Welcome To Hell Traditional Shop Sculpture
ENGR 2330 Mech Proto

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Project Team:

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Everardo Gonzalezz

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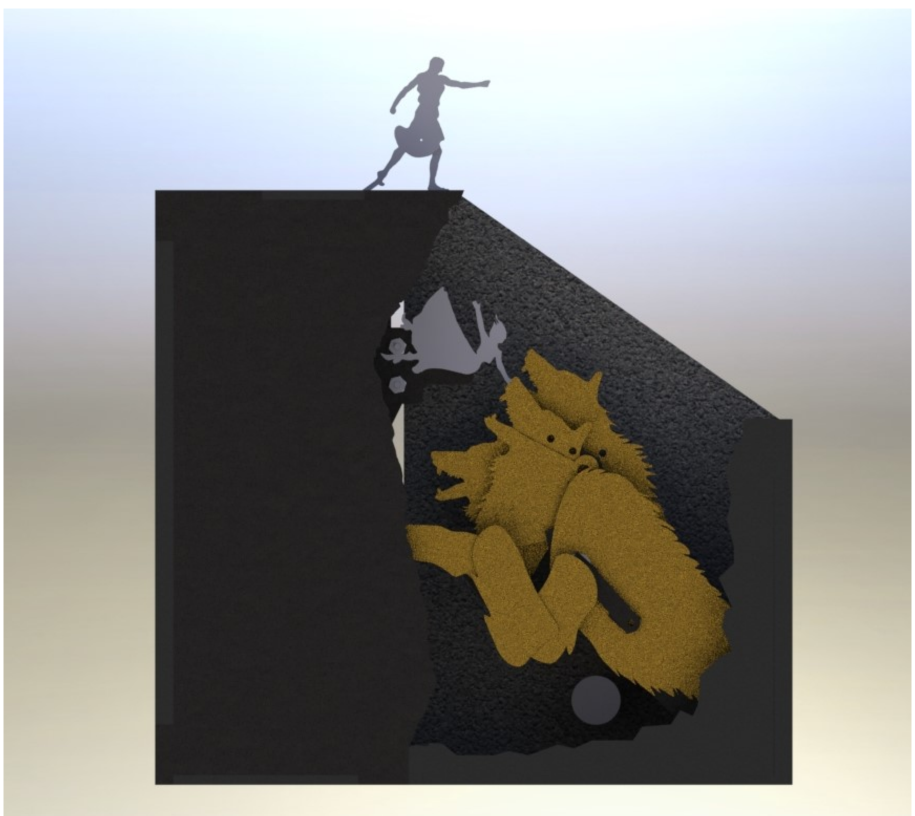


1 Executive Summary

Welcome to Hell, land of Hades and mythical creatures that lie beyond the surface world. We follow the myth of Orpheus and Eurydice, a tale where the brave Orpheus travels to the land of the dead to rescue his beloved Eurydice, only to turn around at the last moment to witness her be dragged back to the depths of hell. The mythical three-headed dog Cerberus leaps up over the River Styx to attack, as he dutifully guards the gates of the underworld to prevent Eurydice's spirit from escaping to the land above

Cerberus's legs are driven by a four-bar linkage that creates a pawing motion. Each of the three heads is driven by a separate cam so that they all move independantly of one another. The falling motion of Eurydice is achieved with a modified slot-slider: when she reaches the top, the slider pushes Orpheus's foot, causing him to lean over and look at her. When she reaches the bottom, she brushes against a limit switch, causing the purple glow of the LEDs in the River Styx to turn red.

Figure 1: Front photo of finished assembly

2 Detailed Design

2.1 Power Transmission

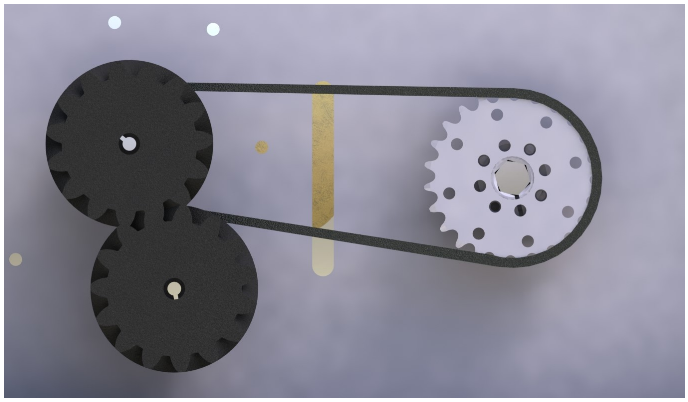


Figure 2: SolidWorks render of power transmission on back of box

I worked on the design of the power transmission subsystem. This subsystem starts with the motor, which is powered off a 12V power supply and is connected to a 4mm clamping hub that holds a 3D printed 15T helical gear. We chose to use helical gears here to ensure continuous motion even as the load changes, which happened with our vertical slot-slider. This gear meshes with another 15T 3D printed helical gear that shares a 3D printed 1/4in clamping hub with a 16T sprocket. This gear drives the shaft that powers the Cerberus sub-assembly. The 16T sprocket is chained to a 24T sprocket that drives the slot-slider sub-assembly through the 3/8in hex clamping hub.

2.2 Cerberus Sub-Assembly

Cerberus consists of two sub-sub-assemblies that work together to create the motion of the mythical creature. Cerberus's body utilizes a clock-cage structure that is mounted to the back aluminum plate. Both sides of the clock-cage are machined from 1/4in aluminum and are held together with posts made from 1/4in aluminum rod. The bolts that hold in these posts are also used to hold in the decorative plasma-cut brass plates. Bearings and bushings for moving components are press-fit into the aluminum plates to reduce slop in the system. In this sub-assembly, I designed the clock-cage and linkage assembly, Ever designed the cam assembly, and Eric designed the brass plates.

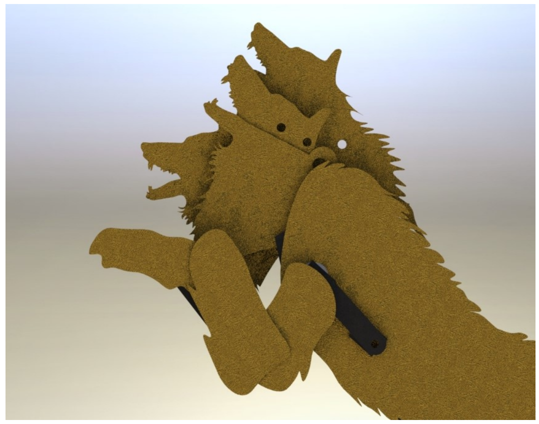


Figure 3: SolidWorks render of Cerberus sub-assembly

Figure 4: SolidWorks render of Cerberus cam sub-assembly

2.2.1 Cerberus Sub-Assembly: Cams

This sub-assembly is driven off of the helical gear from the power transmission. The 3 cams and custom hub are all 3D printed as one piece and are held onto the 1/4in shaft with a through-hole spring pin. The cam followers are laser-cut, and are secured axially on the clock-cage posts with retaining rings. Decorative plasma-cut dog heads are glued onto the followers, and these cause a notable imbalance in the cam. To offset the weight of the heads, rubber bands are tied to the back-end of the rods to pull the heads back up as the cam revolves.

The back two heads that move up and down share the same cam profile. However, the cam profiles for each cam are rotated slightly so that the heads move up and down at a slightly different time. The front head has a different cam profile to make it look like the head is biting instead of moving up and down.

2.2.2 Cerberus Sub-Assembly: Linkages

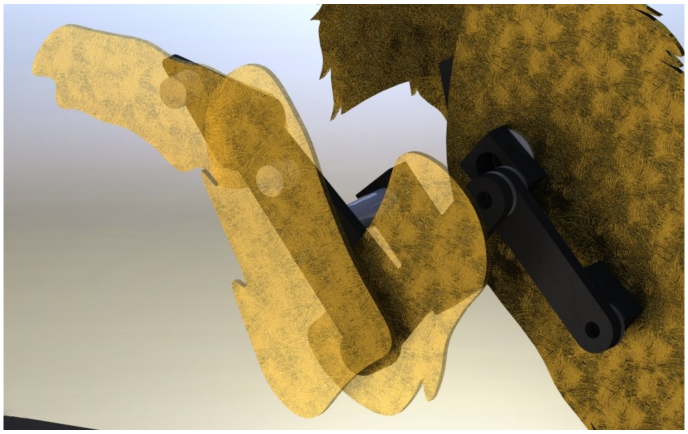


Figure 5: SolidWorks render of Cerberus leg linkage sub-assembly

Cerberus's leg is a 6 bar linkage that is powered by a 4 bar parallelogram linkage. One of the short bars on the parallelogram linkage share a shaft with the cams, and the other short bars is connected to the driving end of the 6 bar linkage. The longer linkages are made of acrylic, and the short ones that connect to the driving shafts are made of milled 1/4in aluminum.

