Summer 8-19-2017

JME 4110 – Media Plate Wrapping Device

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Please **embargo** this document for **one year**

(at least until August 2018).

Thank you!

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Joint Engineering Program

University of Missouri–St. Louis ▪ Washington University in St. Louis

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This document provides an in depth analysis on a device that will wrap media plates (petri dishes) in plastic wrap or tape. This report includes the reasoning for design decisions, from interviews with our client, to engineering analysis. All CAD drawings are included. from initial to final design, as well as the selection process for our final design. Also included are pics of the design process and a video link to the working design.

JME 4110
Mechanical Engineering
Design Project

Media Plate Wrapping Device

John Hahler
Wade Twellman
Isaac Asaro

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1 Introduction

1.1 Value Proposition / Project Suggestion

Our Media Plate Wrapping Device will make wrapping media plates (petri dishes) very easy, and with much less effort than before. The design is simple, reliable, and is easy to wash, which is very important criteria for the lab technicians that will be using this at the Danforth Plant Science Center.

1.2 List of Team Members

Our team consists of John Hahler, Wade Twellman, and Isaac Asaro.

2 Background Information Study

2.1 Design Brief

Currently the only way to wrap these plates is by hand. Our design allows the user to load the plate onto a turntable with a non slip grip. This bottom also has a weighted hockey puck design top that allows the user to rotate the hockey puck into device, clamping the plate in place. Then a motor mounted underneath the box turns the turntable.

2.2 Background Summary

https://www.youtube.com/watch?v=3amBu_Y4kAQ
(http://www.phoenixwrappers.com/packaging-equipment/automatic/prta-2100-overview.php)

(http://www.phoenixwrappers.com/packaging-equipment/automatic/pcta-2300-overview.php)

3 Concept Design and Specification

3.1 User Needs and Metrics

3.1.1 Record of The User Needs Interview

Project/Product Name: Automated Petri Dish Wrapper Customer: Veena Veena Address: 975 N Warson Rd, St. Louis, MO 63132 Willing to do follow up? Yes Type of user: Lab technician Currently uses: Wrapping by hand Interviewer(s): John Hahler, Wade Twellman, Isaac Asaro Date: 06/22/17			
Need Number	Question	Need	Importance

1	How fast should our device wrap your petri dishes?	1 minute	5
2	How big of an area should this device fit in (in inches)?	14” x 14”	5
3	How often will you be using this?	Multiple times a day.	3
4	How long will this device be used in one day?	Depends, could be anywhere from 1-4 hours	4
5	Do you intend this to be a permanent installation?	No, it needs to be portable.	2
6	Can this be used with a 110 volt wall outlet?	Make the motor powered by 110 VAC	4
7	How much can this thing weigh?	Less than 20 pounds	2
8	How fast does it need to process the plates so that a hopper is not required?	Less than 30 seconds	4
9	How fast does it need to process the plates with a hopper?	2 minutes	1
10	How many dishes do you want the hopper to be able to hold?	Approximately 20 - one package	3
11	What price would you consider reasonable for the device?	$250	3
12	What would would be the most you would spend for the device?	$500	5

13	How important is it that it can be used for either petri dish size?	Not very much.	2
14	Which petri dish size do you most prefer the device to wrap?	Either one	1

Table 2: Identified Metrics

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1, 3, 8, 9	Time per Plate	Seconds	2	120
2	7	Weight	Pounds	0	20
3	2, 5, 6, 7	Portability	Percent	0	100
4	2	Width	Inches	6	20
5	2	Length	Inches	6	14
6	8, 9, 10	Dishes Held	dishes/stack	10	20
7	3, 4	Duty Cycle	Hours/Use	.5	3
8	11, 12	Cost	US Dollars	0	500
9	13, 14	Can use either size petri dish	Binary	0	1

3.1.2 List of Identified Metrics

Table 3: Concept 1 Quantified Needs Matrix

Automated Petri Dish Wrapper		Metric: Time per Plate	Weight	Removable	Width	Length	Dishes Held	Duty Cycle	Cost	Variable Size Petri Dish	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9			
1	Speed of the entire process	1									0.847457	0.114	0.096302
2	Size of device			0.3	0.35	0.35					0.4075	0.114	0.046306
3	Quickness of setup	0.6						0.4			0.908474	0.068	0.061941
4	Durability							1			1	0.091	0.090909
5	Portability							1			1	0.045	0.045454
6	Compatible with 110V outlet			1							0.9	0.091	0.081818
7	Light (not heavy)		0.6	0.4							0.51	0.045	0.023181
8	Speed per plate without hopper	0.5					0.5				0.448728	0.091	0.040793
9	Speed per plate with hopper	0.5					0.5				0.448728	0.023	0.010198
10	Dishes the hopper will hold						1				0.05	0.068	0.003409
11	Affordableness								1		0.25	0.068	0.017045
12	Max price								1		1	0.114	0.025
13	Compatibility									1	1	0.045	0.075
14	Dish Preference									1	0	0.023	0
Units		Seconds	Pounds	Percent	Inches	Inches	Dish/Sta	Hrs/Use	USD	Binary	Total Happiness		0.6174
Best Value		2	0	100	6	6	20	3	0	1			
Worst Value		120	20	0	20	14	0	0.5	500	0			
Actual Value		20	15	90	18	12	1	3	375	0			
Normalized Metric Happiness		84745762	0.25	0.9	14285714	0.25	0.05	1	0.25	0			

Table 4: Concept 2 Quantified Needs Matrix

Automated Petri Dish Wrapper		Metric: Time per Plate	Weight	Removable	Width	Length	Dishes Held	Duty Cycle	Cost	Variable Size Petri Dish	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9			
1	Speed of the entire process	1									0.847457	0.114	0.096302
2	Size of device			0.3	0.35	0.35					0.4075	0.114	0.046306
3	Quickness of setup	0.6						0.4			0.908474	0.068	0.061941
4	Durability							1			1	0.091	0.090909
5	Portability							1			1	0.045	0.045454
6	Compatible with 110V outlet			1							0.9	0.091	0.081818
7	Light (not heavy)		0.6	0.4							0.51	0.045	0.023181
8	Speed per plate without hopper	0.5					0.5				0.448728	0.091	0.040793
9	Speed per plate with hopper	0.5					0.5				0.448728	0.023	0.010198
10	Dishes the hopper will hold						1				0.05	0.068	0.003409
11	Affordableness								1		0.25	0.068	0.017045
12	Max price								1		1	0.114	0.025
13	Compatibility									1	1	0.045	0.075
14	Dish Preference									1	1	0.023	0.022727
Units		Seconds	Pounds	Percent	Inches	Inches	Dish/Sta	Hrs/Use	USD	Binary	Total Happiness		0.6401
Best Value		2	0	100	6	6	20	3	0	1			
Worst Value		120	20	0	20	14	0	0.5	500	0			
Actual Value		20	15	90	18	12	1	3	375	1			
Normalized Metric Happiness		84745762	0.25	0.9	14285714	0.25	0.05	1	0.25	1			

Table 5: Concept 3 Quantified Needs Matrix

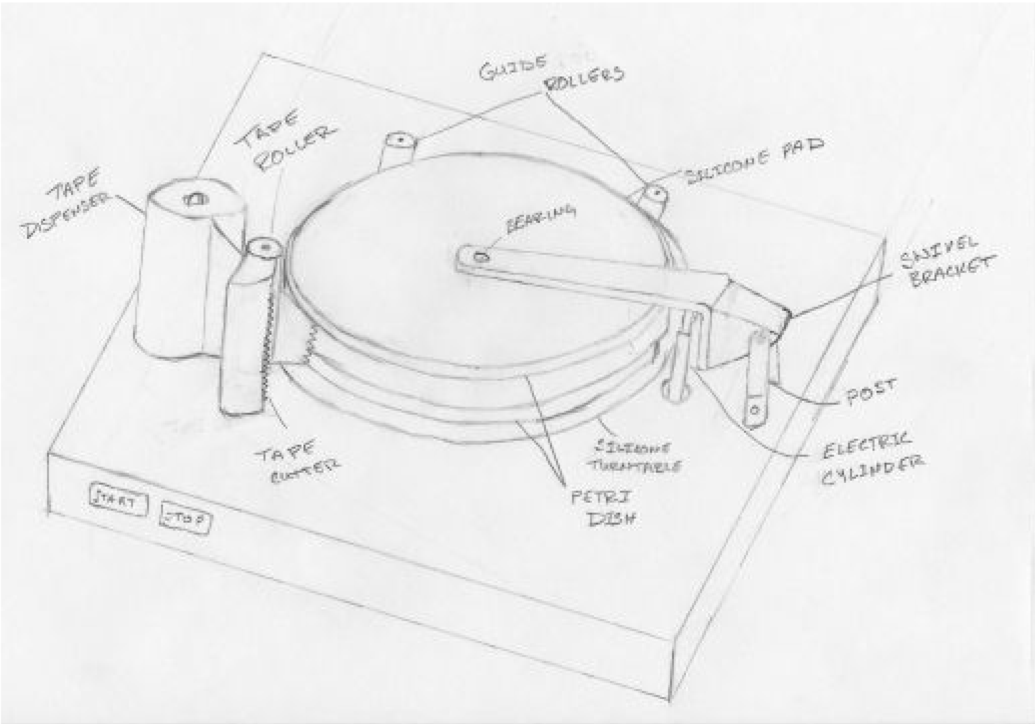
Automated Petri Dish Wrapper		Metric											
		Time per Plate	Weight	Removable	Width	Length	Dishes Held	Duty Cycle	Cost	Variable Size Petri Dish	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9			
1	Speed of the entire process	1									0.847457	0.114	0.096302
2	Size of device			0.3	0.35	0.35					0.035	0.114	0.003977
3	Quickness of setup	0.6						0.4			0.908474	0.068	0.061941
4	Durability							1			1	0.091	0.090909
5	Portability							1			1	0.045	0.045454
6	Compatible with 110V outlet			1							0.7	0.091	0.063636
7	Light (not heavy)		0.6	0.4							0.34	0.045	0.015454
8	Speed per plate without hopper	0.5					0.5				0.923728	0.091	0.083975
9	Speed per plate with hopper	0.5					0.5				0.923728	0.023	0.020993
10	Dishes the hopper will hold						1				1	0.068	0.068181
11	Affordableness								1		0.25	0.068	0.017045
12	Max price								1		1	0.114	0.025
13	Compatibility									1	1	0.045	0.075
14	Dish Preference									1	1	0.023	0.022727
Units		Seconds	Pounds	Percent	Inches	Inches	Dish/Sta	Hrs/Use	USD	Binary	Total Happiness		0.6906
Best Value		2	0	100	6	6	20	3	0	1			
Worst Value		120	20	0	20	14	0	0.5	500	0			
Actual Value		20	18	70	20	18	20	3	375	1			
Normalized Metric Happiness		847457627	0.1	0.7	0	-0.5	1	1	0.25	1			

Table 6: Concept 4 Quantified Needs Matrix

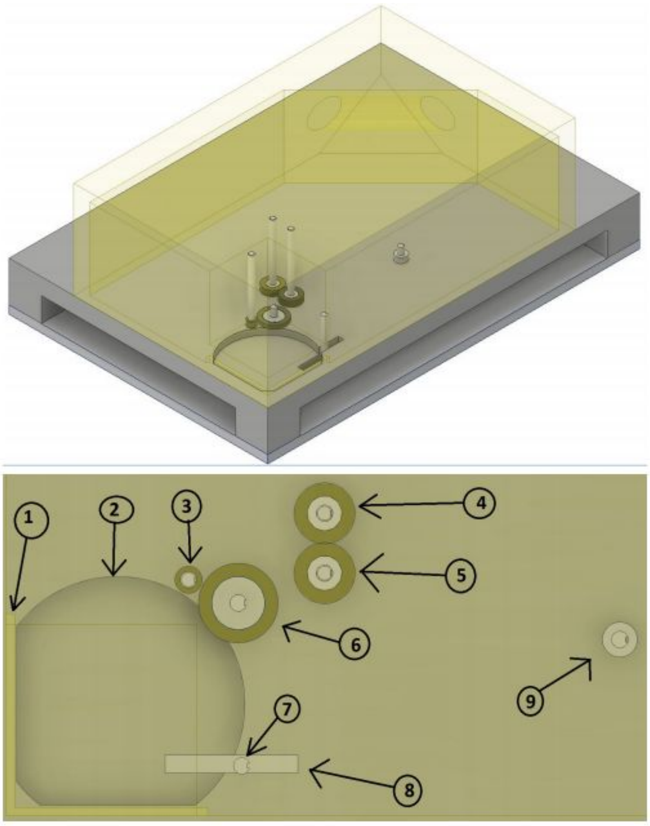
Automated Petri Dish Wrapper		Metric											
		Time per Plate	Weight	Removable	Width	Length	Dishes Held	Duty Cycle	Cost	Variable Size Petri Dish	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9			
1	Speed of the entire process	1									0.847457	0.114	0.096302
2	Size of device			0.3	0.35	0.35					0.5875	0.114	0.066761
3	Quickness of setup	0.6						0.4			0.908474	0.068	0.061941
4	Durability							1			1	0.091	0.090909
5	Portability							1			1	0.045	0.045454
6	Compatible with 110V outlet			1							1	0.091	0.090909
7	Light (not heavy)		0.6	0.4							0.55	0.045	0.025
8	Speed per plate without hopper	0.5					0.5				0.923728	0.091	0.083975
9	Speed per plate with hopper	0.5					0.5				0.923728	0.023	0.020993
10	Dishes the hopper will hold						1				1	0.068	0.068181
11	Affordableness								1		0.25	0.068	0.017045
12	Max price								1		1	0.114	0.025
13	Compatibility									1	1	0.045	0.075
14	Dish Preference									1	1	0.023	0.022727
Units		Seconds	Pounds	Percent	Inches	Inches	Dish/Sta	Hrs/Use	USD	Binary	Total Happiness		0.7902
Best Value		2	0	100	6	6	20	3	0	1			
Worst Value		120	20	0	20	14	0	0.5	500	0			
Actual Value		20	15	100	12	12	20	3	375	1			
Normalized Metric Happiness		847457627	0.25	1	571428571	0.25	1	1	0.25	1			

3.2 Concept Drawings

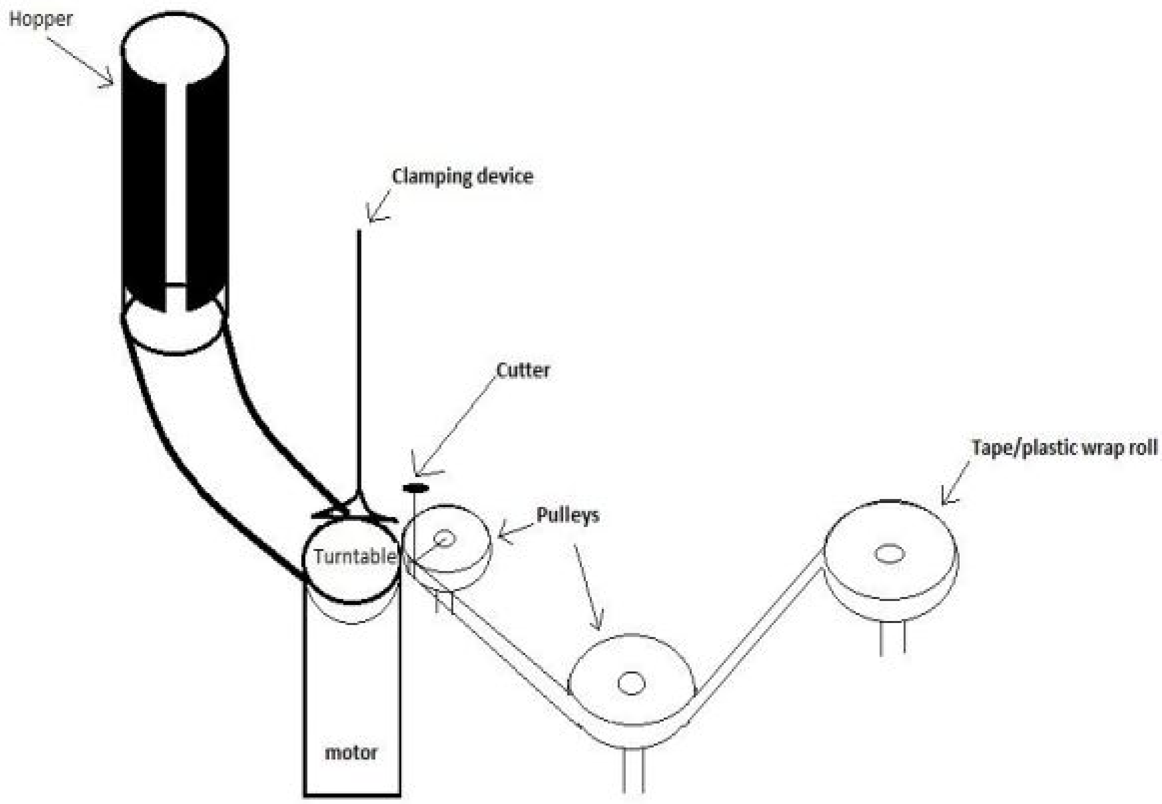
Concept 1:



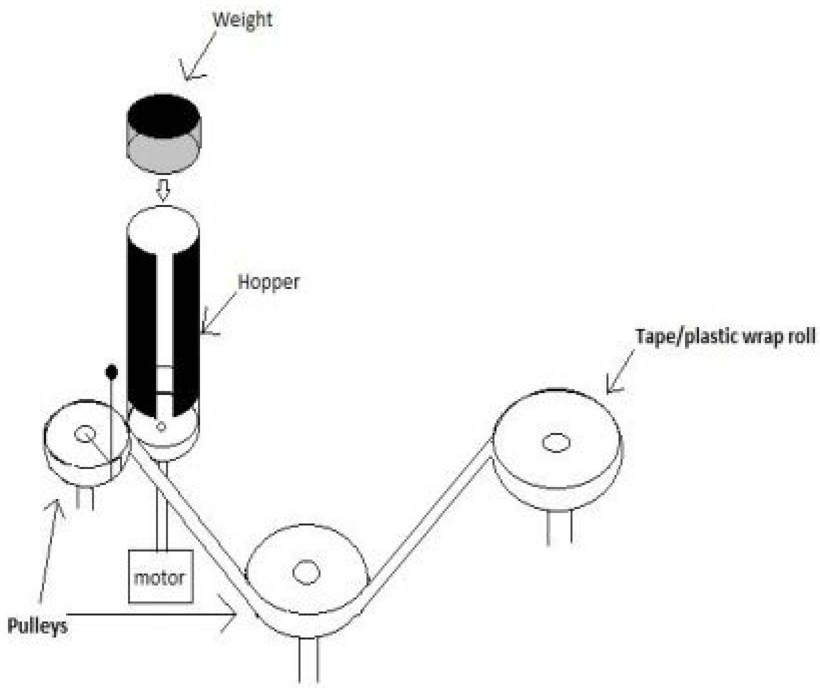
Concept 2:



Concept 3:



Concept 4:



3.3 A Concept Selection Process.

3.3.1 Concept Scoring (Not Screening)

We each made our own design, without seeing the other person's until it was time to decide on one. Wade came up with design 1, Isaac 2, and John 3 and 4. We more or less went with We scored Wade's idea 1, Isaac 2, and John's designs 3rd, but our final design had elements of all 4 concepts in it.

