CABLE HOLDER

Individual Project

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ME 1670 Section A | FALL 2023

Project Description:

For this project, I decided to design something which would address a common problem I faced in my dorm room. The primary power outlet in my room is behind my desk so I have a lot of cables which are fed through the back of my desk. As a result of this, many of the shorter cables (like my iPad charger) tend to fall behind the desk which ends up becoming a nuisance.

To address this, I decided to design a cable holder which would keep these kinds of shorter cables on the surface of the desk, enabling easy access whenever necessary. To do this, I decided to create a C clamp which had a cable holder attached on top.

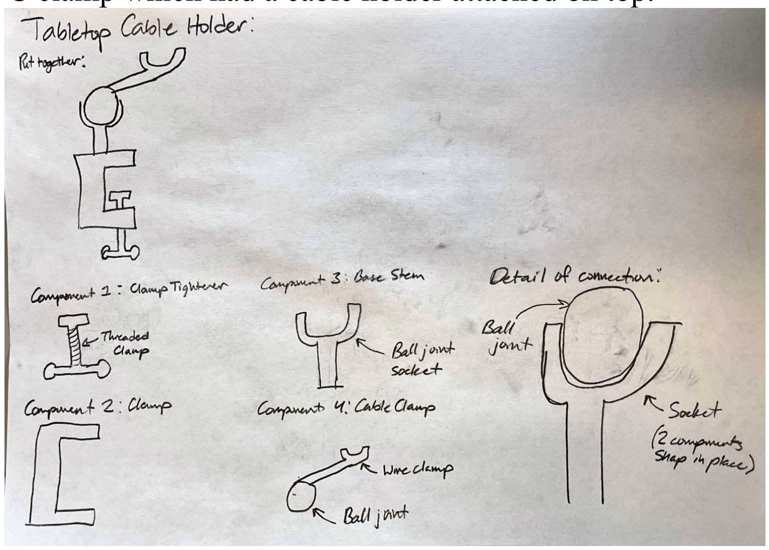


Figure 1: Initial Cable Holder Concept Sketch

As shown in *Figure 1*, when drawing my initial concept sketch, I planned on creating a C clamp, with a ball joint attachment on top, which led to an extended cable holder. But when modeling my parts in SolidWorks, I decided to replace the ball joint attachment with a simpler, more elegant looking cantilever snap fit attachment.

There are 4 main components to my project, the C clamp, the screw, the table stopper, and the cable holder.

Required CAD Features:

C Clamp:

- Extrude – Clamp Thickness
- Extruded Cut 1 – Through Hole for Threads
- Extruded Cut 2 – Snap Fit Hole
- Shell – Internal Hollow

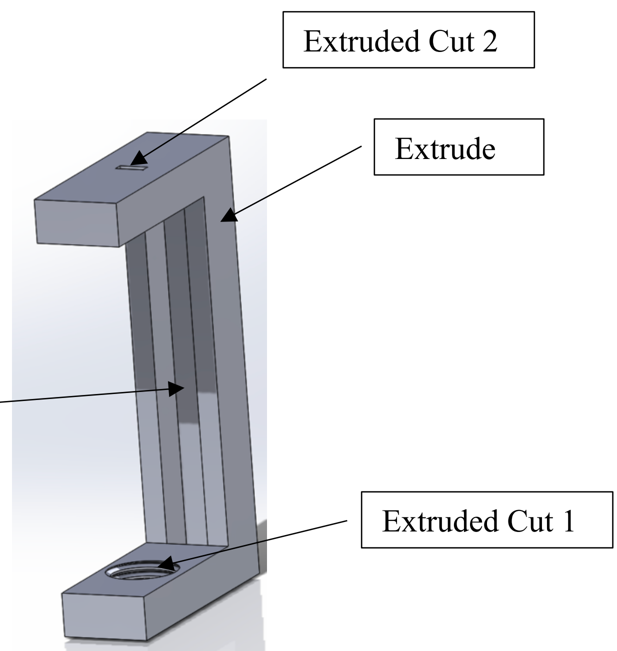


Figure 2: C Clamp Required Features

Screw:
- Extrude 1 – C Clamp Thread Extrusion
- Extrude 2 – Table Stopper Thread Extrusion
- Extrude 3 – Screw Handle Extrusion
- Shell – Screw Hollow

