Material Testing Fixture

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Progress Report

Document

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Introduction

This report is an update on the current status of our project. We will cover the proposed design from last semester, as well as the new design that was created after feedback from our client. This report will also cover the material selection process, including pricing and structural benefits. We will cover some of the analyses that are being performed to ensure that the design meets the specifications. This report will also cover the manufacturing processes in consideration for making our parts. Finally, we will include an updated timeline for this semester, and the drawings for the new design.

Previous Design

At the end of last semester, we met with our client, Dr. Ciocanel and proposed our final design. The most important part of these designs was how they were used to align the specimen. The tip that was designed was a fixed sized tip that had a cavity cut into the top. This cavity was large enough to accommodate the specimen. A tapped hole was cut into the side of the tip which allowed for a small screw to be inserted. This screw was used for securing the specimen in tension and also served to force the specimen into alignment. Below in **Figure 1**, the tip is shown.

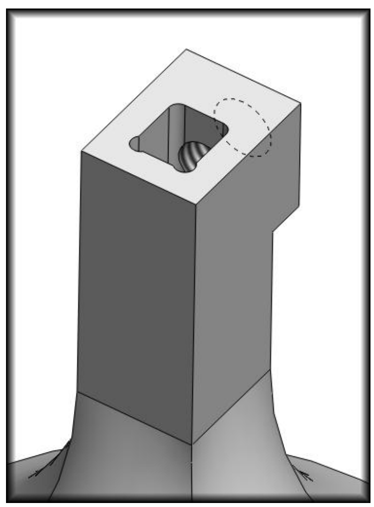


Figure 1 – Previous Tip Design

Another part of our design was the base which secured the push rod to the force analyzer. We had created a base design that hosed the push rod. This base was secured to the fixture with a screw, and a pin was used to secure the push rod to the base. On the next page in **Figure 2**, and **Figure 3**, sectional and isometric views are shown.

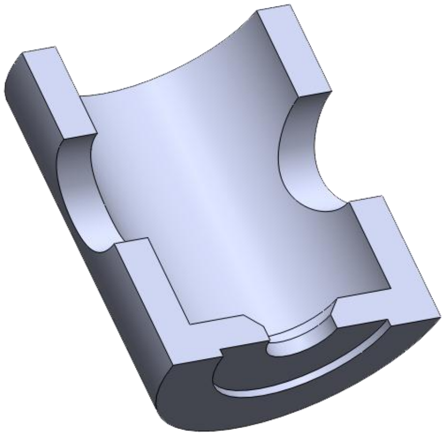


Figure 2 – Section View

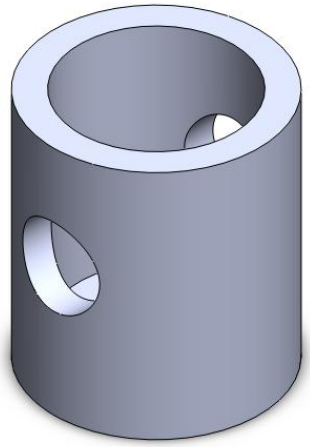


Figure 3 – Isometric View

After working on the project over the winter break, we met with our client who had some new constraints under which we must work. The biggest constraint was that the specimens were not exactly square, and could vary from 2.8 mm to 3.1 mm. This design did not allow for varying specimen sizes and was not compatible. There are many parts of the specimen and it is still lack of the secure device that influences axial alignment. Although this design did not meet all of the constraints, we were able to use some of the features to create a new, modified design.

Modified Fixture

After receiving feedback from our client there were significant changes that we needed to be made to the design. Our previous design was not capable of handling variable sized specimens. Our client informed us that the specimen size may not be square, and could be as far off as (3.1 x 2.8)mm. With this new knowledge we needed to create a compatible tip that would be able to accommodate varying specimen sizes. We based our design on a standard collet that would expand and contract when a sleeve was tightened around the specimen. On the next page in **Figure 4**, an image of this new design is shown.

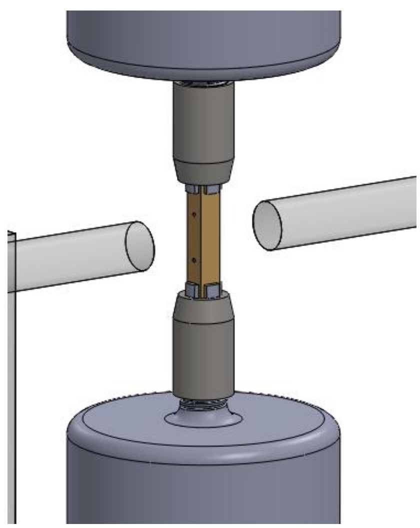


Figure 4 – Collet Tip

In this image we see the two push rods, the tips, and the specimen. This design uses a tapered tip and a corresponding sleeve that when screwed down, produces a lateral force on the tip. This force is then translated to the specimen. To further illustrate this, we created a sectional view of the assembly to show the internal parts. Below in **Figure 5**, the section view of the collet tip is shown. Here the tapered tip and tapered sleeve can be seen.