3.3.2 Preliminary Analysis of Each Concept's Physical Feasibility

3.3.3 Final Summary Statement

For the final design, we decided it was easiest to do away with a hopper style design, which eliminated both of John's ideas. The dishes had grooves on the lids and base, meaning they wouldn't slide off of each other. This made using a hopper very difficult when removing the dishes. The final design turned out to be a cross between concept 1 and 2. The biggest change between these designs and the final design was the system for clamping down on the dish. None of these designs accounted for the fact that the lid and base would move independently of each other. It was later determined that weight alone wasn't enough. Too much weight wouldn't allow the lid to spin with the base. We needed weight with a surface that would let the lid slide on it.

3.4 Proposed Performance Measures For The Design

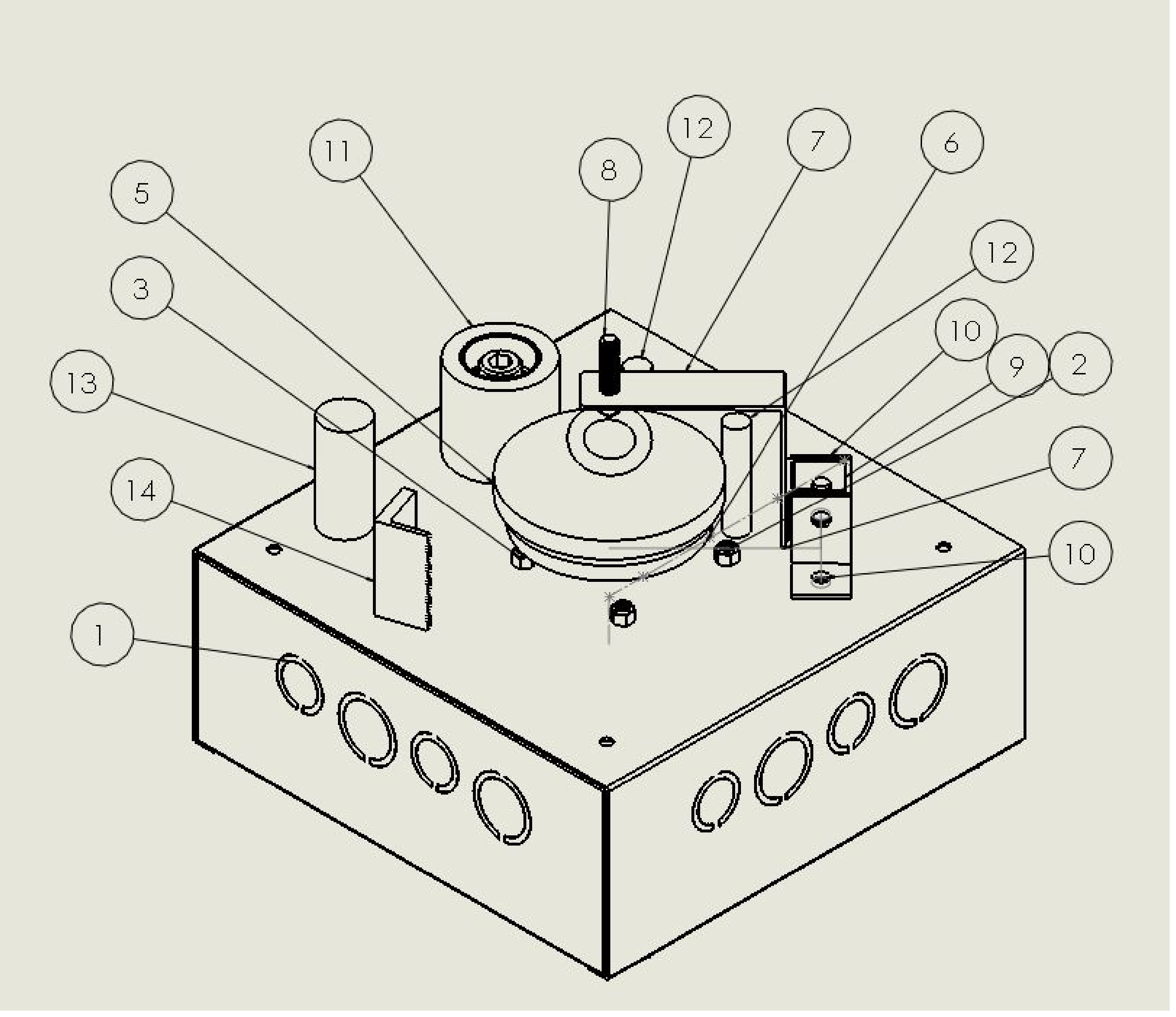
The performance measures were that it would be able to fit on our client's work bench, be washable without corrosion, and wrap media plates in under 20 seconds. It was also obviously important that the device couldn't hurt the user if malfunction were to occur.

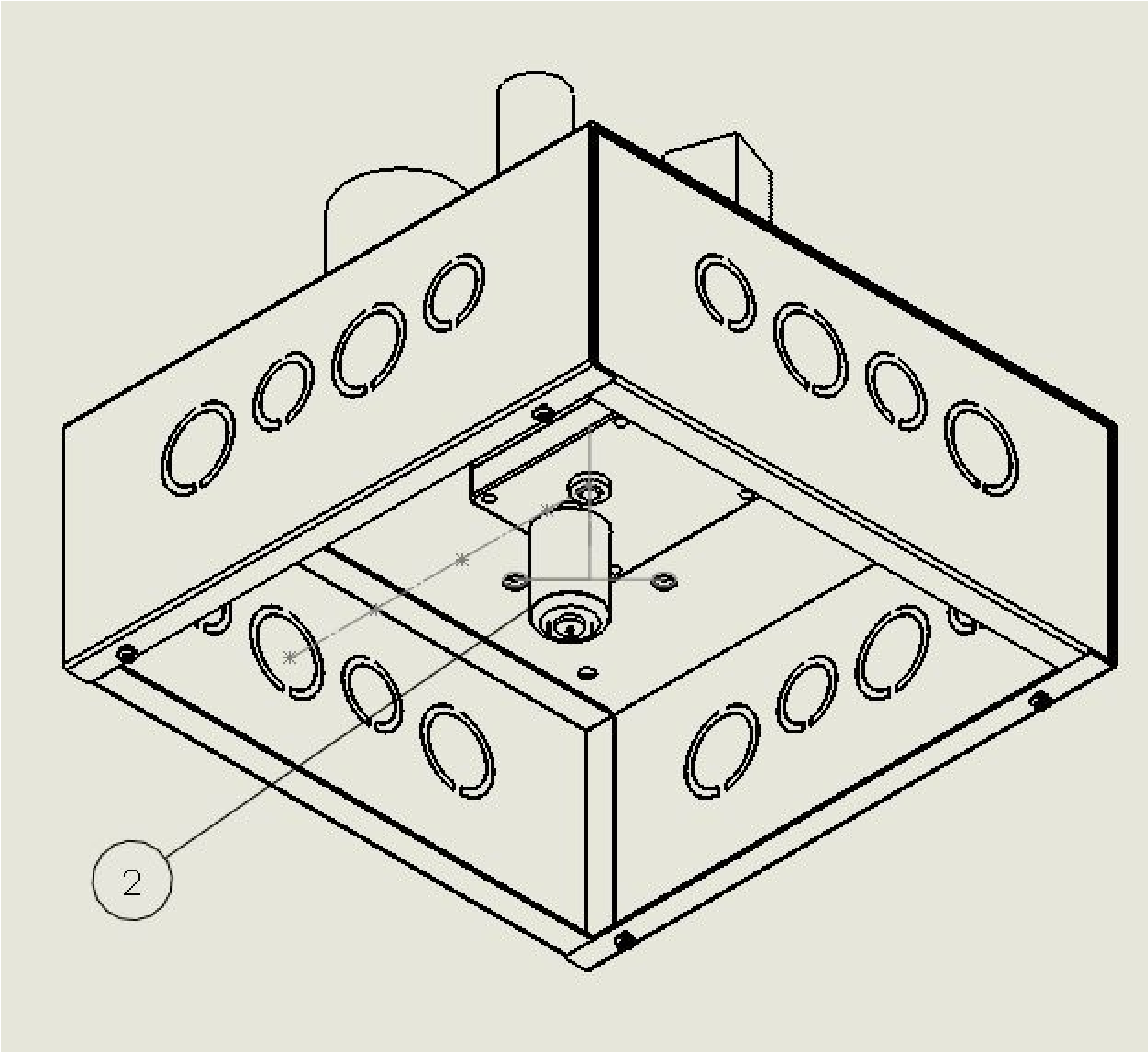
3.5 Revision of Specifications After Concept Selection

We decided concept 1 was our best choice. It was easy to assemble because of the small size, and provided no obvious signs of being dangerous. This design seemed to be easy to use and would be fast enough for the user's needs.

4 Embodiment and Fabrication Plan

4.1 Embodiment/Assembly Drawing



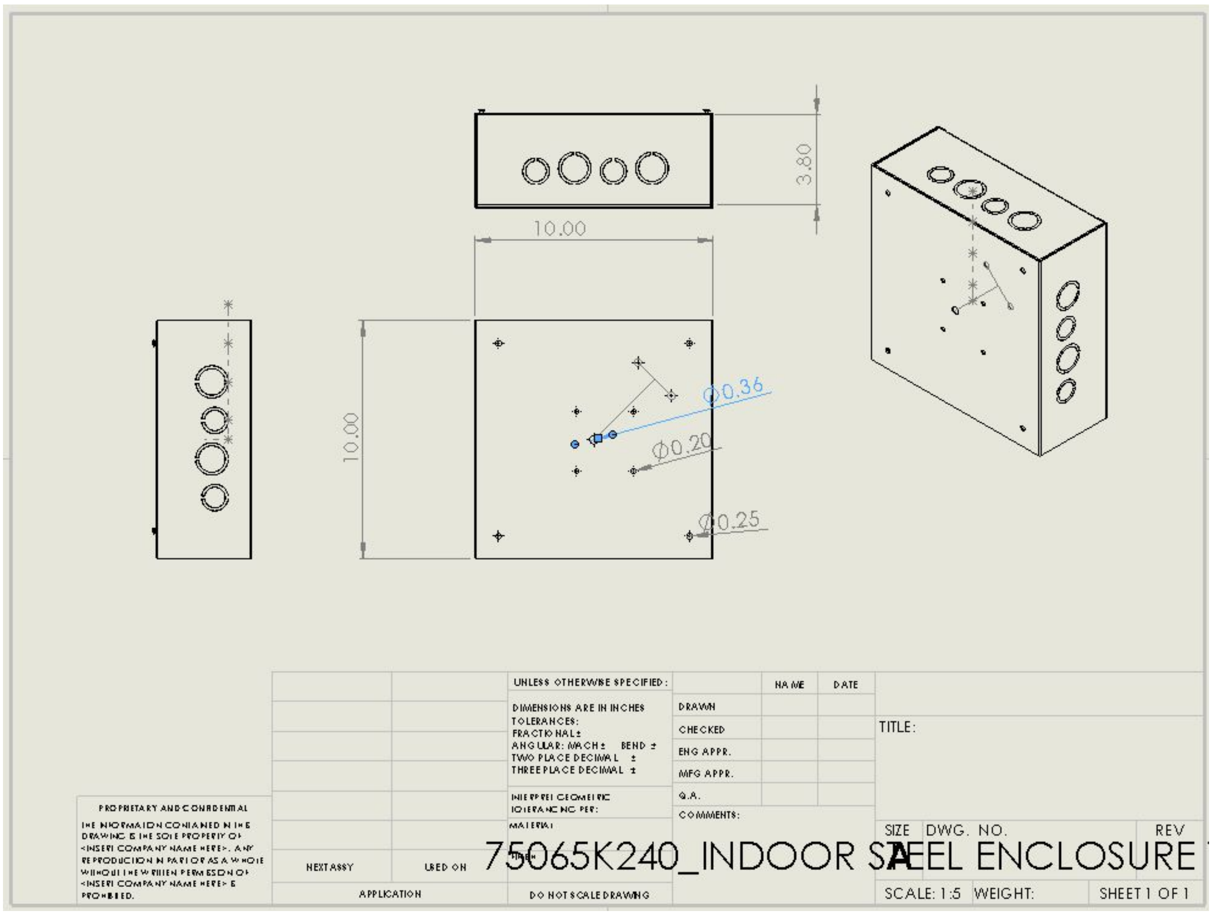

2

4.2 Parts List

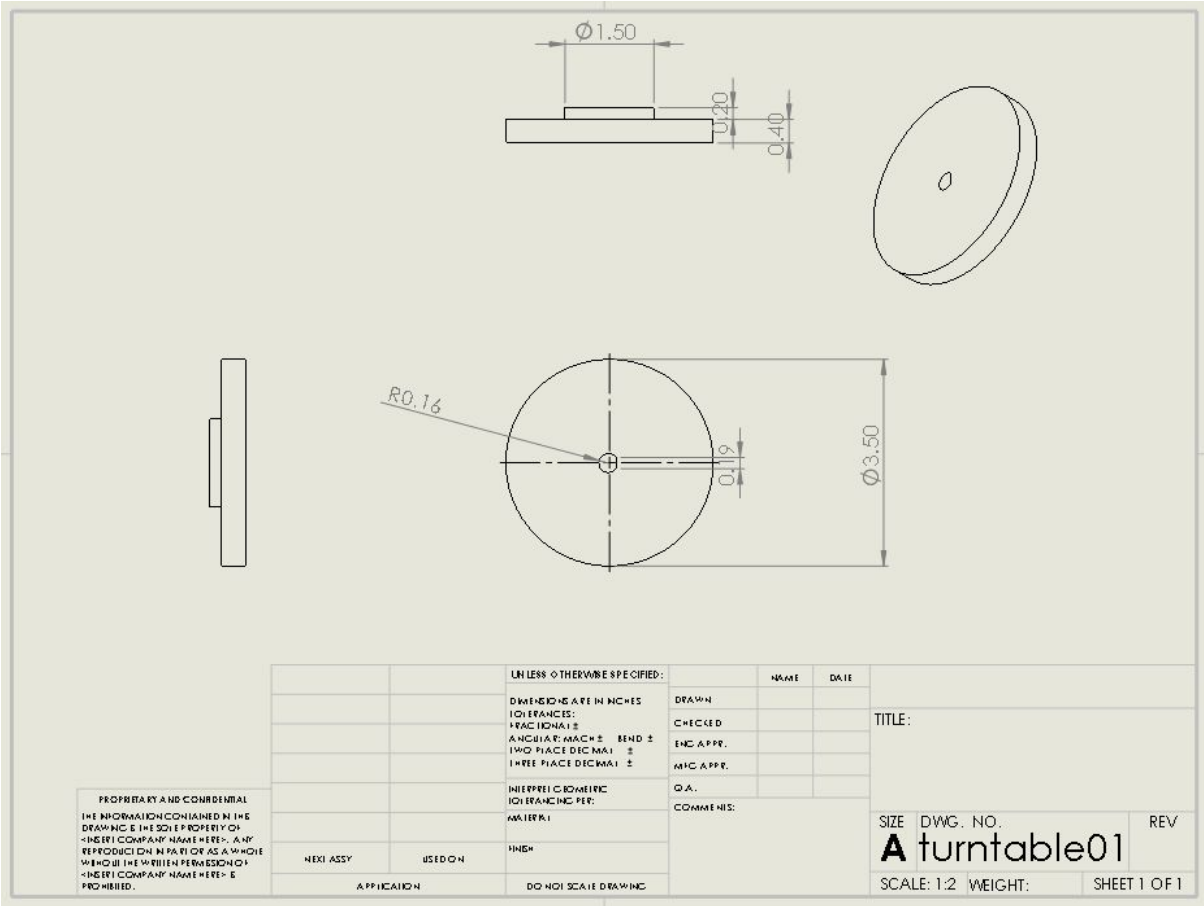
PART NUMBER	DESCRIPTOR	QTY.
1	Base Enclosure	1
2	Electric Motor	1
3	10-32 Nuts	4
4	Polycarbonate Washers	5
5	Petri Dish	1
6	Turn Table	1
7	Arm Bracket	1
8	Eye Bolt	1
9	Swivel Bracket	1
10	Swivel Bracket Holder	2
11	Neoprene Roller	1
12	Petri Dish Gaurd	2
13	Tape Shaft	1
14	Blade	1