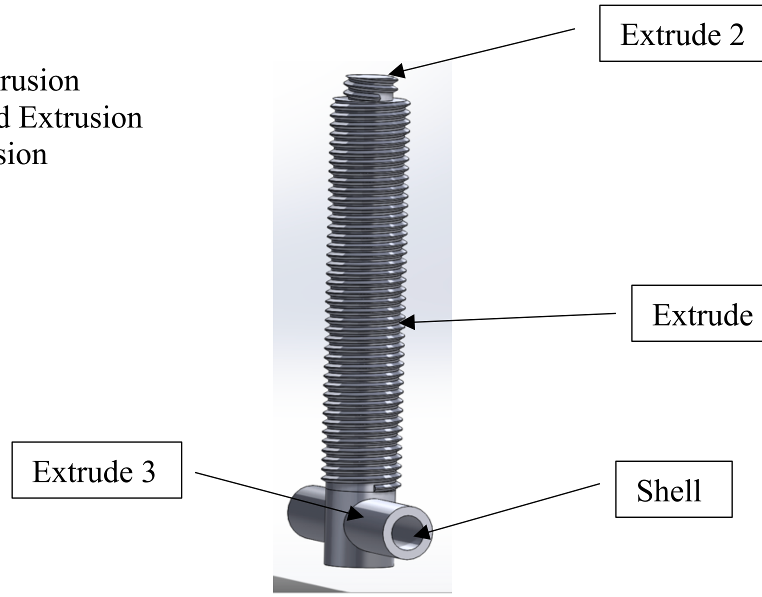


Figure 3: Screw Required Features

Table Stopper:
- Extrude – Table Stopper Depth
- Extruded Cut – Hole for Threads
- Fillet – Hexagon Edge Rounding

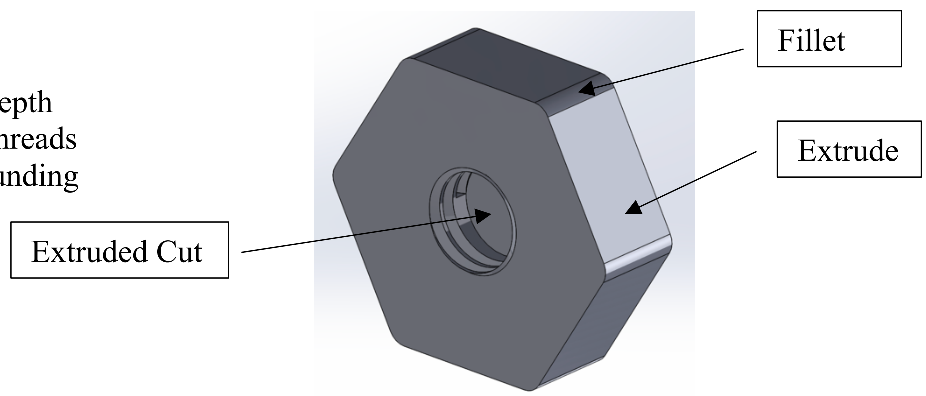


Figure 4: Table Stopper Required Features

Cable Holder:
- Revolve – Cable Holder Body
- Extruded Cut – Cable Holder Slot
- Extrude – Snap Fit Lever
- Mirror – Second Snap Fit Lever
- Chamfer – Cable Holder Lip

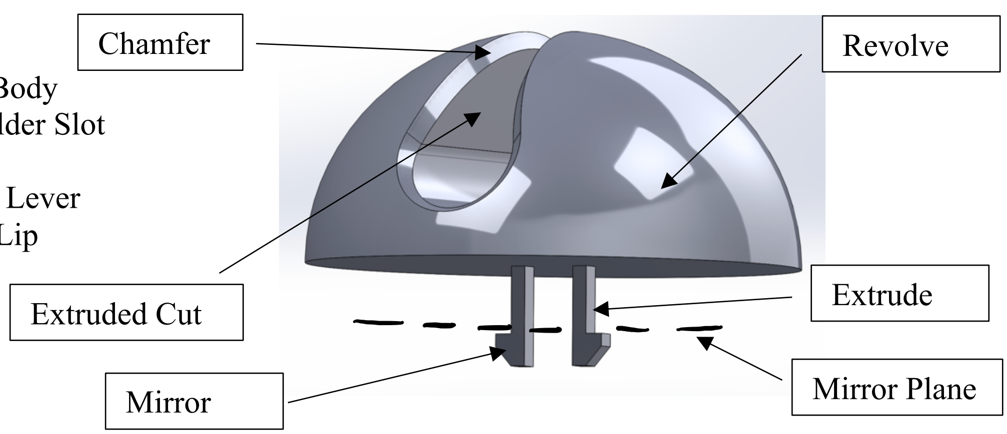


Figure 5: Cable Holder Required Features

Interlocking Parts:

The design has two main interlocking features: threads and a snap-fit fastener. There are two different interlocking threads as shown in *Figure 2, Figure 3,* and *Figure 4.* The screw is threaded through a right-hand internal thread in the C clamp while the stopper is threaded to the screw with a left-hand internal thread. The snap fit mechanism is shown in *Figure* 1 and *Figure 5.* The two levers on the cable holder can be inserted into the rectangular hole on the top surface of the C clamp to hold the two parts together.

Design for Manufacturing Considerations:

When designing my parts I started by first taking basic measurements of various table thicknesses. This was necessary in order to decide how big to make the C clamp. Ultimately, I decided to make the clamp opening 80 mm tall as this would accommodate for a good amount of clearance for the clamp to be used on various table sizes and thicknesses.

When deciding what interlocking features to use, it was a no brainer to use a thread to connect the screw, C clamp, and table stopper together. When 3D printing threads, the thread pitch must be greater than 2 mm so, I decided to use a metric thread size of M16x2 for the screw/C clamp interlocking mechanism and M14x2 for the screw/table stopper interlocking mechanism. For both these mechanisms, the male thread was an extruded thread while the female thread was a cut thread operation in SolidWorks. When tolerancing the threads, I made the male cylinder 0.5 mm smaller than the female hole as threads are classified as a "mechanically active" part. This tolerance was provided in the 3D printing guidelines lecture slides.

