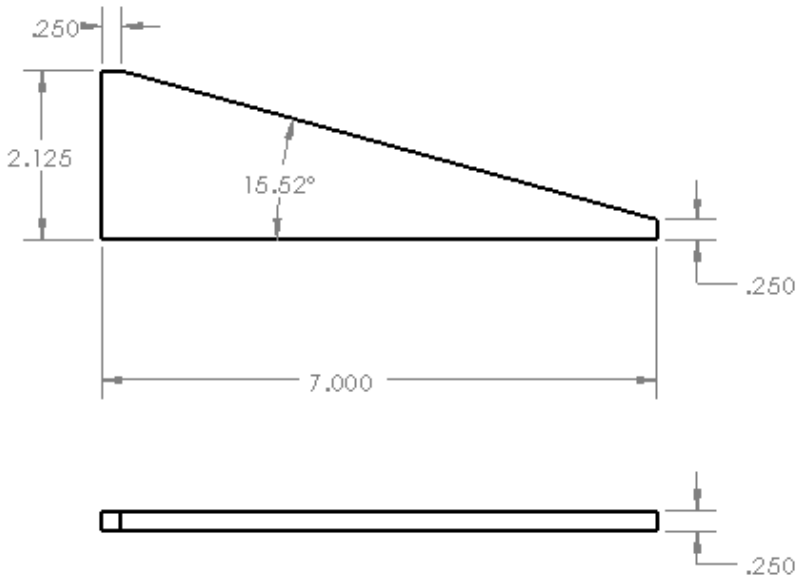
TITLE:

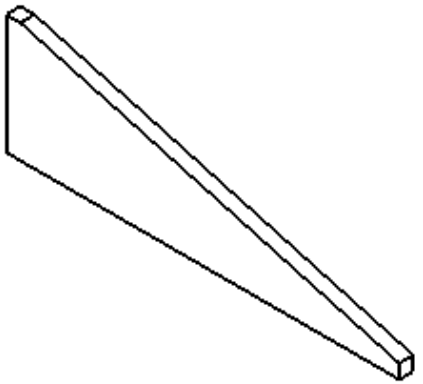
pulley mount mount

SIZE	DWG. NO.	REV
A		

SCALE: 1:4	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1





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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS: Total QTY: 2		
		MATERIAL			
NEXT ASSY	USED ON	FINISH 1/4" plate steel			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

TITLE:

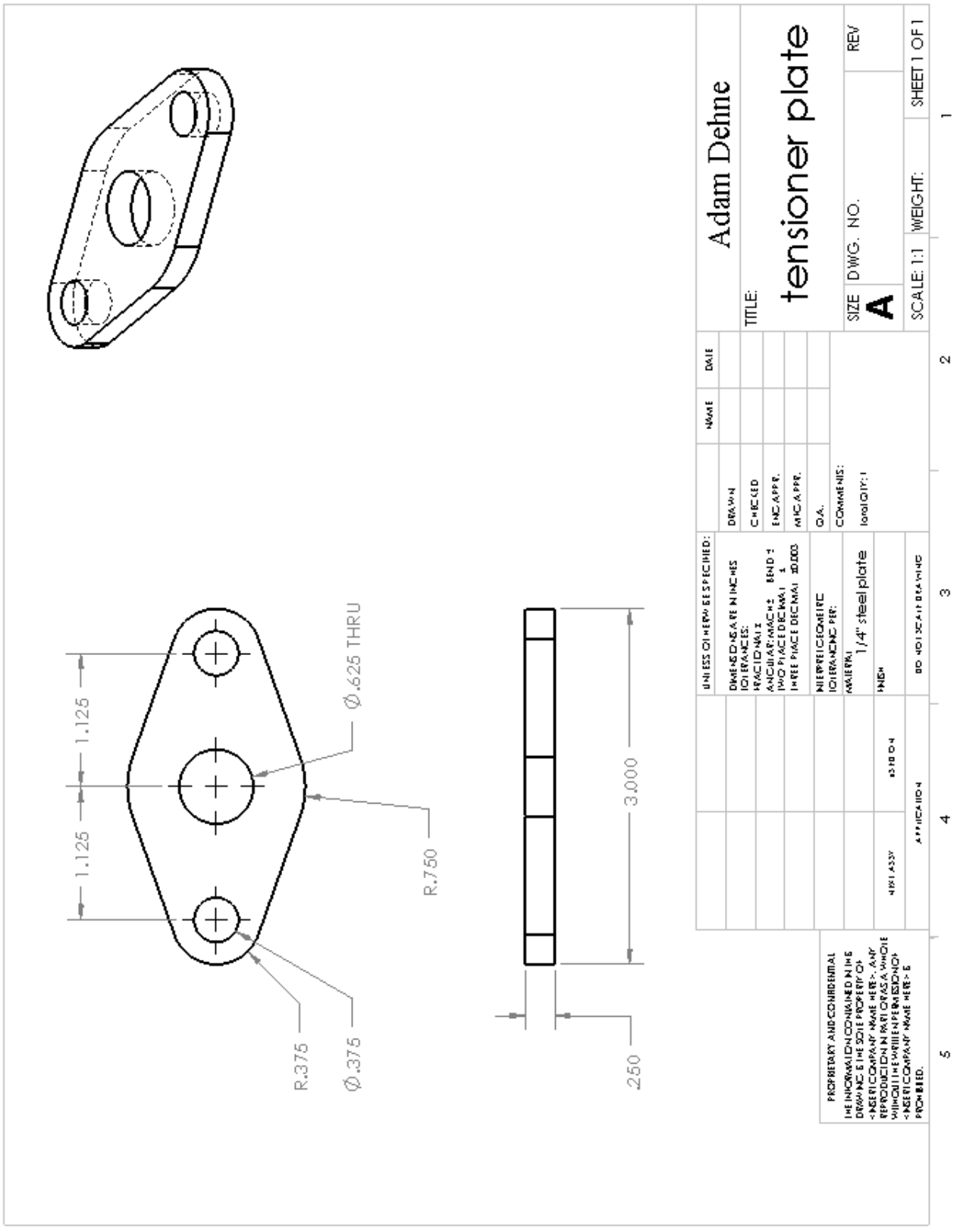
pulley mount upper gussets

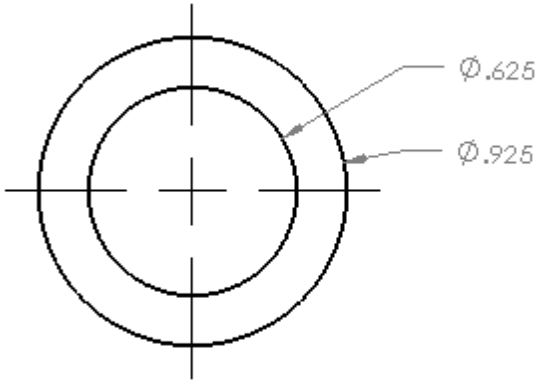
SIZE	DWG. NO.	REV
A		

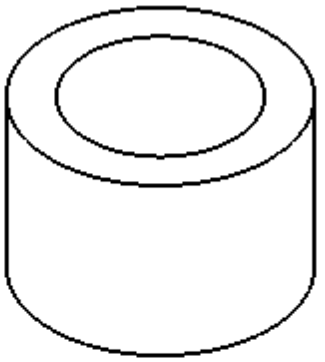
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

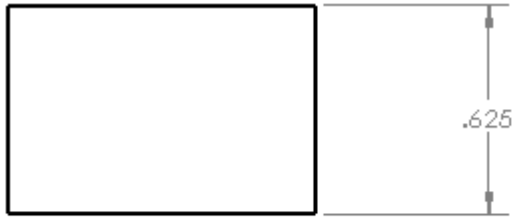
5 4 3 2 1

HYDRAULIC PUMP - BELT TENSIONER:



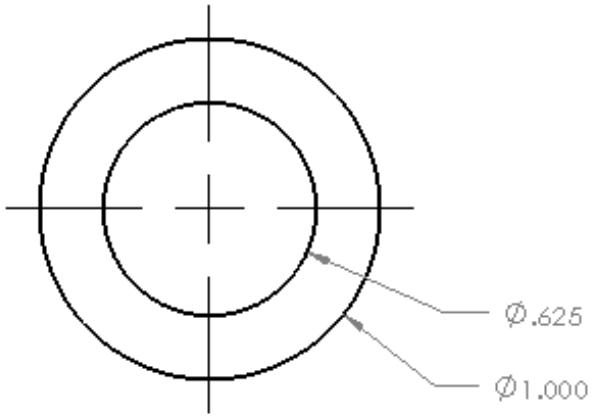


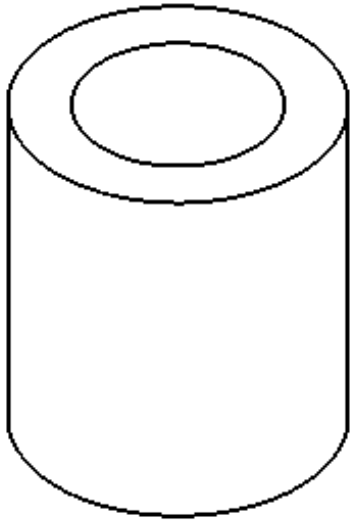


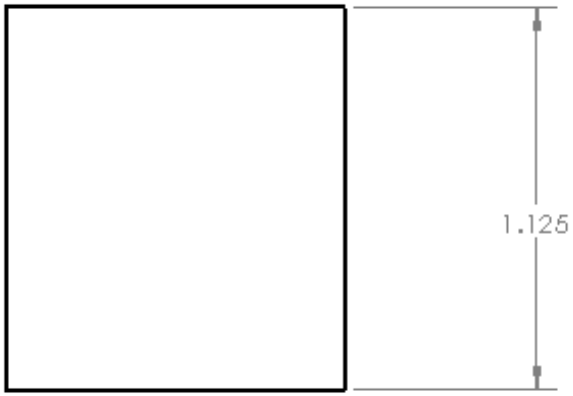


UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: tensioner pulley spacer	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL Steel Rod	COMMENTS: Total QTY: 1			SIZE A	DWG. NO. REV
FINISH				SCALE: 2:1	WEIGHT: SHEET 1 OF 1
NEXT ASSY / USED ON					
APPLICATION / DO NOT SCALE DRAWING					