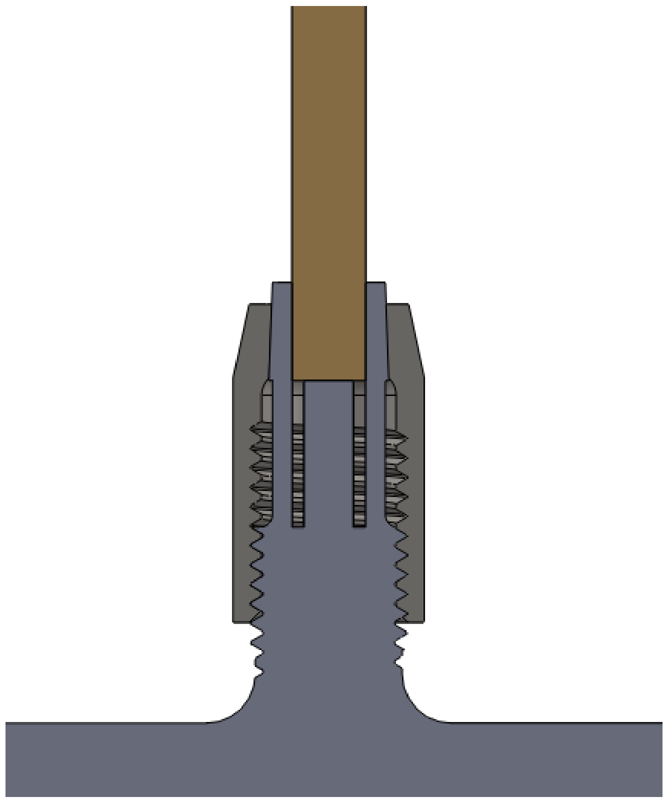


Figure 5 – Sectioned Collet Tip

Another additional design constraint that was added was that there must be a slot for a micrometer on lower push rod. This micrometer is used for applying small lateral forces on the specimens. This device is fitted into the cut out slot and secured with four set screws. In addition, the team has also been given the task of redesigning the tips of the lateral loading components. These tips engage the specimen during loading. Currently the tips are not a precise design and there is a need for a new tip. We have yet to begin designing the new tip for the lateral loading components because their design is relatively simple. Below in **Figure 6**, an image of the full assembly is shown. Here the micrometer clamp can be seen.

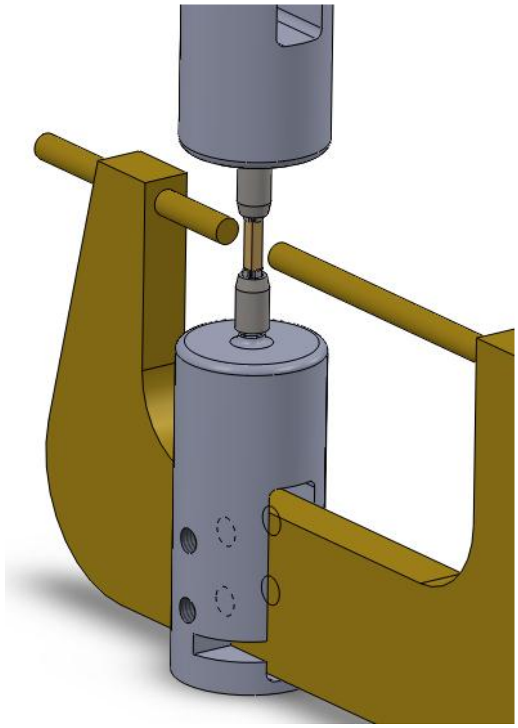


Figure 6 – Full Assembly

Although it is not shown here, the tips for the micrometer fit on the ends of the round rods and apply lateral forces to the specimen. Below in **Figure 7**, a more detailed view of the lower pushrod is shown. Here we can see the cutout for the allen wrench.