4.3 Draft Detail Drawings For Each Manufactured Part

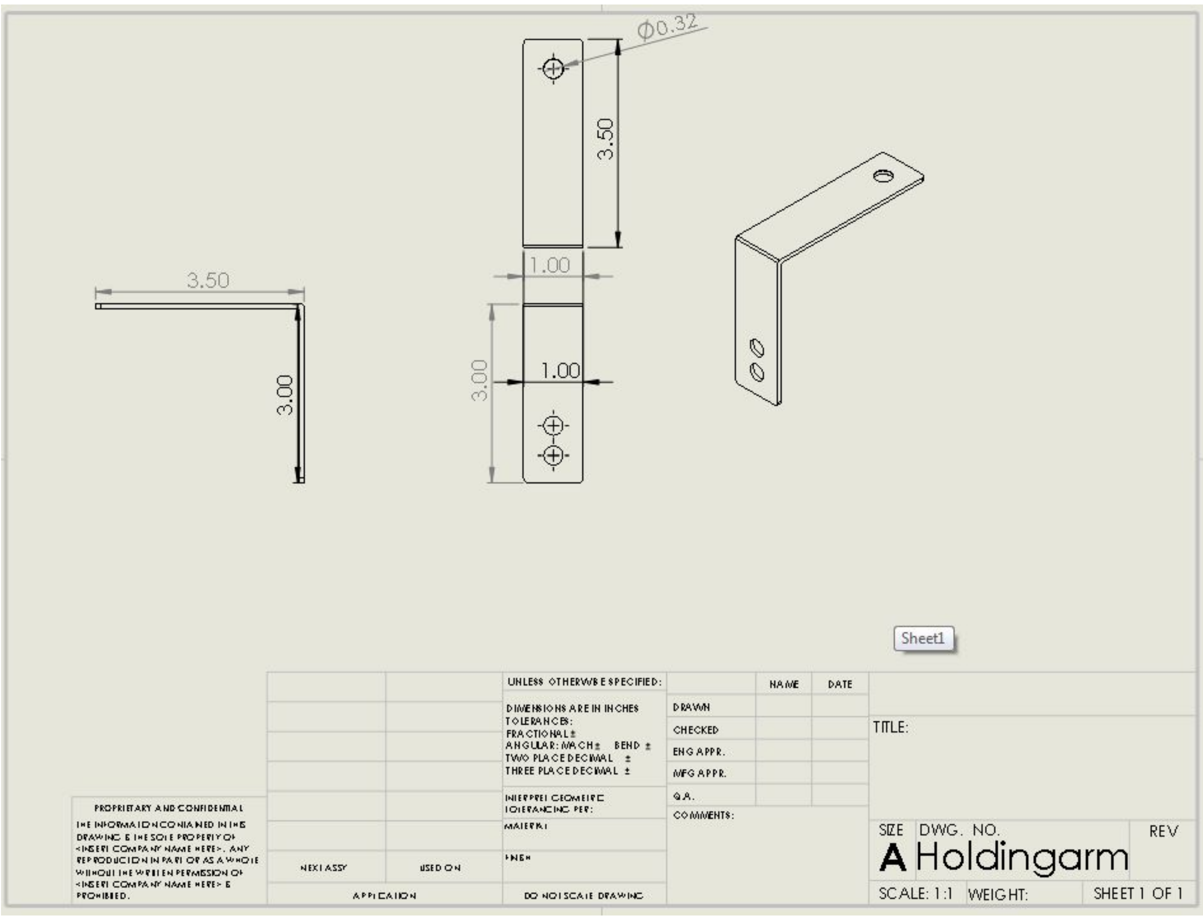
Part 1: Base Enclosure



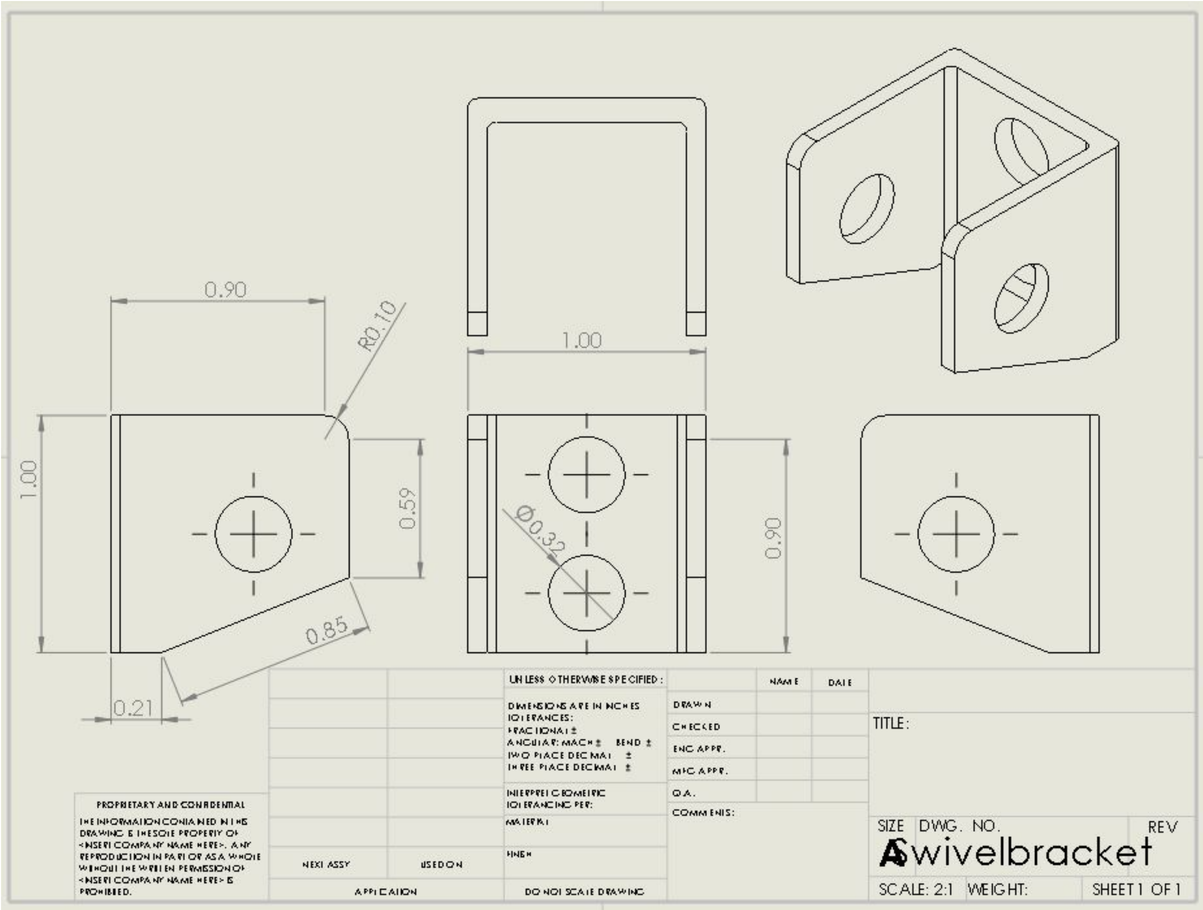
Part 6: Turn Table



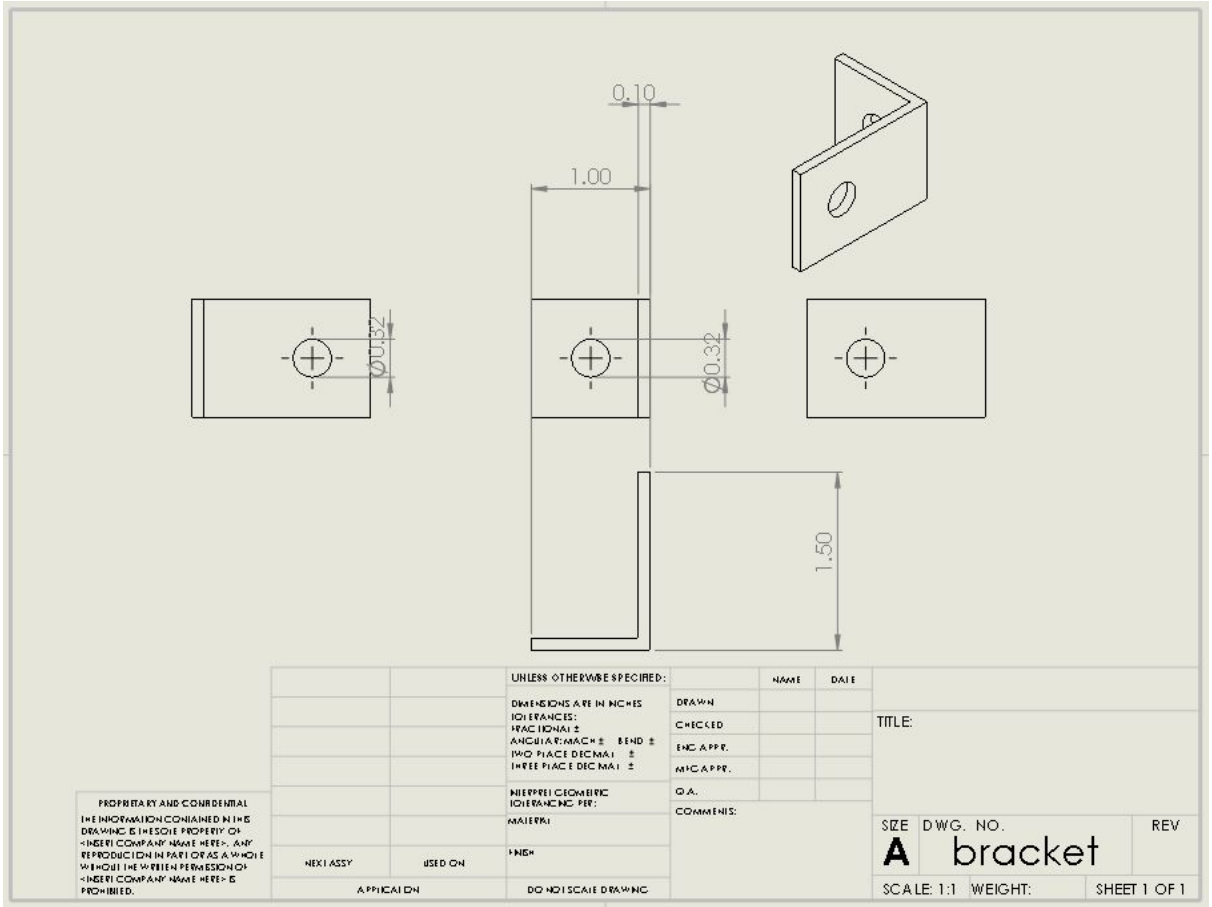
Part 7: Arm Bracket



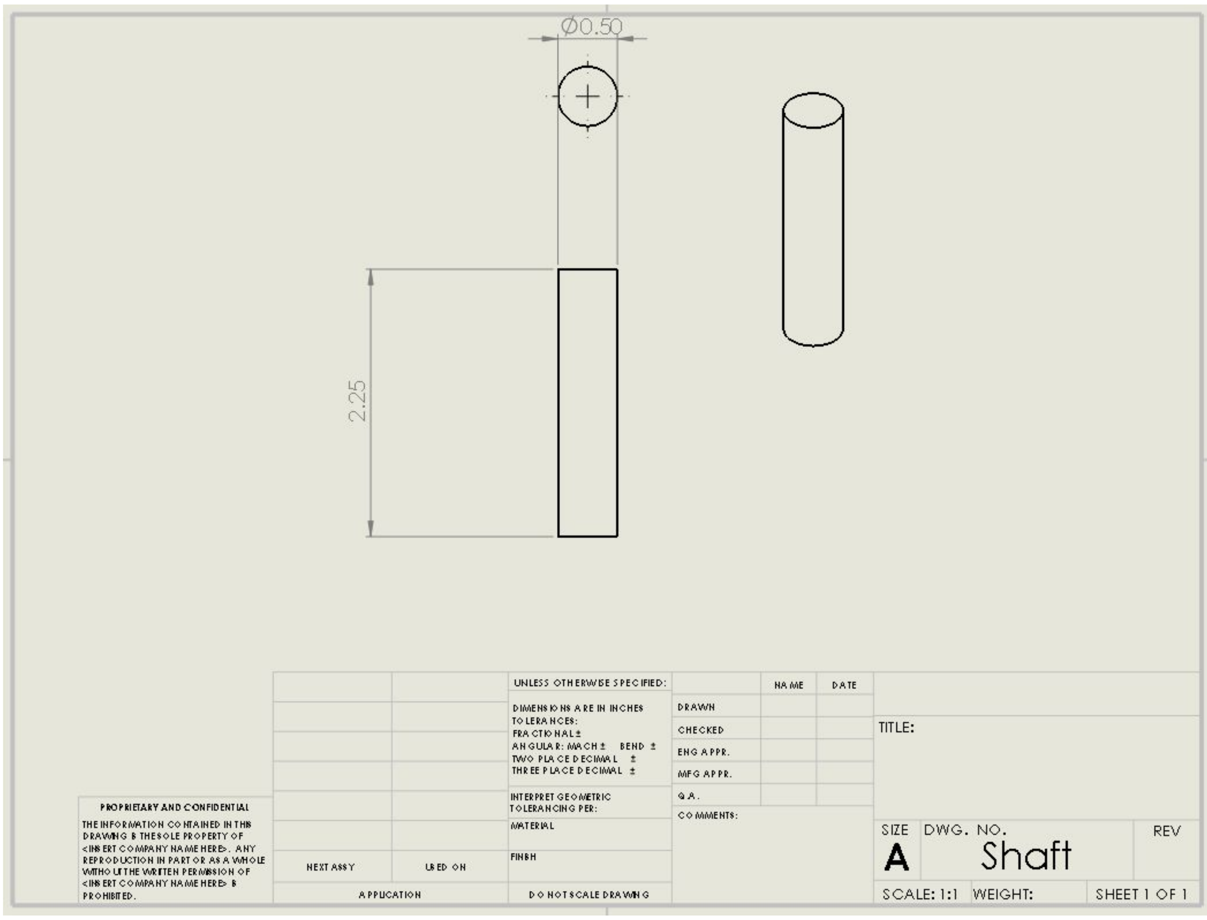
Part 9: Swivel Bracket



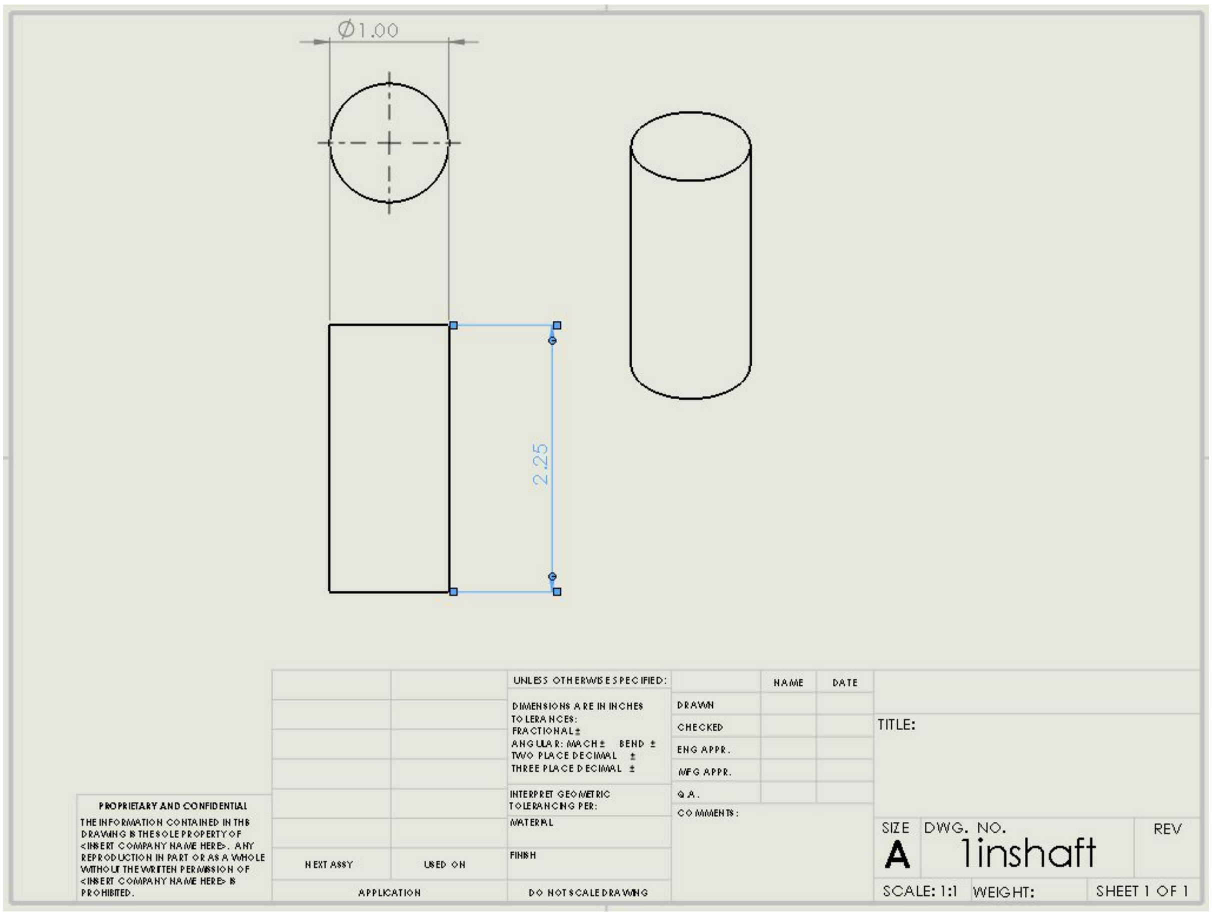
Part 10: Swivel Bracket Holder



Part 12: Petri Dish Guard:



Part 13: Tape Shaft



4.4 Description Of The Design Rationale

Design Rationale

1. Base Enclosure: Before choosing a pre-made box, we were going to do it out of sheet metal. This enclosure is a good size and should be sturdy enough for the project.
2. Motor: This motor should provide the necessary torc without going too fast. This saves in cost and complexity.
3. 10-32 Nuts: These were chosen to match the size the Motor needed for mounting onto the Base Enclosure.
4. Polycarbonate Washers: These washers were chosen because they glide well off eachother even under high compressive load. If the user pushes down on the turntable, the downward load will go onto these rather than the motor shaft.
5. Petri Dish: Either size petri dish should work (either 10 or 25 mm in height).
6. Turn Table: It was decided to 3D print this so that the D shaped shaft of the motor will fit right into it without being a pressed fit.
7. Arm Bracket: Initially it was thought that this arm should be motorized to clamp the petri dish, however after realizing that it didn't take much force to keep the petri dish's lid on, it was decided that the weight of the arm and its components was enough.
8. EyeBolt: In an earlier design, a ball transfer roller was going to be used to keep the petri dish's lid from changing angles during the taping. There were concerns about

keeping it sterile and the cost was much higher, so the eyebolt was chosen for its rounded end.

9. Swivel Bracket: This allows the arm to rotate from the base. The thickness of the metal is more than is needed, but it shouldn't deform from user interaction.
10. Swivel Bracket Holder: Similar rationale as Swivel Bracket.
11. Neoprene Roller: Chosen for being big enough to let the tape go by it.
12. Petri Dish Guard: These are to help ensure that the petri dish is inserted into the machine correctly. They are machined down from a large cylinder of Aluminum.
13. Tape Shaft: The cylinder is designed to be somewhat smaller than the inner diameter of the tape roll. This should allow the tape roll to rotate freely without getting wobbly.
14. Blade: This was chosen because it is serrated and is specifically for cutting tape.
15. Electric Toggle Switch: This toggle switch only lets current through when the user is actively holding it in the on position. It is also washable, which is important in a sterile environment.

Wall Plug: Stepping down the voltage from 110V to 12V at the outlet increases the safety of the device by making it even less likely that a person would get electrocuted.

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

PROJECT: Media Plate Wrap NAMES: Isaac Asaro INSTRUCTOR: Dr. Jakiela
John Hahler
Wade Twellman

Analysis before prototype:

1. Determine how much torque the motor needs to have.
   - Wrap weights with tape (that is still connected to tape that is on the tape spool) and see how much force is required to start the tape unwinding from the spool.

Analysis after prototype:

1. Adjust motor speed
   - Determine by inspection how well the tape comes off the roll and onto the petri dish.
2. Decide how long a tether should be used from the arm to the base to prevent breaking petri dish.
   - Manually try to lift arm up to various heights them let it fall down onto the dish with a “normal” push we’d expect from a user.