5 4 3 2 1



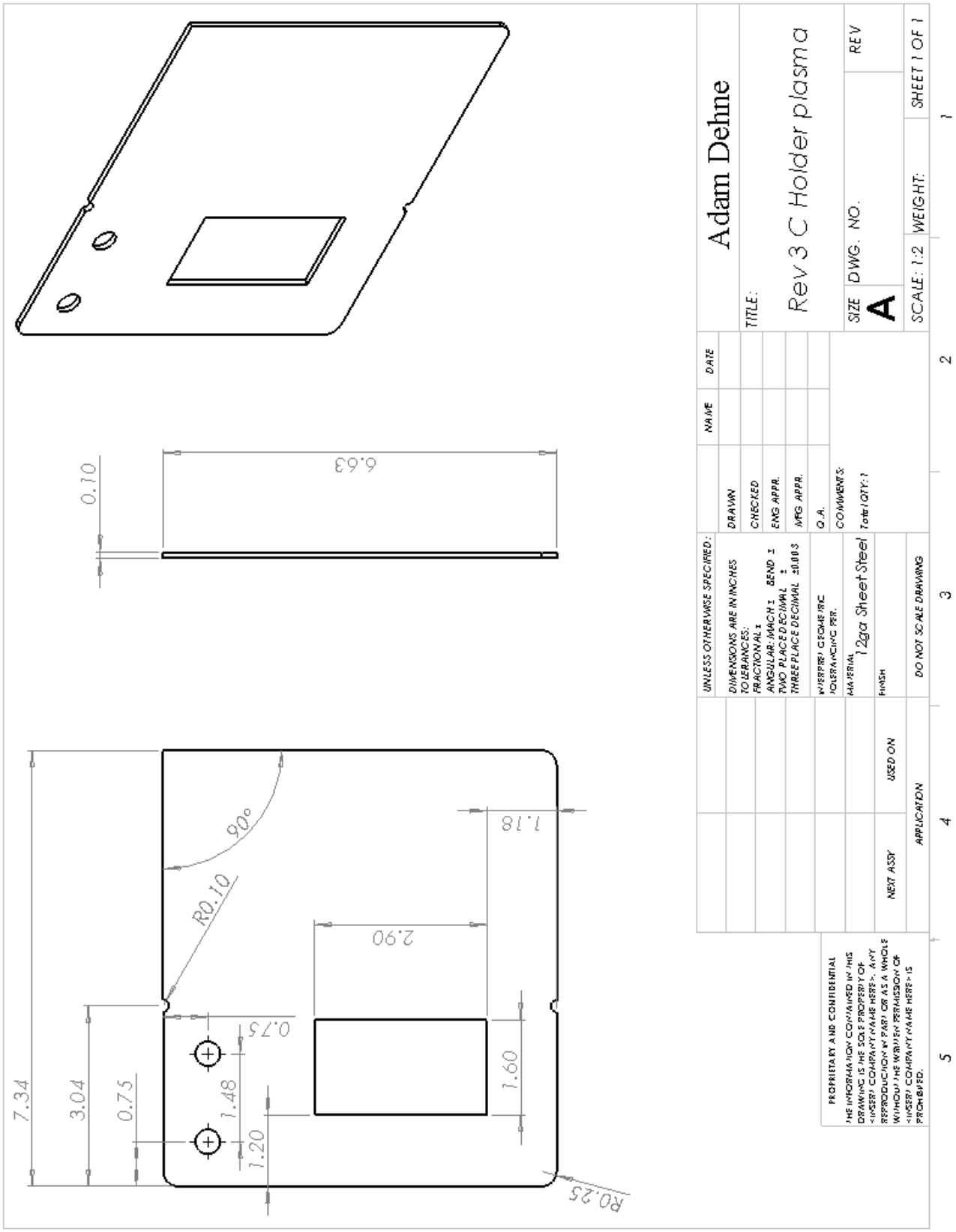




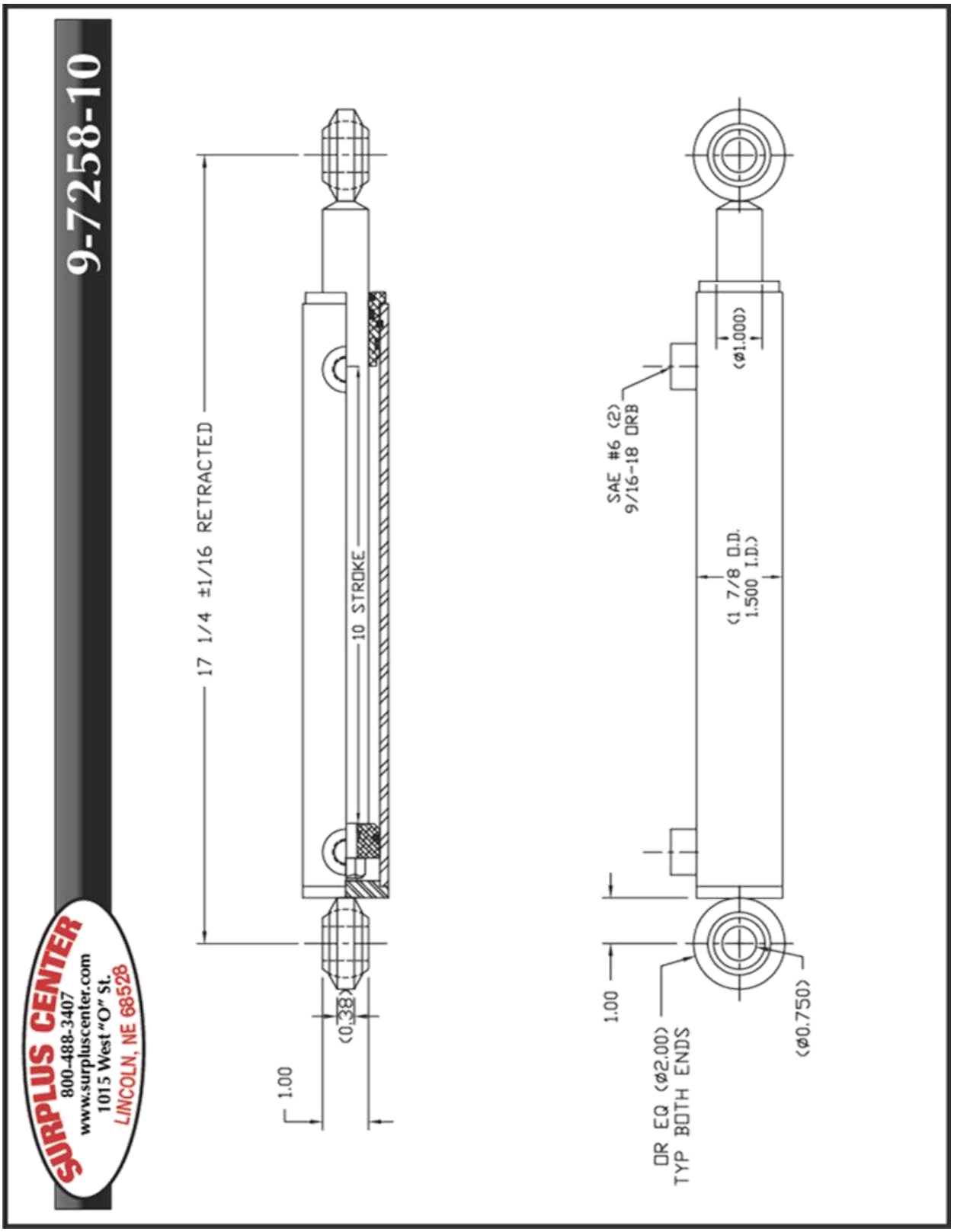
UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Adam Dehne	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.005	DRAWN			TITLE: tensioner shaft	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
	Q.A.				
INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:			SIZE A	DWG. NO. REV
MATERIAL: Steel rod	Total QTY: 1				
FINISH					
NEXT ASSY / USED ON				SCALE: 2:1	WEIGHT: SHEET 1 OF 1
APPLICATION / DO NOT SCALE DRAWING					

5 4 3 2 1

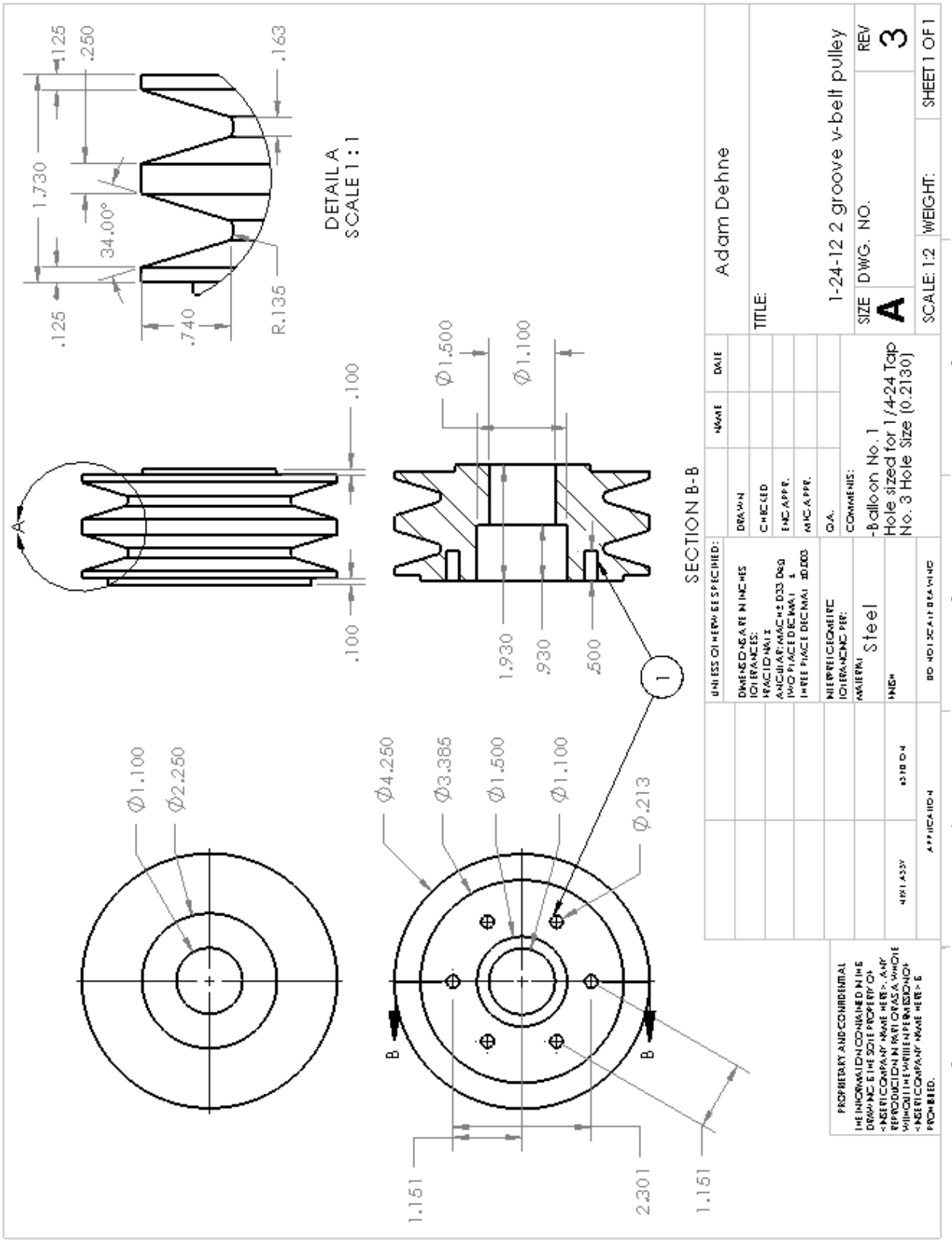
HYDRAULIC CONTROL MOUNT:



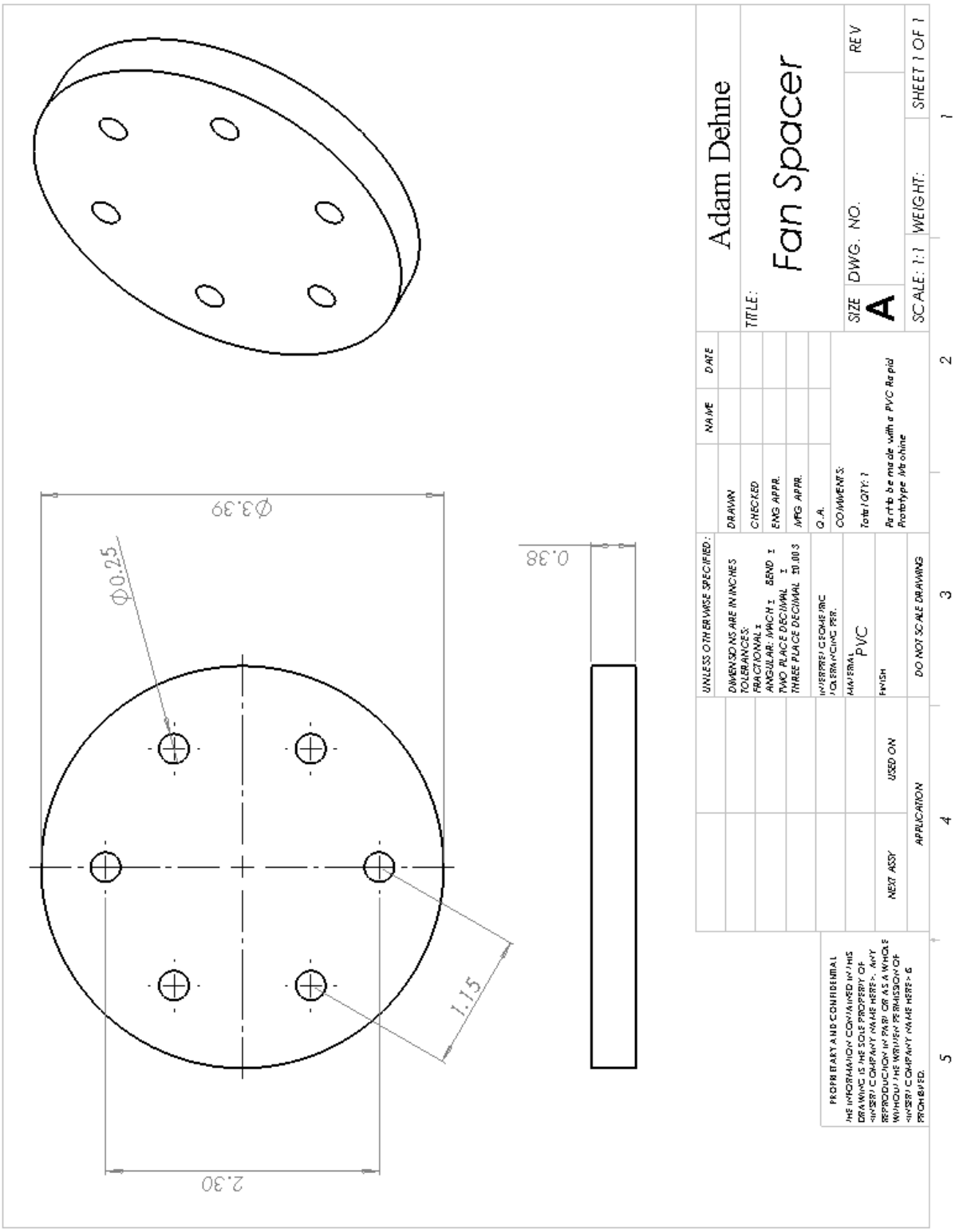
HYDRAULIC CYLINDER(S)