The linkages are held together with brass rivets, and are mounted to the Cerberus clock-cage with a small threaded post. Washers are added in between moving surfaces to reduce friction in the subassembly. Decorative plates are glued to plastic standoffs that are also glued to the acrylic linkages.

2.3 Slot-Slider Sub-Assembly

Eric designed most of the slot-slider sub-assembly. The slot-slider is driven by the hex shaft from the power transmission, and its main linkages are made from acrylic. Delrin is used for the plates in direct contact with the slot in the 1/4in back plate, and acrylic is used for the spacer plates that bridge the gap between the Delrin and the linkages. A plasma-cut Eurydice is glued to a spacer that offsets her from the sliding mechanism such that she falls in-between two of Cerberus's moving heads.

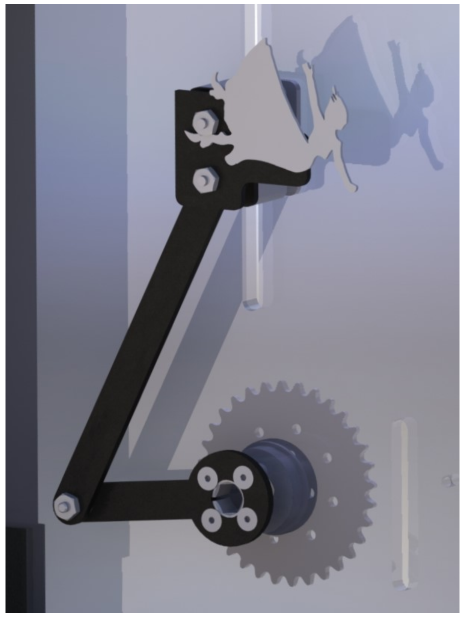


Figure 6: SolidWorks render of slot-slider subassembly

The slot-slider hits a limit switch that changes the lights from purple to red when Eurydice falls to the bottom of the sculpture. The wires and lights in this circuit are hidden by the river and the mud on the back plate. The circuit diagram for the sculpture is as follows:

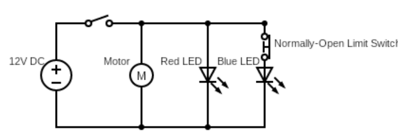


Figure 7: Circuit diagram with limit switch for LEDs and motor

2.4 Enclosure

Ben designed the enclosure for our sculpture. The front, bottom, and top plates are made from laser-cut hardboard, the left and right sides are made from 3/8in plywood, and the back plate is made from 1/4in aluminum. The hardboard and plywood sides are held to each other with finger joints and glue, and the aluminum is held in place with dado cuts into the plywood sides. The slot-slider,

Figure 8: Lights change from purple to red when Eurydice gets dragged back to Hell

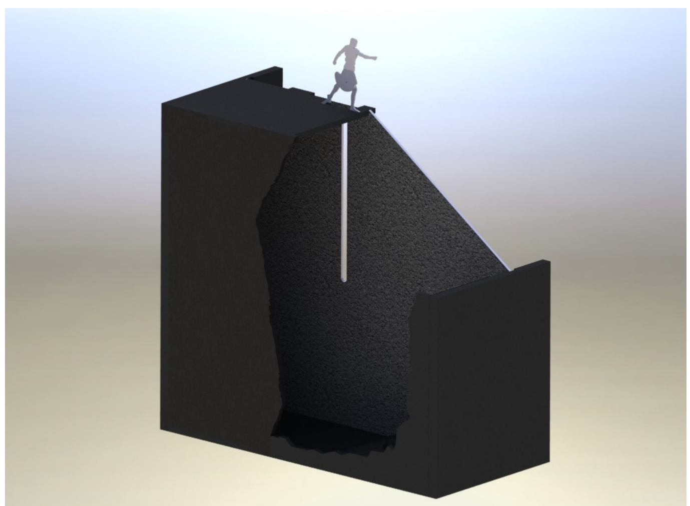


Figure 9: SolidWorks render of sculpture enclosure

power transmission, and Cerberus clock-cage are all mounted to the aluminum back plate.

Decorative elements of the box include fabric and acrylic to make the styx river, a mix of dirt and glue is used on the back plate, and a mix of dirt and glue and fabric are used on the right plate.

3 Team Contributions

3.0.1 Amy

I designed the linkage and power transmission sub-assemblies and machined a lot of parts on the mill and lathe.

Contributions:

- Designed linkage sub-assembly and power transmission
- CAD Integration
- Laser cut parts
- Milled small parts
- Turned some shafts
- Painted parts
- Lights + soldering
- Compiled 3D print order

3.0.2 Ben

Ben designed the box of our sculpture and was heavily involved with the assembly of the sculpture. He also did an amazing job finding interesting materials to use for different decorative elements of the sculpture.

Contributions:

- Designed box
- Shopbot parts
- Painted parts
- Did materials testing to determine the material used for each of the parts
- Added decorative elements to finished sculpture
- Assembly

3.0.3 Eric

Eric designed the slot-slider sub-assembly and made all the decorative plates on our sculpture. He did an especially great job with the design of the decorative elements and integrated them flawlessly with the structural elements of the sculpture.

Contributions:

- Designed slot-slider sub-assembly
- Designed decorative plates (Cerberus, Orpheus, Eurydice)
- Plasma cut parts (Cerberus, Orpheus, Eurydice)
- Assembly

3.0.4 Ever

Ever designed the cam sub-assembly and did a lot of machining on our sculpture. He also did a really good job with fixing errors in the CAD as they came up as we were integrating our different sub-assemblies.

Contributions:

- Designed cam sub-assembly
- Fixed CAD errors
- Milled back plate (most difficult + time-consuming part)
- Turned some shafts
- Assembly

4 Personal Reflection

Our final sculpture looked remarkably like the CAD, which we considered a good thing since that meant we needed few alterations to our design for the sculpture to work successfully. Some mechanical things that were less than ideal included our 4mm clamping hub slipping (which needed some glue to fix), the leg linkage rocked back and forth instead of making a full revolution, the cam shaft was too short (we didn't account for space of bolt heads and an extra back plate was needed to help support the components), and several of our parts weren't machined in the same way we had planned to machine them (we got lucky things worked out, but this could've ended badly if our parts weren't machinable).

Figure 10: Side-by-side comparison of CAD render and physical model

As a team, I think we started off well in high spirits and had a good plan with reasonable organization, but around midway through the project we all started getting really busy and lost track of our current progress in the project. The meetings during this time were also rather lackluster since none of us brought forth good energy or our best selves – we did continue to make steady progress, but there was not a whole lot of enthusiasm for the project during these meetings. If this were to happen again, perhaps setting aside some dedicated time for team bonding might've boosted team morale. One of our main goals as a team at the start was to finish the project early, and while we started the project off with a good start we didn't maintain that momentum through the end. The last night was a lot later than we had aimed for, which was unfortunate. Next time, this could've been fixed if we had kept a better "progress log" to make sure we were on track and distributed the work over a series of "sprints" instead of one long marathon at the end.

On an individual level, I felt that I did a good job with making time for MechProto to get a head-start on machining before there was lots of demand for the machines. Even when the semester got really busy, I still made time during the day since I knew if I waited till later the work would take more time since I'd have to wait in a queue for the machines. Due to this, I felt that I did put in more time at the beginning of the project, but I still don't feel great about the fact that I wasn't there for the late-night last push the night before. I'm still not sure how I feel about this – while I do think my absence was reasonable in some sense since I put a lot more time up front with the machining and assembly and recognize my own limitations when it comes to staying up late, it also doesn't feel great to know that I wasn't there when help was needed most. I'm also not sure how the others feel about it – I can see there being frustration since the project ran late and we all weren't there, but at the same time we prioritized our work differently throughout most of the project. I think next time, this situation could be better remedied if I had communicated this well in advance of the night before it was due.