Work will be divided up as:

Wade Twellman: Determine torque needed for motor.

Isaac Asaro: Decide how long a tether should be used.

John Hahler: Adjust motor speed.

5.2 Signed Engineering Analysis Contract

JME 4110
Group E
Isaac Asaro
John Hahler
Wade Twellman

Engineering Analysis

PROJECT: Media Plate Wrap NAMES: Isaac Asaro INSTRUCTOR: Dr. Jakiela
John Hahler
Wade Twellman

Analysis before prototype:

1. Determine how much torque the motor needs to have.
   - Wrap weights with tape (that is still connected to tape that is on the tape spool) and see how much force is required to start the tape unwinding from the spool.

Analysis after prototype:

1. Adjust motor speed
   - Determine by inspection how well the tape comes off the roll and onto the petri dish.
2. Decide how long a tether should be used from the arm to the base to prevent breaking petri dish.
   - Manually try to lift arm up to various heights them let it fall down onto the dish with a "normal" push we'd expect from a user.

Work will be divided up as:

WT Wade Twellman: Determine torque needed for motor.

I.A. Isaac Asaro: Decide how long a tether should be used.

JH John Hahler: Adjust motor speed.

Instructor signature: [illegible], Printed instructor name: JAKIELA 7/31/17

5.3 ENGINEERING ANALYSIS RESULTS

5.3.1 Motivation

To ensure that our prototype worked as desired, we decided on several analysis task to be completed. Before we could build a prototype we had to determine the force required to adequately spin the turntable. We were able to determine we needed to be able to generate a minimum of 6 oz of force to pull the tape from the roll. Once we knew the minimum force we needed to rotate the turntable we were able to focus on other analysis tasks. We determined there was a need for a tether to eliminate the risk of breaking the petri dishes when they were loaded into the device. This would happen when the arm was lowered onto the petri dish to keep it in place when the turntable rotated. The next task was deciding the speed the turntable would rotate. These tasks were selected to ensure the device would be able to safely and adequately operate as desired.

5.3.2 Summary Statement of Analysis Done

We used the standard equation for torque to determine the size of the motor we would need, $\tau = r * F$. This was calculated using the radius of the provided petri dishes and the minimum force needed to unroll the tape. After the prototype is built we will use the force equation to find the length of the tether, $F = m * g * h$. We will use observational analysis to determine the speed the motor should rotate the turntable

5.3.3 Methodology

Analysis and testing done prior to the prototype were conducted on the provided roll of tape. We suspended the tape roll and attached weights to the tape until it began to unroll. We then performed hand calculations to find the necessary torque of the motor. After the prototype is built we will test the arm to determine the height and force that is needed to crack the petri dishes. We will then use the tether to ensure the arm is not allowed to reach a height in which it can damage the petri dishes. We will also visually test taping the petri dishes to determine the best operating speed.

5.3.4 Results

Using our calculations we were able to determine that we needed a motor that generated a minimum torque of 12 in*oz. These results are about as expected, after physically handling the tape we were able to assume the torque required to pull the tape from the roll would be very small.

5.3.5 Significance

After finding the minimum torque required to rotate the turntable, we found that the desired motor had a torque of 400 in*oz. This will provide us with ample safety factors if the user decides to use other methods to wrap the petri dishes other than the provided tape. This analysis was completed before the build of the prototype therefore there were no modifications needed here. Once the prototype is built we will have to introduce the tether after testing and calculations provide the correct length. After the build it was determined that a tether was not necessary. The speed of the motor may be determined by the introduction of a variable speed controller. This will allow us to change speeds as needed. The motor we chose was suitable and did not need a variable speed motor.

6 Risk Assessment

6.1 Risk Identification

When it comes to risk in the product design there are a few factors that may play a factor in the success of manufacturing these media plate wrapping device. These factors could affect a safe and successful transition from prototype to marketable device. This list more than likely doesn't account for everything that could affect the success, just the most obvious things that could make this endeavor a failure.

- Funding
- Insurance
- Manufacturing
- Marketability
- Supply Chain

6.2 Risk Assessment

6.2.1 Funding

Risk associated with the proper funding of the process.

Probability: Medium

Impact: High

6.2.2 Liability

Risk associated with getting the proper liability insurance against our device malfunctioning by the user

Probability: Low

Impact: Medium

6.2.3 Manufacturing

Risk associated with being able to make enough of these with some parts being custom made

Probability: Medium

Impact: Medium

6.2.4 Marketability

Risk of there being enough of a demand for such a device

Probability: High

Impact: High

6.2.5 Supply Chain

Risk of interruption in the supply chain. This breaks down to being able to get parts from suppliers inexpensively and on time

Probability: Medium

Impact: Medium

6.3 Risk Mitigation

6.3.1 Funding

The risk of funding is impossible to totally mitigate. Getting investors interested in our design is only part of this problem, convincing them of the marketability and success is the hardest part. The best way we can avoid funding issues would be to take out a small business loan from the Small Business Administration. The interest rates would be much lower, and the SBA wouldn't have equity stake. The other thing to consider is setting up dealer accounts with suppliers. This gets us better prices, ensures we have priority with parts we need, and allows us a line of credit. With these tools we can mitigate foreseen funding issues.

6.3.2 Liability

The risk of getting the right insurance to cover us from any unforeseen lawsuits is a top priority! Nothing would ruin our entire business venture like losing everything we have to a lawsuit. To mitigate this we'd have to set up our business as an LLC from the start. This covers us from most cases of liability. This also insures that the person suing us can only get what's in the business, and couldn't go after our personal assets. The other important thing to consider is insurance. We would have to have very good insurance that would protect us against the things that could happen.

6.3.3 Manufacturing

The risk of manufacturing is very difficult to totally mitigate. This covers such a wide spectrum of issues. Sourcing parts is a big concern for mitigation. Obviously outsourcing parts from overseas makes sense from a financial standpoint, but the logistics are complicated. When you do this you run into problems with quality, consistency, and shipping time. Shipping your parts here from China may take a week. This could pose a huge problem if we've got orders to fill. Buying all of your parts from a reputable American supplier takes away a lot of these issues, but makes the cost of your final product a lot higher. It would make the most sense to buy certain parts American, and outsource others.

6.3.4 Marketability

The risk of marketability is an inherent flaw in the entire production process. If we can make these cheap, and have no problems with any other of these risk factors, it's still not certain we can sell lots of them. While we're unaware of how many people would be interested in buying these devices, they wouldn't be as marketable as many household devices everyone has a need for. We would have to pitch our idea to research institutions, and there may be a lot of luck involved with getting these sold. This wouldn't be an item you'd buy in a store. We would rely on huge contracts with schools, hospitals, research institutions, etc that would buy numerous devices for their labs

6.3.5 Supply Chain

Unanticipated issues with the supply chain for this product would be impossible to mitigate. A few of our parts were custom made. Trying to find a reputable source to fabricate a lot of these parts might be a problem. When a supplier gets busy, it's hard to say for sure we would get our parts on time. To mitigate risk, we found it important to have working agreements with many suppliers, that way we could have options for getting the parts made that we need.

7 Codes and Standards

7.1 Identification

Code for machine guards

§1910.212 General requirements for all machines.

(a) *Machine guarding*—(1) *Types of guarding.* One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Examples of guarding methods are—barrier guards, two-hand tripping devices, electronic safety devices, etc.

(2) *General requirements for machine guards.* Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. The guard shall be such that it does not offer an accident hazard in itself.

(3) *Point of operation guarding.* (i) Point of operation is the area on a machine where work is actually performed upon the material being processed.

(ii) The point of operation of machines whose operation exposes an employee to injury, shall be guarded. The guarding device shall be in conformity with any appropriate standards therefor, or, in the absence of applicable specific standards, shall be so designed and constructed as to prevent the operator from having any part of his body in the danger zone during the operating cycle.

(iii) Special handtools for placing and removing material shall be such as to permit easy handling of material without the operator placing a hand in the danger zone. Such tools shall not be in lieu of other guarding required by this section, but can only be used to supplement protection provided.

(iv) The following are some of the machines which usually require point of operation guarding:

(*a*) Guillotine cutters.

(*b*) Shears.

(*c*) Alligator shears.

(*d*) Power presses.

(*e*) Milling machines.

(*f*) Power saws.

(*g*) Jointers.

(*h*) Portable power tools.

(*i*) Forming rolls and calenders.

(4) *Barrels, containers, and drums.* Revolving drums, barrels, and containers shall be guarded by an enclosure which is interlocked with the drive mechanism, so that the barrel, drum, or container cannot revolve unless the guard enclosure is in place.

(5) *Exposure of blades.* When the periphery of the blades of a fan is less than seven (7) feet above the floor or working level, the blades shall be guarded. The guard shall have openings no larger than one-half (½) inch.

(b) *Anchoring fixed machinery.* Machines designed for a fixed location shall be securely anchored to prevent walking or moving.

1. From https://www.ecfr.gov/cgi-bin/text-idx?SID=4218c392bbd733b5ba536ad2e7ca9db9&mc=true&node=sp29.5.1910.o&rgn=div6

Code for power tools

Subpart I—Tools—Hand and Power

AUTHORITY: Sections 4, 6, and 8 of the Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), 9-83 (48 FR 35736), 1-90 (55 FR 9033), or 5-2002 (67 FR 65008), as applicable; and 29 CFR part 1911. Section 1926.307 also issued under 5 U.S.C. 553.

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§1926.300 General requirements.

(a) *Condition of tools.* All hand and power tools and similar equipment, whether furnished by the employer or the employee, shall be maintained in a safe condition.

(b) *Guarding.* (1) When power operated tools are designed to accommodate guards, they shall be equipped with such guards when in use.

(2) Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating or moving parts of equipment shall be guarded if such parts are exposed to contact by employees or otherwise create a hazard. Guarding shall meet the requirements as set forth in American National Standards Institute, B15.1-1953 (R1958), Safety Code for Mechanical Power-Transmission Apparatus.

(3) *Types of guarding.* One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Examples of guarding methods are—barrier guards, two-hand tripping devices, electronic safety devices, etc.

(4) *Point of operation guarding.* (i) Point of operation is the area on a machine where work is actually performed upon the material being processed.

(ii) The point of operation of machines whose operation exposes an employee to injury, shall be guarded. The guarding device shall be in conformity with any appropriate standards therefor, or, in the absence of applicable specific standards, shall be so designed and constructed as to prevent the operator from having any part of his body in the danger zone during the operating cycle.

(iii) Special handtools for placing and removing material shall be such as to permit easy handling of material without the operator placing a hand in the danger zone. Such tools shall not be in lieu of other guarding required by this section, but can only be used to supplement protection provided.

(iv) The following are some of the machines which usually require point of operation guarding:

(*a*) Guillotine cutters.

(*b*) Shears.

(*c*) Alligator shears.

(*d*) Power presses.

(*e*) Milling machines.

(*f*) Power saws.

(*g*) Jointers.

(*h*) Portable power tools.

(*i*) Forming rolls and calenders.

(5) *Exposure of blades.* When the periphery of the blades of a fan is less than 7 feet (2.128 m) above the floor or

2. From https://www.ecfr.gov/cgi-bin/text-idx?SID=200f8eb6c3d55dbc78b58e30e5faa760&mc=true&node=pt29.8.1926&rgn=div5#sp29.8.1926.i

Code for ungrounded electrical conductors

E3307.3 Ungrounded conductors. Insulation on the ungrounded conductors shall be a continuous color other than white, gray and green.

Exceptions:

1. An insulated conductor that is part of a cable or flexible cord assembly and that has a white or gray finish or a finish marking with three continuous white stripes shall be permitted to be used as an ungrounded conductor where it is permanently reidentified to indicate its use as an ungrounded conductor at all terminations and at each location where the conductor is visible and accessible. Identification shall encircle the insulation and shall be a color other than white, gray, and green.
2. Where a cable assembly contains an insulated conductor for single-pole, 3-way or 4-way switch loops and the conductor with white or gray insulation or a marking of three continuous white stripes is used for the supply to the switch but not as a return conductor from the switch to the switched outlet. In these applications, the conductor with white or gray insulation or with three continuous white stripes shall be permanently reidentified to indicate its use by painting or other effective means at its terminations and at each location where the conductor is visible and accessible.

E3307.4 Identification of terminals. Terminals for attachment to conductors shall be identified in accordance with Sections E3307.4.1 and E3307.4.2.

E3307.4.1 Device terminals. All devices excluding panelboards, provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification, except where the terminal intended to be connected to the grounded conductor is clearly evident.

2006 INTERNATIONAL RESIDENTIAL CODE®

3. From http://www2.iccsafe.org/states/seattle2006/seattle_residential/PDFs_residential/Chapter%2033_General%20Requirements.pdf

7.2 JUSTIFICATION

Justification for 1910.212:

This standard was designed to keep the user safe from the regular use of the machine. It gave us insight into making guards around potential pinch points. This was important since we have areas where you could possibly get clothing articles, hair, or fingers caught in moving parts.

Justification for 1926.300:

This standard is similar to 1910.212, but is more specific to power tools. It also was relevant to our cutter for the tape. We designed our cutter to be user friendly where the risk of cutting cut is minimal. We want a safe, responsible design and this standard helps us achieve that.

Justification for E3307.3-4

This electrical code keeps the wiring organized and makes it sensible. We don't want to risk getting someone shocked. It's important to follow this code to keep our wiring safe and easy to understand in case of the need for maintenance. Our device uses an ungrounded electrical circuit.

7.3 Design Constraints

7.3.1 Functional

Our design should be able to wrap petri dishes without breaking the dish, or shaking it enough to upset the contents of the dish.

7.3.2 Safety

We will be using an electric motor, so sensible wiring is necessary to keep from shocking the user. Also, since there is a blade that will be cutting the tape/plastic wrap, it is important to make a guard for the blade to keep the user from getting cut. The other important thing was a pressure switch. This meant if the user became disoriented because of something going wrong, all they would have to do is take their finger off the switch and it would shut off.

7.3.3 Quality

Our parts should be made of something that won't rust or corrode. The parts that aren't made of a non ferrous material should have a coating to resist corrosion.

7.3.4 Manufacturing

All of our parts have to be kept very clean. All uses of lubricants, cutting oil, etc have to be cleaned thoroughly before presenting to the client.

7.3.5 Timing

Our device has to be able to do it's full function in less than 20 seconds.

7.3.6 Economic

The total cost of our device should be less than $300.

7.3.7 Ecological

This design can't use anything that would cause ecological harm to other things in a lab. No use of harmful metals such as lead, and no adhesives. Also, we used powder coat instead of paint so that harmful paint chips wouldn't come in contact with anything

7.3.8 Life cycle

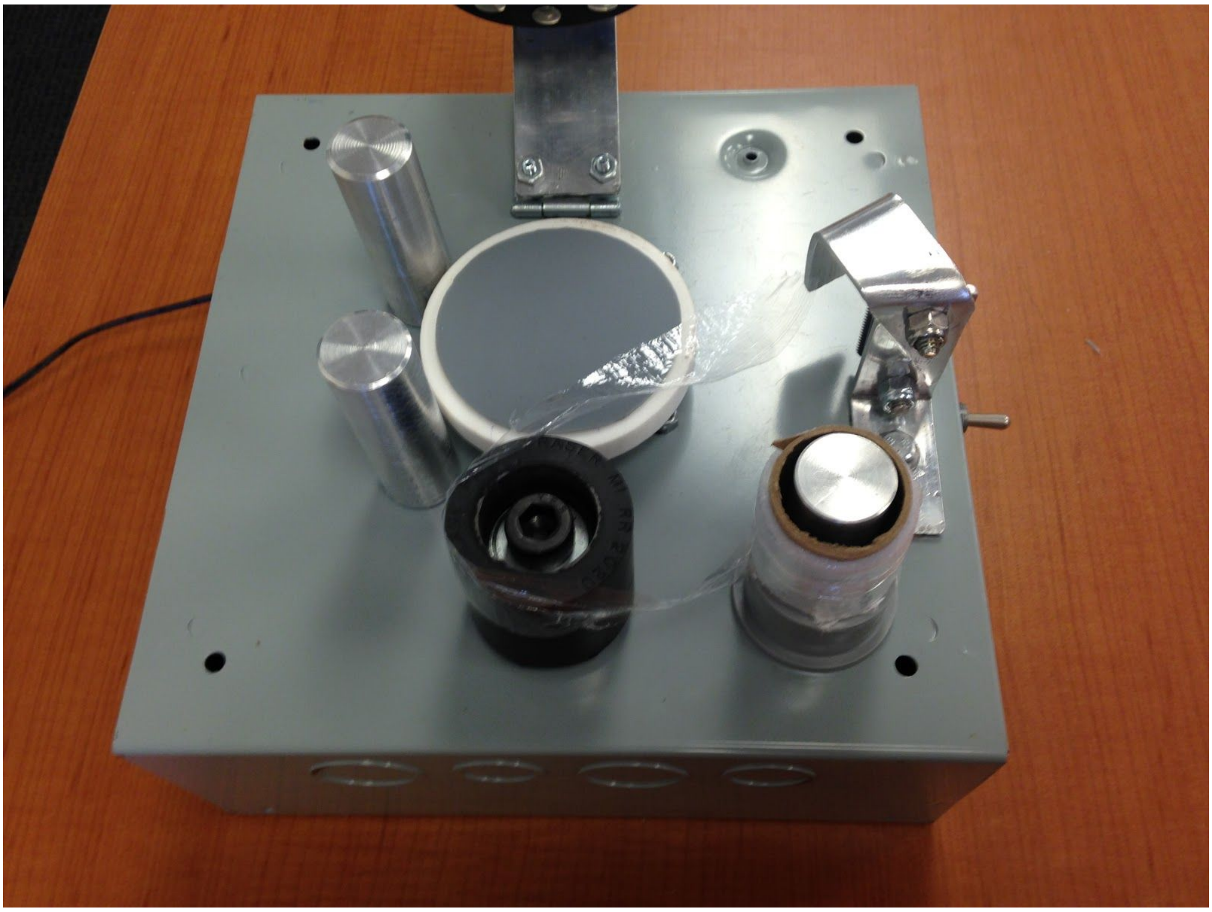
Our design should be able to be used for a very long time without ever having any problems. There are no significant wear points, and unless a motor burns up this design should last forever.