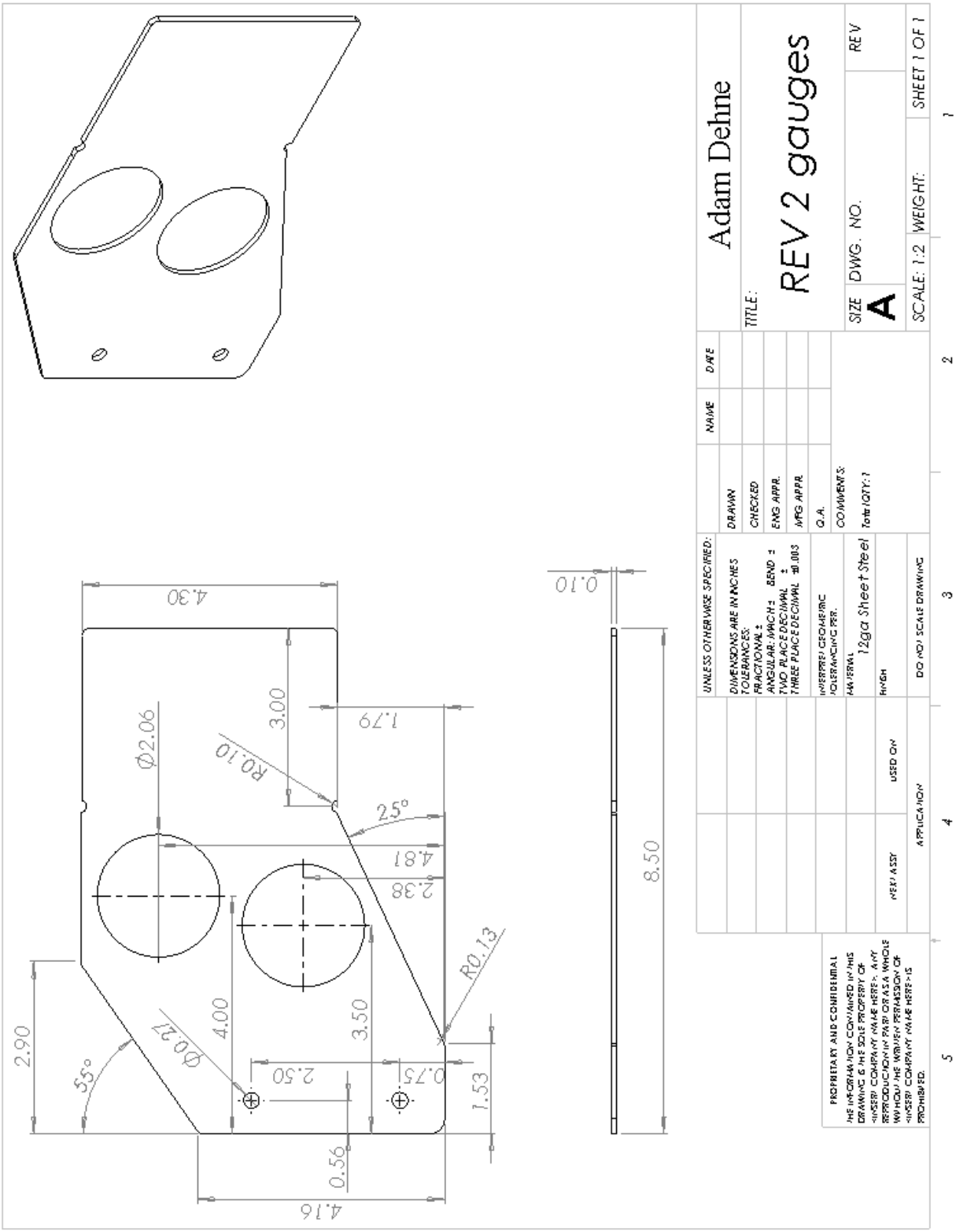
TWO GROOVE PULLEY



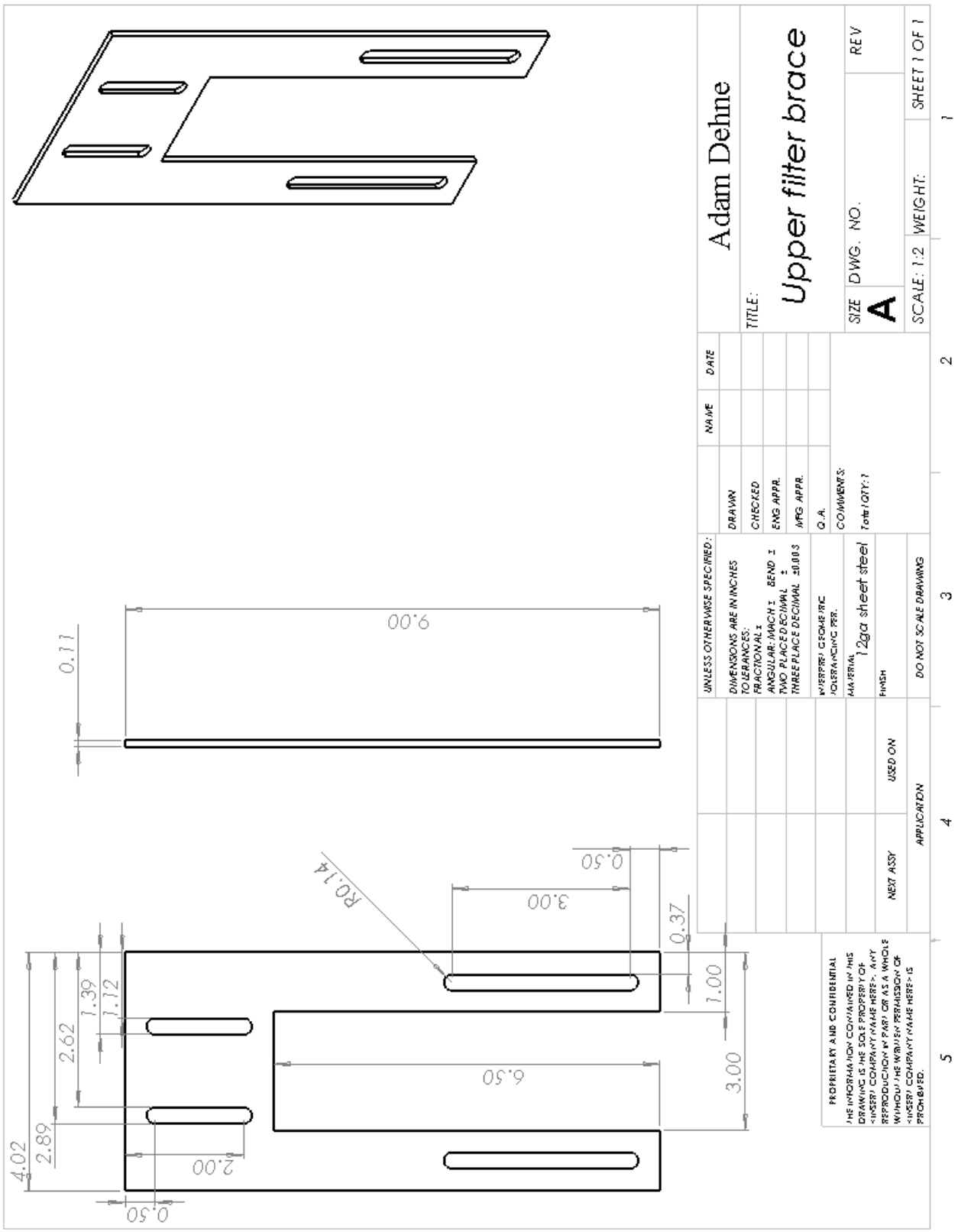
DIFFERENTIAL FAN SPACER

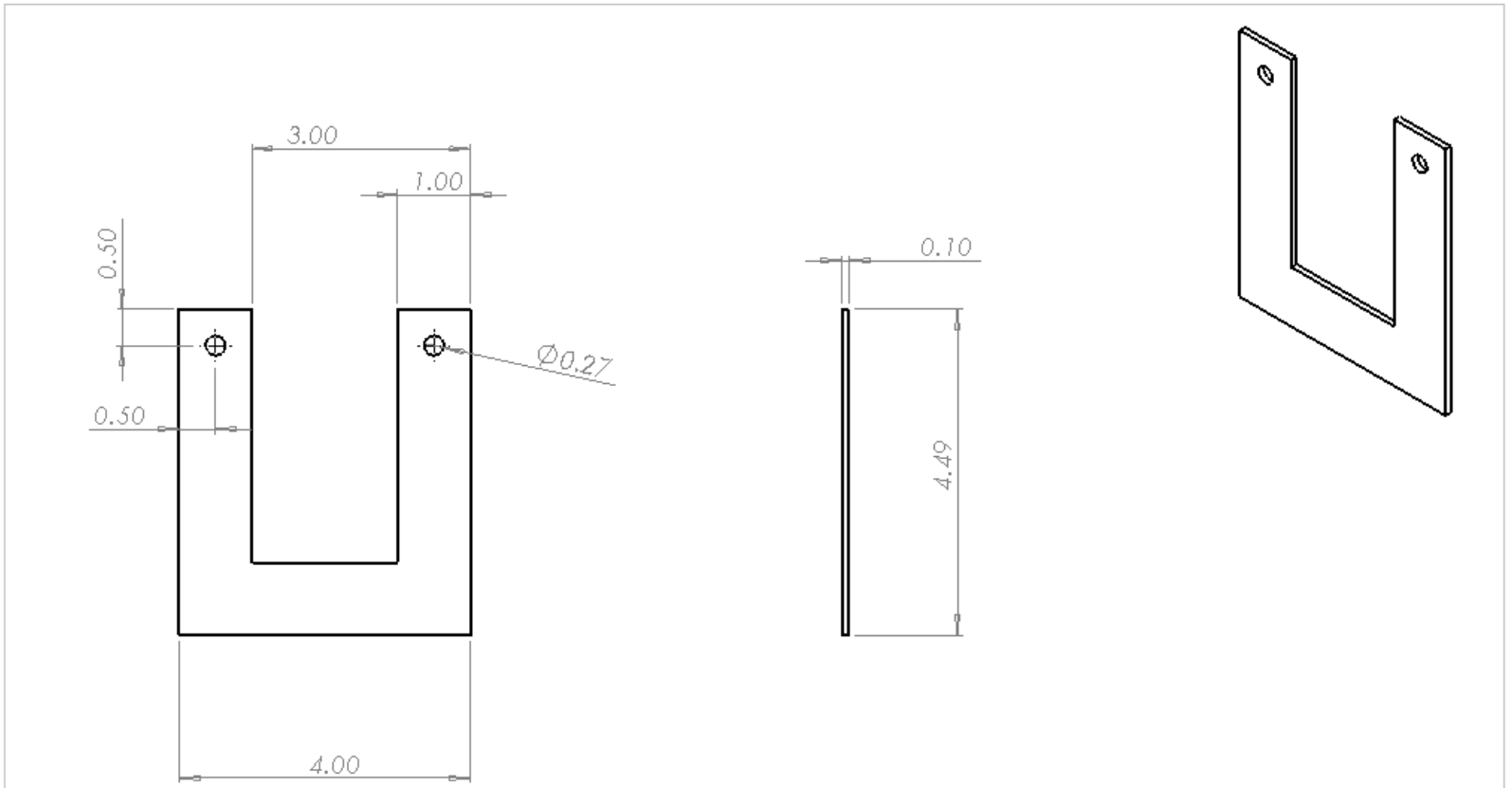


GAUGE CLUSTER



FILTER BRACE/BRACKETS





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±0.003	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL 12ga Sheet Steel	COMMENTS: Total QTY: 1		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