For the C clamp/cable holder connection it took me longer to decided what interlocking mechanism to use. Initially, in my original part drawing I had planned on using a ball joint, but after thinking about how to model it, I figured it would be easier to try using something else. After digging around in the box of sample interlocking mechanisms provided by Professor Dorozhkin, I decided to create a snap fit fastener. Using calipers, I was able to measure the basic dimensions of the snap fit sample part and recreate its design in SolidWorks. When tolerancing the snap fit, I made the snap fit hole 0.4 mm wider than the width from one lever to the other. A snap fit would be classified as a "tightly fitting" part, so according to the 3D printing guidelines the tolerance should be 0.2-0.3 mm. In this case I made it so that there was 0.2mm clearance on either side of the hole which totaled to being 0.4 mm wider.

In addition to taking advantage of the lecture slides, I also used a reference model from Thingiverse to decide how to design my cable holder. The reference model can be seen in *Figure 6* below.

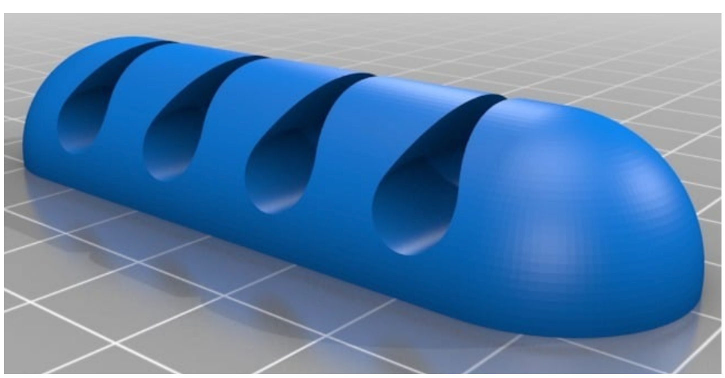


Figure 6: Thingiverse Reference Model

After getting a general idea on how to shape my cable holder, I used calipers to measure the width of a common iPad charger. Then, I made the width of the opening to the cavity of the cable holder 0.2 mm smaller than the measured resulting in a gap of 1.80 mm. To ensure ease of use, I chamfered the edge of in order to make it easier to move the cable in and out of the holder.

During the final stages of the design phase, I encountered a challenge regarding the limitations of the project requirements. Each of our parts had to fit inside of a 3-inch x 3-inch x 3-inch printer bounding box and the combined volume of all the parts needed to be less than 4 cubic inches. My parts outer dimensions and volume were marginally larger than both of these requirements, so I had to figure out a way to fix this.

To accommodate for the bounding box limits, I used the SolidWorks "scale" feature in order to proportionally scale all of my dimensions down by a scaling factor of 0.85. When scaling, I made sure to be mindful that the C clamp's opening did not shrink too much to the point where it wouldn't be able to clamp to a table anymore.

To reduce the volume of my parts, I decided to hollow out my C clamp as well as my screw using the shell operation as shown in *Figures 2 and 3.* This was optimal as I was able to reduce the amount of material used while avoiding changing the functionality of the two parts respectively.

After finalizing all my part models, I used the SolidWorks assembly environment to ensure that all the parts were modeled as intended. I was able to visually check that there was enough tolerance for the snap fit as well as use the cross-section tool in SolidWorks to check the tolerance of the threads.

Challenges Faced in Manufacturing:

As a result of the very high-quality manufacturing process of the high-end SLS printer used, there were no challenges faced during manufacturing.

When assembling the parts, there were a few minor challenges encountered. First, for the initial pass, the threads required some force to rotate. But eventually they began to loosen up adequately in order to move with ease. Finally, the snap fit levers ended up being much thinner than I had anticipated resulting in them being quite flexible. This posed a small issue because if the lever was bent, it had the tendency to stay in the same position rather than flex back to its initial location. As a result of this, the snap fit did end up holding the components together, but not as snug as I would have liked.

If I were to redesign my parts to address these issues, I would have increased the tolerance for the threads by another 0.1 mm so they would have had a better range of motion. For the snap fit levers, I would increase the extrusion length in order to increase the lever thickness which would in turn, increase the lever stiffness.