7.4 Significance

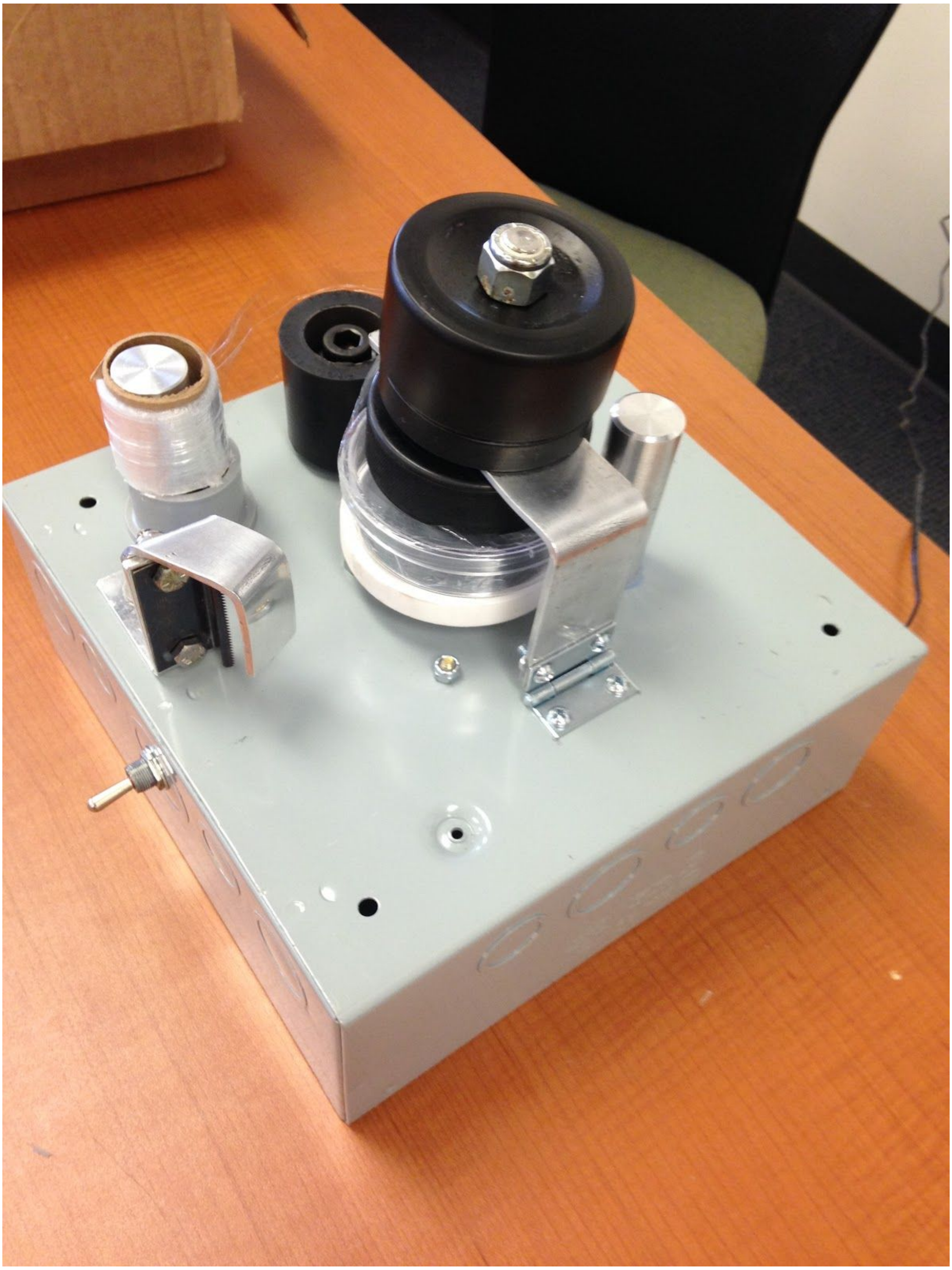
We'll use a dome that the operator can put over the top surface of the device to protect them from moving parts. We'll have the switch in a place where they can run the motor with the dome in place. We'll use another color (or use transparent) insulation on our electrical wires.

8 Working Prototype

8.1 Prototype Photos



This photo shows the device without a media plate in it and the weighted arm in the open position.



This photo shows the weighted arm resting on the Media Plate loaded onto the turntable. Some wrap was applied to the media plate.

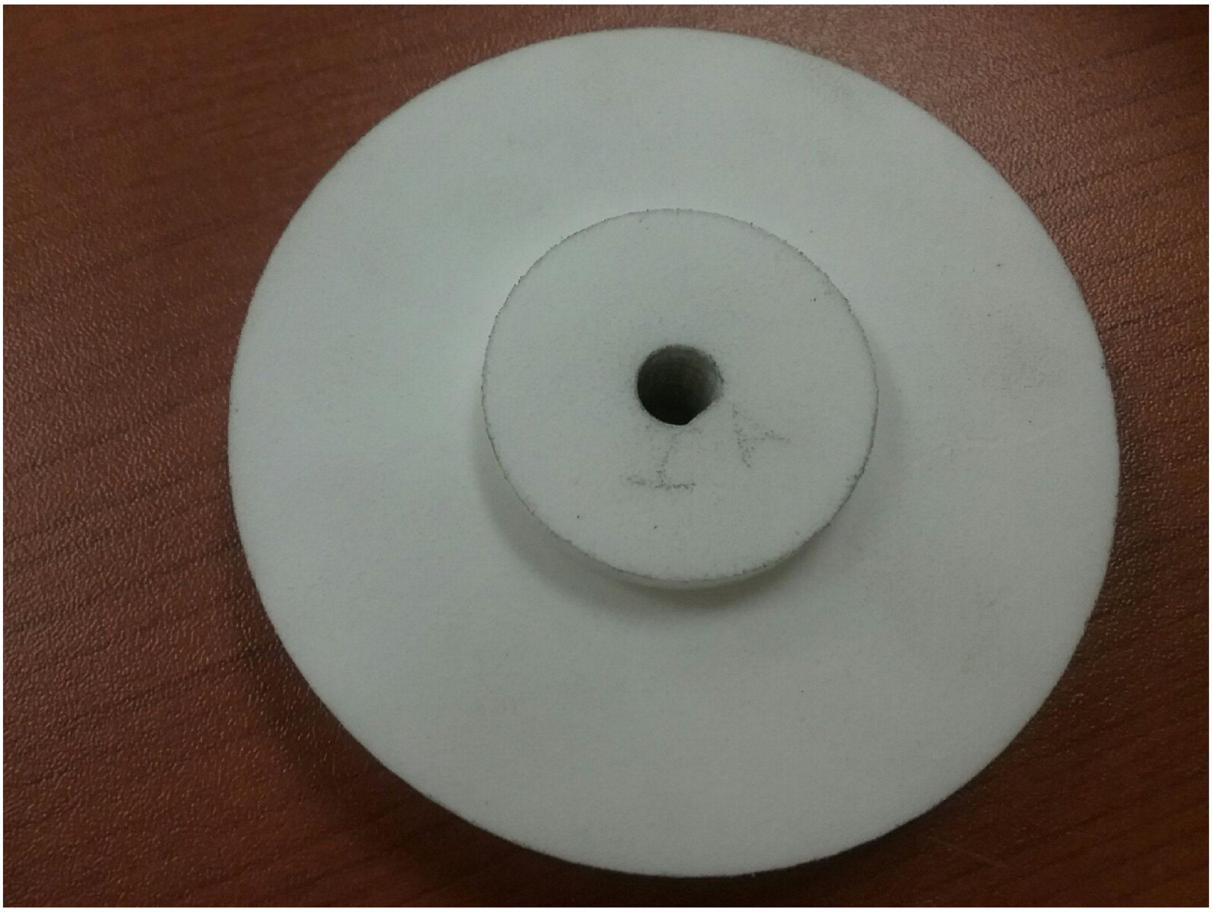
8.2 Working Prototype Video

https://www.youtube.com/watch?v=gfYmcPU6pOU

8.3 Prototype Components

Four photos showing specific things.

This photograph shows the motor inside the enclosure (with the enclosure's panel off).



This photograph shows the underside of the 3D printed turntable without the silicone placed on it.

This photograph shows the motor axle with the turntable behind it and the spacer in front of it.

This photograph shows the weighted arm's spherical bearing.

9 Design Documentation

9.1 Final Drawings and Documentation

It is important to note that the thumb tacks have not yet been added to the drawings. The thumb tacks are very important because they reduce the friction between the weight and the petri dish. Put 8 of them in a circular pattern sticking them into the underside of the hockey puck.

9.1.1 Engineering Drawings

See Appendix B for the individual CAD models.

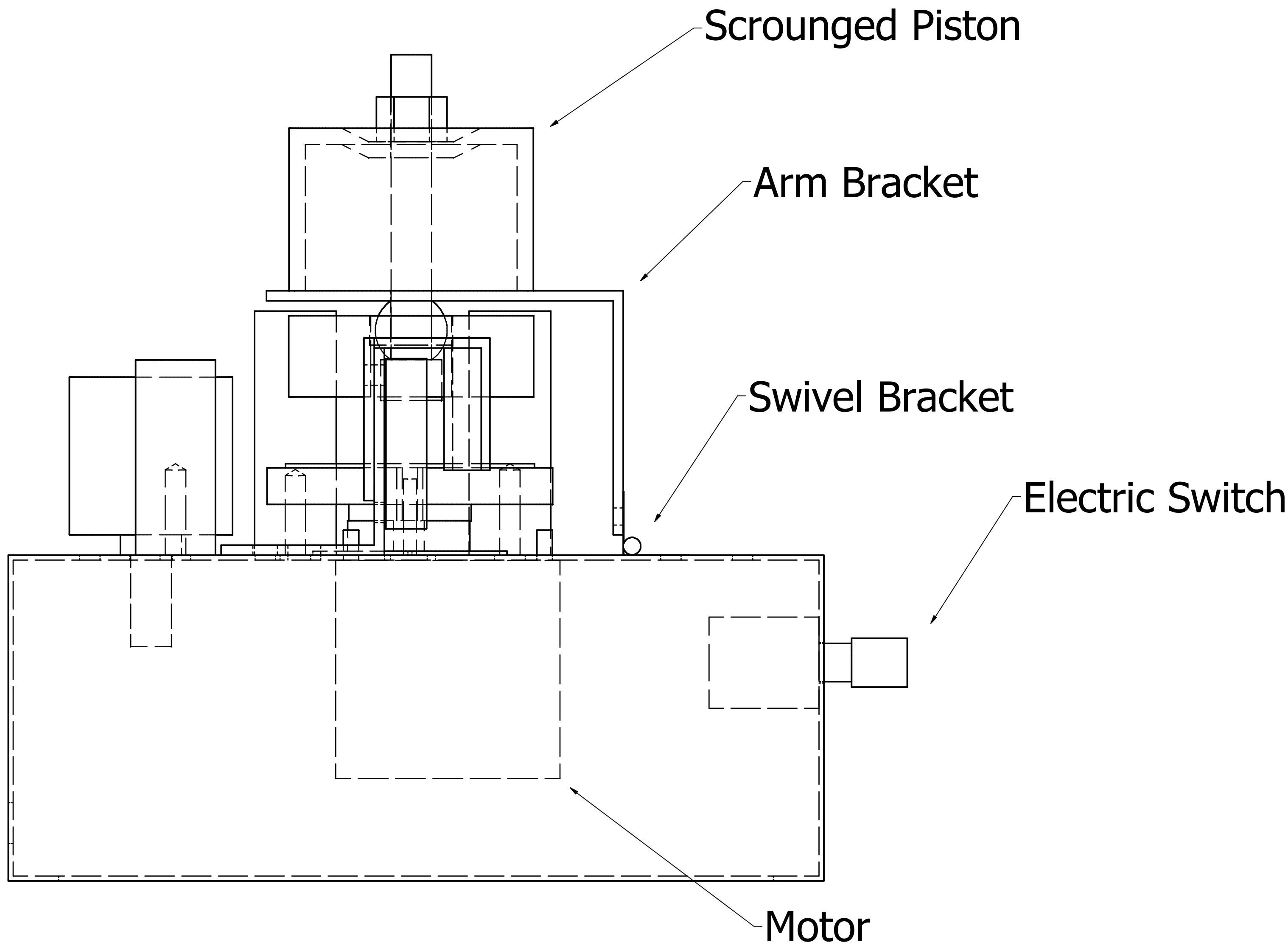
7.2 Final Presentation

https://drive.google.com/open?id=0By8mvccseNaEaVNZWFRKMFFFRzA

Appendix A - Bill of Materials

Where parts like the ones we used can be found.

VENDOR NO	DESCRIPTION	UNITS	QTY/UNIT	VENDOR	PRICE/UNIT
22875T6	Neoprene Roller (80A Rubber)	1	1	MCMASTER.COM	$21.03
6409K16	Compact Square-Face DC Gearmotor	1	1	MCMASTER.COM	$53.16
70235K69	Plug-in Voltage Transformer	1	1	MCMASTER.COM	$9.18
75065K24	Indoor Enclosure 10" x 10" x 4"	1	1	MCMASTER.COM	$26.68
8002K112	Washdown Toggle Switch	1	1	MCMASTER.COM	$17.18
8054T15	18 Gauge Hook-Up Wire (Red)	1	25FT/ROLL	MCMASTER.COM	$5.03
8974K13	6061 Aluminum 1" Diameter Solid Tubing	1	1 ft	MCMASTER.COM	$7.80
8975K596	6061 Aluminum Bar, 1/4" x 1" x 3'	1	1	MCMASTER.COM	$7.00
8975K581	6061 Aluminum Bar, 1/4" x 1.5" x 3'	1	1	MCMASTER.COM	
90940A015	Plastic Washer 5/16"	1	25	MCMASTER.COM	$11.50
91247A591	5/16"-18 Grade 5 Cap Screw 2" Long	1	50	MCMASTER.COM	$10.54
92141A011	#10 Stainless Steel Washers	1	100	MCMASTER.COM	$2.33
92865A583	5/16"-18 Grade 5 Cap Screw 1" Long	1	50	MCMASTER.COM	$7.16
95615A160	Nylon-Insert Locknut 5/16-18	1	100	MCMASTER.COM	$6.18
9983K12	Solder-Loaded Heat-Shrink Ring Terminals	1	10	MCMASTER.COM	$9.33
RP922003	MARSH 50mm Steel Cutter Blade	1	3	AMAZON.COM	$24.71
COMINHKPR13 3946	Silicone Placemat	1	1	AMAZON.COM	$9.99



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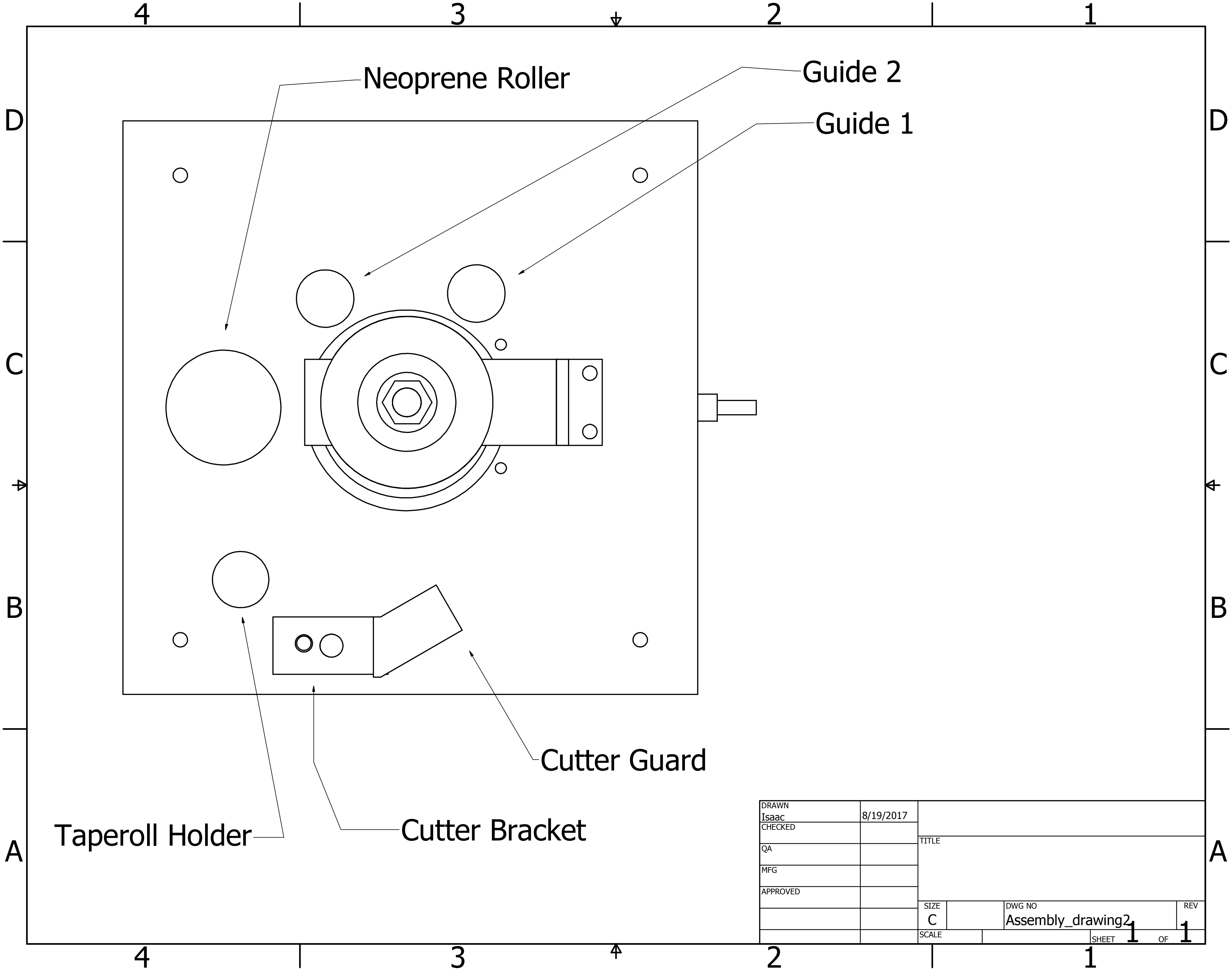
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Taperoll Holder
Cutter Bracket
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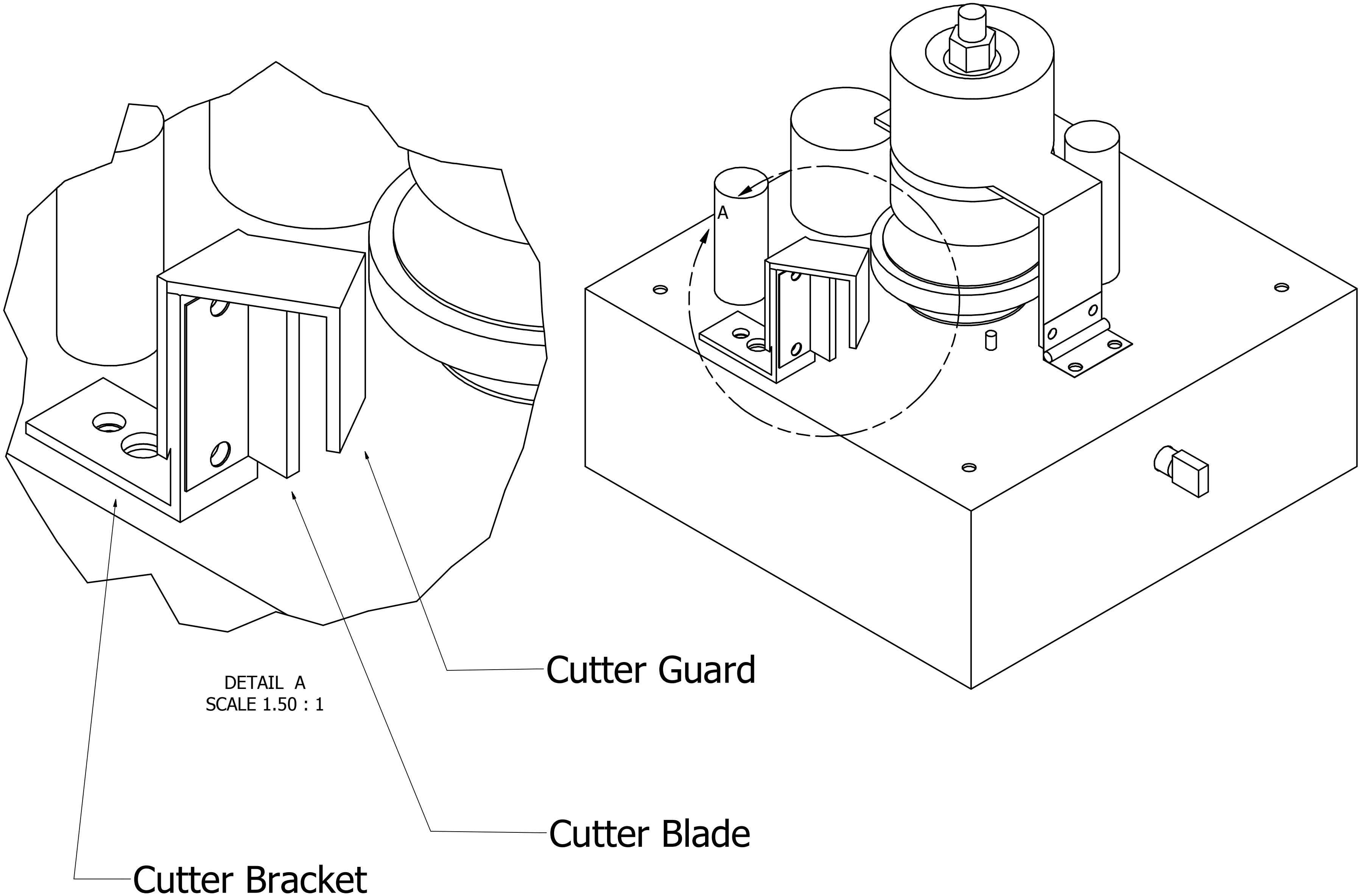