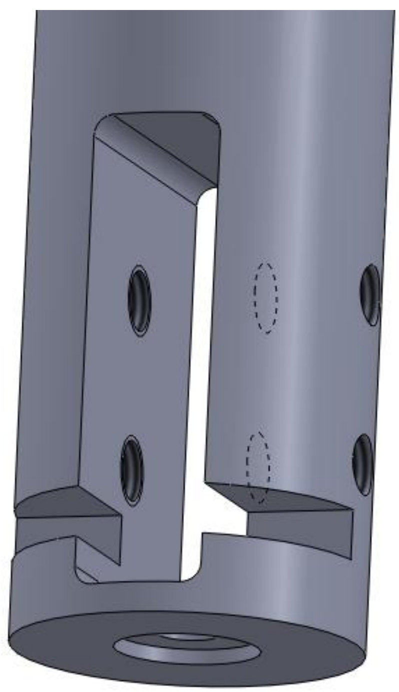


Figure 7 – Lower Pushrod

Material Selection

In this section we will discuss the materials that are involved in this project. There are three main categories of material that are required for this project: Pushrod/Sleeve, rubber sleeve, and screws.

Push rod and Sleeve

For the push rod and sleeve which are the main components of our design, our previous decision was to use the Aluminum Alloy T-6061. Although the yield strength of the aluminum alloy (240MPa) met our requirements we decided to look into a more durable material that could better withstand repeated testing. After looking at several different materials, we decide to use Stainless Steel T-316CR. It has greater yield strength (410Mpa) than the aluminum alloy and will be much more durable. Because the stainless steel has a higher modulus of rigidity than aluminum, many of the variations that would be present in aluminum will not be seen. This will help improve axial alignment, by decreasing the variations that would be found in the aluminum. Most importantly the Stainless Steel T-316CR is a diamagnetic material.

Although the diameter of the pushrod was chosen to be 35mm, we decide to use a round bar which has a diameter of 40 mm. This will allow for a small buffer when machining the parts. Considering waste and manufacture procedure, the length of the bar we will use is longer than the exact length of the push rod which is 300mm. This will also account for the creation of the collet sleeves. After searching online, we found that this amount of material can be bought approximately $50 USD.

Rubber Sleeve

Because the specimen is not always guaranteed to be square, we must ensure that the specimen is in perfect axial alignment regardless of the dimensions. To do this we will use silicon rubber sleeve on the tips of the push rod. This way, when the sleeve is tightened around the specimen, the silicon rubber can compress so as to accommodate varying specimens. The reason we choose silicon rubber sleeve is because we wanted a very thin rubber sleeve, 0.1mm, with good compressive properties.

Because the tip of the push rod is the only part of the fixture that needs these sleeves, we only require a very small amount of the material. The total amount will be less than (200 x 200 x 0.1)mm, and will cost approximately $3 USD.

Screws

There are four screws that go through the push rod to secure the micrometer. We choose the socket set screw (SSS) with dimensions 5/16-18 UNC. The screws are threaded along their entire length with nominal thread diameter of 0.3125 inches. For this project, we will need the screws to be at least 10mm. The screws are unified coarse and machined in black oxide that provides protection against corrosion.

Analysis

In order to secure the push rods to the force analyzer slots will need to be cut into the pushrod. Because of this, it is important to know how these slots will affect the integrity of the material. We performed an analysis on the base of the bottom pushrod where the area of the push rod would be the smallest. In this area a portion of the rod would be cut in order to accommodate an allen wrench which would be used to secure the pushrod to the base of the testing fixture. The idea with this is to tighten the pushrod down and utilize the concentric surface of the load cell to achieve axial alignment. Below in **Figure 8**, a graph that shows the relationship between stress and diameter is shown.