Adam Dehne

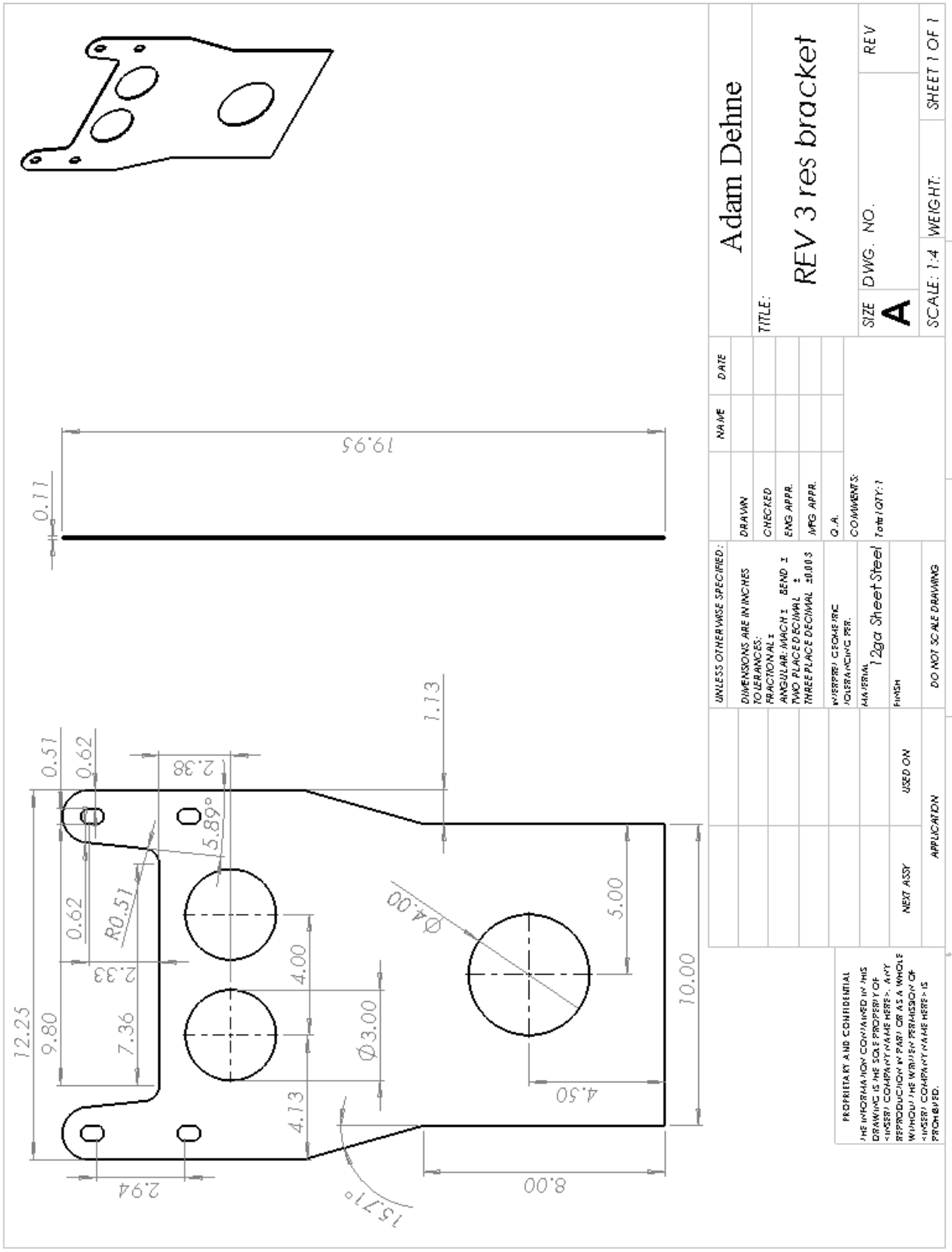
TITLE:
Rev 2 Lower Filter Brace

SIZE	DWG. NO.	REV
A		

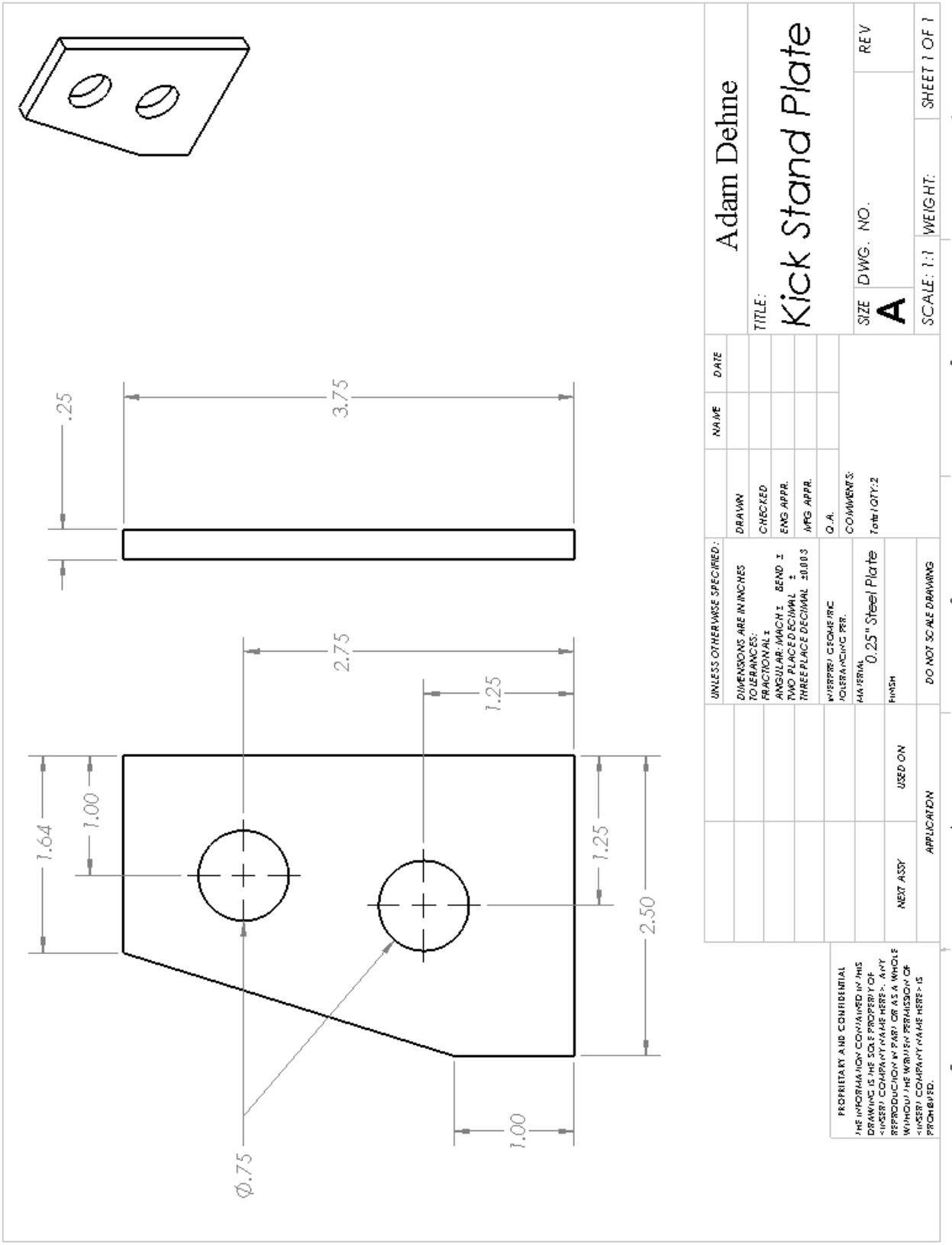
SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1

RESERVOIR BRACE/BRACKET



KICK STAND


.25
3.75
2.75
1.25
1.64
1.00
1.25
2.50
1.00
Ø.75
Adam Dehne
TITLE:
Kick Stand Plate
SIZE
A
DWG. NO.
REV
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±0.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
0.25" Steel Plate
FINISH
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Tank QTY: 2
NAME
DATE
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
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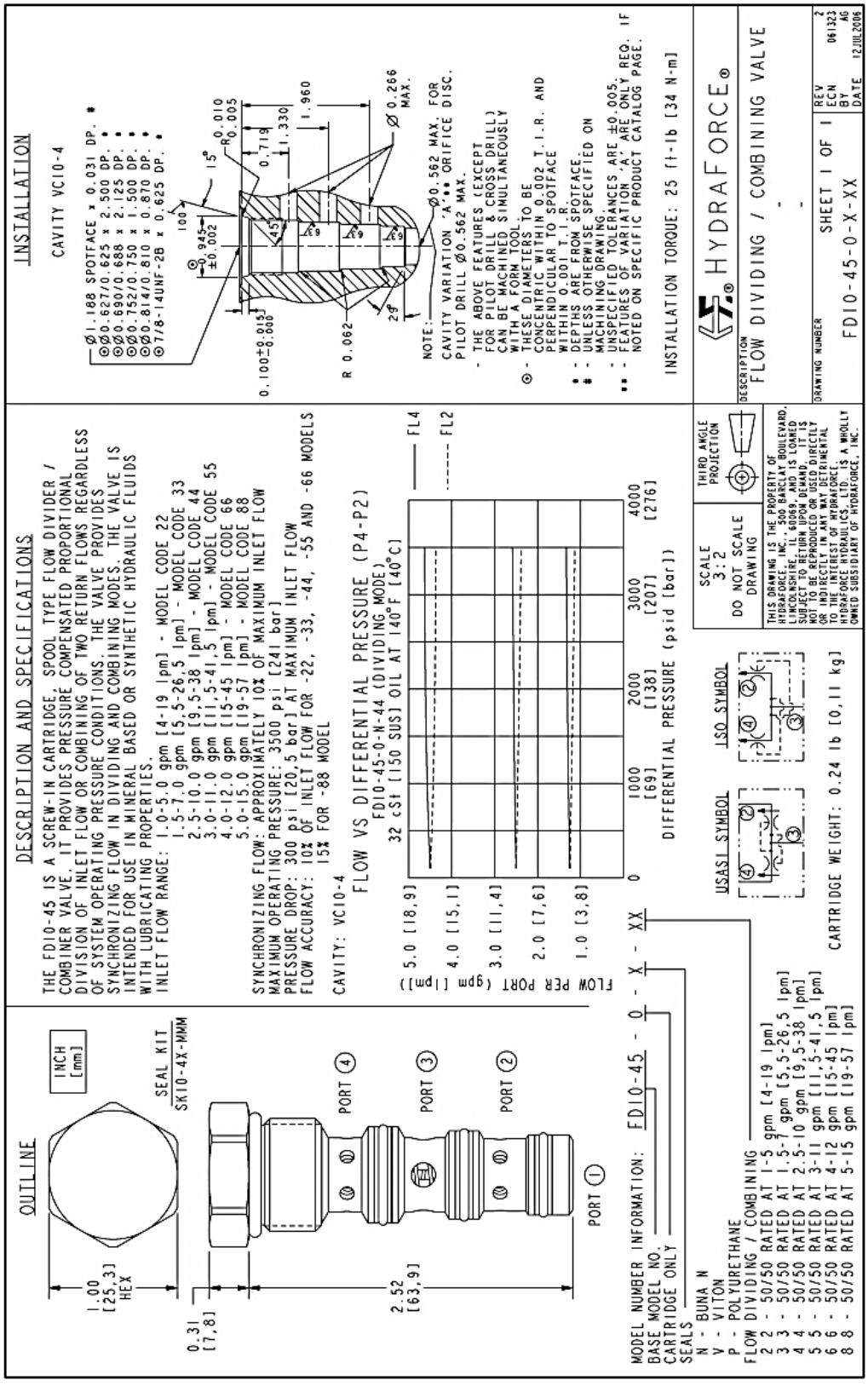
FLOW DIVIDER