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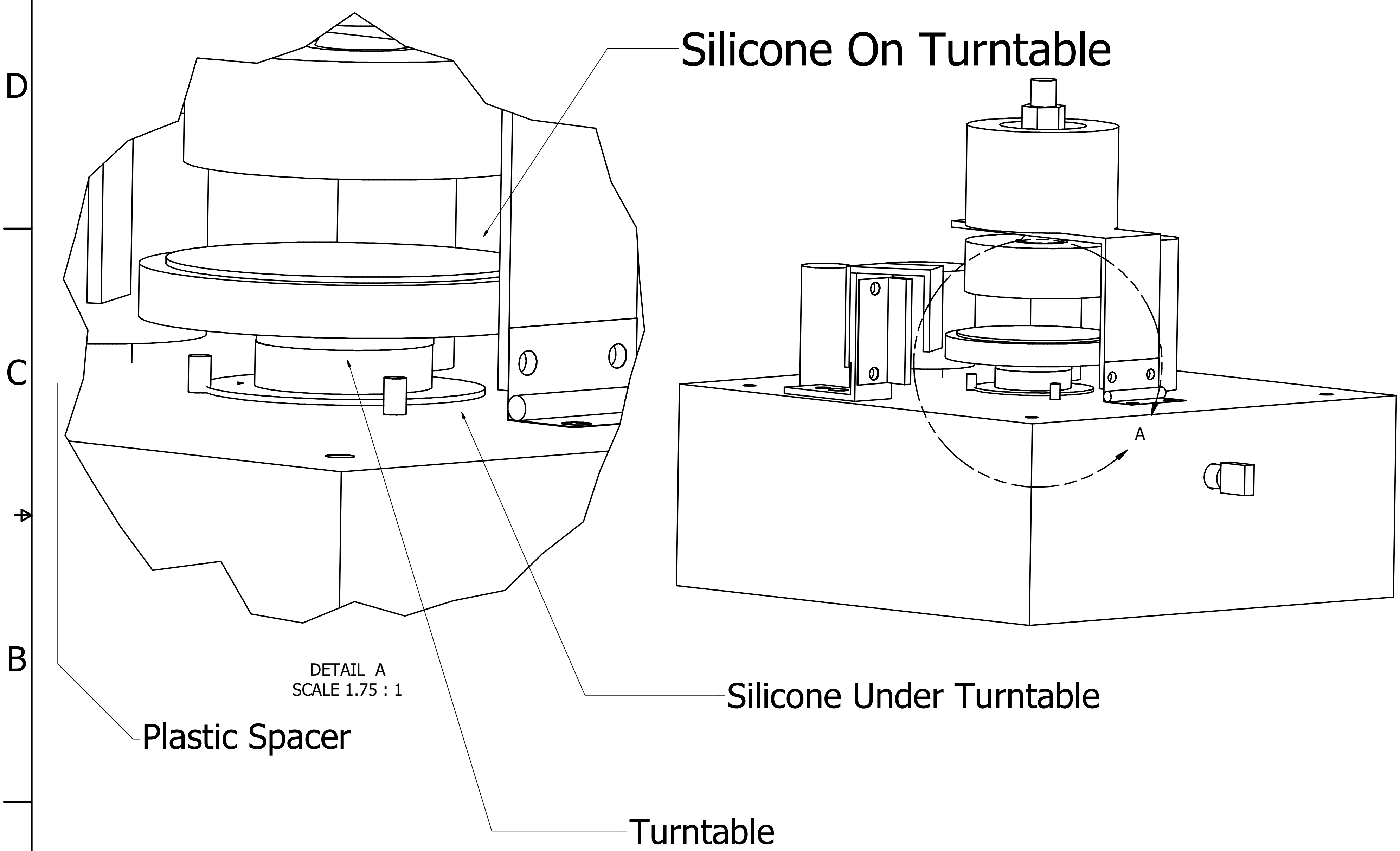

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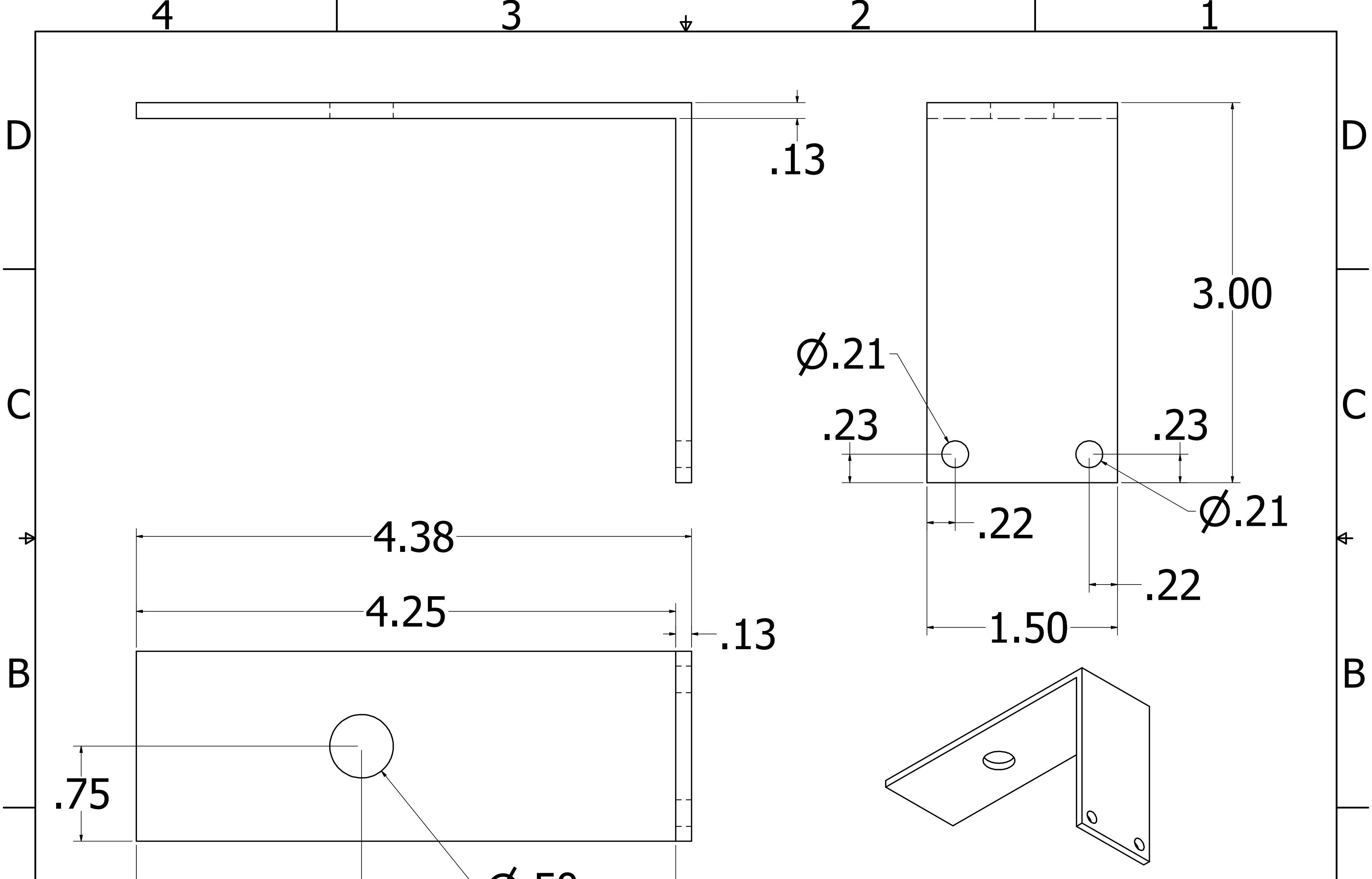

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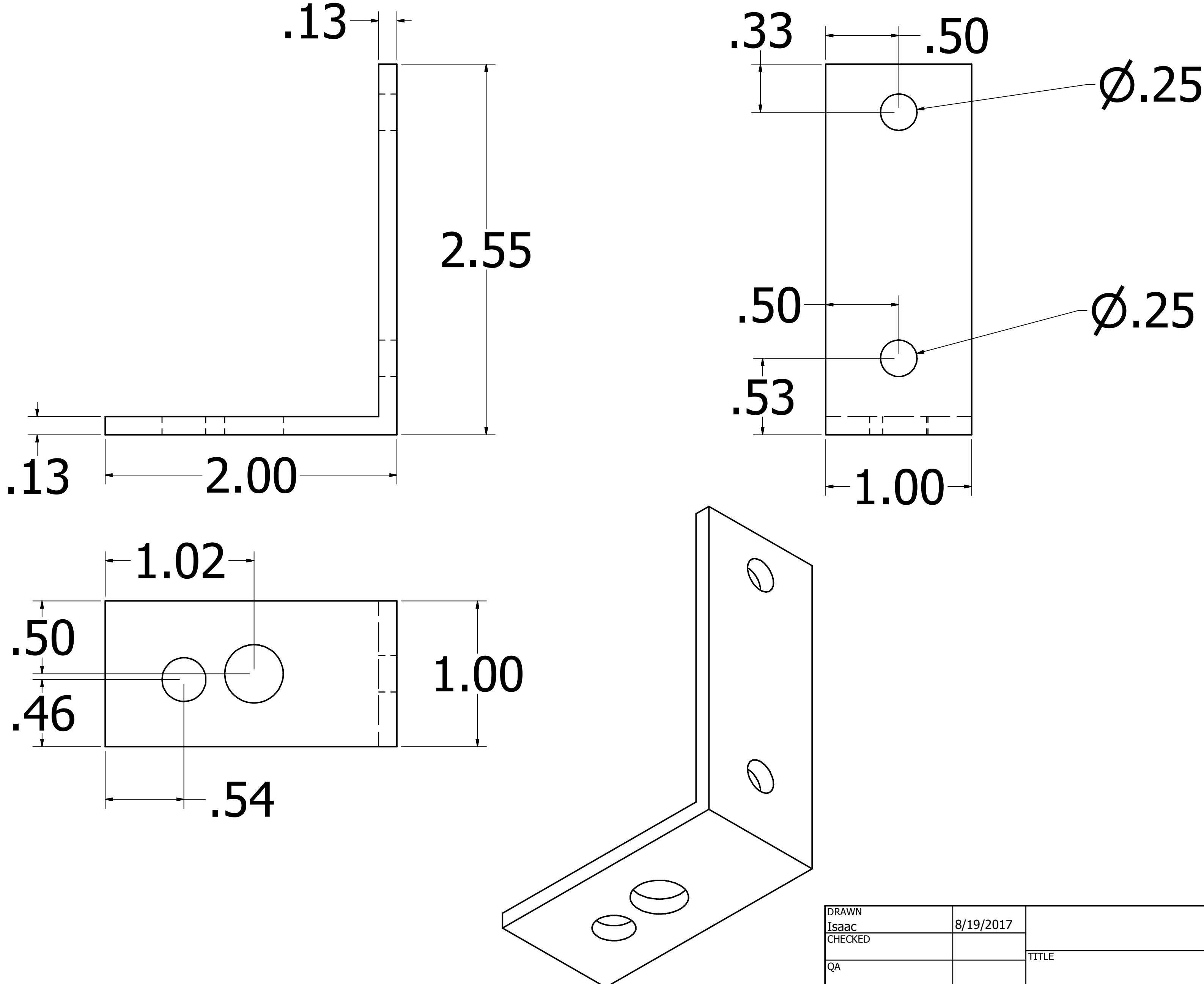

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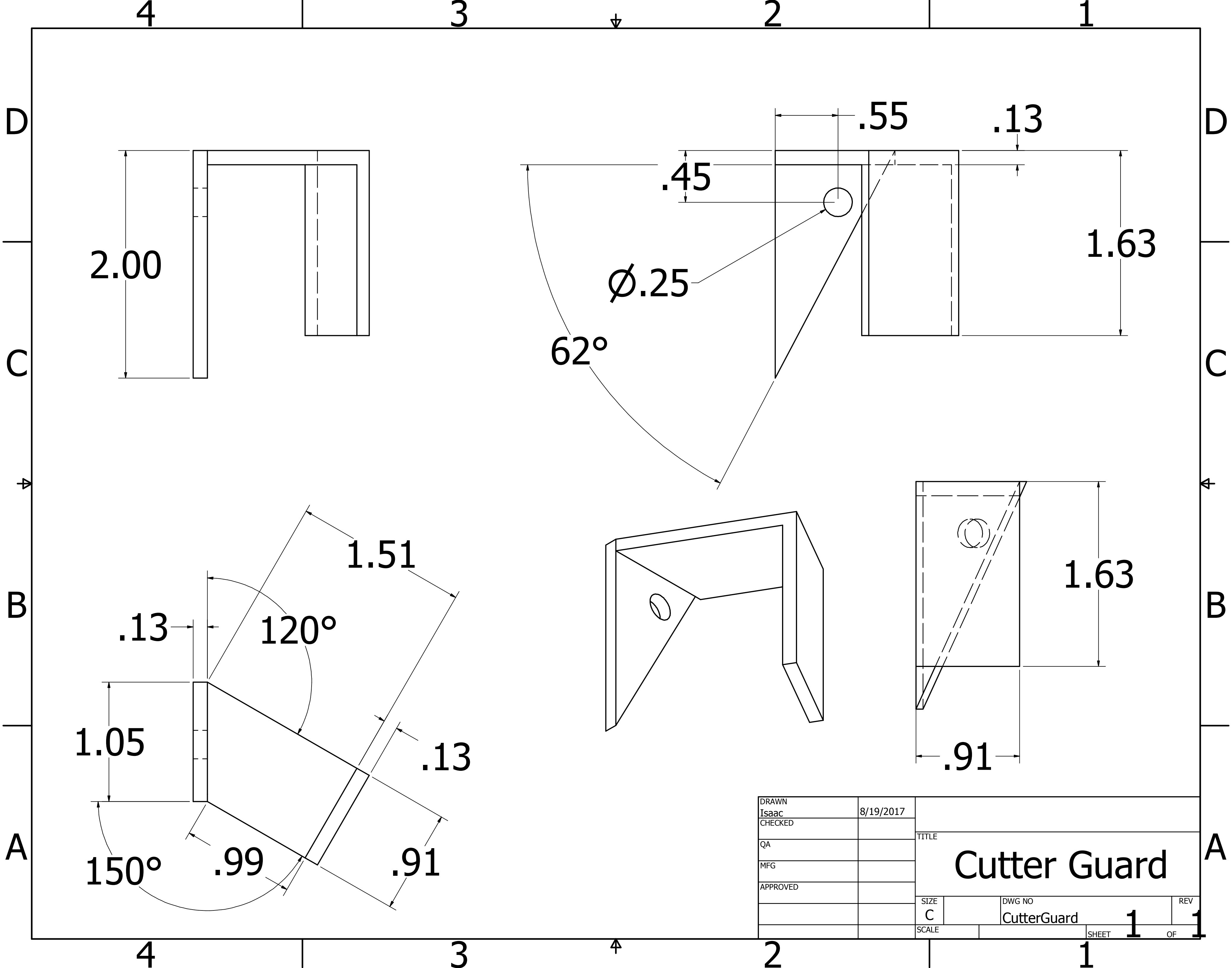