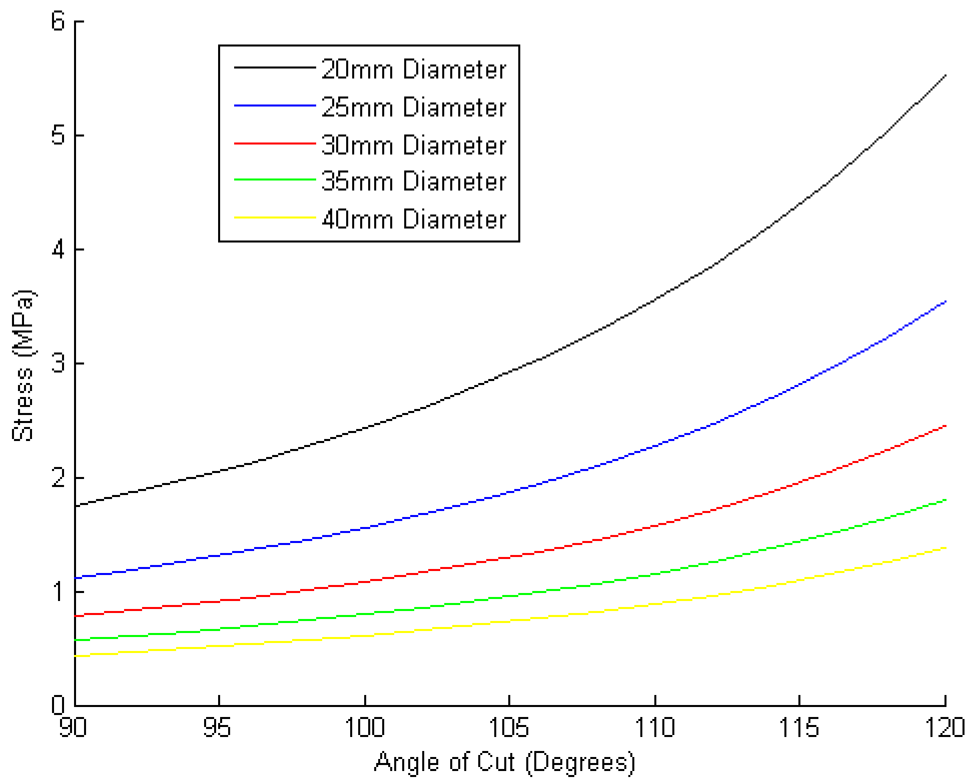


Figure 8 – Stress vs. Angle

As can be seen from this data, the stresses involved at the cut out portions of the push rod are negligible. This is due to the small load that is seen on the push rod itself. The angle of cut is similar to pie shaped cut made from 90-120 degrees and the stress is the force place on the remaining area of the diameter. This analysis was carried out for varying diameters ranging from 20mm to 40mm. As the diameter decreases the stress increases. Below in equation **(1)**, the equation for calculating stress is shown.

$$\sigma = \frac{F}{A} \tag{1}$$

Equation **(1)** was used to determine the amount of stress experienced after the pie shape cut out was made. The average force placed on the pushrods is 60N. This accounts for the negligible stresses that are seen in the diagram.

Manufacturing

One of the main problems we are currently facing is finding a method of manufacturing that will be able to make parts this small, while still maintaining the accuracy. The small scale of the parts makes them difficult to machine, and prevents us from using many conventional machining methods. The tolerances on the parts are extremely critical, which means that many of the most readily available machines are not capable of producing such accurate parts.

We are planning on making our prototype using Fused Deposition Modeling (FDM). This process lays down beads of plastic, layer by layer, until the part is complete. Fused deposition modeling is a relatively inexpensive way to manufacture prototypes, and is available in Northern Arizona University's machine shop.

For the final product, we are currently in contact with a company in California who may be able to make the part. They use a special process call Electro Discharge Machining (EDM). This process removes material by discharging a current between an electrode and the material. Each time the electrodes arc, a small amount of material is removed from the part. This process allows for very high tolerances, and extreme accuracy. By using this process, small dimensions and tolerances can be easily achieved.

Conclusion

In conclusion, we have changed our previous design in order to ensure that the testing fixture can handle variable size of specimen from 2.8mm to 3.1mm. After consulting with our client and proposing our new design, he is satisfied with our final design concept, and has agreed that we should proceed with the new design.

The next steps for our project require that we meet with Dr. John Tester to discuss the use of the FDM machine to produce our prototype. We are also in the process of creating manufacturer's drawings that can be sent to a machine shop and be produced. These drawings, although not fully completed, are located at the end of this report. This means that we are also keeping in contact with the David Barnes Company about manufacturing our final product.