APPENDIX G – BUDGET

Front-End Loader/Snow Plow for a Personal Lawn Tractor Budget

Donated Funds	$2,500.00	Personal Funds	$3,980.00	Money to spend (so far)	Money left to spend	Totals (USD)		Total % Diff
				$ 6,480.00	$ 1,502.94	$9,767.58	$4,977.06	49.05%
Category	**Componet/Material**	**Description**	**Vendor**	**Estimated/Procured Prices (taxes included)**	**Shipping Cost**	**Estimated Budget Total(s)**	**True Expenditures**	**% Difference**
Example	*Example*	*Example*	*Example*	2	3	5	3	40
Hydraulics	*Pump*	Pump	Surplus Center	700	15	715	89	**88**
Hydraulics	*Cylinder(s)*	Arm cylinder(s)	Surplus Center	500	30	530	202	**62**
Hydraulics		Bucket cylinder(s)	Surplus Center	250	10	260	101	**61**
Hydraulics	*Fittings*	Fittings	Cincinnati Hose and Fitting	198		198	850	**329**
Hydraulics		Quick dissconnect fittings	Cincinnati Hose and Fitting	250		250	0	**100**
Hydraulics		Thread Seal	lowes	7		7	0	**100**
Hydraulics		Fitting/line docks	Cincinnati Hose and Fitting	230		230	0	**100**
Hydraulics		Fitting Caps	Cincinnati Hose and Fitting	35		35	0	**100**
Hydraulics		Temperatue Gauge fittings		30		30	15	**50**
Hydraulics		Seals		7		7	5	**29**
Hydraulics	*Hoses/hard lines*	Main Hose/Line wrap		35		35	0	**100**
Hydraulics		Main Hose	Cincinnati Hose and Fitting	441		441	0	**100**
Hydraulics		Thread Seal		10		10	0	**100**
Hydraulics		Main Hard Line	Cincinnati Hose and Fitting	60		60	0	**100**
Hydraulics		Temperatue Gauge Hose/Line		35		35	0	**100**
Hydraulics	*Mounting hardware*	Clamps	Cincinnati Hose and Fitting	80		80	25	**69**
Hydraulics		Brackets off-shelf		100		100	0	**100**
Hydraulics		Brackets Machine Made		25		25	0	**100**
Hydraulics		Zip Ties		10		10	10	**0**
Hydraulics		Hardware/fasteners	MMC	66.08	9	75.08	45	**40**
Hydraulics	*Reservoir*	Reservoir	Donated (Firestone)	150		150	0	**100**
Hydraulics		Mounting hardware		15		15	15	**0**
Hydraulics	*Manifold(s)*	Flow Divider	Donated (Hydraforce)	100		100	0	**100**
Hydraulics	*Fluid*	Fluid TBD		45		45	30	**33**
Hydraulics	*Cooler*	Cooler TBD		50		50	0	**100**
Hydraulics	*Filter(s)*	In-line Filter and housing	Donated (Atlas Dowel)	32		32	0	**100**
Hydraulics	*Other hardware*	Nuts, bolts, Screws, washers, lock washers		100		100	25	**75**
Hydraulics		Set Screws		15		15	15	**0**
Hydraulics		Cotter and other Pins		10		10	0	**100**
Hydraulics		Rivets		10		10	0	**100**
Hydraulics	*tooling*	Other TBD				0	0	**0**
Hydraulics		Drill(s)		25		25	0	**100**
Hydraulics		Tap(s)		15		15	0	**100**
Hydraulics	*Raw Material*	Sheet Steel		12.5		12.5	633	**4967**
Hydraulics		Plate Steel		31.25		31.25	0	**100**
Hydraulics		Plate Aluminum		40		40	0	**100**
Hydraulics	*Other Machine Time*	$35/hr TBD		175		175	0	**100**
Hydraulics	*Drive Components*	Pulley(s)	Surplus Center	50		50	45	**10**
Hydraulics		Belts		62.5		62.5	30	**52**
Hydraulics		Bushing(s)		15		15	0	**100**
Hydraulics		Tensioner(s)		30		30	70	**133**
Hydraulics		Bearing(s)		35		35	0	**100**
Hydraulics	*Controls*	Main Controls at qty. 2	Surplus Center	380		380	224	**41**
Hydraulics		In-line valves		100		100	0	**100**
Hydraulics		Raw material (Bracket) Controls		25		25	0	**100**
Hydraulics		Mounting hardware		20		20	0	**100**
Hydraulics	*Other*	Thread Locker	Lowes	5		5	5	**0**
Hydraulics		Fluid Temperature Gauge		60		60	58	**3**
Hydraulics		Grease fittings		3.25		3.25	0	**100**
Hydraulics		Grease		5		5	0	**100**
Hydraulics		TBD				0	0	**0**
Hydraulics	*Paint*	Paint ColorTBD	Lowes			0	0	**0**
Hydraulics		Brush(s)		3		3	0	**100**
Hydraulics		Spray Can(s)		9		9	25	**178**
Hydraulics	*Powder Coating*	TBD	American Metal Cleaning			0	0	**0**
Hydraulics	*Cleaning/Prep Stuffs*	Solvant(s)		2		2	5	**150**
Hydraulics		Rags		5		5	5	**0**
Hydraulics		Containers		2		2	0	**100**
Hydraulics		Brush(s)		2		2	0	**100**