Tolerance Analysis:

Feature	Original Dimensions in CAD (mm)	Scaled Dimensions in CAD (SF: 0.85) (mm)	Actual Measured on 3D Part (mm)	% Difference
C Clamp Thickness	20	17.00	17.38	2.24
C Clamp Height	100	85.00	85.02	0.02
C Clamp Width	60	51.00	50.96	0.08

C Clamp Internal Shell Thickness	5	4.25	4.41	3.76
Table Stopper Width	30.31	25.76	25.82	0.23
Table Stopper Height	10	8.50	8.66	1.88
Screw Height	105	89.25	90.05	0.90
Screw Handle Width	55	46.75	46.63	0.26
Cable Holder Width	50	42.50	42.06	1.05
Cable Holder Cantilever Thickness	2	1.70	1.64	3.66

The measured dimensions ended up being very close to the dimensions in the CAD model. The measured difference ranged anywhere from 0.02-3.76 percent. I couldn't measure some dimensions on the part accurately using calipers (like the thread width). So, instead I focused on mainly the outer bounds of each part. Here is a summary of my tolerance analysis:

- For the C Clamp, the thickness and height were both slightly larger than the dimensions in the CAD model (2.24 and 0.02 percent bigger respectively). And the width of the clamp was 0.08 percent smaller than the CAD dimensions.
- The table stopper width was 0.23 percent larger than the CAD dimensions and the stopper height was 1.88 percent larger than the CAD dimensions.
- The screw height was 0.90 percent larger than expected and the screw handle width was 0.26 percent smaller than expected.
- The cable holder width was 1.05 percent smaller than expected and the cantilever thickness was 3.66 percent smaller than expected.

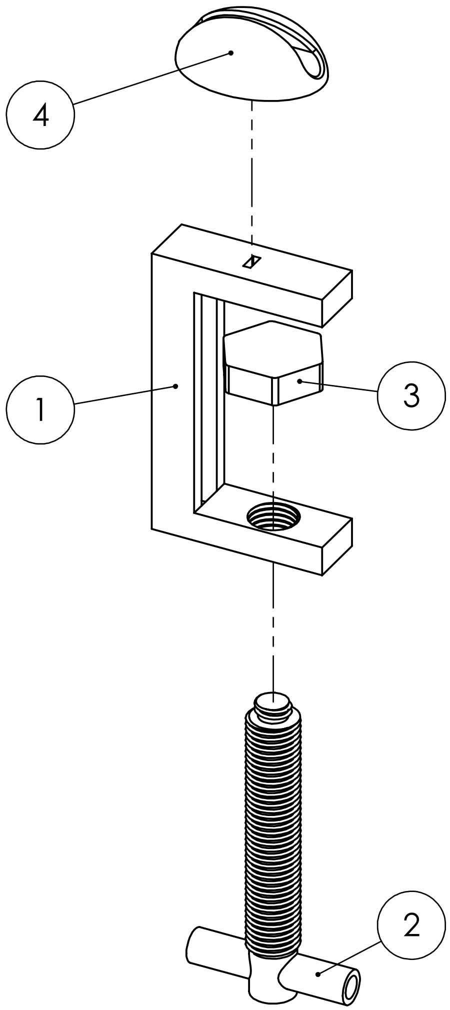
Overall, the parts fit together well. The threads loosened up nicely as the clamp continued to be used, and the snap fit held onto the main body of the clamp well enough to not impair the functionality of the cable holder.

As you may have noticed, the observed differences in dimensions were inconsistent. Some of the parts were slightly smaller than the CAD dimensions (like the width of the cable holder) and some of the parts were slightly larger than the CAD dimensions (like the height of the screw).

Final Design and Conclusion:

From my initial design sketch to the final 3D printed product, my design had a few changes. The most notable change was using a cantilever snap fit attachment for the cable holder rather than a ball joint.

The full design to manufacturing process for this project was much more labor intensive than I had originally imaged as there were a lot of factors which I didn't know I needed to consider, like tolerances and wall thicknesses. One big lesson I learned from this project is to keep the complexity of each part to a minimum. This way, the SolidWorks modeling and part dimensioning process is streamlined. While my design does fit all of the project requirements, if given more time, I would have thought of different ways to optimize my design and created more iterations to refine my idea.



ITEM NO.	PART NUMBER	QTY.
1	C Clamp	1
2	Screw	1
3	Table Stopper	1
4	Cable Holder	1

Georgia Institute of Technology	TITLE Exploded Assembly		DATE 11/30/2023		NAME Shreyas Subramanian	
	COURSE ME 1670	SEMESTER FALL 2023	SECTION A	LAB	ACTIVITY	DIMENSIONS ARE IN MM ANGLES ARE IN DEGREES SCALE 1:2 SHEET 1 OF 1 | SIZE A