References

http://www.davidbarnescompany.com/

http://www.solidworks.com/

http://www.engineershandbook.com/Tables/frictioncoefficients.htm

http://www.engineersedge.com

http://www.alibaba.com

http://www.tcdcinc.com

http://www.engineeringtoolbox.com/friction-coefficients-d_778.html

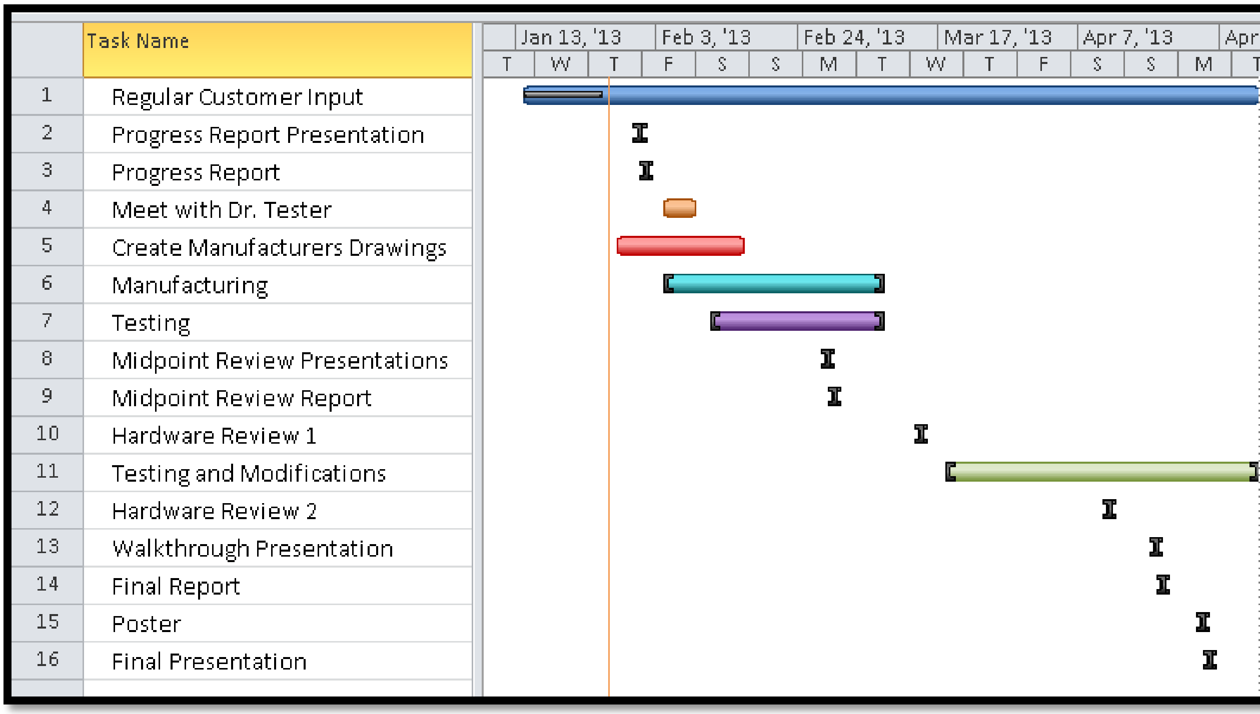
http://www.youtube.com/watch?v=sPwURRG9_Gs

http://nau.edu/Research/Feature-Stories/NAU-on-Leading-Edge-of-Smart-Materials-Research/

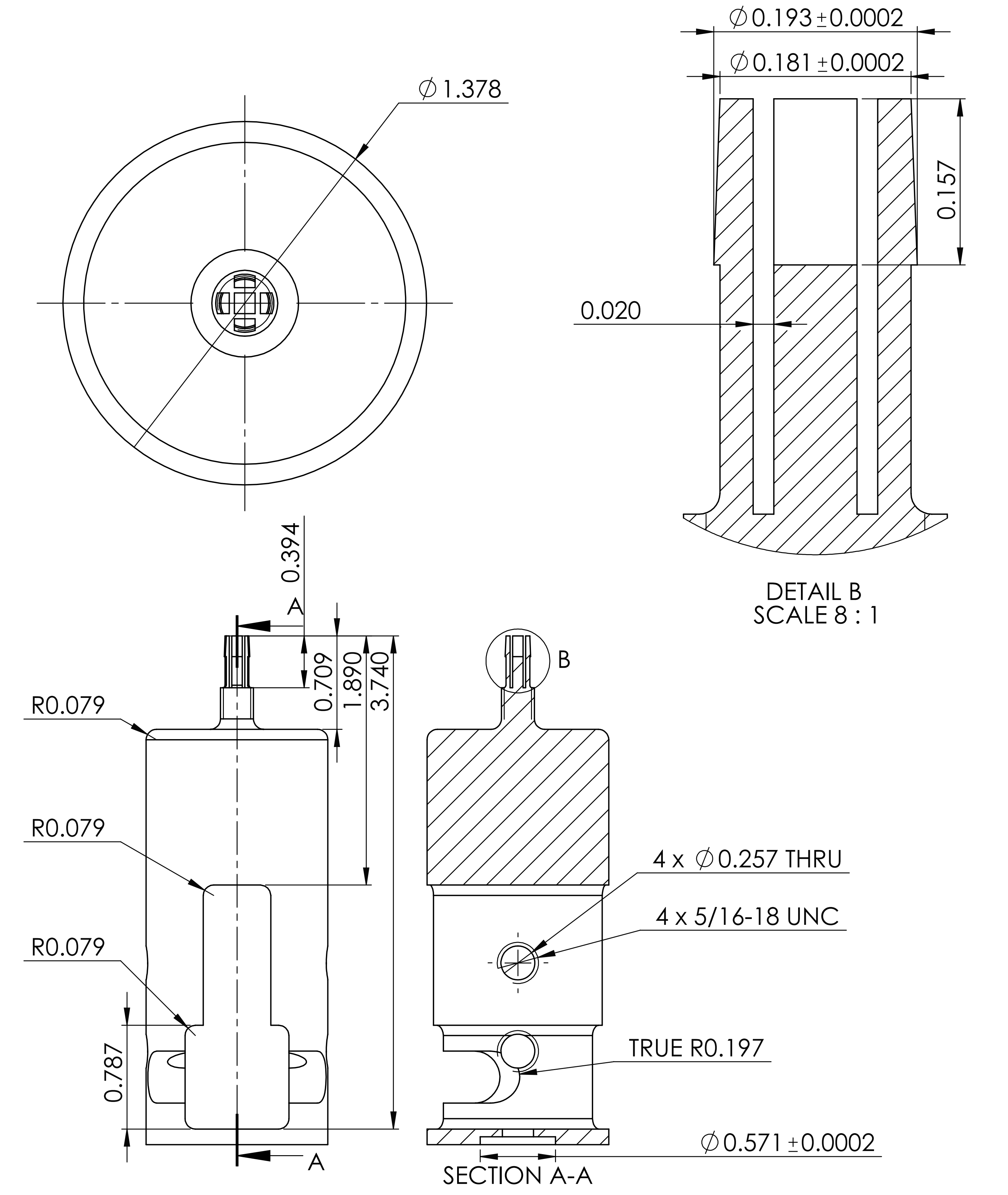
Shigley's Mechanical Engineering Design, 9th Edition.