Loader Arms	Paint	Paint ColorTBD		0	0	0	0	0
Loader Arms		Brush(s)		5		5	0	100
Loader Arms		Spray Can(s)		24		24	25	4
Loader Arms	Powder Coating	TBD	American Metal Cleaning	200		200	0	100
Loader Arms	Other Hardware	Nuts, bolts, Screws, washers, lock washers		65		65	35	46
Loader Arms		Set Screws		15		15	5	67
Loader Arms		Cotter and other Pins		10		10	0	100
Loader Arms		Rivets		10		10	0	100
Loader Arms	Bearings	Bearings		80		80	0	100
Loader Arms		Bushings		35		35	0	100
Loader Arms	Machine Time	$35/hr TBD		350		350	0	100
Loader Arms	Off shelf Components	TBD (pin(s))		1		1	40	3900
Loader Arms	Tooling	Other TBD		1		1	0	100
Loader Arms		Drill(s)		30		30	0	100
Loader Arms		Tap(s)		15		15	0	100
Loader Arms	Raw material	Tube Steel		250		250	0	100
Loader Arms		Attachment Raw Material		50		50	633	1166
Loader Arms		Sheet Steel		35		35	0	100
Loader Arms		Plate Steel		20		20	0	100
Loader Arms		Plate Aluminum		35		35	0	100
Loader Arms	Other	Grease fittings		4.25		4.25	0	100
Loader Arms		Grease		5		5	5	0
Loader Arms		TBD				0	0	0
Loader Arms		Thread locker		5		5	5	0
Loader Arms	Mounting hardware	Clamps		15		15	0	100
Loader Arms		Brackets off-shelf		40		40	0	100
Loader Arms		Brackets Machine Made		40		40	0	100
Loader Arms		Zip Ties		5		5	0	100
Loader Arms		Hardware		15		15	25	67
Loader Arms	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Loader Arms		Rags		5		5	0	100
Loader Arms		Containers		2		2	0	100
Loader Arm Support(s)	Raw Material	Plate Steel		31.25		31.25	316	911
Loader Arm Support(s)		Sheet Steel		12.5		12.5	0	100
Loader Arm Support(s)	Mounting hardware	Clamps		15		15	0	100
Loader Arm Support(s)		Brackets off-shelf				0	0	0
Loader Arm Support(s)		Brackets Machine Made		50		50	0	100
Loader Arm Support(s)		Zip Ties		8		8	0	100
Loader Arm Support(s)		Hardware		30		30	30	0
Loader Arm Support(s)	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Loader Arm Support(s)		Rags		5		5	0	100
Loader Arm Support(s)		Containers		2		2	0	100
Loader Arm Support(s)	Machine Time	$35/hr TBD		70		70	0	100
Loader Arm Support(s)	Off shelf Components	TBD				0	0	0
Loader Arm Support(s)	Tooling	Other TBD				0	0	0
Loader Arm Support(s)		Drill(s)		25		25	0	100
Loader Arm Support(s)		Tap(s)		15		15	0	100
Loader Arm Support(s)	Paint	Paint ColorTBD				0	0	0
Loader Arm Support(s)		Brush(s)		3		3	0	100
Loader Arm Support(s)		Spray Can(s)		9		9	25	178
Loader Arm Support(s)	Powder Coating	TBD	American Metal Cleaning	40		40	0	100
Loader Arm Support(s)	Other Hardware	Nuts, bolts, Screws, washers, lock washers		10		10	25	150
Loader Arm Support(s)		Set Screws		3		3	0	100
Loader Arm Support(s)		Cotter and other Pins		10		10	0	100
Loader Arm Support(s)		Rivets		5		5	0	100
Bucket	Raw Material	Sheet Steel		100		100	317	217
Bucket		Plate Steel		30		30	0	100
Bucket		Attchment Material		25		25	0	100
Bucket		Paint		18		18	25	39
Bucket		Powder Coating		80		80	0	100
Bucket		Bottom ware material		20		20	0	100
Bucket	Tooling	TDB				0	0	0
Bucket	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Bucket		Rags		5		5	0	100
Bucket		Containers		2		2	0	100
Bucket	Other Hardware	Nuts, bolts, Screws, washers, lock washers		10		10	0	100

Bucket		Set Screws				0	0	0
Bucket		Cotter and other Pins		10		10	0	100
Bucket		Rivets		3		3	0	100
Snow Plow	Plow	Used plow	Donated	125		125	0	100
Snow Plow	Raw Material	Attchment Material		25		25	0	100
Snow Plow		Plate Steel		10		10	0	100
Snow Plow		Sheet Steel		10		10	0	100
Snow Plow		Lower scraper material		15		15	0	100
Snow Plow	Paint	Paint ColorTBD				0	0	0
Snow Plow		Brush(s)		2		2	0	100
Snow Plow		Spray Can(s)		18		18	0	100
Snow Plow	Sand Blasting	TBD		50		50	0	100
Snow Plow	Powder Coating	TBD		50		50	0	100
Snow Plow	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Snow Plow		Rags		5		5	0	100
Snow Plow		Containers		2		2	0	100
Snow Plow	Tooling	TBD				0	0	0
Snow Plow	Other Hardware	Nuts, bolts, Screws, washers, lock washers		20		20	0	100
Snow Plow		Set Screws				0	0	0
Snow Plow		Cotter and other Pins		10		10	0	100
Snow Plow		Rivets				0	0	0
Additional Rear Weight Added	Raw Material	Sheet Steel		30		30	0	100
Additional Rear Weight Added		Plate Steel		20		20	0	100
Additional Rear Weight Added	Other Hardware	Nuts, bolts, Screws, washers, lock washers		25		25	0	100
Additional Rear Weight Added		Set Screws				0	0	0
Additional Rear Weight Added		Cotter and other Pins				0	0	0
Additional Rear Weight Added		Rivets		10		10	0	100
Additional Rear Weight Added	Weights	Wheel Weight		120		120	85.19	29
Additional Rear Weight Added		Rear weights		62		62	95	53
Additional Rear Weight Added	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Additional Rear Weight Added		Rags		5		5	0	100
Additional Rear Weight Added		Container(s)		2		2	0	100
Additional Rear Weight Added		Brush(s)				0	0	0
Additional Rear Weight Added	Paint	Paint ColorTBD				0	0	0
Additional Rear Weight Added		Brush(s)				0	0	0
Additional Rear Weight Added		Spray Can(s)		9		9	0	100
Additional Rear Weight Added	Powder Coating	TBD				0	0	0
Additional Rear Weight Added	Other maching time	$35/hr TBD		35		35	0	100
Potential Axel Reinforcement	Raw Material	Tubing		35		35	0	100
Potential Axel Reinforcement		Round Stock		30		30	0	100
Potential Axel Reinforcement	Bearings	Bearings		30		30	0	100
Potential Axel Reinforcement		Bushings		15		15	0	100
Potential Axel Reinforcement	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Potential Axel Reinforcement		Rags		5		5	0	100
Potential Axel		Container(s)		2		2	0	100

Potential Axel Reinforcement		Brush(s)				0	0	0
Potential Axel Reinforcement	Paint	Paint ColorTBD				0	0	0
Potential Axel Reinforcement		Brush(s)				0	0	0
Potential Axel Reinforcement		Spray Can(s)		9		9	0	100
Potential Axel Reinforcement	Powder Coating	TBD				0	0	0
Potential Axel Reinforcement	Other maching time	$35/hrTBD		70		70	0	100
Potential Axel Reinforcement	Tooling	TBD				0	0	0
Potential Axel Reinforcement	Other Hardware	Nuts, bolts, Screws, washers, lock washers		20		20	0	100
Potential Axel Reinforcement		Set Screws				0	0	#DIV/0!
Potential Axel Reinforcement		Cotter and other Pins		5		5	0	100
Potential Axel Reinforcement		Rivets				0	0	#DIV/0!
Potential Frame Reinforcement	Raw Material	Tubing				0	0	#DIV/0!
Potential Frame Reinforcement		Round Stock				0	0	#DIV/0!
Potential Frame Reinforcement		Sheet Steel		35		35	0	100
Potential Frame Reinforcement		Plate Steel				0	0	#DIV/0!
Potential Frame Reinforcement	Cleaning/Prep Stuffs	Solvant(s)		2		2	0	100
Potential Frame Reinforcement		Rags		5		5	0	100
Potential Frame Reinforcement		Container(s)		2		2	0	100
Potential Frame Reinforcement		Brush(s)				0	0	0
Potential Frame Reinforcement	Paint	Paint ColorTBD				0	0	0
Potential Frame Reinforcement		Brush(s)				0	0	0
Potential Frame Reinforcement		Spray Can(s)		9		9	0	100
Potential Frame Reinforcement	Powder Coating	TBD				0	0	0
Potential Frame Reinforcement	Other maching time	TBD				0	0	0
Potential Frame Reinforcement	Tooling	TBD				0	0	0
Potential Frame Reinforcement	Other Hardware	Nuts, bolts, Screws, washers, lock washers		20		20	0	100
Potential Frame Reinforcement		Set Screws				0	0	0
Potential Frame Reinforcement		Cotter and other Pins				0	0	0
Potential Frame Reinforcement		Rivets		5		5	0	100
Other Raw Material	Materials	TBD		100		100	0	100
Other Miscellaneous Components	Miscellaneous	TBD		100		100	225	125
Other	Floor	Scales	Taylor	60		60	34.04	43
Other	Other	TBD		50		50	500	900
Tractor	Lawn Tractor	4000YT	sears	1700		1700	0	100
Totals						9767.58	4977.063333	