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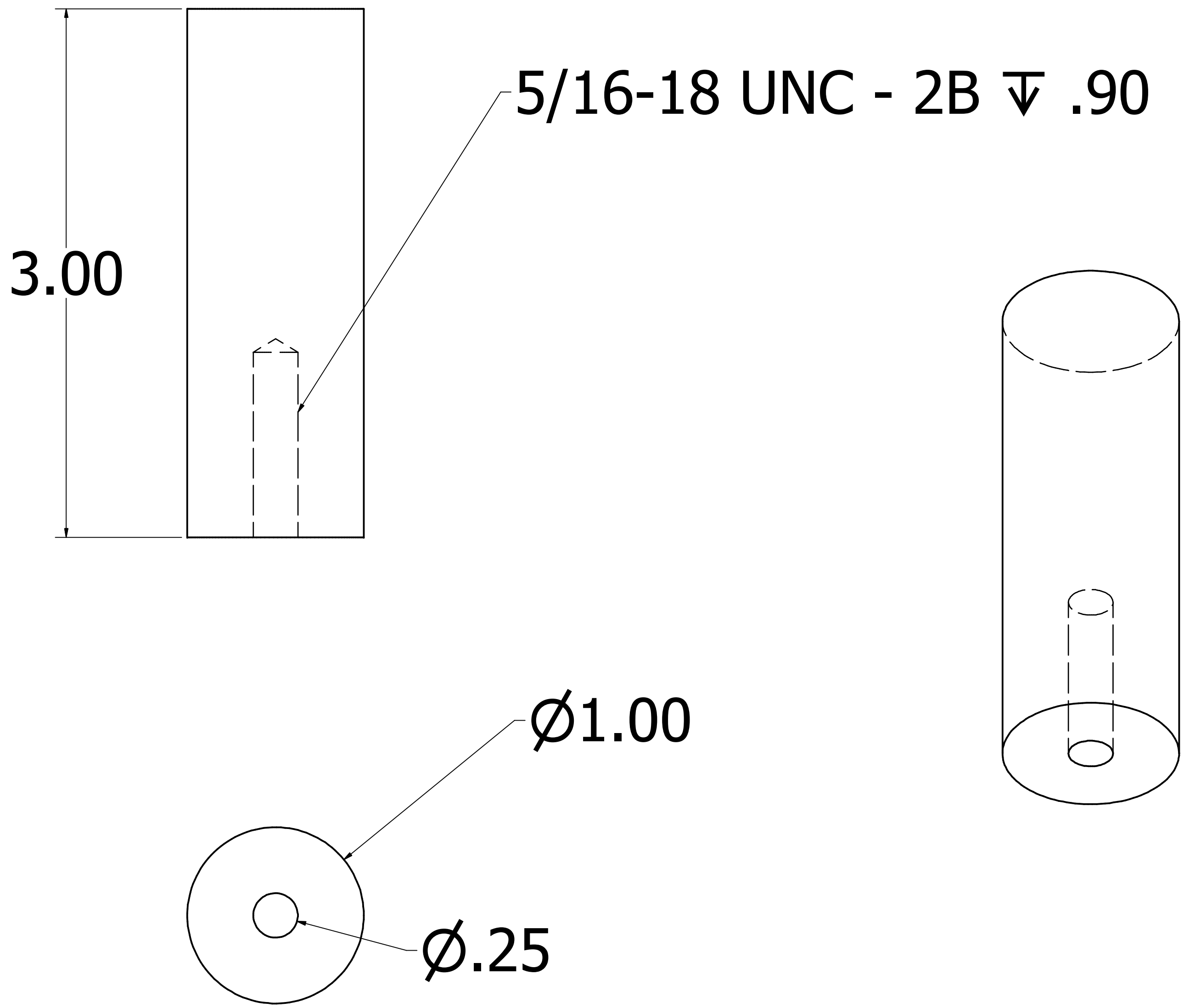

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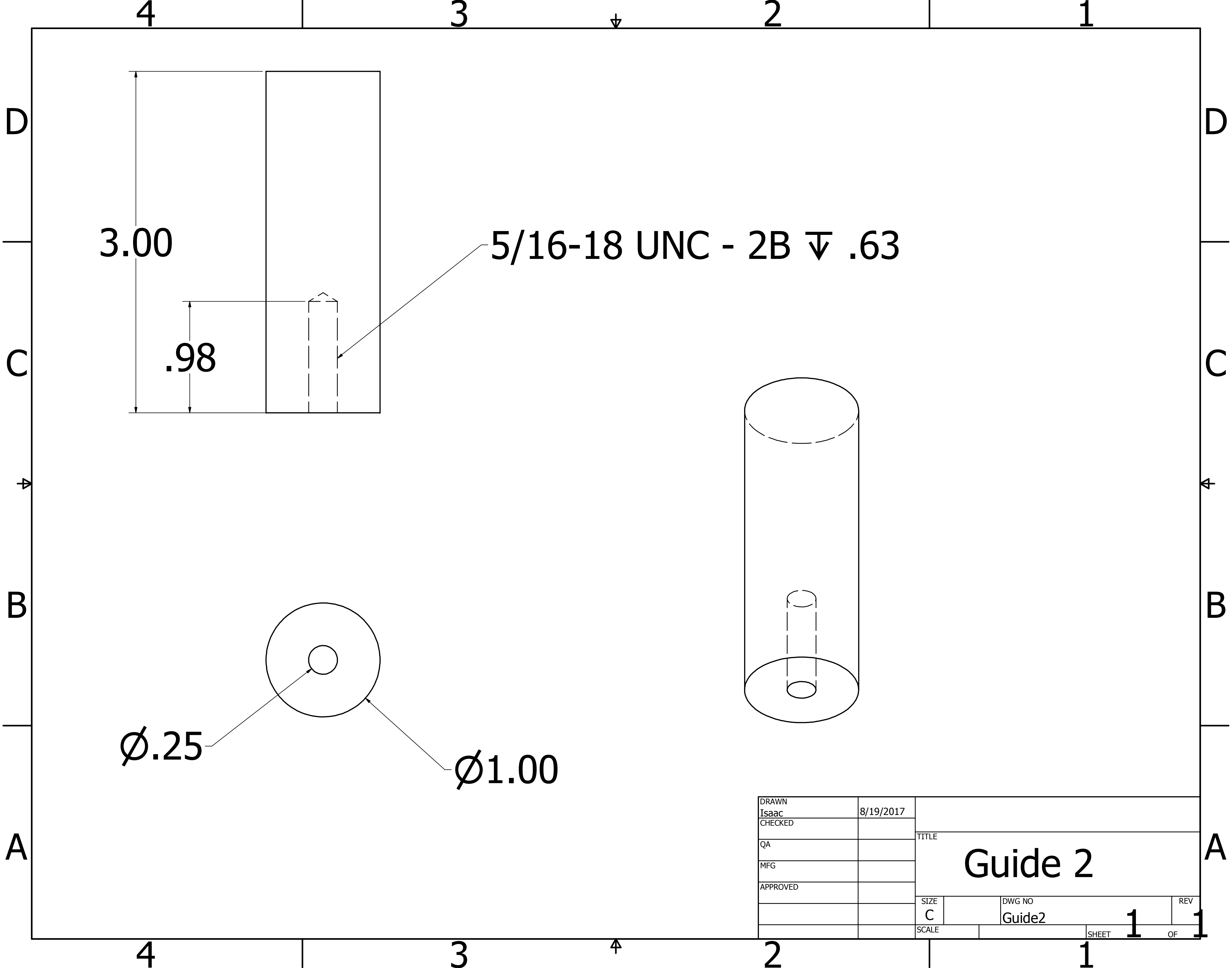
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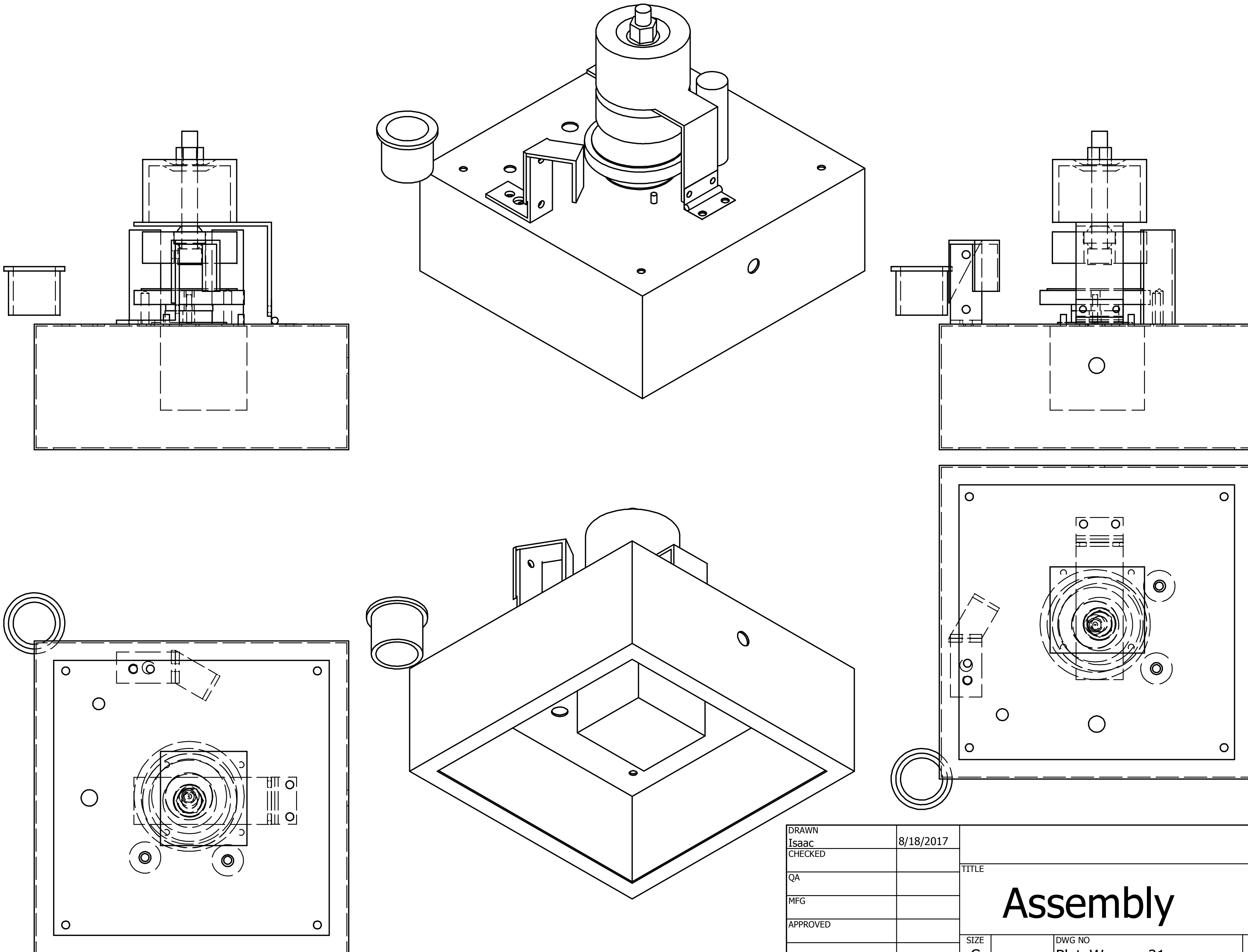

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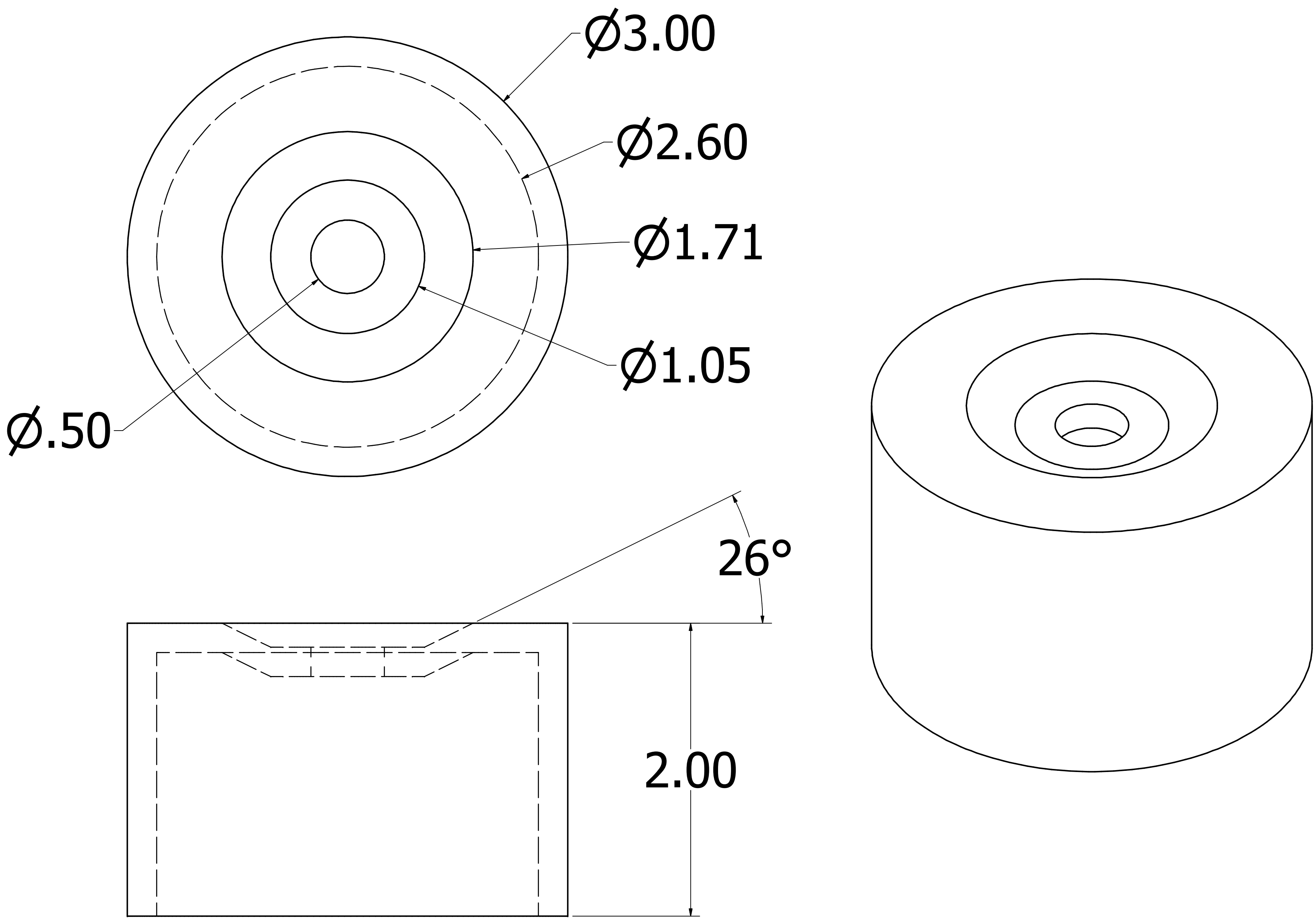

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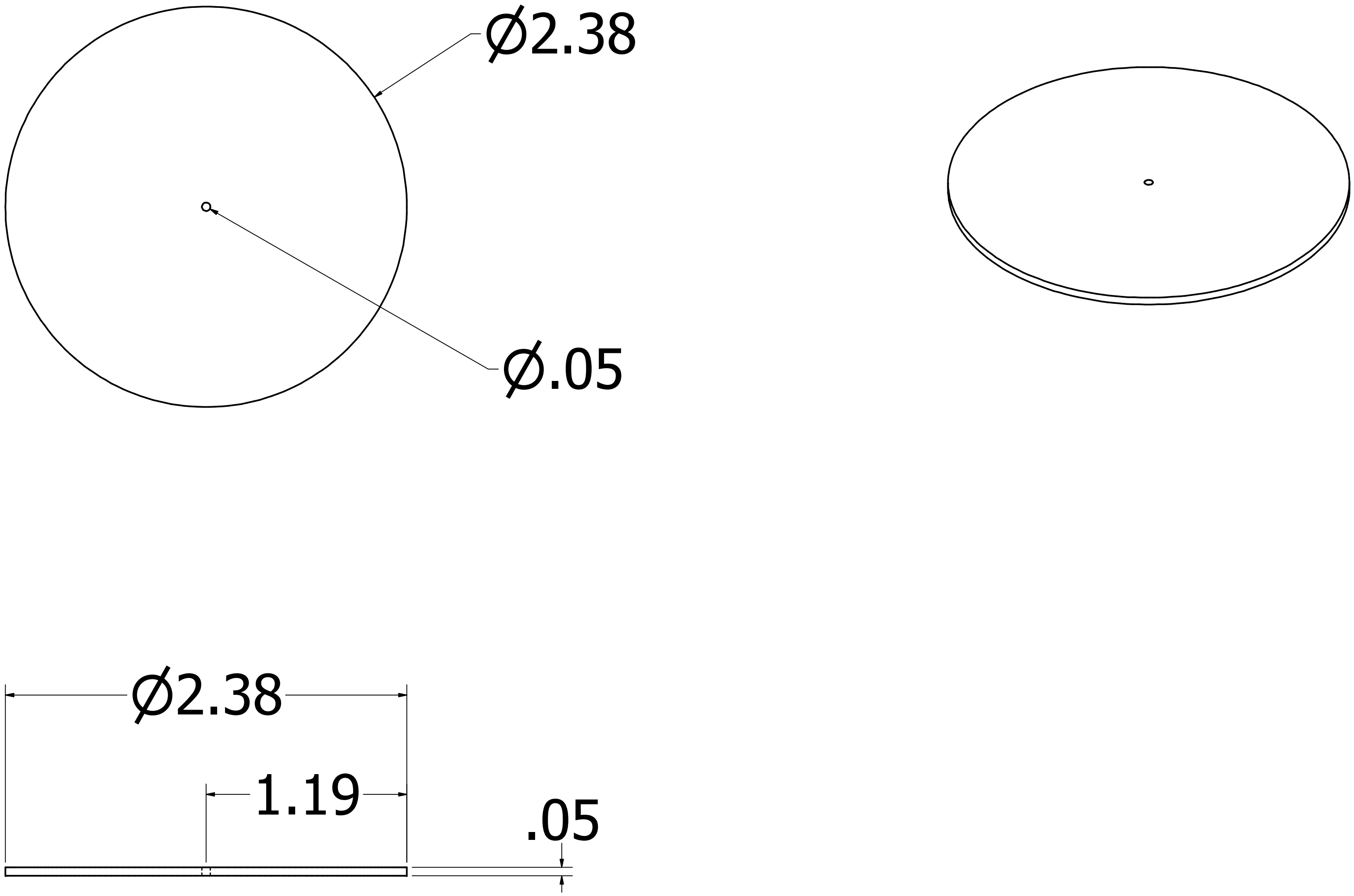