Dr. Constantin Ciocanel

Updated Timeline



Drawings



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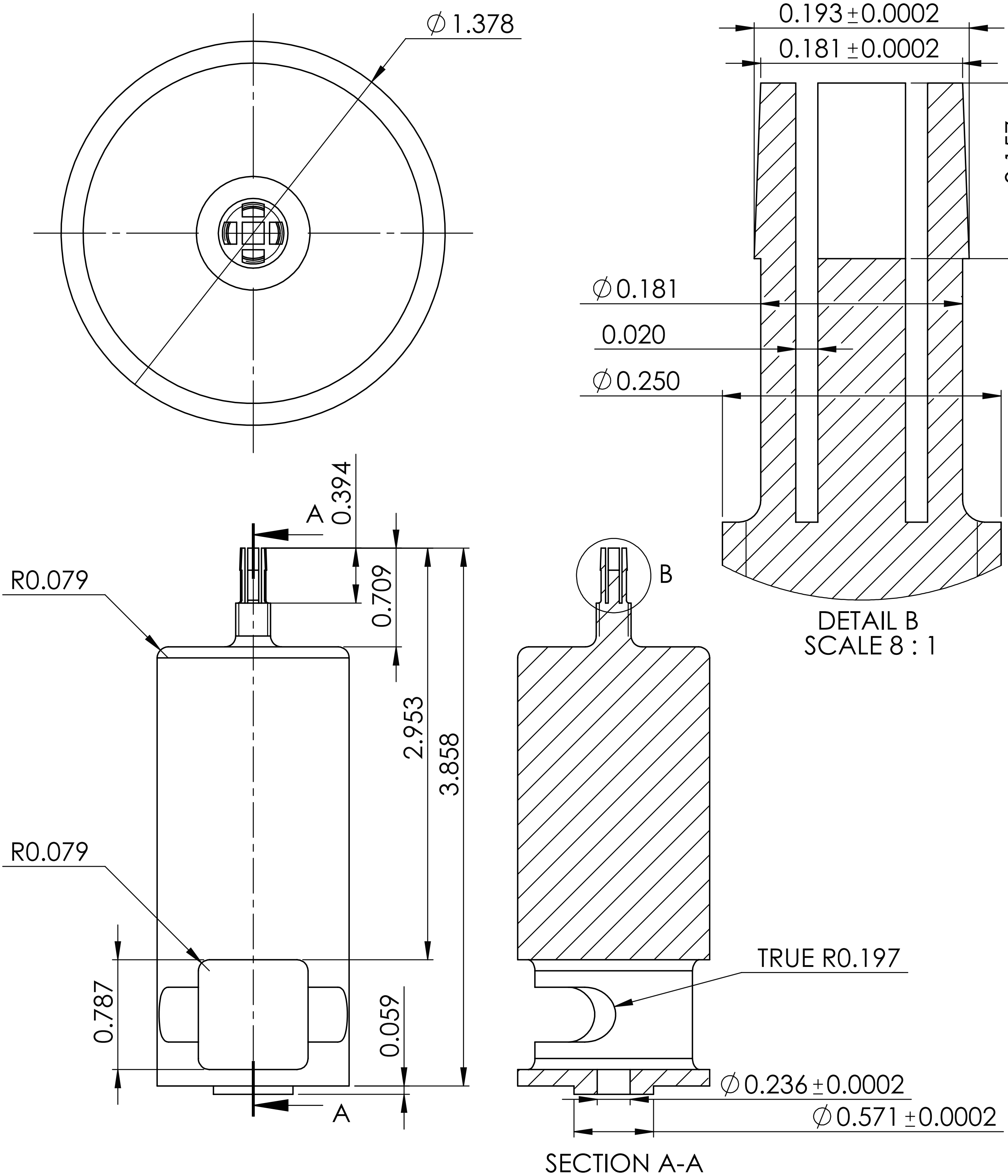