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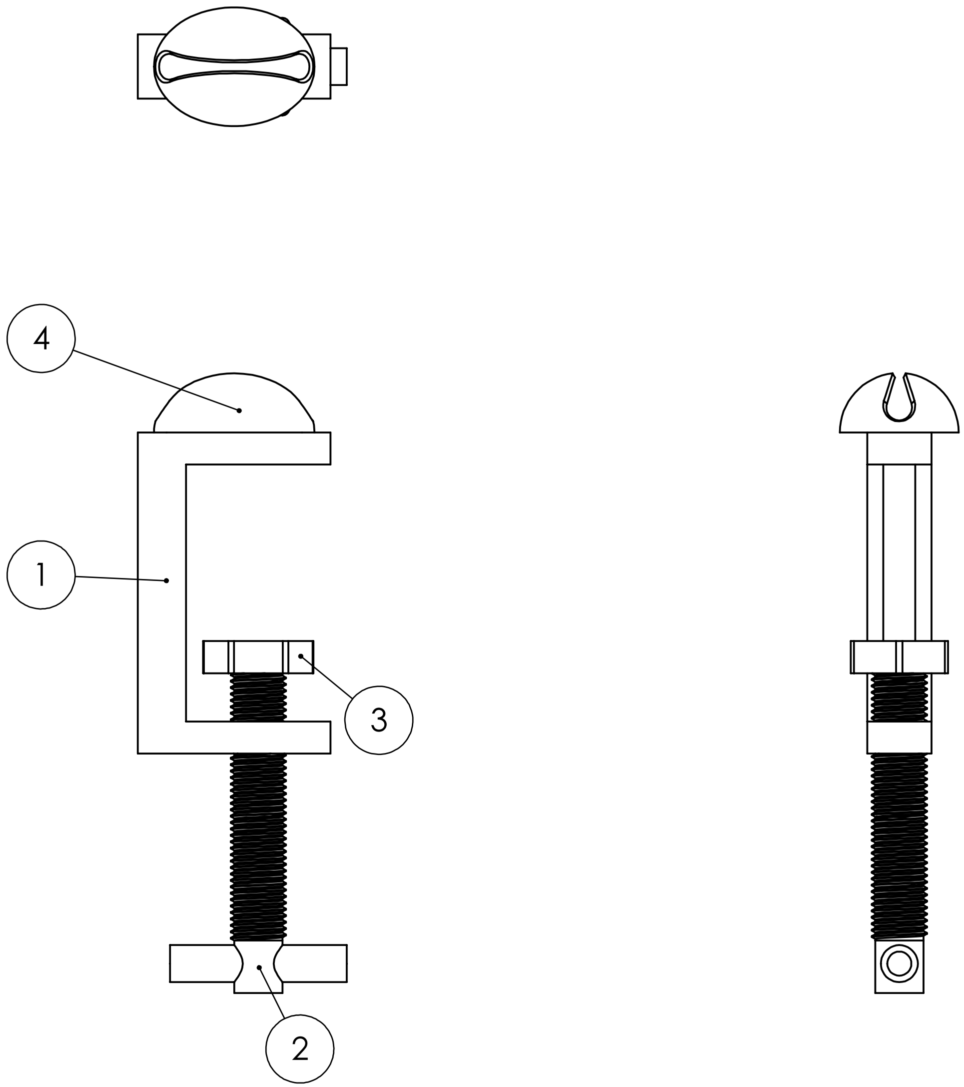

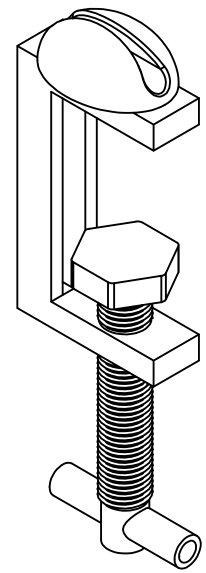

Pictorial For Clarity

Georgia Institute of Technology	TITLE: Outline Assembly		DATE: 11/30/2023	NAME: Shreyas Subramanian		
	COURSE: ME 1670	SEMESTER: FALL 2023	SECTION: D	LAB	ACTIVITY	DIMENSIONS ARE IN MM ANGLES ARE IN DEGREES; SCALE 1:2; SHEET 1 OF 1; SIZE: A