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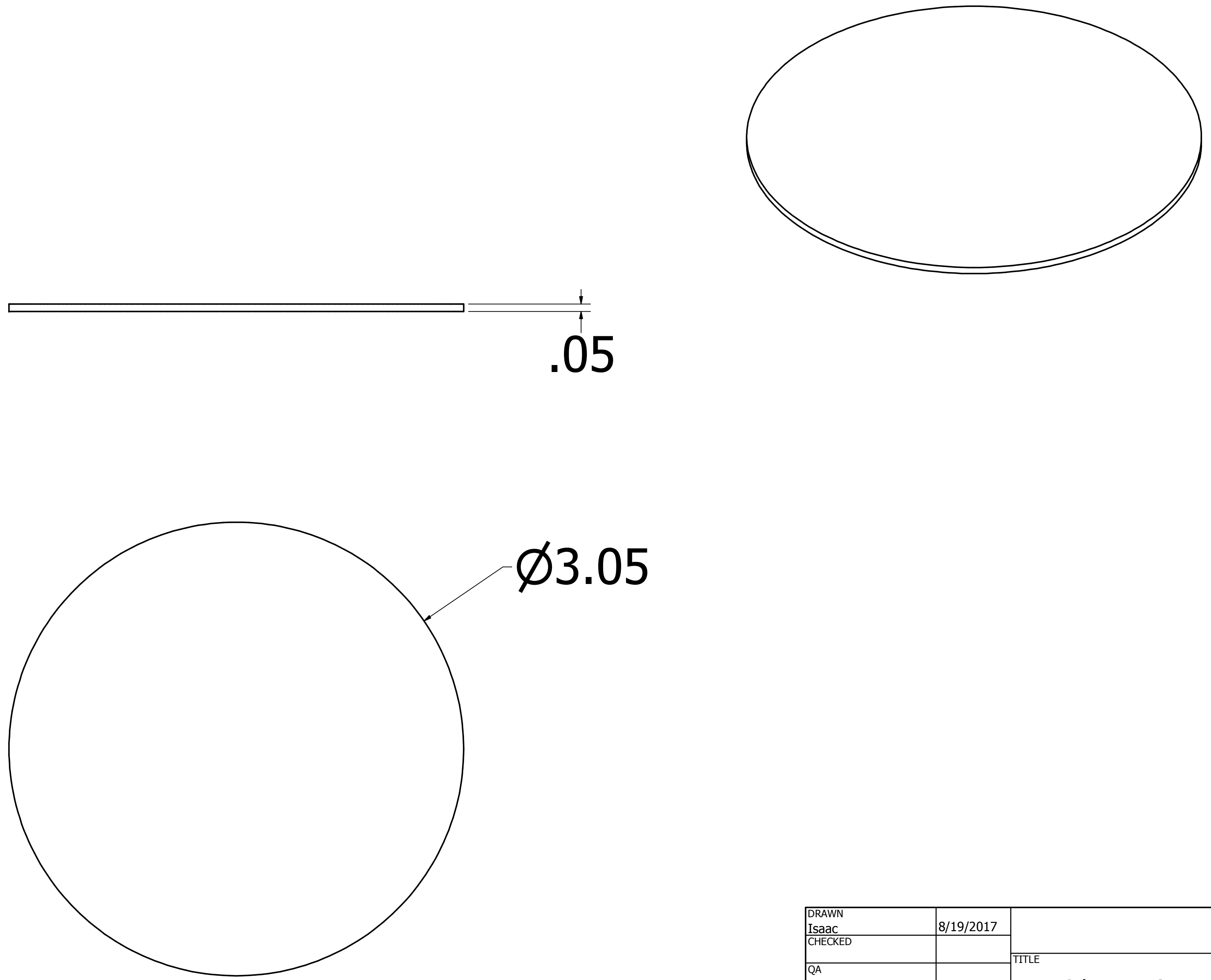

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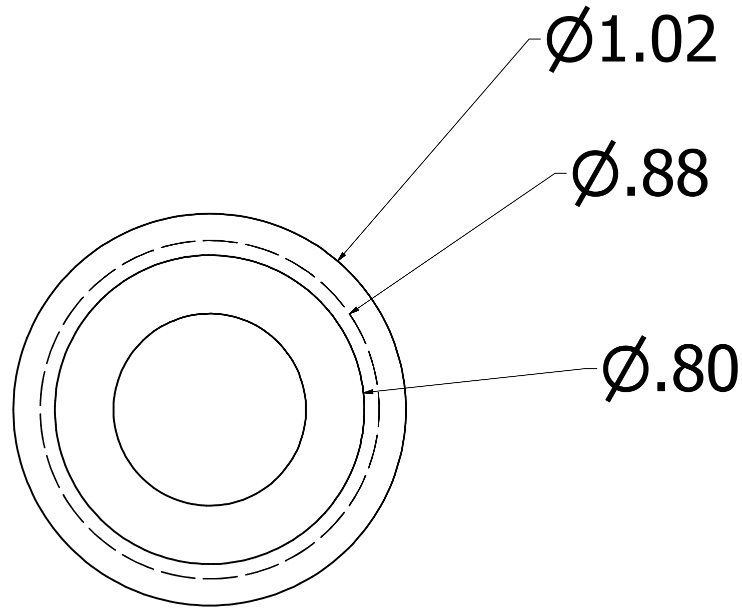

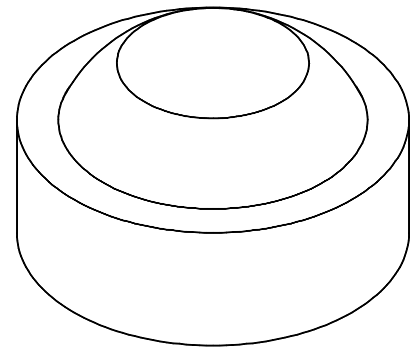

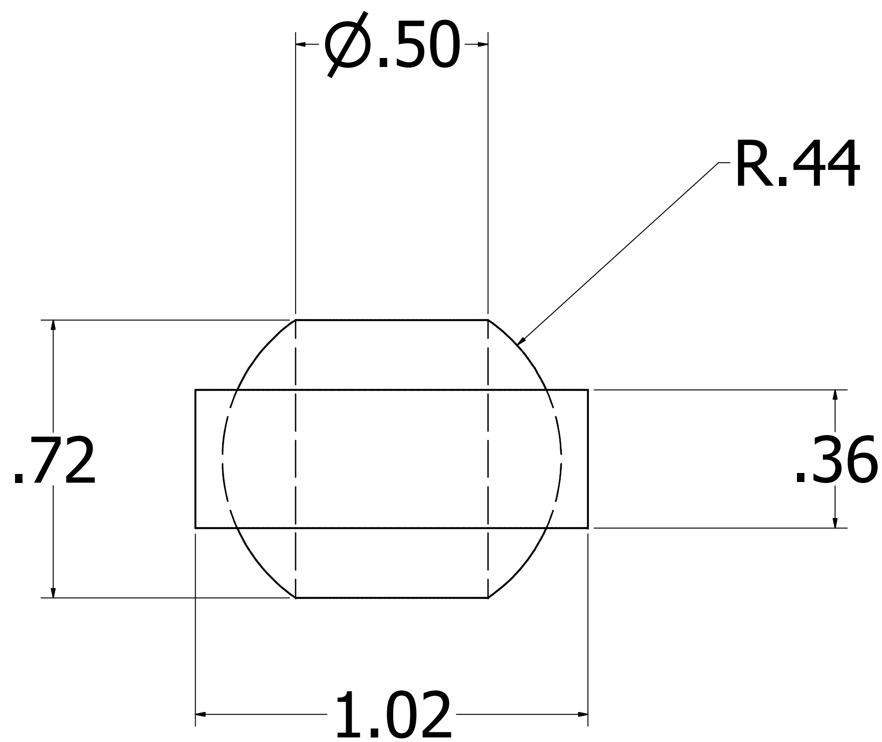

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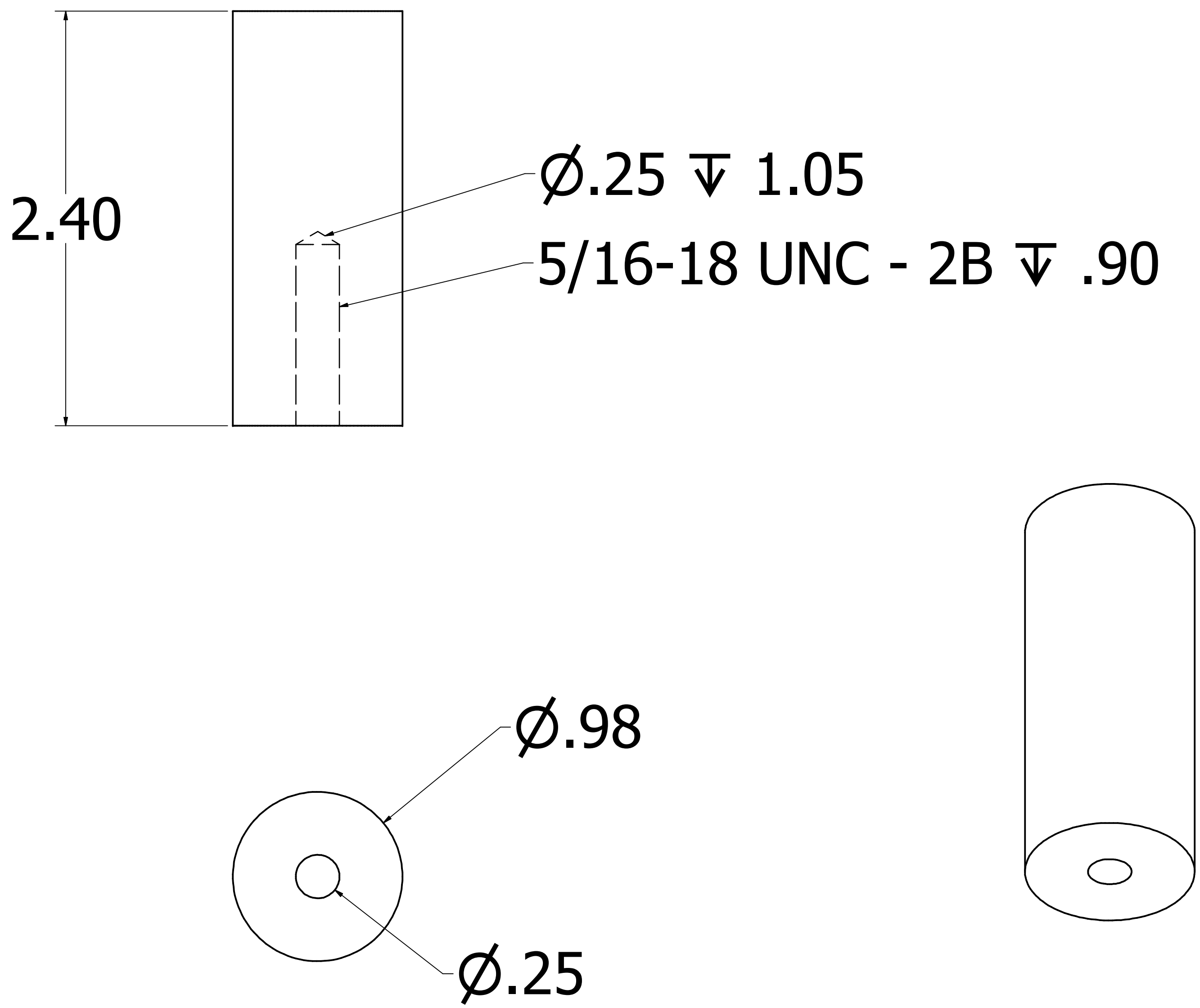

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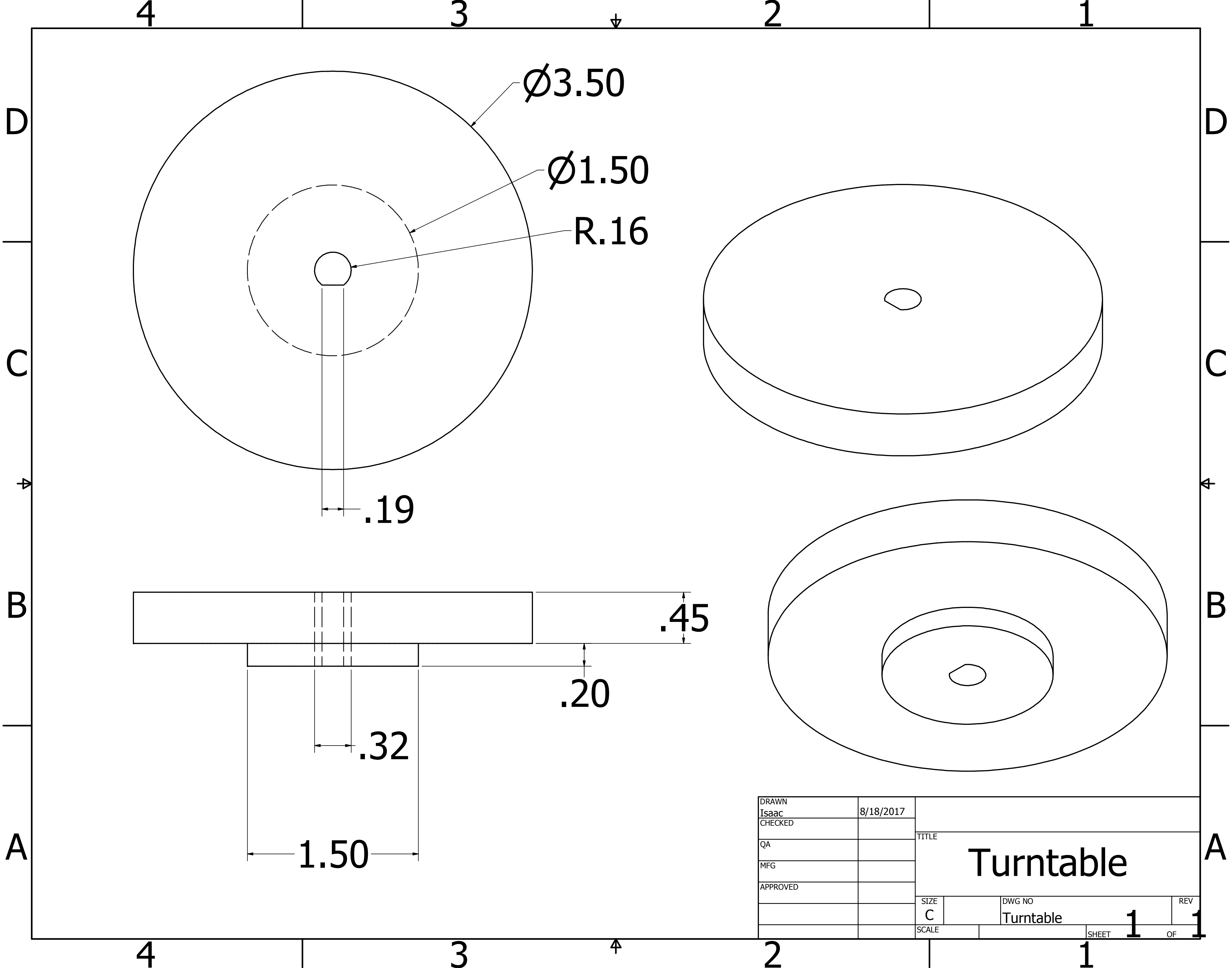

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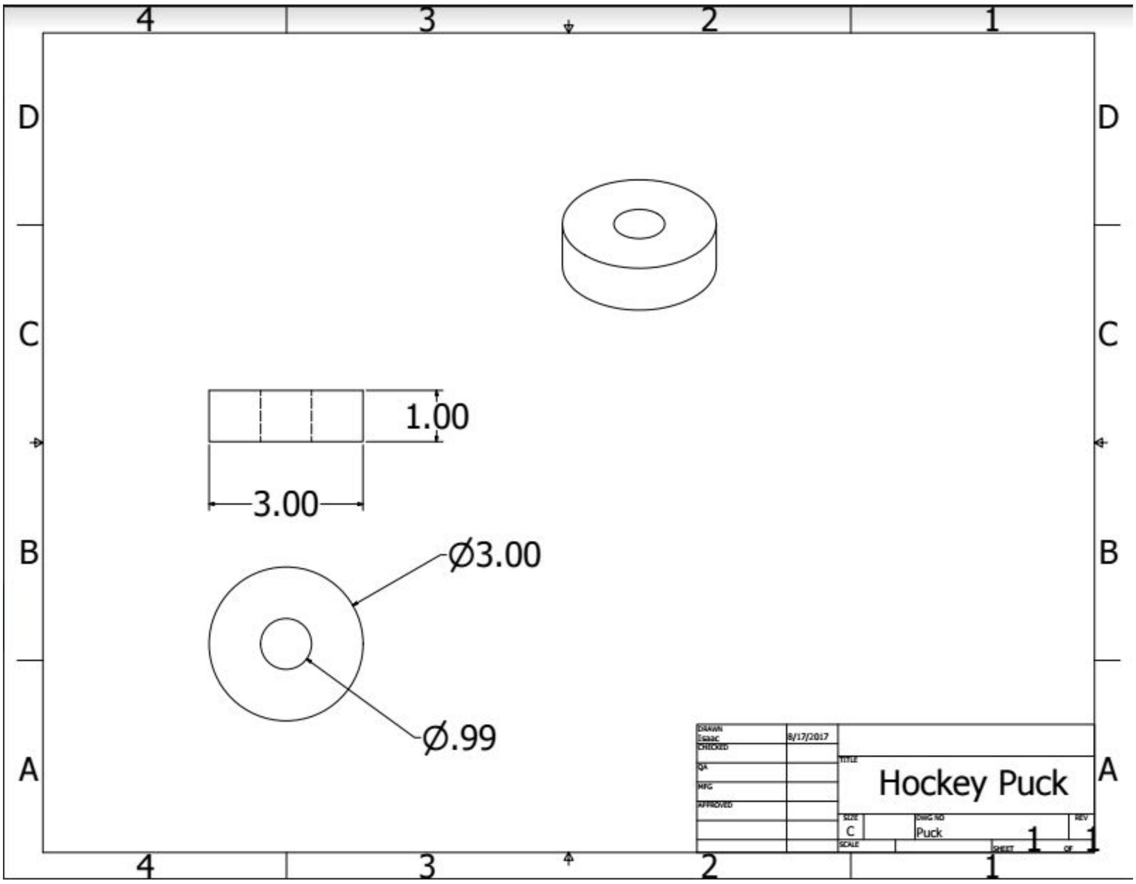
10110	Lorell 5/16" Steel Thumb Tacks	1	1	WALMART.COM	$3.49
90640A133	½”-13 Steel Nylon Insert Lock Nuts (50 Pack)	1	1	MCMASTER.COM	$9.42
92196A727	Stainless Steel Socket Head Screw ½”-13	1	1	MCMASTER.COM	$3.89
	Custom 3D Printed Turntable	1	1	SHAPEWAYS.COM	$42.77
63215K68	Corrosion-Resistant Swivel Joint ½” ID 1.025” OD	1	1	MCMASTER.COM	$15.77

Scrounged Part:

The first part we scrounged was the weight for the mechanism that clamped down on the dish. This was actually a piston from an old brake caliper. I’m unsure of the year/make/model of the car you’d have to get this from, but such calipers could be purchased from a parts store for as low as $10. Another part we scrounged was the spherical bearing.

8 Appendix B – Complete List of Engineering Drawings



9 Annotated Bibliography

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