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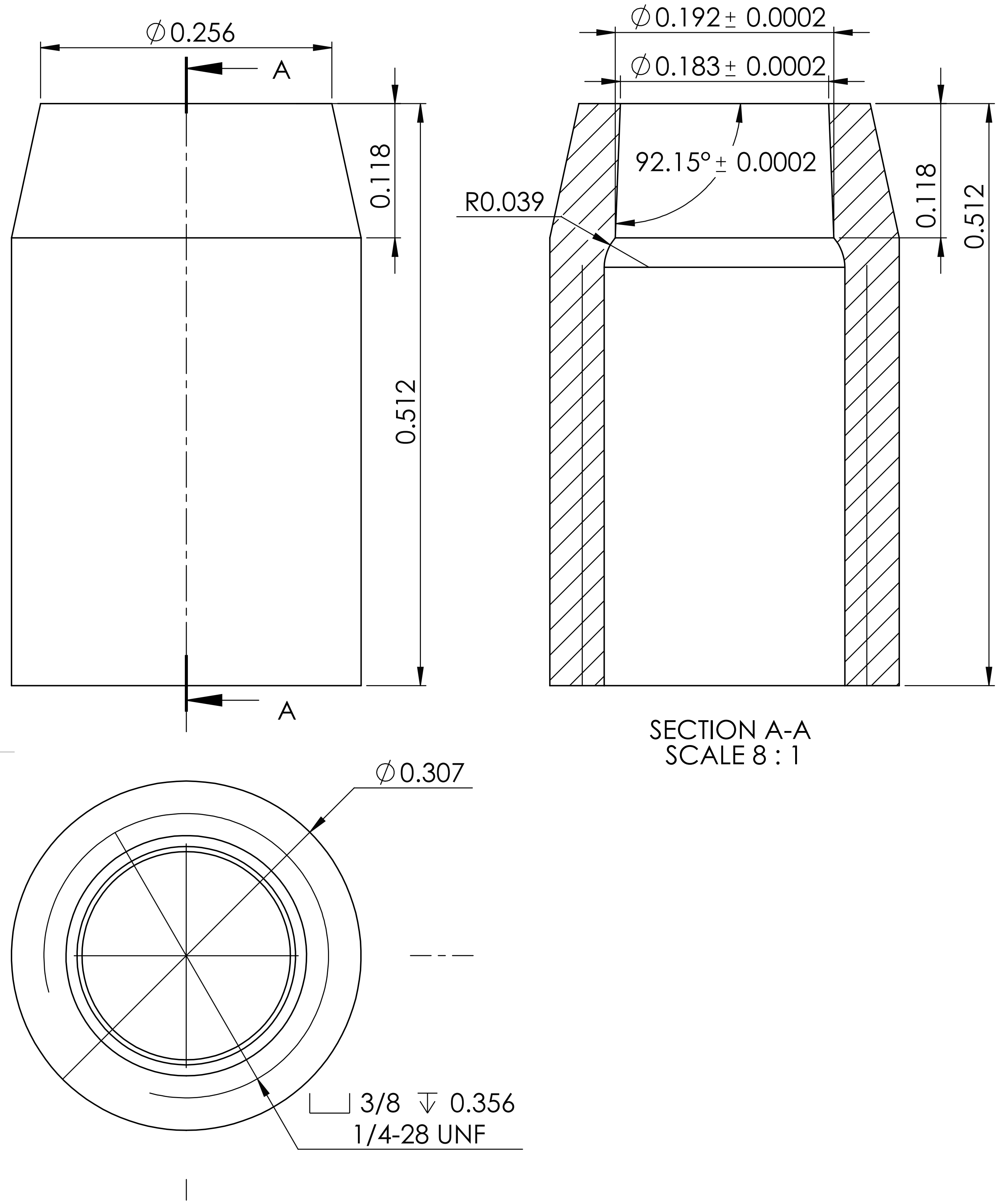