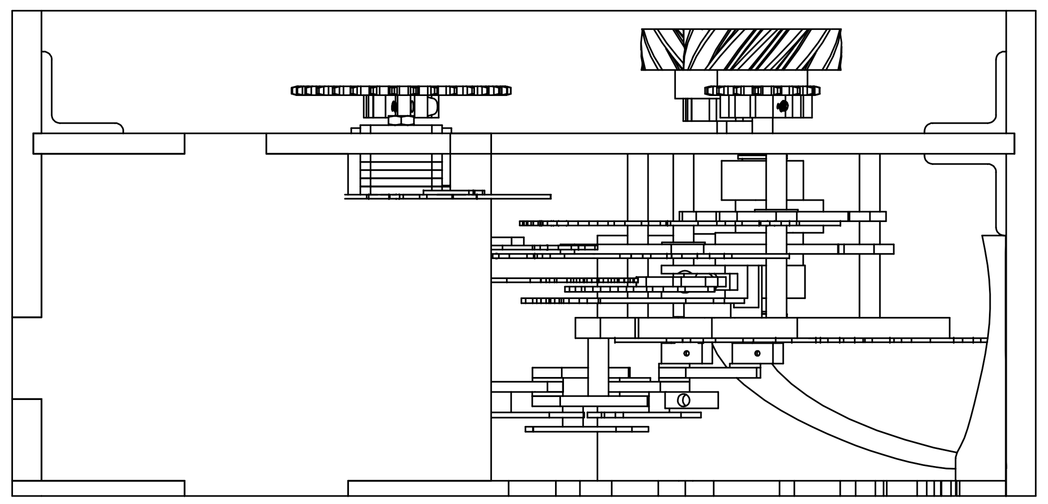
5 Conclusion

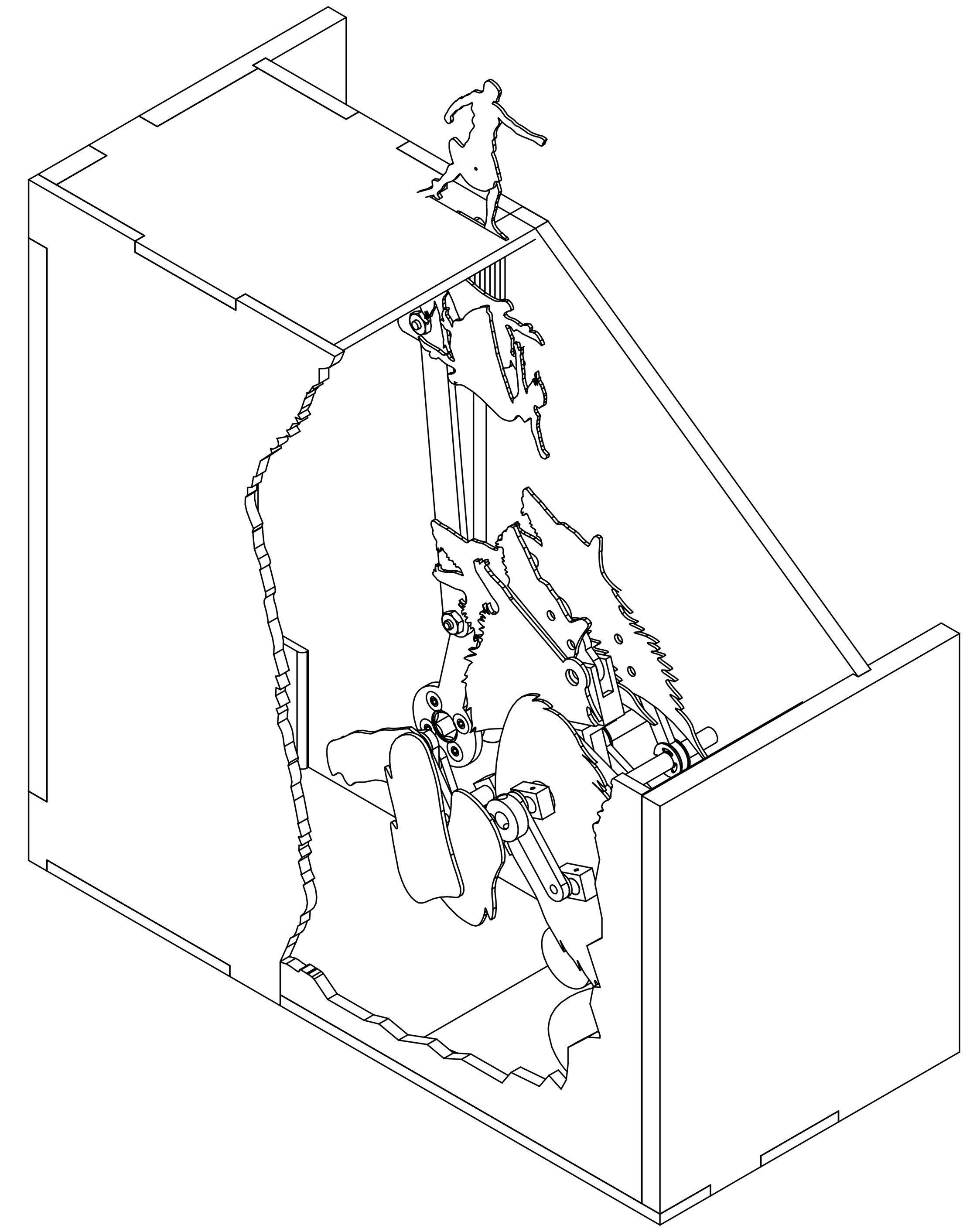
In the end, I was pretty happy with how our project turned out, especially since I was able to get more practice with skills that are useful to me as a Robo:E. As a Robo:E, one of the most interesting and informative parts of any project is the systems integration component, and this project was particularly interesting since we successfully attempted to merge a mechanical project with organic elements and LEDs while making everything look like it “belonged” together. The organic elements and extra circuitry added another layer of necessary integration for our sculpture to work but it was in line with the skills I’m trying to develop at Olin overall, which was very fulfilling.