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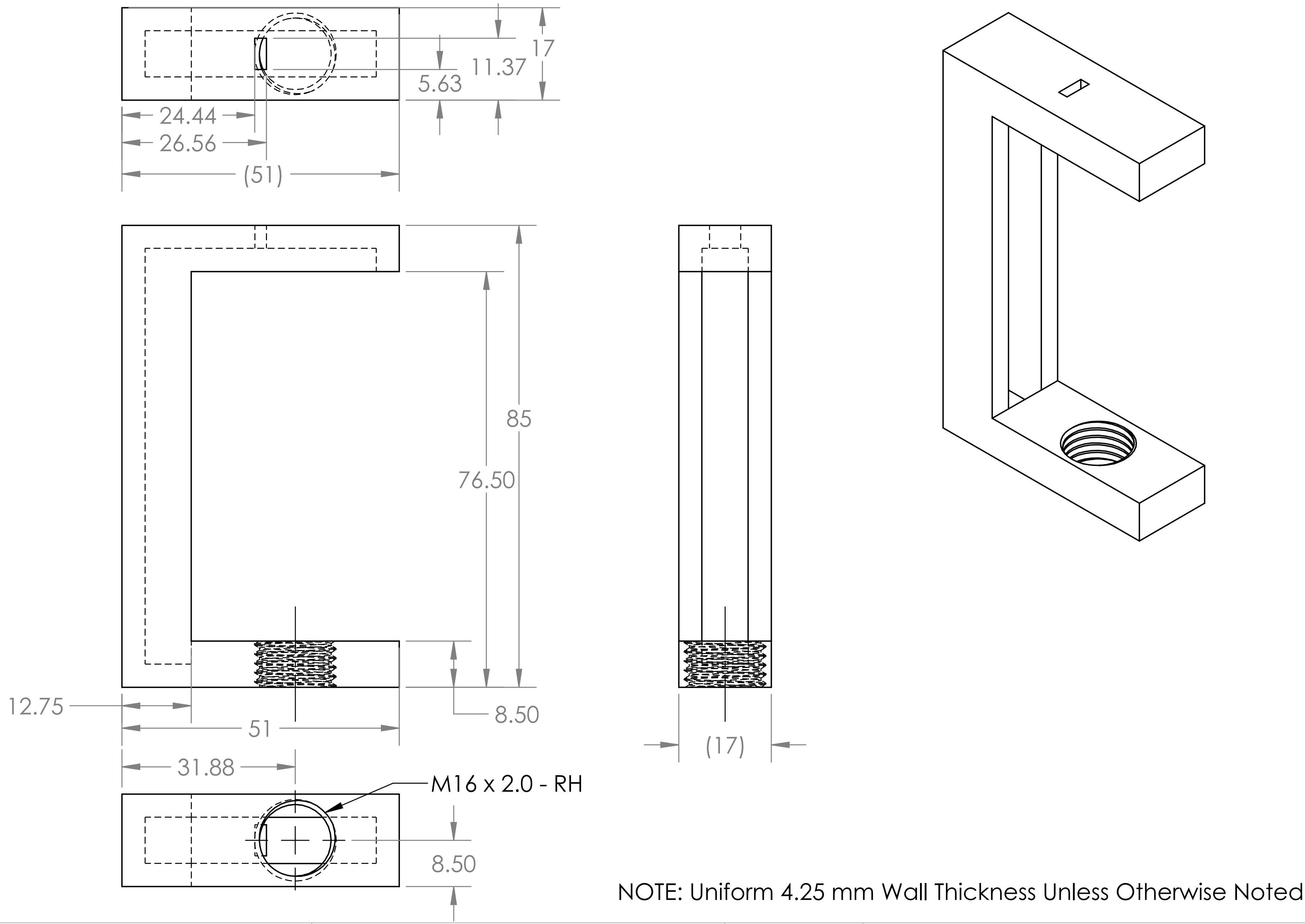

NOTE: Uniform 4.25 mm Wall Thickness Unless Otherwise Noted

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TITLE	DATE	NAME
C Clamp	**11/30/2023**	**Shreyas Subramanian**

COURSE	SEMESTER	SECTION	LAB	ACTIVITY	DIMENSIONS ARE IN MM ANGLES ARE IN DEGREES	SIZE
ME 1670	**FALL 2023**	**A**			SCALE 1:1 SHEET 1 OF 1	**A**

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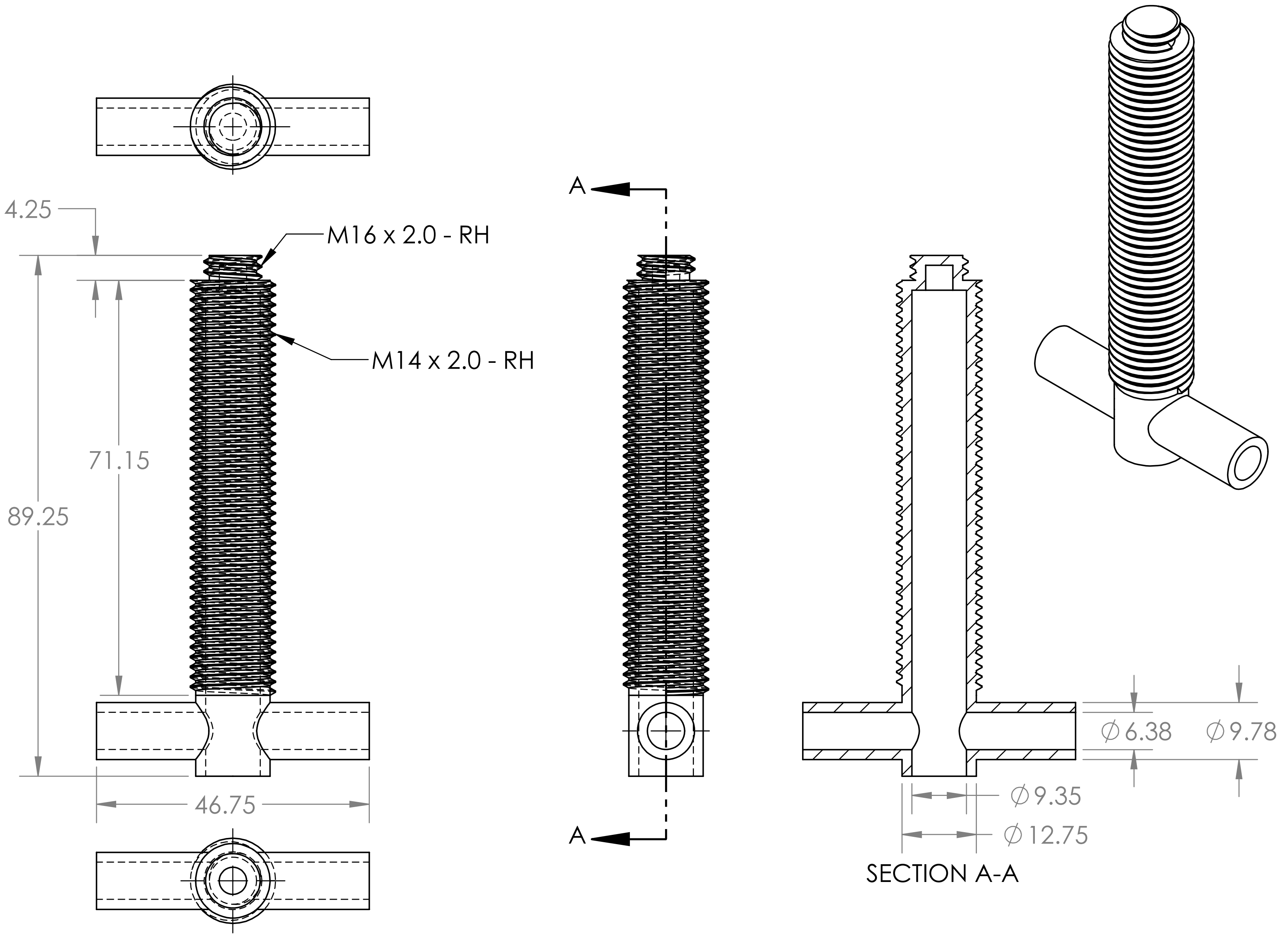