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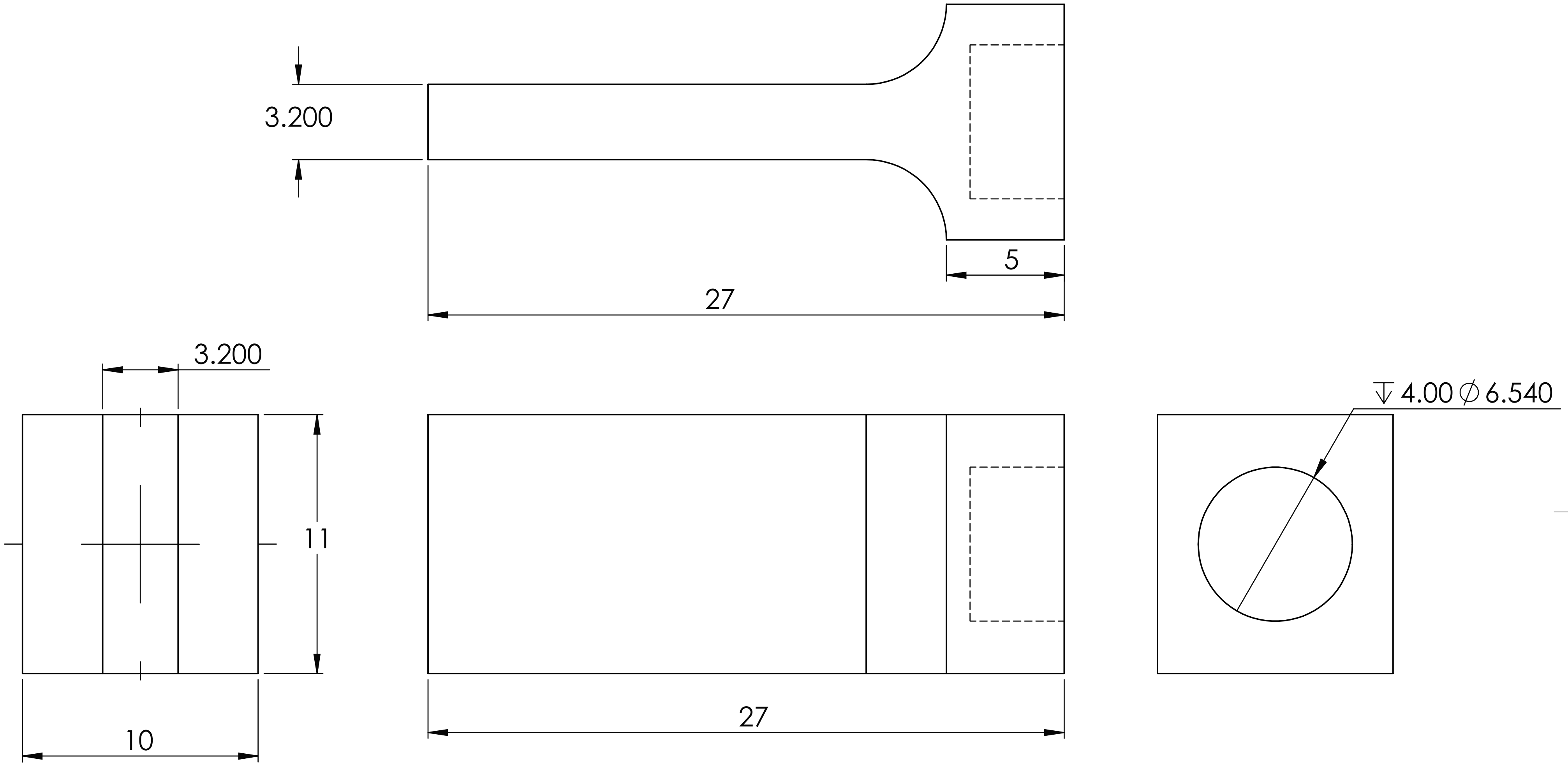

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