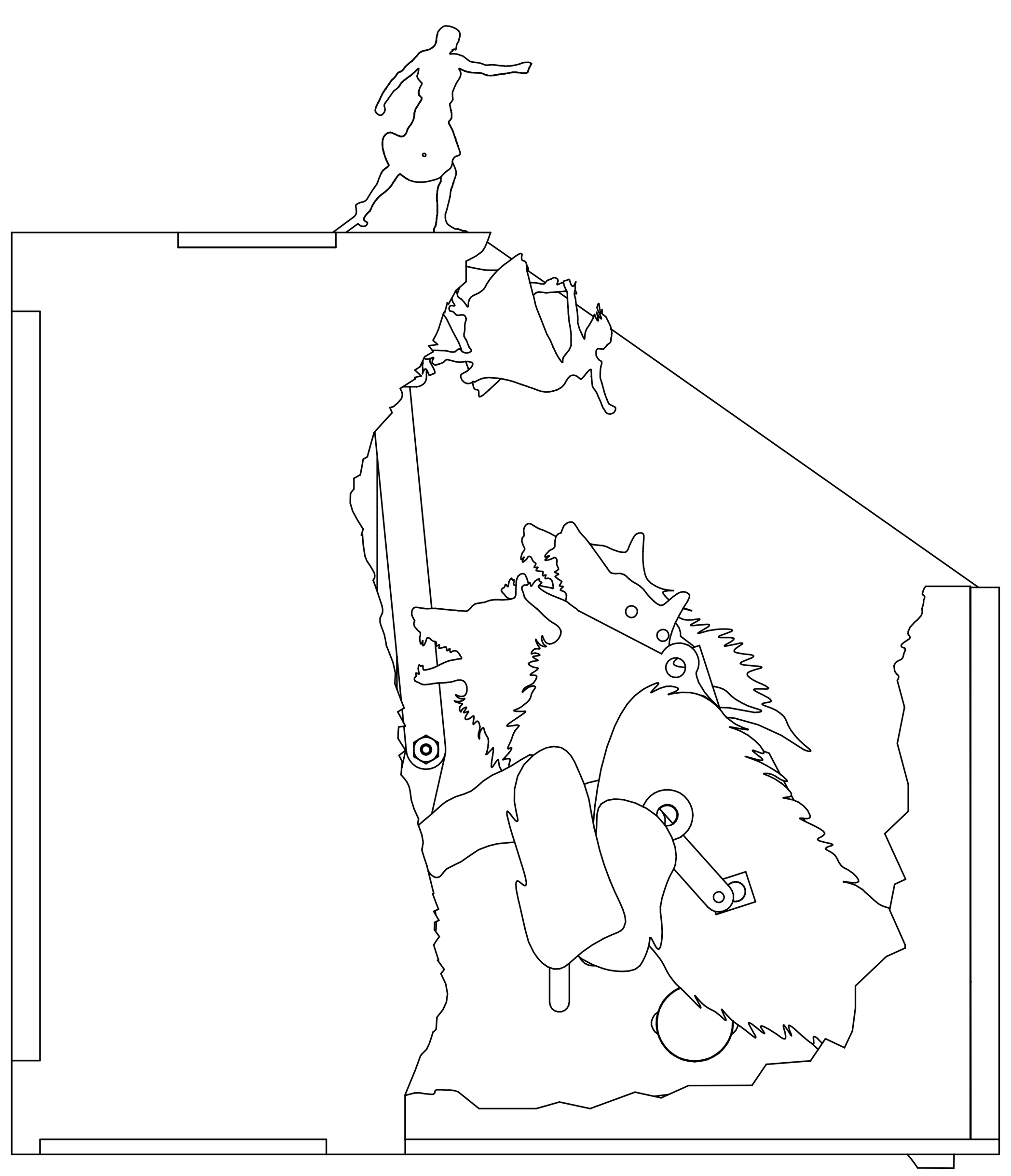
6 Appendix

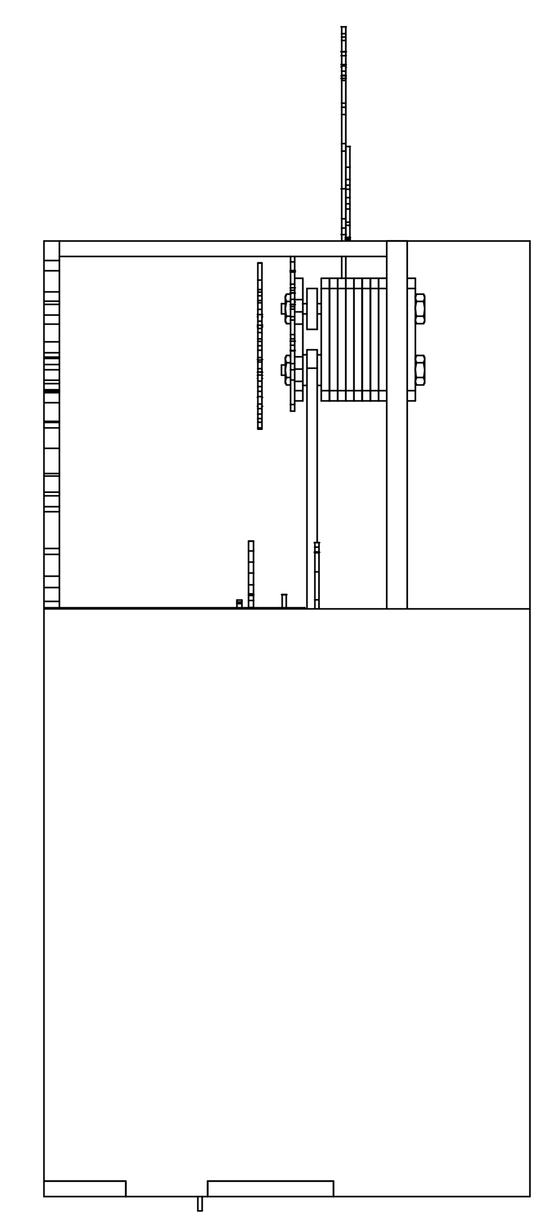
See following pages for bill of materials, assembly drawings, and individual part drawings

ITEM NO.	PART NUMBER	FABRICATION METHOD	MATERIAL	QTY.
	CLOCKCAGE			
1	clockcage_bottom	Laser Cut	Hardboard	1
2	clockcage_cliff	Laser Cut	Hardboard	1
3	clockcage_leftwall	Laser Cut	Hardboard	1
4	clockcage_rightwall	Laser Cut	Hardboard	1
5	clockcage_backwall	Mill	Aluminum	1
6	clockcage_platform	Laser Cut	Hardboard	1
7	clockcage_bracket	Bandsaw + Drill Press	Aluminum	3
8	dirtwall	Glue	Dirt + Wood Glue	1
9	clockcage_cliff2	3D Print	PLA	1
	SLOT SLIDER			
10	wheel_link	Laser Cut	Acrylic	1
11	Arm	Laser Cut	Acrylic	1
12	Slider_Plate	Bandsaw + Drill Press	Delrin	9
13	Spacer	Laser Cut	Acrylic	2
14	arcylicSpacer	Laser Cut	Acrylic	1
15	pla_slider_plate	3D-print	PLA	1
16	0.125 Aluminum Shaft^Eurydice_Slider	Bandsaw	Aluminum	2
17	orpheus_final	Plasma Cut	Steel	1
18	leg_final	Plasma Cut	Steel	1
19	body_final	Plasma Cut	Steel	1
20	eurydice	Plasma Cut	Steel	1
	CERBERUS			
21	outer_structural_plate	Mill	Aluminum	1
22	mill_power_transfer	Mill	Aluminum	2
23	acrylic_power_transfer _link	Laser Cut	Acrylic	1
24	Cams	3D Print	Onyx	1
25	chompCamSupport	3D Print	Onyx	1
26	transferRodChompy	Laser Cut	Acrylic	1
27	headLink	Laser Cut	Acrylic	1
28	dog Head 2 TransferRod	Laser Cut	Acrylic	1
29	dog head 3 transfer rod	Laser Cut	Acrylic	1
30	camRod	Bandsaw	Aluminum	1
31	camRod1	Bandsaw	Aluminum	1
32	camRod2	Bandsaw	Aluminum	1
33	camRod-Support	Lathe	Steel	2
34	support-rod	Lathe	Steel	1
35	link3	Laser Cut	Acrylic	1
36	link4	Laser Cut	Acrylic	1
37	link1	Laser Cut	Acrylic	1
38	link2	Laser Cut	Acrylic	1
39	Standoff	COTS	Delrin	3
40	Upper_Leg_Plate	Plasma Cut	Brass	1
41	Lower_Leg_Plate	Plasma Cut	Brass	1
42	Paw_Plate	Plasma Cut	Brass	1
43	Head_Plate_One	Plasma Cut	Brass	1
44	Head_Plate_Two	Plasma Cut	Brass	1
45	Upper_Jaw_Plate	Plasma Cut	Brass	1
46	Lower_Jaw_Plate	Plasma Cut	Brass	1
47	Body_Plate	Plasma Cut	Brass	1
48	Helical gear 12DP 15T 45HA 20PA 0.5FW	3D Print	Onyx	2
49	0.25 Clamping Hub	3D Print	Onyx	2
	COTS COMPONENTS			
50	Steel Washer #6 Screw, 0.156" ID, 0.375" OD	COTS - McMaster 98023A112	Steel	19
51	Steel Hex Nut, 6-32 Thread Size	COTS - McMaster 90480A007	Steel	7
52	4mm Clamping Hub	COTS	Aluminum	1
53	0.375 Hex Clamping Hub	COTS - ServoCity 545672	Aluminum	1
54	24T Sprocket	COTS - ServoCity 615106	Aluminum	1
55	16T Sprocket	COTS - ServoCity 615102	Aluminum	1
56	56 RPM Econ Gear Motor	COTS - ServoCity 638348	motor	1
57	Hex Bearing	COTS - VexRobotics 217-2735	Aluminum	1
58	Flanged Sleeve Bearings 1/4" Shaft Diameter, 1/4" Long	COTS - McMaster 1677K1	Bronze	1
59	Two-Piece Rivets 0.112" Diameter	COTS - McMaster 96082A100	Brass	4
60	Stainless Steel Slotted Spring Pin 1/16" Diameter	COTS - McMaster 92373A113	Stainless Steel	3
61	1/4" ID X 1/2" OD Flanged Ball Bearing	COTS - ServoCity 535198	Metal	3
62	Chain	COTS - ServoCity 615146	Metal	1
63	Side-Mount External Retaining Ring for 1/4" Shaft	COTS - McMaster 98398A134	Steel	6









Mech Proto Team 1

TITLE:

Welcome to Hell

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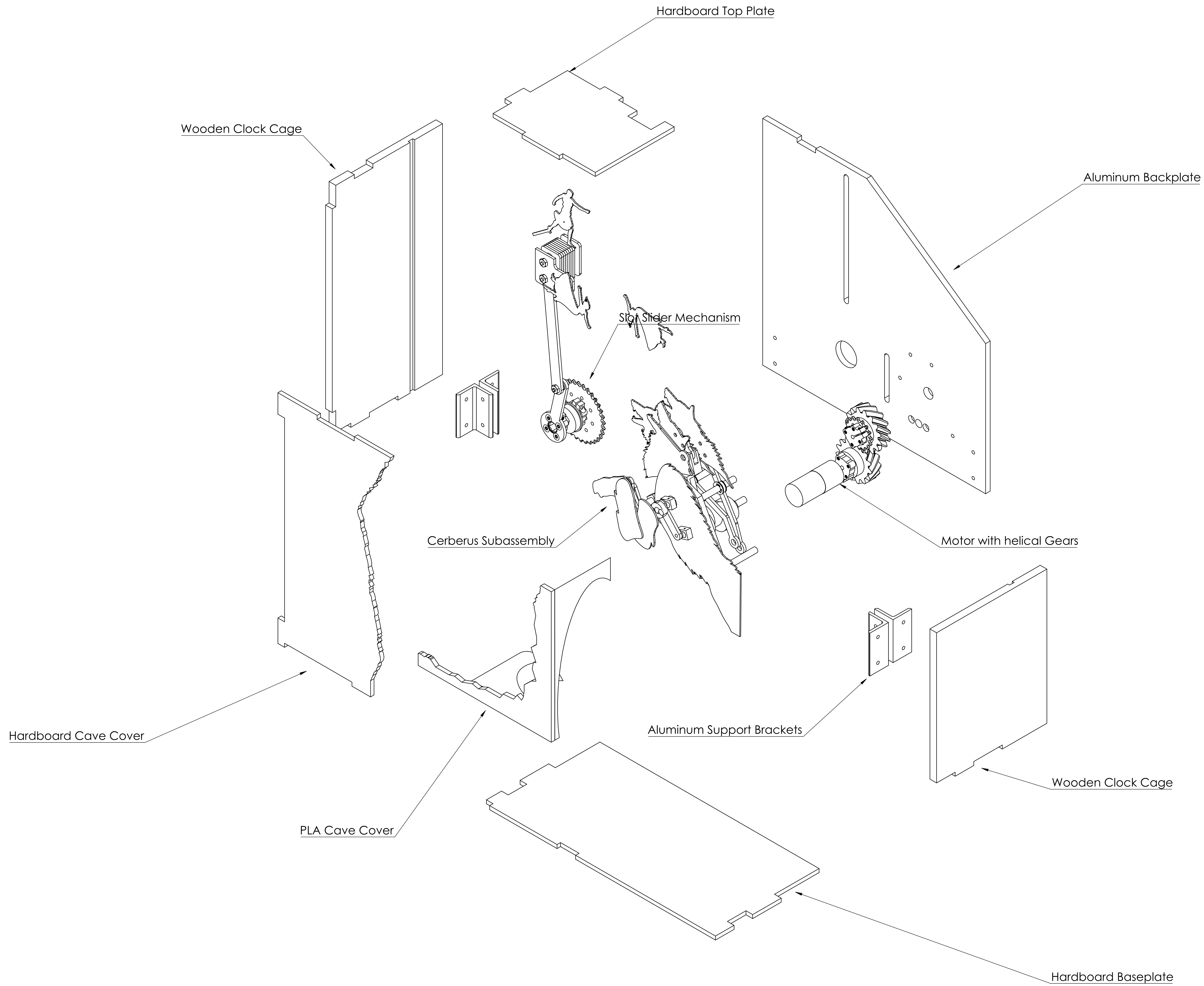

Mech Proto Team 1

TITLE:

Welcome to Hell

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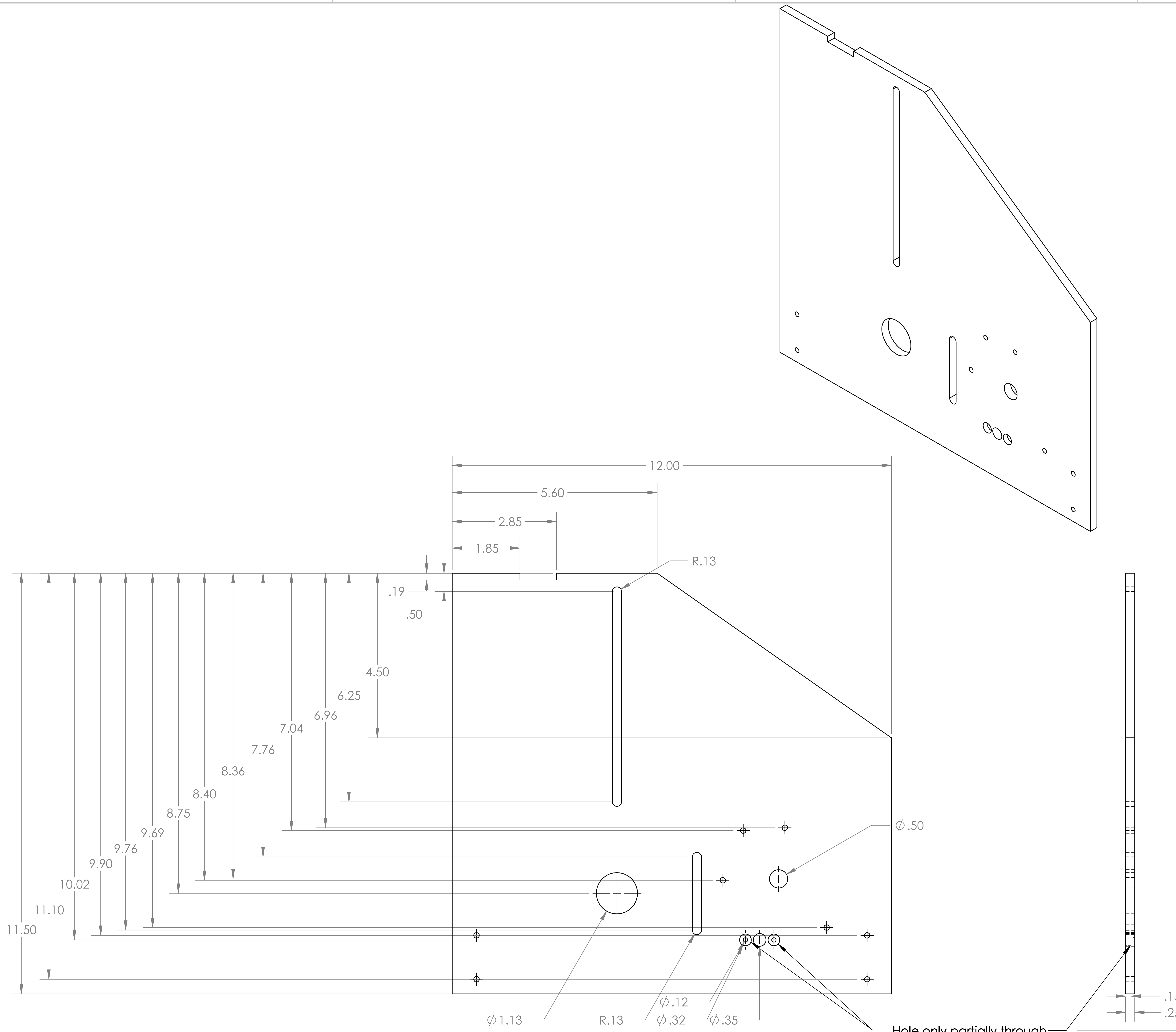