NOTE: Uniform 1.7mm Wall Thickness Unless Otherwise Specified

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TITLE **Screw**		DATE **11/30/2023**	NAME **Shreyas Subramanian**		
COURSE **ME 1670**	SEMESTER **FALL 2023**	SECTION **A**	LAB	ACTIVITY	DIMENSIONS ARE IN MM ANGLES ARE IN DEGREES SCALE 1:1 · SHEET 1 OF 1 · SIZE **A**

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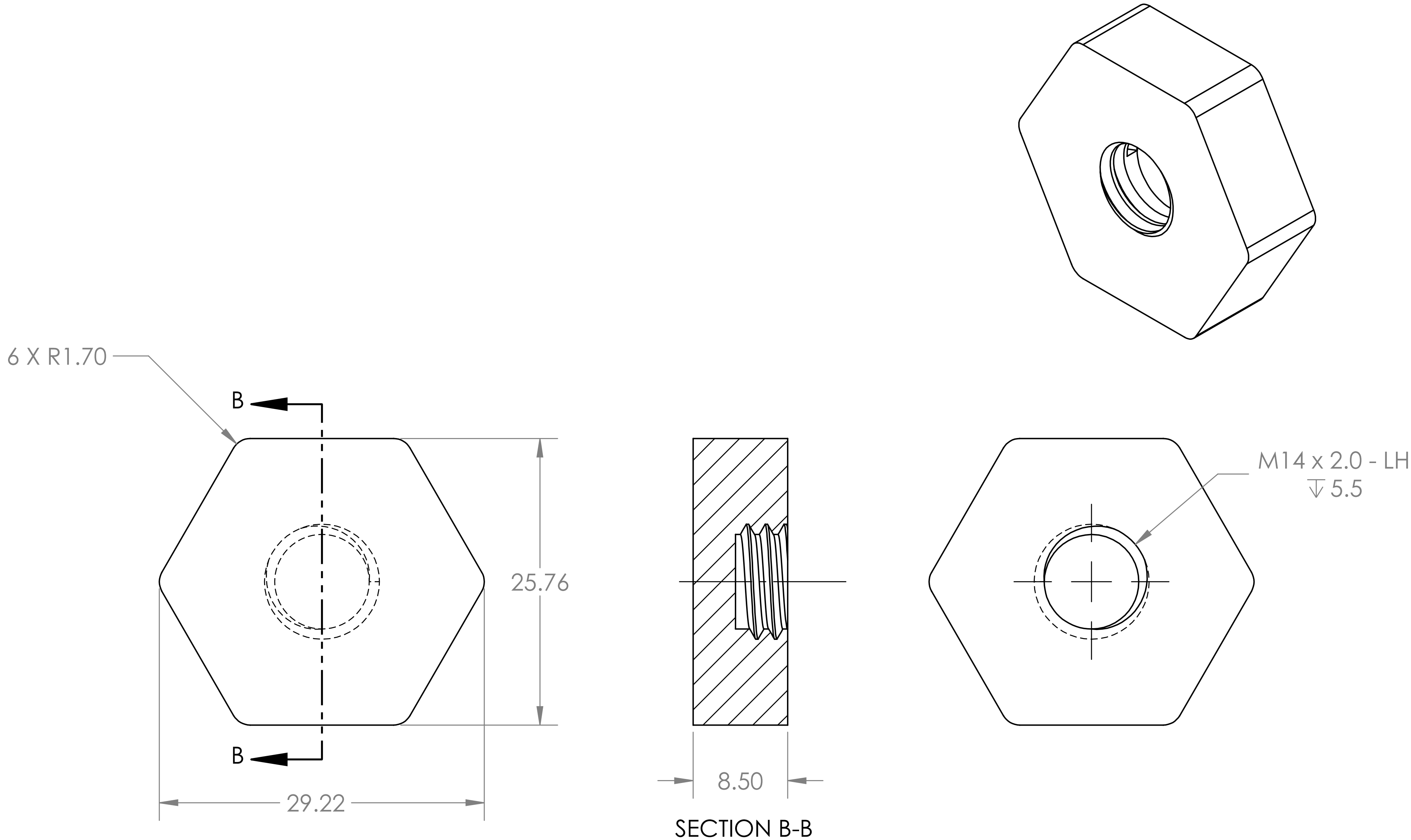