All holes are 0.15in in diameter unless otherwise marked

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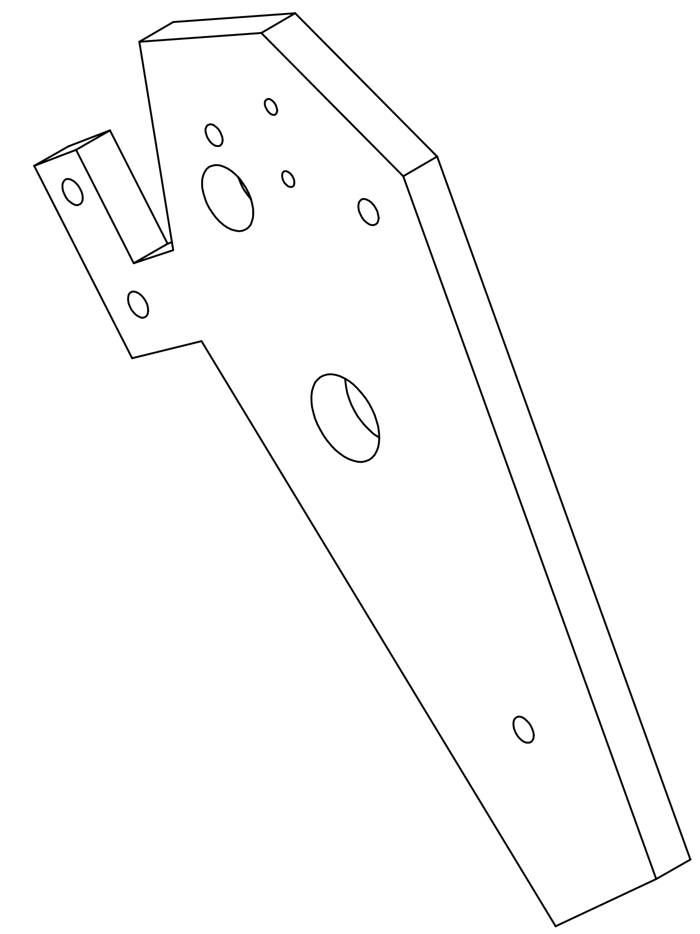
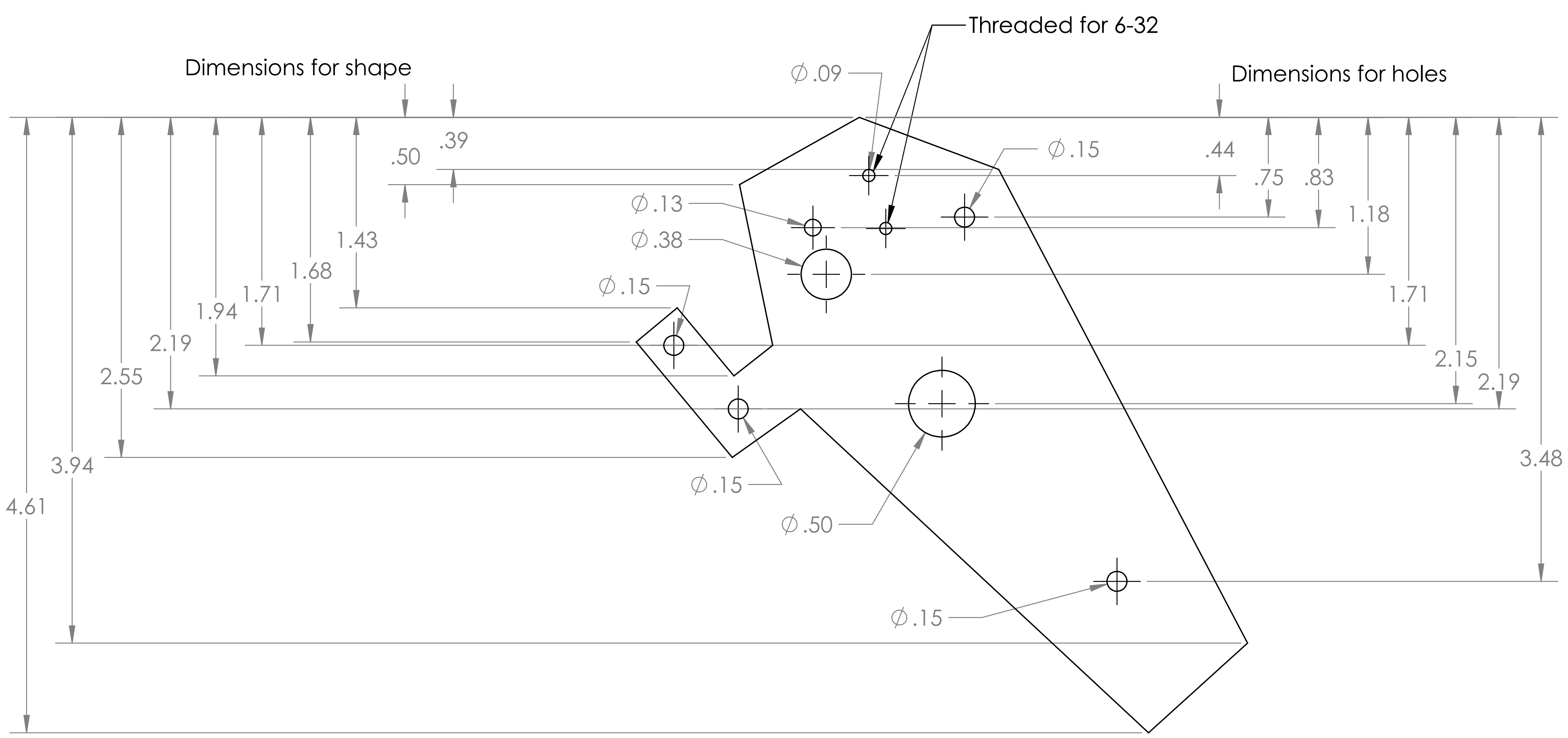
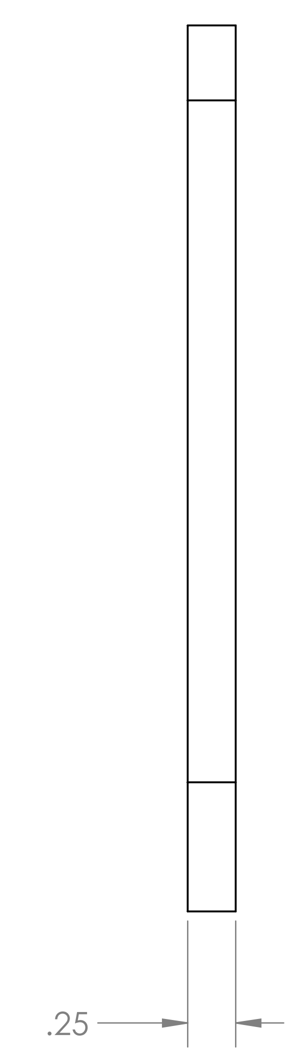
DO NOT SCALE DRAWING			SCALE: 1:2 WEIGHT: SHEET 1 OF 1







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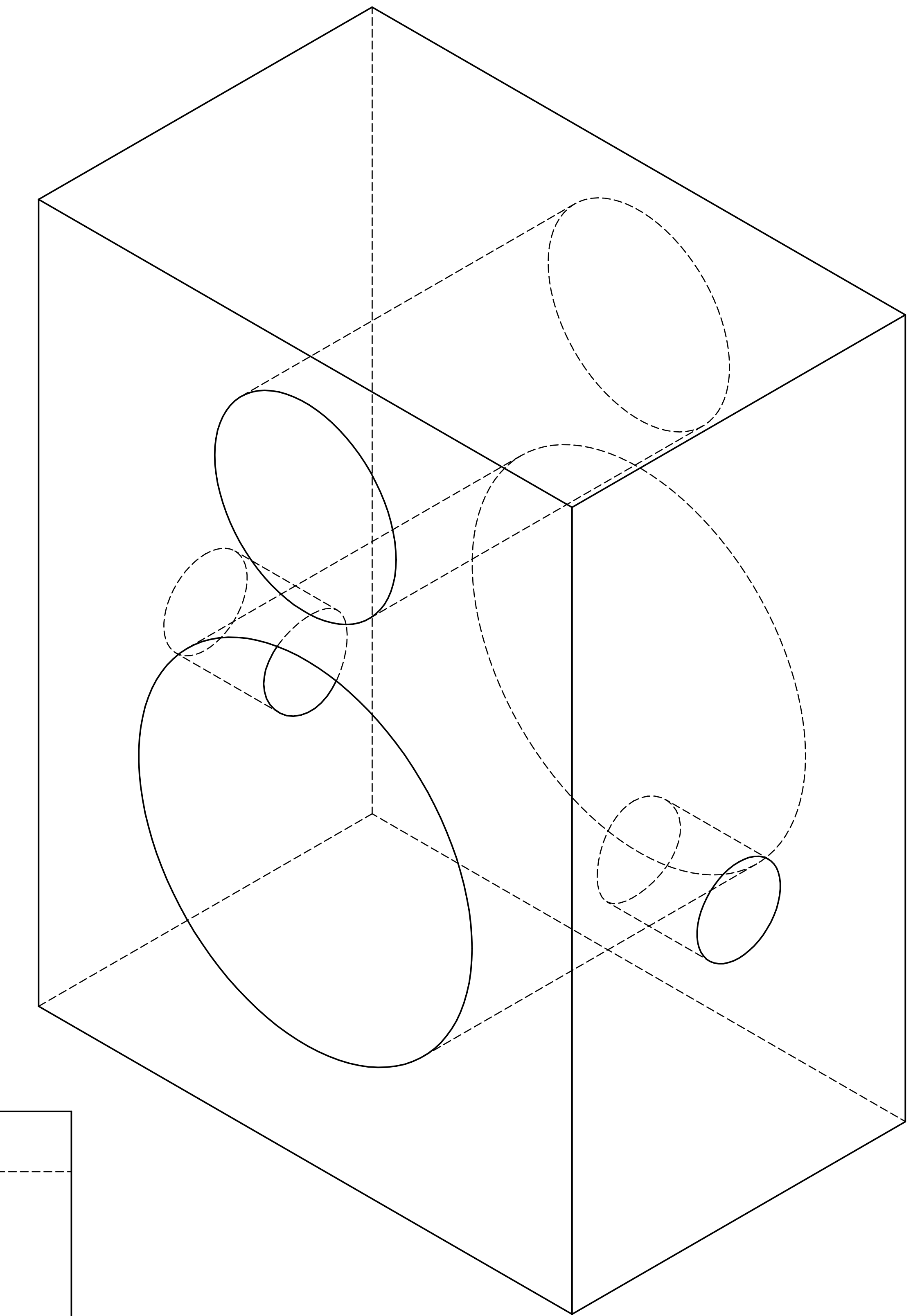