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TITLE		DATE	NAME
Table Stopper		11/30/2023	Shreyas Subramanian

COURSE	SEMESTER	SECTION	LAB	ACTIVITY	DIMENSIONS ARE IN MM ANGLES ARE IN DEGREES		SIZE
ME 1670	FALL 2023	A			SCALE 2:1	SHEET 1 OF 1	A

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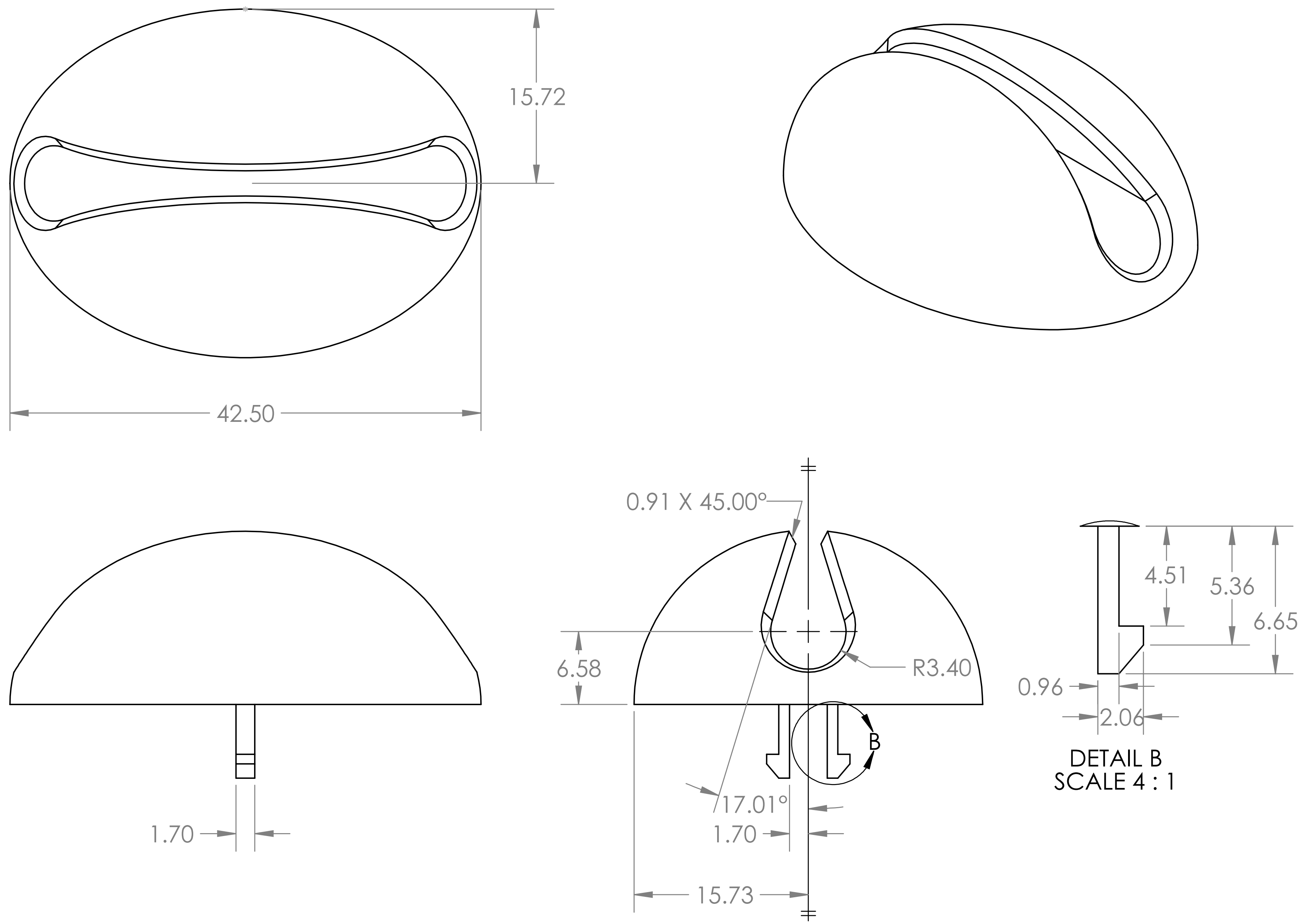

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TITLE
Cable Holder

DATE
11/30/2023

NAME
Shreyas Subramanian

COURSE
ME 1670

SEMESTER
FALL 2023

SECTION
A

LAB

ACTIVITY

DIMENSIONS ARE IN MM
ANGLES ARE IN DEGREES

SCALE 2:1 SHEET 1 OF 1

SIZE
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