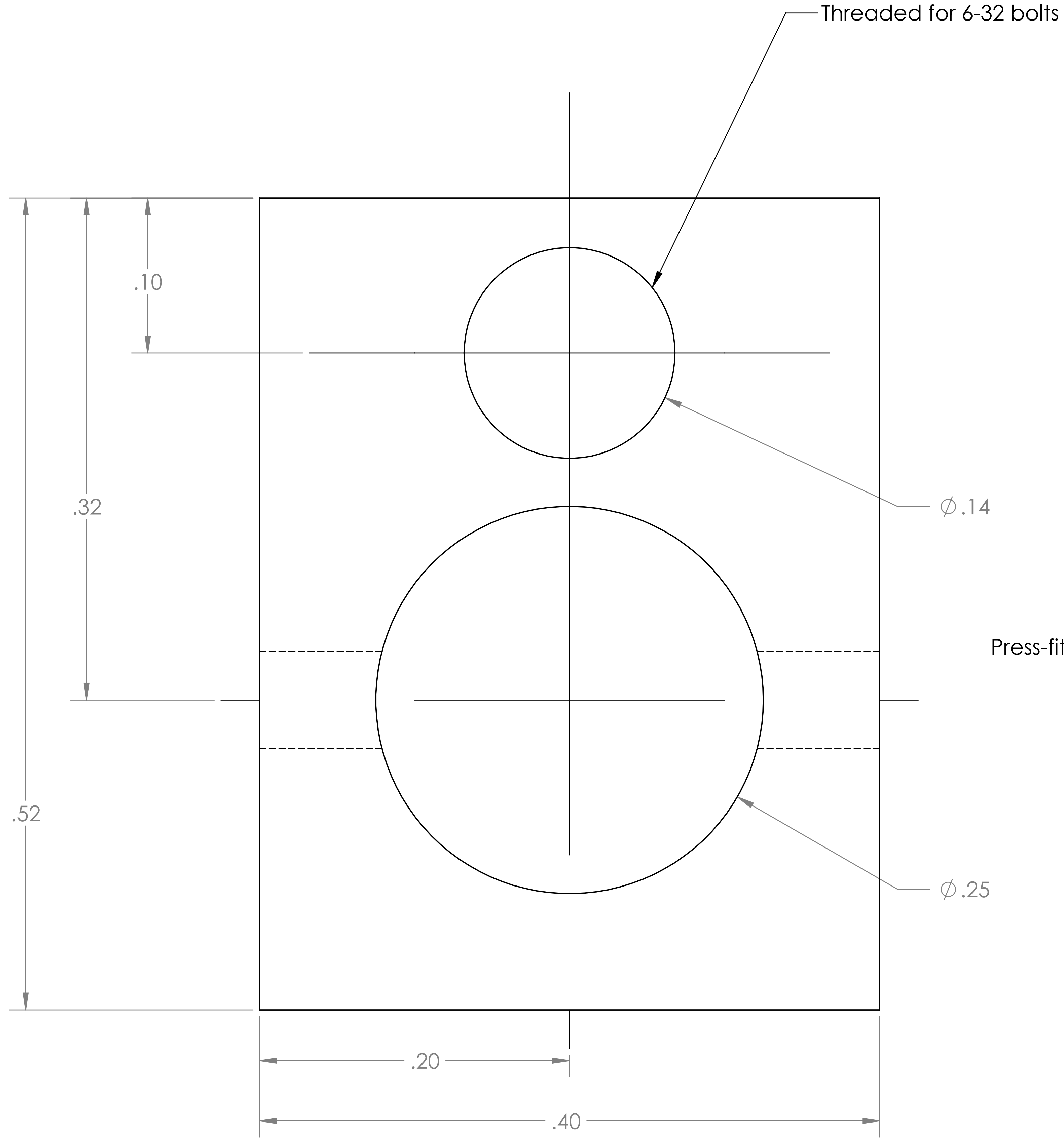

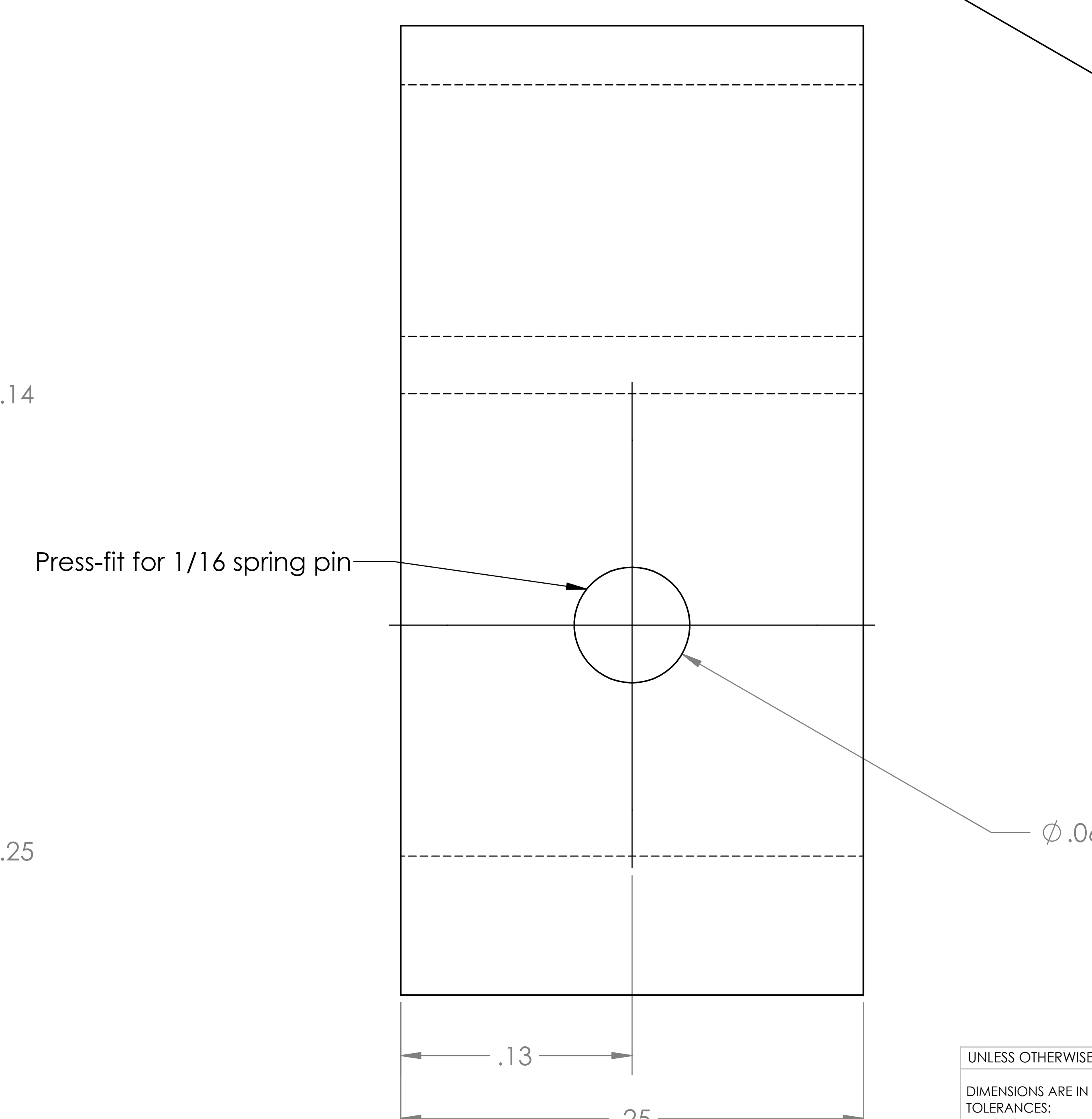

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ± .01
THREE PLACE DECIMAL ± .001

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
1/4in Aluminum Plate

FINISH
Black Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Amy Phung	5/9/19

COMMENTS:

Quantity: 2

ENGR 2330 Mech Proto

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Power Transfer Link

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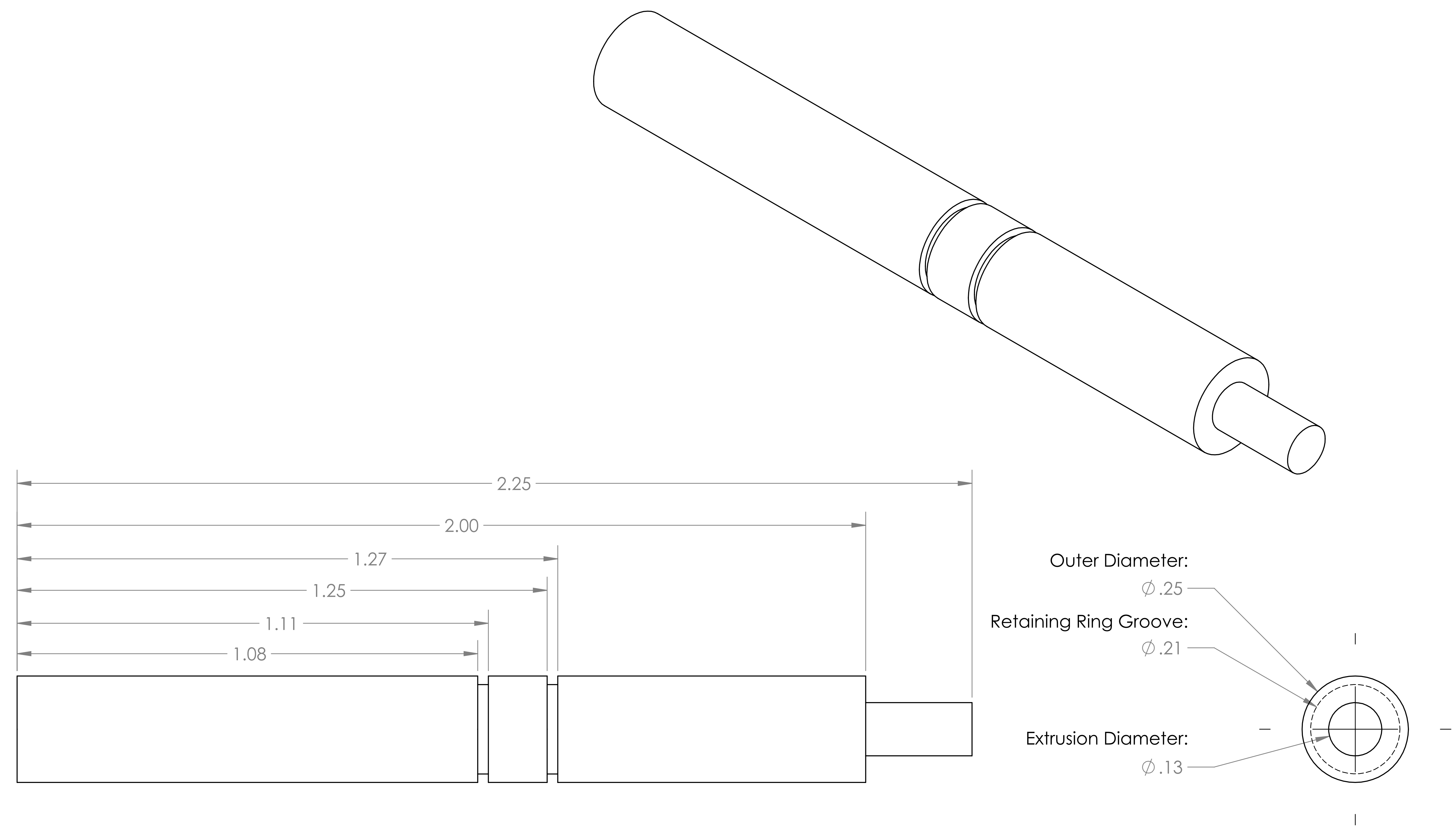

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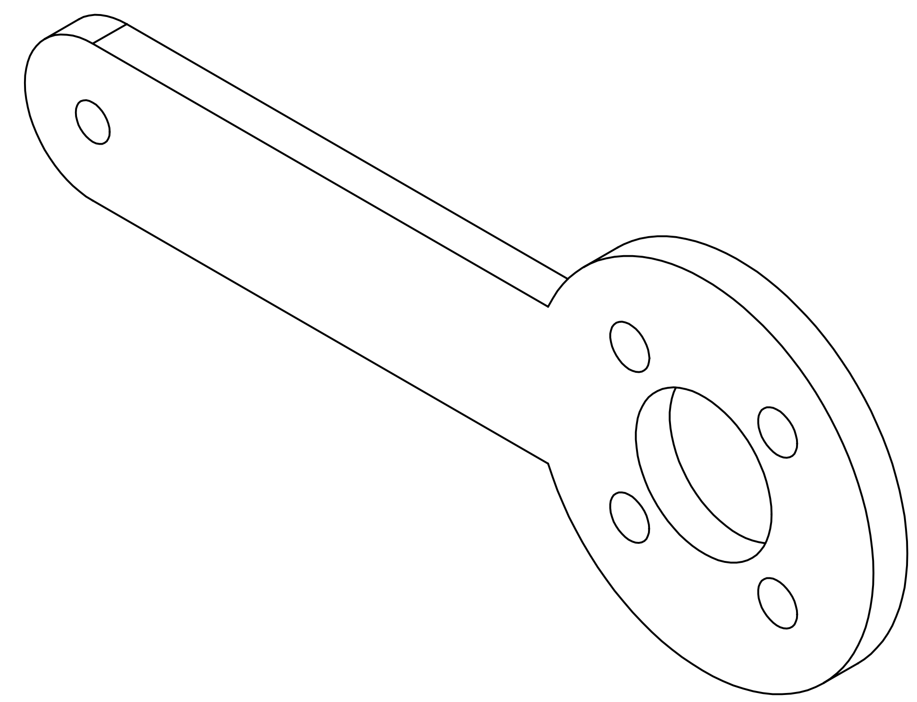

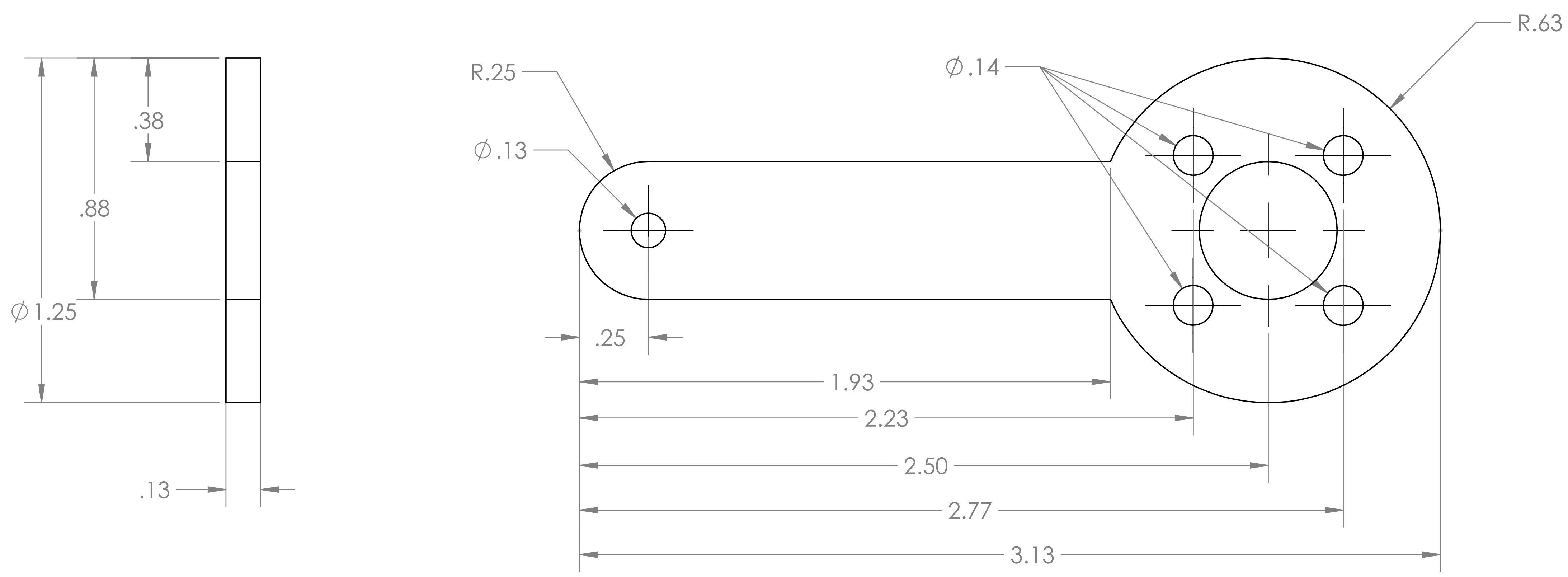

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